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Agenzia Regionale
per la Protezione Ambientale

Arpa and the Games

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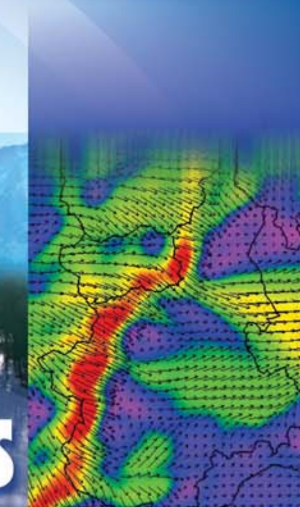

Final report on the activities performed by the Regional Agency for the Environmental Protection of Piedmont for the XX Olympic Winter Games Torino 2006

Editorial and publishing coordination
Elisa Bianchi
Arpa Piemonte, Institutional Communication

Images extracted from Arpa Piemonte archives

Graphic concept and design
La Réclame, Torino

Translation
Global Target, Torino

Printed in December 2006 by
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PRESENTATION

The XX Olympic Winter Games Torino 2006 were undoubtedly an excellent opportunity for the relaunch of the entire territory of Piedmont. They provided a unique opportunity to open up Piedmont, through the city of Torino and the surrounding mountains, to an international panorama, and proudly display the resources available.

Many people were also preoccupied with monitoring the state of the environment to ensure that the works necessary to the organisation of the Games not only respected the environment, but also fitted in perfectly with the territory.

To organise really sustainable Games, the environmental issue had to play a central role, focussing the choices of the decision-makers on the most compatible solution with the least impact.

It is no mere coincidence that the International Olympic Committee considers the environment to be the third dimension of the Olympic Movement, together with Sport and Culture, and that the Olympics are no longer just a big international sporting event, but an opportunity to create awareness of the issues related to environmental protection and sustainable development.

The challenge of the Torino 2006 Olympic Games, which were a success thanks to the commitment of everyone concerned, was to organise an edition capable of leaving a heritage of development and a new identity for our Region, basing the success on the balance between the urban and mountain territory.

The important collaboration of Arpa Piemonte was concentrated in this direction: the controls, checks and monitoring operations carried out before, during and after the event, enabled the territory to conserve the pre-existing natural heritage.

Nicola de Ruggiero
Regione Piemonte Councillor for the Environment

PREFACE

Now that the practical work is over, we have been able to dedicate time to summarising the activities performed in the past; analysing and processing the data gathered to gain a complete picture of what has been done.

The XX Olympic Winter Games gave Arpa Piemonte an opportunity to prove itself, testing its professional skills and instruments, partly through everyday contact with people from very different situations with completely different types of experience.

This publication testifies the hard work and intense commitment of all the people involved in the activities which, for some, began way back in 2000 with the preparations for the Salt Lake City Olympic Games, which were extremely useful in order to assess the strengths and overcome the limits.

Over the years we worked with Regione Piemonte, the Provincia di Torino, the Olympic Towns, Agenzia Torino 2006 and the TOROC to favour the accomplishment of the Olympic Games, also in terms of environmental protection and sustainable development.

I would just like to briefly mention a few points of excellence that characterised our work: the contribution offered for the first time, in conjunction with the Police Department, for planning the organised response to collective emergencies; the meteorology and nivology service, which proved fundamental to the correct management of the competitions and transport; during the post Olympic phase, still underway, the performance of environmental restoration tasks and completion of compensation works, which has represented a very interesting and innovative aspect and has helped us mitigate the impacts of the Olympic works, facilitate their inclusion in the territory and, in some cases, also offset critical environmental situations with operations to improve the quality of the territory.

I would like to take this opportunity to thank every member of the staff of Arpa Piemonte who, with their important daily activities, contributed to the huge success of our assignment. Obviously there is always room for improvement, but we can be satisfied with the way the task assigned to our Agency has been brought to term.

Vincenzo Coccolo
General Director of Arpa Piemonte

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This publication has been made possible thanks to the collaboration of the numerous authors, members of the staff of Arpa Piemonte, listed below:

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The entire managerial staff and those operating in the Area for the coordination of environmental matters, the Area for industrial risk and compatible economic development and the Department of Torino involved in the specialised investigation, conceptual elaboration, design and construction of the activities, for their professionalism and extensive commitment.

Communication activities

Marcella Luparia
Sara Seghetti

INTRODUCTION

In June 1999, the International Olympic Committee (IOC) chose Torino as the city that would, in 2006, host the XX Olympic Winter Games from the 10th to the 26th of February and the IX Paralympic Winter Games from the 10th to the 19th of March.

During this period, Torino became the world sports' capital. A magical atmosphere, all the sensations of which were lived and breathed to the full and will remain indelibly impressed upon the minds of all those who were involved, either directly or through the media, along with the athletes, in those fantastic days that gave an incredible boost to the region of Piedmont.

Fifteen disciplines: biathlon, bob, Nordic combined, curling, freestyle, ice hockey, figure skating, speed skating, ski jump, alpine skiing, cross-country skiing, short track, skeleton, luge and snowboard, filled the thousands of athletes competing in the Games with the joy of taking part and battling to win one of the 252 gold, silver and bronze medals assigned.

The organisation of the Games required the construction of numerous works. A total of over 65, including sporting venues, road infrastructures and villages for the athletes and press, were built in the metropolitan areas of Torino, Valle di Susa and Val Chisone, in the Olympic Towns of Bardonecchia, Cesana, Pinerolo, Pragelato, Sauze d'Oulx and Sestriere.

To guarantee an effective and non-invasive activity, as of March 2000, Regione Piemonte set up a multi-discipline technical team which also included technicians from Arpa Piemonte. In the years that followed, agreements and operating protocols were entered into with the Provincia di Torino, Agenzia Torino 2006 (a public body created for the construction of the works necessary to the completion of the XX Olympic Winter Games), the TOROC (Committee for the Organisation of the XX Olympic Winter Games Torino 2006) and, subsequently, with the Police Department of Torino, involving Arpa Piemonte in supporting and technical scientific activities, in the processing of information on the state of the environment and the eco-compatibility study of the area affected by the Olympic event.

STRUCTURE OF THE BOOK

This publication aims to describe the activities accomplished from 2000 to the present day by Arpa Piemonte for the Olympic Games. The book is divided into six chapters, each providing details on individual aspects: air, water, weather, terrain and sites, chemical risk and communication. Every chapter has been organised, generally speaking, in to the analysis of the three operating phases, i.e.: before, during and after the Olympic event, distinguishing the preparatory planning and monitoring phase, the operational forecasting and monitoring of the event phase and the phase involving the restoration of the pre-existing conditions, some aspects of which are still in progress. The next paragraph offers a summarised explanation of the contents.

The description of the methods used and the critical situations faced, as well as the analysis of the settings, makes this editorial product a useful work tool for similar experiences, inasmuch as it can be considered, to all intents and purposes, a pilot project.

Given the explanatory nature and general interest of the subject matter, the publication has also been translated in to English.

Moreover, the informative work has been completed by the addition of a detailed CD Rom. The CD Rom contains the digital reproduction of the paper publication, both in Italian and English, and details of the nivo-meteorological service and the air quality monitoring activity. The details are split into separate sections for the Olympic and Paralympic periods, in which it is possible to find a description of the general situation observed and all the forecasting products, divided by the days of distribution, issued during the Olympic period.

CHECK ON FULFILMENT OF ENVIRONMENTAL OBLIGATIONS

In the so-called authorisation and site phase, within the context of the Olympic Programme, Arpa's contribution to Regione Piemonte was arranged into two phases: technical-scientific support for Conferences of Authorisation services and verification activities during the site phase for the construction of the Olympic works.

In this way it was possible to supervise the birth of the projects and, right from the beginning, highlight potentially critical situations, assess possible alternatives and possible mitigations and the necessary compensatory actions.

During the event, Arpa Piemonte carried out on-site inspections of the Olympic competition venues, with the following aims:

- to check for any interference of the temporary works with the areas already restored by Agenzia Torino 2006,
- to check the functionality and operation of the EMAS procedures implemented by the TOROC for the environmental management of the territories and competition venues,
- to check the correct execution of the monitoring activity during the event requested by Strategic Environmental Assessment.

A slight overlap was found between the TOROC works and the areas restored by Agenzia Torino 2006, as the environmental restoration activities already in progress were not, other than in some very marginal cases, affected by the installation of the competition venue infrastructures.

A good level of respect of the regulations and application of the EMAS procedures was found, especially with regard to the management, transport and final disposal of waste in the Torino area.

In the post Olympic phase, the job of Arpa Piemonte continues to focus on the following aspects:

- control of the dismantling of temporary structures built in the competition venues, by TOROC,
- check on the restoration of the locations to the same conditions as they were in prior to the Olympics,
- check on the performance of the environmental restoration activities still to be carried out with regard to all the operations in the Olympic Programme for which Agenzia Torino 2006 is responsible,
- check on the performance of the environmental monitoring activities post operam, as required by the authorising executive deliberations,
- post operam environmental balance of the Olympic towns.

In completion of the checks on the restoration activities, Arpa Piemonte will gather and check all the documentation regarding the declarations of completion of the environmental recovery works and respect of the instructions by the directors of works and those responsible for the proceedings.

NIVO-METEOROLOGICAL ASSISTANCE

The activities were carried out in compliance with that programmed: large scale involvement of the staff of the Agency which, starting from January 31st 2006, supervised, for every competition venue, the evolution of the nivo-meteorological conditions, supplying useful indications for the competitions, for preparing the slopes and for managing the venues and roads for any problems occurring as a result of snowfall.

A few summarised figures to support the overall work are given by the products delivered:

- 29,989 messages to the INFO2006 system,
- 785 specific meteorology reports for the single competition venues,
- 35 reports on the snow conditions on the slopes,
- 70 nivological and meteorological reports dedicated to the Olympic area.

In the 10 meteorology offices situated in the Olympic valleys, about 4,400 man-hours were dedicated to the provision of meteorology forecasting, the measuring and distribution of the data observed, nivology forecasting, assessment of the snow conditions on the slopes, briefings with team leaders (about 16 for every outdoor competition) and thermal mapping of the cross-country routes.

The weather favoured both the opening and closing ceremonies, with fair conditions, no precipitation or wind and temperatures which, as forecast, posed no problems with regard to the operation of the more exposed technological equipment.

The downhill skiing disciplines scheduled for the initial days of the event, and particularly sensitive to atmospheric conditions, took place in excellent meteorological conditions.

On the evening of Wednesday February 15th, the weather deteriorated, with quite unusual phenomena, such as the passage of a frontal system typical of summer instability, which determined a lowering of the snowfall to 800 metres, below freezing level, leaving Torino under heavy snowfall for the whole evening, accompanied by thunder and lightening while the cold front passed. The subsequent persistent flow of damp air from the east, caused by a closed perturbation over the Mediterranean, blocked to the north by a mass of cold air, caused frequent sleet and poor visibility.

Due to the bad weather and frequent high winds blowing in variable directions in the ski jump area, the judges – with the forecasting support of Arpa Piemonte – were forced to postpone numerous competitions and official training sessions. The competitions went ahead successfully in the new schedule.

MONITORING THE AIR QUALITY

With financial aid from the Provincia di Torino, Arpa Piemonte carried out a specific air monitoring activity in the competition venue areas of the Susa and Chisone Valleys, with a permanent station installed especially for this purpose at Oulx, which continues to be part of the equipment of the regional air quality system, and four mobile stations positioned in Pragelato, Sauze d'Oulx, Sestriere and Bardonecchia, these being venues which give an overall representation of the air quality in the mountain towns where the Games were held.

As happens for the main urban areas of Piedmont, the data produced by the stations located in mountain areas was used for the presentation of the daily report of the Air Quality Index (AQI), calculated using a method perfectly especially for the Olympic mountain areas. This index supplies, on a scale from 1 to 7, summarised information related to PM_{10} and nitrogen dioxide, the two most critical atmospheric pollutants in the region during the winter. The report was distributed through the websites of Arpa Piemonte and the Provincia di Torino.

Chapter three presents an overall analysis of the data acquired during the monitoring activity. In short, the major criticalities discovered during the campaigns concerned PM_{10} and nitrogen dioxide, as well as the weather conditions which, on some days, prevented the dispersion of the pollutants produced by the traffic and local sources represented particularly by domestic heating (liquid or solid fuels).

WATER PLAN

The agreement that led to the Water Plan Project was stipulated between the Provincia di Torino and Arpa Piemonte in 2001. Its aim is to assess the environmental quality of the drainage basins of the Dora Riparia and the Chisone stream in the upper Susa and Chisone Valleys, involved in the Olympic events. Upon completion of the first joint project in February 2003, Arpa Piemonte and the Provincia di Torino stipulated three new agreements for the continued collaboration on the Water Plan Project in 2004, 2005 and 2006.

The results achieved during the monitoring activity enabled the constant assessment of the effects induced by the anthropic activities connected both to the preparation and accomplishment of the Olympic events and to other activities, also providing useful instruments for the correct environmental planning of water resources in the mountain area of the drainage basins of the Dora Riparia and the Chisone stream.

The experience gained during the study may also be valuable to the planning of the provincial surface water monitoring network, of which the activity performed forms a significant pilot nucleus.

PREVENTION AND CONTROL OF THE ANTHROPIC RISK

Arpa Piemonte has performed activities for the prevention and control of the chemical risk, in the context of that provided for by the Civil Defence Plan approved by Torino Police Department.

In particular, the Agency was involved in monitoring activities in five indoor Olympic venues (Torino Esposizioni, Palavela, Oval Lingotto, Palasport Olimpico, Pinerolo Palaghiaccio), in accordance with an operational programme covering the dual front of on-site analytical investigation and laboratory analysis. The planning and performance of the activities were prepared in relation to the event calendar and involved a total of 40 Agency employees, who occupied a series of roles: operational, technical, organisational, support and coordination.

Altogether 50 gaseous samples were taken using canisters and then subject to fixed-station analysis to find components extraneous to the environmental air.

There were also 65 hours of on-site monitoring using portable instruments for the instant measurement of gas and volatile organic substances.

All the results of the tests carried out were transmitted to the Arpa Piemonte department set up in the Olympic Operating Centre at TOROC Headquarters and then transmitted to the Police Department by the deadlines set.

During the Olympic Games, Arpa Piemonte also boosted the usual service of prompt availability, activating, among other things, a nucleus of technical and laboratory staff appointed specially to supply non-stop operational and specialised support in the event of receipt of signals indicating possible collective emergencies generated by NBCR (nuclear, bacteriological, chemical and radiological) attack.

COMMUNICATION

The communication activities were mainly carried out in proximity to and during the Olympic event. An important precursory action was implemented in December 2005 with the arrival on-line of the website http://meteogiochi.arpa.piemonte.it, in Italian and English, dedicated to the weather forecast for the Olympic Winter Games.

Arpa Piemonte operated at full capacity to give the public and press information in real time.

The feedback to the website was more than satisfactory. The webcams installed at the competition venues were visited and taken as reference not only by the public, but also by local authorities and foreign publications on-line. The mass media allocated visibility to the weather forecast, especially in the days leading up to the downhill skiing official training sessions and competition, when the weather was particularly unsettled.

Arpa Piemonte was acknowledged in the articles and radio-television broadcasts as an official and authoritative provider of weather forecasting service.

PROFESSIONAL FIGURES INVOLVED

Lastly, it is interesting to see how the activities in which Arpa Piemonte was actively involved required the participation of numerous technicians with specific skills. The meteorological activity in particular was carried out mainly by physicist who were joined by an engineer for the environment and the territory and two aerospace engineers. The nivological activity was carried out by geologists and graduates in natural and forestry sciences.

The planning and performance of the chemical risk activities involved the cooperation of chemical engineers, chemists, chemical experts and industrial experts specialised in mechanics and electrics.

The systems installed at the sites opened for the construction of temporary works were checked by industrial experts specialised in mechanics and electrics.

The activities regarding the assessment of environmental impacts involved graduates in natural, forestry, biological and geological science, as well as engineers for the environment and the territory.

The air quality measuring activities were carried out by chemical engineers, graduates in chemistry and pharmaceutical technologies, chemistry experts and biologists.

Journalists, graduates in communication sciences, languages, foreign literature and political science took care of the communication activities.

The water monitoring and sampling activities were carried out mainly by biologists, with the contribution of an agronomist and a naturalist.

1 Instruments for planning and assessing the impacts

1. Instruments for planning and assessing the impacts

1.1 INTRODUCTION

During the organisation of the Olympic event and the construction of the necessary venues, it was inevitable that there would also be a need to take into consideration the heritage that would be left for our territory. The design of the works and organisation of the event were, in fact, based upon principles of sustainability and maximum reduction of the impacts, a new way of conceiving design which passed through instruments for the planning and assessment of impacts, such as the Strategic Environmental Assessment (SEA) and the Environmental Impact Assessment (EIA).
In this context, Arpa Piemonte provided technical support for Regione Piemonte within the Olympic Plan, which was carried out at two levels:

- one aimed initially at participation in the SEA procedure and subsequently at the decision-making process of the Service Conferences for the authorisation of the projects. This role consequently involved activities to check sites and the prescriptions contained in the Executive Deliberations in accordance with L.285/00 and the assessment of the environmental monitoring activities carried out by Agenzia Torino 2006 during the construction of each Olympic venue;
- the other aimed at the analysis and assessment of the monitoring activities and the large scale environmental balance performed by the TOROC in the context of the instructions indicated by the SEA.

1.2 PRE-EVENT PHASE

1.2.1 THE SEA OF THE OLYMPIC PLAN

The first organic and structured example of the Strategic Environmental Assessment procedure in the Regione Piemonte is represented by the fulfilments of L. 285/2000 which, besides setting up, at national level, the Agency for the organisation of the Olympic Games, explicitly requires that the Torino 2006 Olympic Plan (O.P.) be accompanied by the Strategic Environmental Assessment, thus becoming the first SEA required by the national law. In this context, the studies aimed at obtaining environmental compatibility, begun in 2000 through the *ex ante* phase of the SEA, took into consideration the direct or indirect positive and negative effects on the territory in the short and mid term related to the works connected with the Olympic Games, "measuring", as part of a combined logic, their compatibility with the territory and their economic sustainability.

The O.P. was drawn up by the Organising Committee, the TOROC, in order to strengthen and improve existing apparatus, services and natural spaces, viability and transport, eliminating or alleviating shortcomings and risk situations which could have jeopardised or obstructed the Games. The Plan gives greater details of that previously contained in the Candidacy Dossier, on the basis of which the International Olympic Committee chose Torino as the Host City for the Games, with some variations to improve the feasibility of the operations in compliance with further requests by the IOC (International Olympic Committee) and with reference to L. 285/2000 with which the funds were set aside for the same operations and Agenzia Torino 2006 was set up to manage them.

Therefore the aim of the Strategic Environmental Assessment was to consider and highlight all the positive and negative effects that the implementation of the Plan could have generated in relation to the physical, social-economic and cultural situations in the areas concerned, in order to reduce or minimise the negative effects and strengthen those that were positive.
The numerous "actors" that took part in the SEA of *Torino 2006* represented the different aspects of collectiveness:

- the TOROC, the proponent body which, together with certain Departments of Torino Polytechnic, as well as translating the obligations imposed by the IOC (International Olympic Committee) with regard to the Olympic Plan into practical facts, also prepared the Environmental Compatibility Study requested by the SEA (used by Regione Piemonte, in agreement with the Ministry for the Environment, to express the "compatibility judgement" which enabled the Organising Committee to go ahead with the development of the Programme);

- the Regional Council which, with the participation of all the Regional Executives and with the scientific technical support of Arpa Piemonte, critically examined all the aspects related to the produced subject to SEA, established the criteria of admissibility of the projects to financing and guaranteed the control of the works also from an environmental viewpoint;
- the Ministry for the Environment, which actively participated in the study check phase and defined, in conjunction with Regione Piemonte, the procedural sequence;
- the public, directly or indirectly represented by the Local Authorities, Associations and Spontaneous Committees, who expressed fears or suggested new solutions in terms of locations and planning.

The following schedule summarises the main phases laid out by the community for the preparation of the SEA, describing the various levels into which it is divided and highlighting the contexts and main sectors in which Arpa Piemonte provided scientific technical support for the Regional sectors:

- *Assessment of the environmental situation and elaboration of the reference data*: this first phase, carried out mainly by the TOROC with Torino Polytechnic, involved the individuation, re-elaboration and presentation of information on the state of the environment and the natural resources in the area covered by the Olympic Plan, starting with the candidacy document containing the environmental information (Green Card). This activity was also carried out using the information on the environmental quality indicators supplied by the Regional and Provincial Sectors and used by Arpa Piemonte in its normal territorial monitoring activities. This phase was completed in February 2000.
- *Environmental assessment of the environmental compatibility study*: following the delivery and publication of the environmental compatibility study by the Proponent in compliance with that requested by L.285/2000, the Region set up (in September 2000) an intercouncil regional team also comprising Arpa Piemonte, to perform the critical analysis:
  - of the implications from the environmental viewpoint of the O.P.;
  - of the development priorities provided for by plans or programmes regarding the area or the sectors covered by the O.P.;
  - of the definition of the project aims and the degree of integration of the environmental problems within the respective aims;
  - of the finalities and priorities of the operations within the O.P.

  This phase was articulated through the examination of the draft document in terms of conformity to regional, national and EU policies and legislation for environmental issues and, specific to Arpa Piemonte, the checking and comparison of the data and forecasts drawn up by the TOROC.
- *Definition of the Indicators in the environmental sector for checking the performances of the O.P.*: the end of the Environmental Compatibility document analysis phase was followed by the proposition and definition of the environmental and sustainable development indicators which were implemented, with a specific Deliberation by the Regional Council, with the intention of qualifying and simplifying the environmental information collected, in order to facilitate the understanding of the interactions between the environment and the key problems of the O.P.
- *Integration of the results of the assessment in the final decision regarding the plans and programmes and preparation of the environmental balance*: this phase required the checking of the data collected and validated by the proponent for the *ante operam* reference phase and the adoption and implementation of the O.P. Environmental Balance, an activity which involved Arpa Piemonte in the capacity of assessor.

The main aims of sustainability individuated to which the O.P. made reference were:

- the minimisation of the use of non-renewable resources;
- the use of renewable resources within the limits of the possibility of their regeneration;
- the eco-compatible management and reuse of the waste and pollutant substances;
- the conservation and improvement of the situation of the eco-systems and their connectivity;
- the maintenance and improvement of the ground and water resources;
- the maintenance and improvement of the historical and cultural heritage;
- the maintenance and improvement of the quality of the local environment;
- the defence of the atmosphere at local and regional level;
- the local development of sensitivity, instruction and education in relation to environmental issues;
- the promotion of public participation in decisions regarding sustainable development.

These aims can be divided into:

- *"rationalisation"* aims, to make the transformation processes compatible with respect for the environment and to cope in a more systematic and complex way with the basic factors that influence environmental conditions;
- *"sustainability"* aims, not only to avoid aggravating the critical situations underway but also to imprint radical improvements, focusing on concrete and durable, albeit gradual elevation of the environmental quality and development conditions;
- *"mitigation"* aims, essentially to contain or reduce current or feared failures, to mitigate the negative effects, avoid worsening the situations underway by taking appropriate technological measures, repair damages with compensation, restoration or recovery operations which neither intervene in the processes nor influence the causes.

The intervention sectors individuated in which to develop the aims were:

- Energy: the Plan had to contribute to improving energy balances.
- Water and ground: the Plan had to contribute to the improvement of the stability and management of the ground and water.
- Biodiversity and landscape: the Plan had to contribute to the defence of biodiversity, the improvement of quality and ecosystem efficiency and to the enhancement of the value of the landscape.
- Mobility and transport: the Plan had to contribute to the improvement of the ratio of costs to benefits of the whole mobility and transport systems.
- Local sustainable development: the Plan had to contribute to the activation of processes of innovation and local endogenous and sustainable development.

Compared with that presented earlier, the main stages of the SEA of the Olympic Plan in accordance with Law no. 285 dated 9/10/2000 "Interventions for the Torino 2006 Olympic Winter Games" can be summarised as follows:

- **Regional Council Decree no. 61 – 1774 dated December 18th 2000** "Procedures and contents for the Environmental Impact Assessment of the plan of interventions for the Torino 2006 Olympic Winter Games – adoption in accordance with art.1 subsection 4 of Law 285/00".
- **Regional Council Decree no. 45 – 2741 dated April 9th 2001**, "Strategic Environmental Assessment of the Plan of interventions for the Torino 2006 Olympic Winter Games" which considers as sustainable the overall plan of the Olympic interventions and individuates aims and prescriptions the pursuit of which is able to guarantee the sustainability of the Olympic event.
- Preparation by the TOROC **of a monitoring plan** to control the attainment of the sustainability aims over a period of time, in order to prepare the overall environmental balance of the programme of interventions.
- **Agreement of September 3rd 2001** between the Region, the Ministry for the Environment and the TOROC (Official Regional Gazette no. 37 dated 12/9/01) which individuates the indicators of the monitoring plan.
- **Agreement of May 8th 2002** between the Region, the Ministry for the Environment and the TOROC (Official

Regional Gazette no. 28 dated 11/7/02) for the specification of the indicators of the monitoring plan and delivery of the data related to the definition of the initial state.

In this context, the role of Arpa Piemonte was configured mainly with:

- The participation in the Olympic Plan assessment procedures and the drawing up of the aims and environmental prescriptions for the pursuit of environmental sustainability of the Olympic Plan.
- The validation of the data gathered and examination of the assessment process managed by the TOROC.
- The participation in the large scale environmental monitoring activity.

1.2.2 SERVICE CONFERENCES IN ACCORDANCE WITH LAW 285/00, REGIONAL LAW 40/98 AND PRESIDENTIAL DECREE 357/97

Starting in summer 2001 and continuing until the end of 2004, Service Conferences were activated in relation to part of the works for the Olympic Games presented by Agenzia Torino 2006 in accordance with the provisions made by art. 9 of Law 285/00.

Some of these Service Conferences, finalised at granting authorisation for the projects and interventions within the territory involved in the Olympic Games, were flanked by the Conferences set up in accordance with Regional Law 40/98[1] for the pronunciation of the environmental compatibility of the projects included in the annexes to the regional law, and therefore subject to the procedures of Environmental Impact Analysis.

In the case of future projects or those falling within Areas of Community Importance, the Ecological Incidence Assessment procedure was also applied in order to assess the interference of the project actions on the Areas of Community Importance interfered with, in accordance with Presidential Decree 357/97 implemented with Regional regulation no. 16/R/2001[2].

180 Service Conferences were set up in relation to the following projects:

NECESSARY WORKS	CONNECTED WORKS	ACCESSORY WORKS	TEMPORARY WORKS
97	48	29	6

Of these, the following number of projects were subject to the EIA and Incidence Assessment Procedures (in accordance with Regional law 40/98 and Decree of the President of the Regional Council no. 16/R/2001):

	MAIN WORKS	CONNECTED WORKS	ACCOMPANYING WORKS	TOTAL
Check	18	8	8	34
Assessment	8	2	3	13
Assessment of Influence	3	6	2	11

In this context, Arpa Piemonte participated in the assessment of the projects, providing scientific – technical support for the Region.

In the majority of cases the projects were supervised from the preliminary design phase through to the final phase, enabling the supervision of the birth of the works, the immediate highlighting of the potential criticalities and the pos-

[1] Regional law no. 40 dated 14/12/98 "Provisions concerning environmental compatibility and the procedures of assessment" and subsequent amendments.

[2] Presidential Decree no. 357 dated September 8th 1997 "Regulation comprising actuation of Directive 92/43/CE in relation to the conservation of natural and semi-natural habitats as well as wild flora and fauna".
Regional regulation no. 16/R dated November 16th 2001, comprising "Provisions for the matter of the Incidence Assessment procedure".

sible analysis of the alternatives, mitigations and compensations. This system also enabled the accurate assessment of the possible residual impacts, appropriate mitigating actions and possible monitoring activities. During the service conferences, Arpa Piemonte was asked to provide monitoring plans for the environmental components potentially exposed to interference which, specifically aimed at the construction of the works, would have had the purpose of enabling the recognition and assessment of the criticalities generated by the sites and, consequently, the effectiveness of the mitigation measures adopted in response to the criticalities that emerged (figures 1.1 and 1.2).

Figure 1.1 - Bob run site

Figure 1.2 - Bob run after the Olympic event

For each procedure implemented as part of the Service Conference, Arpa Piemonte prepared a report comprising the analysis of the territory from an environmental viewpoint, the assessment of the possible interactions between project and territory, the probability of such occurrence, the possible recommendable mitigations and the appropriate monitoring measures.

1.2.3 SUPPORT AND ASSESSMENT OF THE ENVIRONMENTAL BALANCE AND THE LARGE SCALE MONITORING BY THE TOROC

The large scale environmental monitoring in relation to the implementation of the Olympic Plan was based upon a set of indicators agreed and described in the agreement between the Region, the Ministry for the Environment and the TOROC. The indicators were established using the DPSIR model, which organises environmental information into 5 macro-contexts: Determinants (D), Pressures (P), State (S), Impacts (I), Responses (R).
The following table shows the indicators chosen for each topic:
Arpa Piemonte checked the data and results of the environmental monitoring carried out by the TOROC in accordan-

TOPICS	INDICATOR	DPSIR
Atmosphere	NOx, CO, CO_2 totals emitted	P
Water	BOD, COD and Nitrogen conveyed to surface hydra bodies	P
Water	BOD, COD and Nitrogen in surface hydra bodies	S
Waste	Total waste produced	P
Waste	Amount of waste sent for recovery and reuse	R
Hydrogeological risk	Overall hydrogeological risk	P
Water	Hydro criticalities in the supply points	P
Energy	Total consumption of energy (pressure indicator)	P
Energy	Production at municipal level of energy from renewable sources and cogeneration	R
Ecosystems	Quality of the eco-mosaic	S
Ecosystems	Quali-quantitative status of the natural heritage	S
Sustainable mobility	Collective urban transport of the Metropolitan area	R
Sustainable mobility	Collective extra-urban transport on wheels	R
Sustainable mobility	Collective extra-urban transport on rails	R
Sustainable mobility	Vehicular transport on wheels	P
Sustainable mobility	Interchange areas	R
Quality of installations	Quality of the installation (bio-architecture, use of eco-compatible materials, urban restoration)	S

ce with Regional Council Decree 45-2741 dated April 9th 2001 and the agreement signed by the Ministry for the Environment, Regione Piemonte and the TOROC on 8/05/2002, published in issue no. 28 of Regione Piemonte Official Gazette on July 11th 2002.

In this context, the role of Arpa Piemonte consisted in analysing the data gathered and delivered to the Ministry for the Environment, Regione Piemonte and the TOROC, agreed at the time of approval of the O.P. Monitoring Plan, in the areas interfered with (the Torino Metropolitan Area, the Pinerolo Area, Val Chisone, Val Germanasca and Val di Susa). Said activity also included the assessment of the methodological settings adopted by the TOROC for the aggregation of the environmental indicators and the data related to their initial state, consistent with the prescriptions of Regional Council Decree no. 45-2741 dated April 9th 2001. This assessment was based upon the aspects of completeness, congruence, consistency, structure and resolution of the environmental data gathered and aggregated.

On the basis of that stated earlier, the large scale environmental balance was characterised by three different moments:

1. The first involved the acquisition of the data of the indicators. The rough data acquired in the assessment of the initial state represented 100. This data was regularly updated and the difference between the updated data compared with the initial data was assessed. At this level, Arpa Piemonte validated the data referred to the state of zero, acquired by the TOROC.
2. The second consisted in the definition by the TOROC of the environmental balance of the Olympic towns, these being those directly involved in the Olympic event. At this level, Arpa Piemonte assessed the validity of the metho-

dology implemented and checked the numeric results obtained.

3. The third was developed by Arpa Piemonte and regarded the environmental balance of the whole territory involved in the Olympic event, also including the towns not classed as "Olympic", situated between the metropolitan area and the high valley, in order to check the effects of the event on a large scale.

1.2.4 CONTROL OF THE SITES AND CHECK ON RELATIVE ENVIRONMENTAL PRESCRIPTIONS

During the construction of the works, Arpa Piemonte carried out technical inspections of the various Olympic sites to check the state of progress of works and the observance of the prescriptions contained in the final provisions of the relative authorisation Service Conferences in accordance with Law 285/00 and Regional Law 40/98 for the updating of the time schedules in order to make, on the basis of the work envisaged, assessments of the possible risks of environmental impact that might occur from day to day (figure 1.3).

When any anomalies or criticalities caused by incorrect site management were found, Arpa Piemonte promptly informed the Directors of Works and the Manager of the procedure of Agenzia Torino 2006, inviting them to take all the corrective and mitigation measures possible to solve the problems (figure 1.4).

Figure 1.3 - Dustiness determined by site equipment

Figure 1.4 - Operations to mitigate the dustiness at Sansicario

Arpa Piemonte also forwarded news of the criticalities and non-conformities found at the site to the local authorities concerned, such as the ASL (Local Health Department) territorially responsible, Municipal Councils and Regional Directions involved in the expression of opinions and issue of instructions during the Service Conference phase.

During the subsequent technical inspections, Arpa Piemonte checked both the effective adoption of the measures finalised at solving the criticalities and that they actually worked, reserving judgement with regard to the need for further intervention if the measures taken were insufficient.
The results of the technical inspections, the interventions by Arpa Piemonte and all the checking activities were recorded in a database from which it was possible to extract update reports on the state of progress of the activities to send to the Regional Directions concerned.

1.2.5 ENVIRONMENTAL MONITORING ACTIVITIES (ANTE OPERAM AND WORK IN PROGRESS)

During 2002, the targets were set for the activities to monitor the sites for the construction of the Olympic works in the mountain area and subsequently, in the same way, the targets and characteristics were set for the monitoring activities for the viability works. The main aim of these activities was:

- to supply elements useful to the prompt adoption of corrective measures in order to comply with the laws in force, the SEA prescriptions and the authorisation provisions for the works in accordance with Law 285/00 and Regional Law 40/98;
- to check the temporary effects in relation to the site activities for the purpose of detecting abnormal situations and non-conformities and, lastly, checking the suitability and effectiveness of the measures to mitigate the impacts envisaged in the design phase.

The environmental components to be monitored were those listed below, with the following aims:

- *Atmosphere*: check on the impacts produced near the neighbouring receptors installed near the site area during the construction of the works using equipment and by the movement of potentially pollutant materials.
- *Noise*: check on the noise level attributable to the induced traffic and site activities.
- *Surface and underground water*: check on changes to the surface and deep water situation as a result of interference with the project and check on the pollution induced during the construction phase, with risk assessment in relation to accidental spillage of pollutant substances.
- *Ground*: check on the materials resulting from the excavation activities in accordance with the prescriptions of the laws in force (subsections 17-18-19 of art. 1, Law 443/02).
- *Ecosystems*: check on the changes in the equilibrium of the natural ecosystem present prior to the project activity, the loss of biodiversity, changes to the natural habitat, with particular reference to protected species and areas most sensitive.

For the definition of the site monitoring plan, it became necessary to characterise every environmental component, highlighting the levels of quality:

- before opening the sites, in the absence of changes induced by their operation;
- during the site activities, during the various operating phases;
- at the end of the site activities, in order to check any differences compared with the initial quality.

Considering the fact that most of the Olympic sites were close to one another and operational at the same time, the monitoring activities were planned inside the most significant sites and also in the neighbouring areas, joining up with the monitoring activity underway at the same time in relation to the SEA (carried out by the TOROC). Unlike the monitoring activity inside the sites ("working environment"), for which Agenzia Torino 2006 assigned the execution directly to the firms assigned the task of constructing the works, that in the neighbouring areas was assigned by the Agency to a consulting firm, *Golder Associates*. Comparing notes constantly with the Agency and its consultants, Arpa Piemonte established the monitoring methods, the times and data transmission methods.

1.2.5.1 Definition, coordination and control of the environmental monitoring plans of Agenzia Torino 2006

The programming of the monitoring activity, agreed between Arpa Piemonte and the Proponent on a fortnightly basis, turned into the operational phase with the preparation of specific monitoring plans, in order to provide elements useful to the prompt adoption of corrective measures in observance of the legal limits in force, the general prescriptions of Law 285/2000 and the specific authorisation provision for the works in question.

To this end, the Olympic territory covered by the works was split into uniform areas for each of which an environmental monitoring plan was drawn up for the ante operam, work in progress and post operam phases.

Figure 1.5 - Dust and asbestos monitoring

The monitoring points (figure 1.5) were chosen on the basis of the presence of:

- sensitive receptors;
- sensitive areas from the ecosystem viewpoint;
- areas subject to high environmental pressure.

The mountain area was split into six areas within which the monitoring points were individuated. These areas included the following Olympic sites:

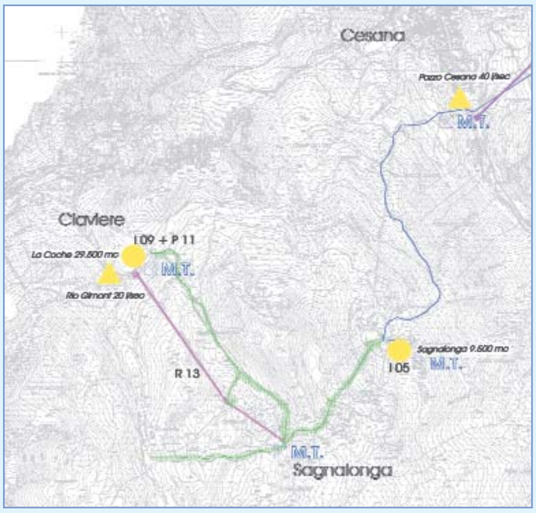

Figure 1.6 - Claviere Sagnalonga Cesana Area

Area 1 - Claviere - Sagnalonga - Cesana (figure 1.6)

Claviere - Sagnalonga programmed snow cover
Serra Granet - Colle Bercia programmed snow cover
La Coche - Serra Granet - Colle Bercia lift system

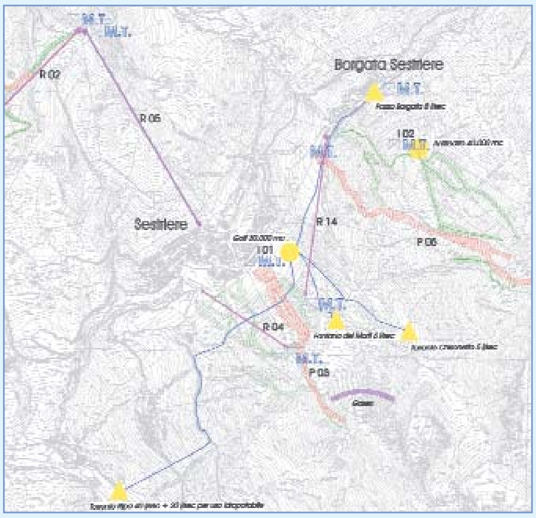

Figure 1.7 - Sestriere Area

Area 2 - Sestriere (figure 1.7)

Amphitheatre programmed snow cover
Slalom – Giant Slalom ski run
DHM and men's GS run
Nuovo Garnel lift system
Sestriere – Fraiteve lift system
Trebials lift system

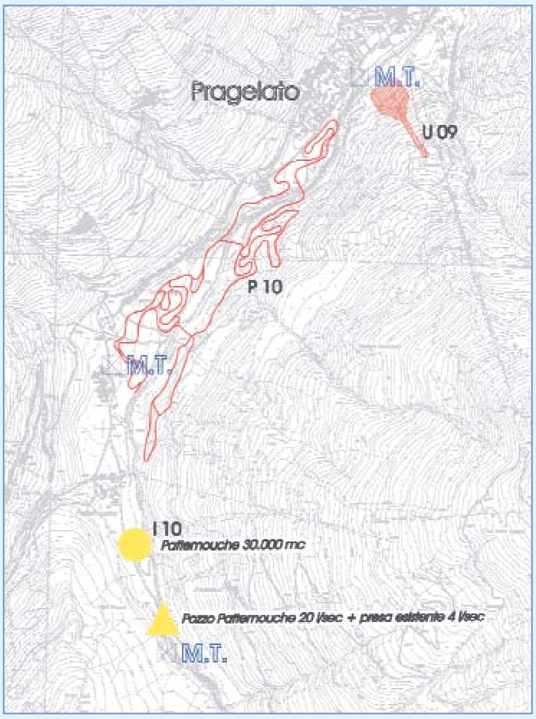

Figure 1.8 - Pragelato Area

Area 3 - Pragelato (figure 1.8)

Pragelato programmed snow cover system

Cross country ski run and diversion of the Chisone stream

Ski jump (figure 1.9)

Figure 1.9 - Ski jump site

Figure 1.10 - Oulx Sauze d'Oulx Area

Area 4 - Oulx - Sauze D'Oulx (figure 1.10)

Clotes programmed snow cover system

Nuova Sauze d'Oulx – Clotes lift system

Freestyle (figure 1.11)

Figure 1.11 - First excavations at the site for the Freestyle run

Figure 1.12 - Cesana Sansicario Area

Figure 1.13 - Artificial basin for snow cover

Area 5 - Cesana Sansicario (figure 1.12)

Sansicario programmed snow cover (figure 1.13)
Sky Lodge Le Sellette lift system
Fraiteve 3 lift system
Cesana Sky – Lodge lift system
Baby Sansicario lift system
DHW run
Biathlon venue
Bob Luge Skeleton

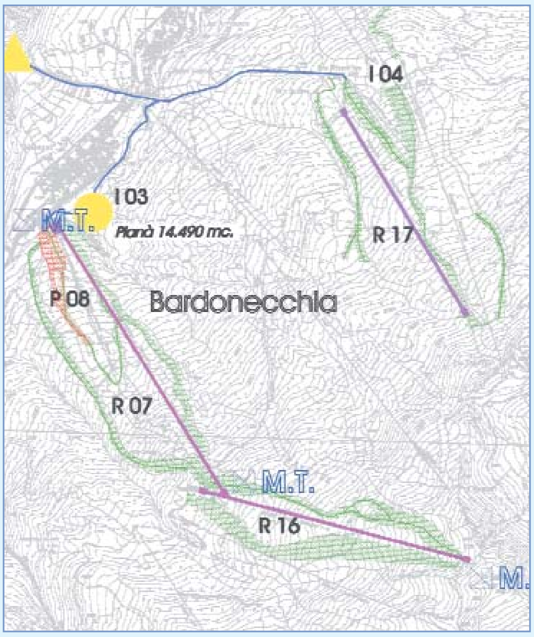

Figure 1.14 - Bardonecchia Area

Area 6 - Bardonecchia (figures 1.14 and 1.3)

Melezet programmed snow cover
Colomion programmed snow cover
Melezet – Etarpà – Chesal lift system
Chesal – Selletta lift system
Pra Reymond lift system
Halfpipe – snowboard run (figure 1.15)
Bardonecchia Fregiusa eight-passenger single cable telecab

Figure 1.15 - Half Pipe run site

The following road signs were present in these mountain areas and were also subject to monitoring:

- Modernisation of SS23 in the stretch between Perosa Argentina and Cesana T.se.
- Adaptation of the Sansicario municipal road.
- Construction of the fourth lane of the "Torino-Bardonecchia" A32 motorway.

Lastly, at the end of the Olympic event the sites of the following road infrastructures, subject to the controls and monitoring activities of Arpa Piemonte, were still open:

- Variant of S.P. 589 Laghi di Avigliana
- Variant of SS24 Claviere.

Within the context of the monitoring activities, as mentioned earlier, the environmental components subject to monitoring *ante operam* and *during work in progress* at the sites and in their areas of influence, were:

- Atmosphere
- Physical climate (noise and vibrations)
- Water (surface and underground)
- Flora, fauna and ecosystems

For each environmental component a series of quality indicators were individuated and subject to on-site measurement and processing of the data acquired. The following paragraphs list the indicators associated with each component and the criteria chosen for the individuation of the points from which the samples were to be taken. The choice of the monitoring points was made by Agenzia Torino 2006 and agreed with Arpa Piemonte on the basis of the type of works envisaged at the various sites, their position and their range of influence on the surrounding areas and possible neighbouring receptors.

Elements of the monitoring plan:

Atmosphere: Dust (DU), Asbestos (AS) and Air Quality (AQ) (figure 1.16)

Figure 1.16 - Air quality monitoring

The monitoring points were individuated in relation to the state of the places, the presence of receptors, the main wind direction and work envisaged.

The parameters used for the monitoring activities were:

- Total suspended dust (TSD)
- Breathable fraction of suspended dust (PM10)
- Dust deposited (DD)
- Total and asbestos-form airborne fibres (MOCF analysis)
- Asbestos fibres (SEM analysis)
- Pollutants linked with vehicle traffic (nitrogen oxide, sulphur dioxide, carbon monoxide, ozone, benzene and volatile organic composts)

Physical climate: Traffic Noise (TN), Site Noise (SN) and Vibrations (VB)

The monitoring of the physical climate included measuring the sound level and the vibration climate of an area.
The final aim of the noise level monitoring was the characterisation of the acoustic climate and the measurement of the noise produced by the sites. The monitoring points were established in accordance with the zoning of the territory and potential receptors present. The type and density of the receptors was taken into particular consideration, along with

the distance of the receptors from the roads and the site areas, the presence of sensitive receptors, the intensity of vehicle traffic due to the site vehicles and their ratio to ordinary traffic.
The noise monitoring activities envisaged were split into:

- monitoring of vehicle traffic noise, in order to determine the noise level in the zones crossed by vehicles for the transport of materials to and from the site areas; the increase in the flow of heavy vehicles was assessed in accordance with the entity of the works.
- monitoring of noise near the site area, in order to determine the noise level near sensitive receptors in the area of potential impact of the site.

The final aim of the vibration monitoring activity was the individuation of vibration phenomena acquired by the receptors. In the preliminary phase, in order to verify the effective impact on the territory around the site, monitoring activity was carried out in the sensitive points; the aim of this monitoring activity was to establish the initial conditions at which to compare vibrations during work in progress.

Surface water (SW) and underground water (UW)
The monitoring of the hydro environmental component included the measurement of the surface and underground water. The monitoring activities were:

- on-site measuring of the hydrological and basic chemical-physical parameters (capacity, average current speed, air and water temperature, colour, conductibility, pH, Redox potential, dissolved oxygen);
- sampling and laboratory analysis of chemical-physical parameters (suspended solids, hardness, ammoniac nitrogen, nitric nitrogen, nitrous nitrogen, chlorides, sulphates, BOD_5, COD);
- determination of the Extended Biotic Index (EBI).

For every site, the sampling points were established on the basis of the possible impacts of the site on the surrounding hydro bodies, orography and hydrology of the study areas and the works envisaged.

As far as underground water is concerned, the monitoring activities envisaged were:

- measurement of the static water table;
- on-site measuring of the hydrological and basic chemical-physical parameters (temperature, pH, colour, conductibility, Redox potential, dissolved oxygen, volatile organic substances);
- sampling and laboratory analysis of chemical-physical parameters (total dissolved solids, carbonate alkalinity, chlorides, ammoniac nitrogen, mineral oils, organic solvents and chloride solvents, total coliforms, faecal coliforms, faecal streptococci, total hydrocarbons, aromatic polycyclic hydrocarbons).

The choice of the sampling points was made by individuating a sampling point upstream from the site area (comparative sample), compared with the direction of the main flow of the underground water, and one or more sampling points downstream from the site area.

For the ante operam and work in progress phases the following 90 monitoring points were individuated, associated with the different environmental parameters to be investigated:

STAT. CODE	INDICATOR	MUNICIPALITY	Po	PD	AM	QA	RT	RC	VB	ASP	AST
1.1	Claviere, roundabout in the town centre	Claviere	X			X	X		X		
1.2	Bar restaurant La Coche	Cesana T.se	X		X			X			
1.3	Rio Gimont, uphill from La Coche	Cesana T.se								X	
1.4a	Sagna Longa	Cesana T.se	X		X			X			

STAT. CODE	INDICATOR	MUNICIPALITY	PO	PD	AM	QA	RT	RC	VB	ASP	AST
1.4b	Sagna Longa	Cesana T.se									X
1.5	Torrente Ripa, downhill from pumping station	Cesana T.se								X	
1.6	Rio Gimont, uphill from La Coche	Cesana T.se								X	
1.7	Torrente Ripa, uphill from pumping station	Cesana T.se								X	
1.8	Colle Bercia	Cesana T.se	X		X						
1.9	Intermediate station	Cesana T.se			X						
2.1	Sestriere, Fiat Towers area	Sestriere	X		X	X	X	X	X		
2.2	Sestriere, lake site parking lot	Sestriere	X		X	X	X	X			
2.3	Borgata, campsite	Sestriere	X		X			X			
2.4	Borgata, opposite Trebials start point	Sestriere	X		X			X			
2.5	Sauze di Cesana, Torrente Ripa downhill from Argentera weir	Sauze di Cesana								X	
2.6	Chisonetto creek, downhill	Sestriere								X	
2.7	Sestriere, Amphitheatre hollow	Sestriere	X		X						
2.8	Sestriere, Alpette bar	Sestriere	X		X						
2.9	Sestriere, Tana della Volpe bar	Sestriere	X		X						
2.10	Sestriere, Motta ski lift departure	Sestriere			X						
2.11	Sauze di Cesana, Torrente Ripa weir	Sauze di Cesana	X		X						
2.12	Sauze di Cesana, Torrente Ripa uphill from Argentera weir	Sauze di Cesana								X	
2.13	Chisonetto creek Mount Borgata	Sestriere								X	
3.1	Traverses, junction for Plan	Pragelato	X		X	X	X		X		
3.2	Plan	Pragelato	X		X						
3.3	Pragelato, cemetery area	Pragelato	X		X			X			
3.4	Chisone stream jump bridge	Pragelato								X	
3.5	Pragelato, case Riviere	Pragelato	X		X			X			
3.6	Pragelato, road junction site diversion	Pragelato				X	X				
3.7	Chisone stream Das Itreit bridge	Pragelato								X	
3.8	Pattemouche	Pragelato	X		X			X			
4.1	Jouvenceaux, La Chapelle parking lot – road side	Sauze d'Oulx			X						
4.2	Jouvenceaux, La Chapelle parking lot – houses side	Sauze d'Oulx	X			X	X		X		
4.3	Sauze d'Oulx, road junction near Freestyle summit	Sauze d'Oulx	X		X			X			
4.4	Sauze d'Oulx, downhill from North site	Sauze d'Oulx	X		X						
4.5	Sauze d'Oulx, play area	Sauze d'Oulx	X		X			X			
4.6	Jouvenceaux, houses downhill from site	Sauze d'Oulx			X						
4.7	Sauze d'Oulx, downhill from South site	Sauze d'Oulx			X						
4.8	Sauze d'Oulx, point between the two roads	Sauze d'Oulx			X						
4.9	Jouvenceaux, La Chapelle houses towards site East	Sauze d'Oulx			X						
4.10	Jouvenceaux, La Chapelle houses towards site West	Sauze d'Oulx			X						
4.11	Sauze d'Oulx, course excavation West	Sauze d'Oulx			X						
4.12	Sauze d'Oulx, course excavation East	Sauze d'Oulx			X						
4.13	Gran Comba	Sauze d'Oulx	X		X						
4.14	Ciao Pais Refuge	Sauze d'Oulx	X		X			X			
4.15	Gad	Oulx	X		X						
5.1	San Sicario	Cesana T.se	X	X	X			X	X		
5.2	High San Sicario	Cesana T.se	X	X	X			X			
5.3	San Sicario, houses at bar Ceccarelli	Cesana T.se	X	X	X						
5.4	Rio Pre Claud South of the course 200 metres downhill from discharges	Cesana T.se								X	
5.5	Rio Jaffeul 200 metres downhill from discharges	Cesana T.se								X	
5.6	San Sicario, Pariol junction	Cesana T.se	X	X	X	X	X	X	X		
5.7	Cesana T.se, Pariol chair lift junction	Cesana T.se	X	X	X	X	X		X		
5.8	Cesana T.se town, road to campsite	Cesana T.se	X		X						
5.9	Cesana T.se town centre, roundabout for Sestriere	Cesana T.se	X			X	X				
5.10	Cesana T.se, well uphill from town Torrente Ripa	Cesana T.se									X

STAT. CODE	INDICATOR	MUNICIPALITY	PO	PD	AM	QA	RT	RC	VB	ASP	AST
5.11	San Sicario, Soleil Boeuf	Cesana T.se			X						
5.12	San Sicario, finish point of baby lift system	Cesana T.se			X						
5.13	Cesana T.se, Rougies basin	Cesana T.se	X		X						
5.14	Rio Pre Claud South of the course 200 metres uphill from discharges	Cesana T.se								X	
5.15	Rio Jaffeul 200 metres uphill from discharges	Cesana T.se								X	
5.16	San Sicario, tennis courts	Cesana T.se	X								
5.17	Rio Pre Claud, uphill from Pariol discharge	Cesana T.se									
5.18	Rio Pre Claud, downhill from Pariol discharge at station 5.4	Cesana T.se									
5.19	Rio Pre Claud, downhill from Pariol discharge and uphill from station 5.4	Cesana T.se									
6.1	Melezet Les Arnauds, opposite site area	Bardonecchia	X	X	X			X			
6.2	Bardonecchia, roundabout in the town centre at ATL	Bardonecchia				X	X		X		
6.3	Pian del sole	Bardonecchia	X		X			X			
6.4	Chesal	Bardonecchia	X		X						
6.5	Southwest departure of Chesal-Selletta chair lift	Bardonecchia			X						
6.6	Selletta	Bardonecchia	X		X						
S06.1	Shopping centre on Pinerolo bypass	Pinerolo	X			X	X	X			
S06.2	Houses opposite San Martino bridge	San Secondo di Pinerolo	X					X	X		
S06.3	Houses at Porte opppsite entrance to tunnel	Porte	X					X			
S06.4	Hamlet of Turina	San Germano Chisone	X					X	X		
S06.5	Houses at San Antonio	San Germano Chisone	X					X	X		
S06.6	Hamlet of Malanaggio	Porte	X					X	X		
S06.7	Chisone stream downhill from Porte	Pinerolo								X	
S06.8	Torrente Turinella	Porte								X	
S06.9	Torrente in the hamlet of Malanaggio	San Germano Chisone								X	
S10.1	Cesana T.se, picnic area	Cesana T.se			X						
S10.2	Champlas du Col	Sestriere				X	X				
S10.3	Rio di Champlas	Sestriere								X	
S10.4	Pragelato, "La Ghironda" restaurant park area	Pragelato	X			X	X				
S10.5	Fenestrelle, town centre	Fenestrelle				X	X				
S10.6	Hamlet of Depot	Fenestrelle	X					X			
S10.7	Hamlet of Meano	Perosa Argentina				X	X				
S10.8	Rio Agrevo	Perosa Argentina								X	
S10.9	Perosa Argentina, town centre	Perosa Argentina	X			X	X	X			
S10.10	Perosa Argentina, start of town	Perosa Argentina	X					X			

For the *ante operam* phase, between May and June 2003, the significant monitoring points for characterising the different environmental components in the various Olympic mountain areas were individuated. The ante operam data was very useful in order to gain a picture of the environmental components before activating the site and for comparison with the work in progress phase.

Lastly, Agenzia Torino 2006 assigned the monitoring of the **"Ecosystems, fauna and flora"** component to the Department of Animal Biology of Torino University in the *ante operam* and work in progress phases. During the monitoring activities, any changes or alterations in the various components were highlighted, taking into consideration the biological cycles of the animal and vegetable components. The locations concerned and monitoring times were defined by way of Environmental Monitoring Plans (EMP).

The locations where the samples of vegetation and fauna were collected are listed below:

CODE	LOCALITY	TYPE	BIRD LIFE	HOOFED ANIMALS	ECO SYSTEMS	FLORA
1	San Sicario – Loc. Pariol	grassy pasture	X	X	X	
2	San Sicario – Loc. Pariol	wood	X	X	X	
3	San Sicario – Italsider Colony	wood	X	X	X	
4	San Sicario – Loc. Soleil Beuf	grassy pasture	X	X	X	X
5	San Sicario – Loc. Fraiteve (R02 departure)	mountain pa-sture and quarry	X	X	X	
6	Champlas Seguin	grassy pasture	X	X	X	
7	Sauze d'Oulx – Loc. Frumentine G.	grassy pasture	X	X	X	
8	Sauze d'Oulx – Loc. Ciao Pais	wood	X	X	X	
9	Sauze d'Oulx – Loc. Clotes	grassy pasture	X	X	X	
10	Pragelato – Loc. Plan left orogr	meadow	X	X	X	
11	Pragelato – Loc. Plan right orogr	wood	X	X	X	X
12	Pragelato – Opposite Loc. Granges	wood	X	X	X	
13	La Coche	meadow - peat bog	X	X	X	X
14	La Coche	Gimont forest	X	X	X	
15	Gimont intermediate	Gimont forest	X		X	
16	Gimont arrival	meadow forest	X	X	X	
17	Sagnalonga	forest	X	X	X	
18	Sagnalonga	Cesana forest	X	X	X	X
19	Borgata Sestriere Pian del sole	grassy pasture	X		X	X
20	Sestriere Banchetta	mountain pa-sture and quarry	X	X	X	
21	Sestriere Trebials	wood	X	X	X	
22	Sestriere Alpette	grassy pasture	X	X	X	
23	Sestriere Principi	grassy pasture	X		X	
24	Bardonecchia – Loc. Planà	wood with meadow	X		X	X
25	Bardonecchia – R07 arrival	wood	X	X	X	
26	Bardonecchia – Loc. Pian d. Sole	wood	X	X	X	

1.2.5.2 Planning the environmental monitoring activities during work in progress in the Olympic areas

The planning of the monitoring activity during work in progress (sampling frequency and areas to be monitored) was established every eleven days on the basis of the work in progress time schedules (updated and transmitted by the various Directors of Works to the Arpa Piemonte EIA/SEA Coordination) and of the environmental forecasts elabora-

ted for the period in question and divided across the various areas of intervention. This operating method was developed in order to optimise the monitoring activities and correlate them to the effective site activities underway. It then became necessary to actuate a closely coordinated relationship between Arpa Piemonte and Agenzia Torino 2006, aimed at planning and solving environmental problems and consequently focussed on the preventive assessment of the "impact risk" and the consequent "environmental charge" of the activities.
The criterion with which the type, location and frequency of the monitoring activities was established was linked to the types of activity envisaged in the various sites, their timed succession, the vulnerability of the territory in which the various sites were located and the location of the receptors in the area concerned.
For each work, the activities considered to be sources of possible pressure were grouped into the following general types:

- demolition of reinforced concrete or brick structures
- dismantling of electromechanical structures
- removal of vegetation
- ploughing
- piling up the earth
- digging foundations
- earth moving for reshaping the surface
- digging trenches
- drilling wells and pilings
- construction of foundations
- construction of buildings
- installation of electromechanical structure
- plumbing works
- road construction
- vehicle traffic
- construction of parking lots
- disposal of materials
- provision of inert materials
- installation of plinths
- production of waste
- use of the helicopter.

Operationally, to be able to quantify the potential pressure of the various sites on the relative neighbouring areas, the different activities programmed in every site were assigned incidence values on a scale of 0 to 5, and in particular:

Values	0	1	2	3	5
Risk	Nil	Negligible	Low	Medium	High

Values attributable to the risk of impact in site areas

The risk values were aggregated in six classes of impact which summarise the following situations:

CLASSES OF IMPACT					
negligible	low	medium-low	medium	medium-high	high

The attribution of the classes in this way enabled the charting of the forecasts for each area.
In this way the daily assessment of the impacts in each area was the result of the sum of the values of all the activities underway. Fortnightly summarised pictures of the impacts were thus defined for the different Olympic areas.
By way of example, the impact forecast for the period from 1/9/03 to 15/9/03 is shown for the different site areas (figure 1.17) and in particular for the same period in the Sestriere area (figure 1.18).

From the analysis of these graphs, we can see that the area in which critical situations occurred was that of Sestriere, due to the fact that numerous sites were open at the same time and also to the type of activities envisaged; next came the Cesana-Sansicario area, while the other areas presented less critical situations as many of the sites had completed the most incisive activities (mainly excavations and filling, the movement of material and consequent heavy traffic).
Following the scenario which emerged for the period analysed, the monitoring activity making provision for particular attention to the more critical areas was programmed in conjunction with Agenzia Torino 2006.

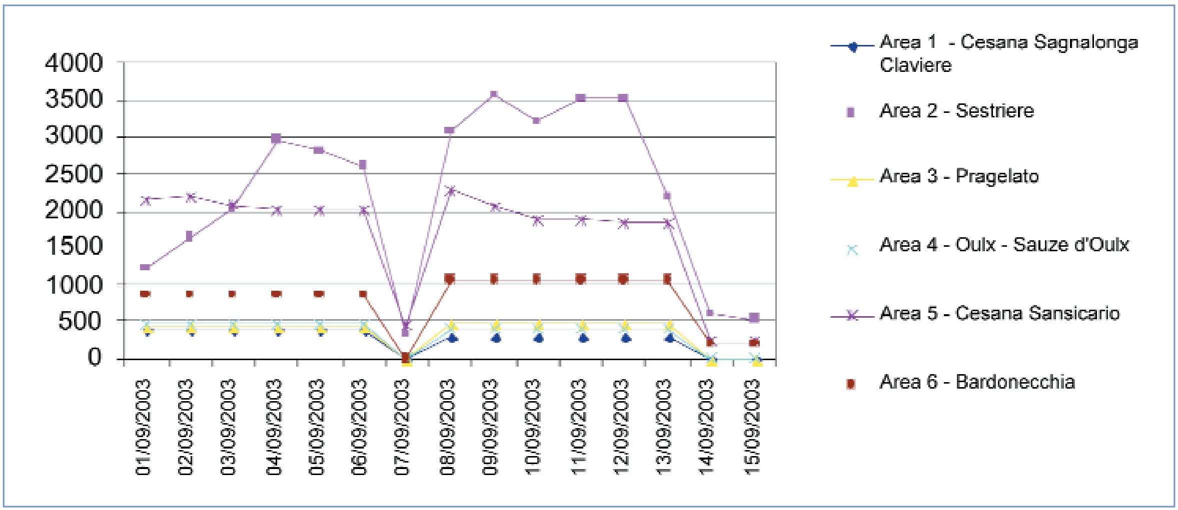

Figure 1.17 - Forecast of impact in the Olympic areas between 01/09/03 and 15/09/03

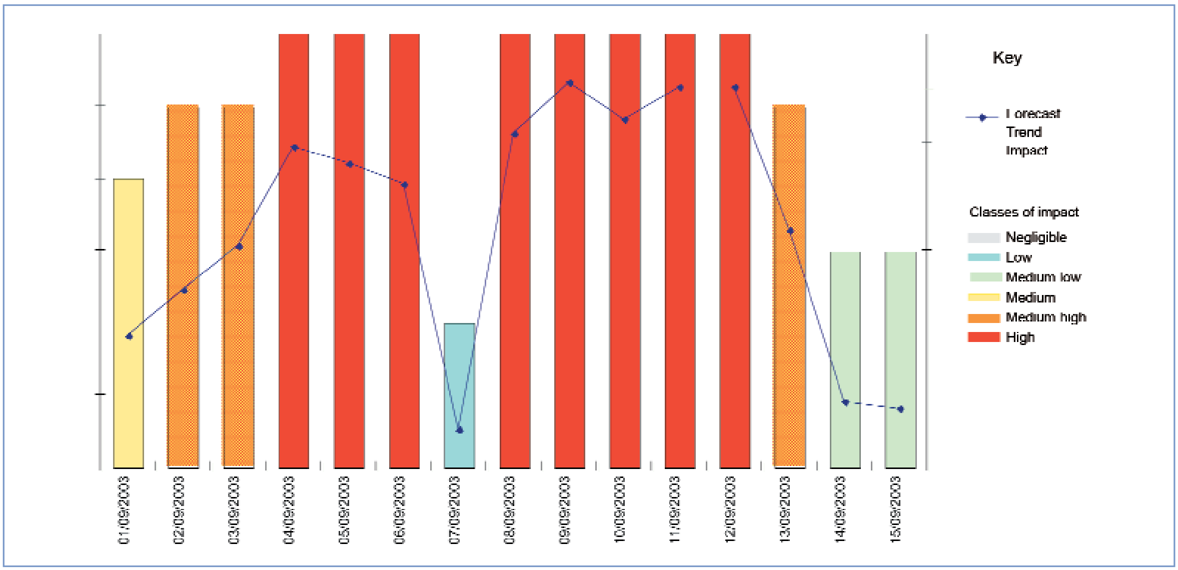

Figure 1.18 - Forecast of impact in the Sestriere area between 01/09/03 and 15/09/03

1.2.5.3 Analysis of data and management of criticalities

The results of the monitoring activities were sent to Arpa Piemonte every month, but the monitoring teams had to send information on data in excess of the legal limits, or the presence of particular environmental criticalities highlighted by the data obtained, within 48 hours (a week for surface and underground water). On its part, Arpa Piemonte used its structures to carry out sample analyses to check the effectiveness of the mitigation measures, the correct performance of the monitoring activities and the validity of the data transmitted.

In the event that the legal limits were exceeded or when particular criticalities were identified, communication within 48 hours enabled Arpa Piemonte to promptly inform Agenzia Torino 2006, the Directors of Works of the sites monitored and the controlling authorities of the problem, in order to urgently actuate all the appropriate measures to eliminate or mitigate the environmental criticality found. This "alarm system" was particularly activated for the atmosphere component, in relation to the dust and airborne fibre parameters, for which frequent situations of criticality were found and with regard to which Arpa Piemonte asked the firms to take specific mitigation measures (e.g.: wetting the site areas and roads and the wheels of the heavy vehicles in transit) and, in some cases, also asked for temporary interruption of the site activity.
For the assessment of any changes in the quality of the components, Arpa Piemonte compared the quality data measured before and during the site activities by Agenzia Torino 2006. This investigation was carried out using the complete series of data belonging to the monitoring plans of the mountain areas which Arpa Piemonte received every month from Agenzia Torino 2006.
The work of Arpa Piemonte consisted therefore in a statistic elaboration of the data received through the use of the SPSS programme and a subsequent analysis aimed at presented the large number of parameters investigated in a summarised and comparable way, in order to succeed in establishing an *judgement of environmental quality*. For this last purpose, Arpa Piemonte applied a method the main characteristics of which are described below.

The environmental data obtained from the monitoring activity is expressed with different units of measure, pertinent to the type of parameter measured, and is not therefore directly assessable and comparable in terms of environmental quality. Each of these parameters is expressed with a specific unit of measure and it is possible to establish a scale of judgement of quality for each one, deriving from the use of *threshold values* contained in scientific literature and reflected by the various European, national and regional laws; however this scale is rarely expressed and represented.
It is therefore necessary to use a user-friendly, *scientifically* valid instrument which is also useful in *communication to those who are not experts in the sector*, enables the expression of *environmental quality judgements*, operation on large amounts of data, heterogeneous parameters and different assessment scales.
The method used has two fundamental characteristics:
- The environmental quality assessment scale in relation to the data obtained from the environmental monitoring activities is explicit and shared. This has an important influence on the transparency of the assessment process and enables improved legibility of the criteria used.
- The environmental quality assessment scale is consistent, so that several parameters can be dealt with at the same time and/or different environmental components can be compared.

By way of the method used, derived from the analysis of the literature available, starting with the first experiences of the Battelle Institute in the field of planning and assessment of the environment in the seventies[1] through to multicriteria assessment systems, *environmental quality functions* which express a judgement of environmental quality starting from the values of the parameters measured are individuated and described.
The function-curves that make up the interpretive model are described by equations that enable the fast passage from the environmental parameter values measured (concentrations, noise levels, etc.) to quality values expressed through an *Environmental Quality Index* (EQI). This enables comparison and an assessment, which is not exclusively specialised, of the environmental parameters, assigning a quality judgement to each one and relating the values of the parameters expressed with different units of measure to a single scale of reference.
The quality judgement is represented on a scale which takes on, in our case, index values between 0 and 10, which are assigned a value of *Dreadful Environmental Quality* (EQI=0) and *Excellent Environmental Quality* (EQI=10) respectively.

[1] *E.g.: Battelle Dredging Impact Assessement Method, Battelle Environmental Evaluation System for Water Resources, Battelle Water resource Project*

The *function-curves*, which enable the transformation of the environmental data measured into an *Environmental Quality Index*, are individuated starting from simple tables or nomograms and are defined on the basis of shared trends at scientific level or gathered from the law. They are formed by conventionally assigning *cornerstone values* of quality judgement to specific values taken from reference thresholds provided for by the European, national and regional environmental legislation, scientific literature or assigned on the basis of judgements by experts in the sector.
The assessment method used was applied during the *monitoring phase* to assess the change in environmental quality responsible for the change in the values of each parameter measured and, therefore, to describe the evolution of the environmental quality of each component monitored in the short and long term.
In this way, it was possible *to give early* warning of deteriorations in environmental quality in order to prevent the occurrence of risk situations for the environment and public health.

The method used therefore tended to offer a summarised and comparable expression of a judgement on environmental quality and on its change in time, as expressed by the parameters monitored. The check on the individual rising above thresholds or limits established by the legislation or values measured during the *ante operam* phase was carried out at every communication of data by Agenzia Torino 2006 with analysis and managed processing using the SPSS program.

1.2.5.4 Coordination of the Arpa Piemonte monitoring activities carried out parallel to the monitoring activities of Agenzia Torino 2006

As mentioned earlier, during the works, Arpa Piemonte, besides making specific technical inspections of each site in order to check the observance of the environmental prescriptions contained in the authorisation deliberations for the individual operations, also performed a series of monitoring activities parallel to those carried out by Agenzia Torino 2006 in situations of particular criticality, in order to check the effectiveness of the measures taken by the firms to reduce the impacts on the components interfered with. This activity involved Arpa Piemonte in the control of air quality, with particular regard to the measurement of PM_{10} by the staff of the Provincial department of Torino and of airborne fibres by the Regional Asbestos Centre, which analysed samples from the neighbouring receptors of the more critical sites and personal samples provided by those working at the sites.
The main criticalities occurred during the summers of 2004 and 2004, during extremely dry periods while earth moving works were being carried out. The Arpa Piemonte sampling campaigns were carried out mainly at the receptors near the sites in Pragelato and Sauze d'Oulx for airborne fibres and in Cesana T.se (the town centre and Sansicario) and Avigliana for PM10.

1.3 "EVENT" PHASE

During the Olympic event, Arpa Piemonte was involved in emergency planning activities and also in activities to check the environmental management and the management of the systems at the individual venues.

1.3.1 PREVENTION AND CONTROL OF THE CHEMICAL RISK

During the whole Olympic event, control actions were carried out, aimed at preventing collective emergencies due to NBCR terrorist attacks. In particular, the activities related to the chemical risk were planned and carried out by Arpa Piemonte in the context of the provisions made by the Civil defence Plan drawn up by the Torino Police Department, as explained in the specific chapter.

1.3.2 CHECKS ON ENVIRONMENTAL MANAGEMENT AND THE MANAGEMENT OF THE SYSTEMS AT THE VENUES

Before and during the Olympic event, Arpa Piemonte, in observance of its institutional duties, performed an overall action for the defence of the environment and the territory, also providing highly qualified specialised support to guarantee the safety of the whole district from the anthropic and natural risk.

The environmental impact assessment and strategic environmental assessment activities, to which the final works were subject during the design and construction phases, were continued with checks on the temporary works in order to guarantee the respect of the safety requisites and the restoration of the environmental conditions.

In January 2006, the activity was concentrated on the temporary works being prepared by the TOROC at the mountain venues and those in the metropolitan areas, and was carried out in the form of joint on-site inspections by the staff of the EIA/SEA structure flanked, for more general aspects of industrial risk, by System Check department technicians.

With regard to this last aspect, the on-site inspections regarded special checks on electric, heating and lifting systems. Given the considerable number of generation and heating systems (every venue had to be independent in terms of power and provide excess power in case the systems failed), this activity implicated a considerable commitment for Arpa in terms of time and human resources.

Altogether, twelve on-site inspections were carried out in the sites of twelve temporary works at Olympic mountain and indoor venues. The results of the checks carried out on the electric systems, lifting equipment and heating systems were subject to specific technical reports to the TOROC containing, among other things, the indication of comments and notes for the improvement of the safety conditions. In any case, for all the sites inspected, the regulations and technical laws in force were always observed.

As regards the checking of any anomalies and environmental criticalities, special attention has been devoted to possible interferences with the areas already subject to environmental restoration of the site delivered by Agenzia Torino 2006 to the TOROC. To this end, the Olympic works situated in the mountain areas and the temporary works connected with them were subject to detailed examination due to their peculiar characteristics and vulnerability.

The checking of these interferences, despite being difficult due to the numerous work projects in progress and the constantly evolving state of the locations, will enable more accurate control of environmental emergencies during the dismantling of the temporary works and, to an even greater extent, in the environmental restoration phase (both by the TOROC and Agenzia Torino 2006).

It was also checked that in all the temporary works the toilets were connected to the pre-existing sewage network or equipped with tanks which were regularly emptied by expressly individuated firms.

As far as the Arpa Piemonte inspections carried out during the event are concerned, they had the following aims:

- to check the functionality and operation of the EMAS procedures implemented by the TOROC for the environmental management of the individual venues;
- to check the correct execution of the monitoring activity during the event requested by Strategic Environmental Assessment.

In general, from the environmental viewpoint, a slight overlap was found between the TOROC works and the areas restored by Agenzia Torino 2006, as the environmental restoration activities already in progress were not, other than in some very marginal cases, affected by the installation of the individual venues.

A good level of respect of the regulations and application of the EMAS procedures was also found, especially with regard to the management, transport and final disposal of waste in the Torino area; there was a good level of respect of the environmental laws.

1.4 POST EVENT PHASE

With the end of the Olympic event, the activities carried out by the Arpa Piemonte EIA/SEA structure were differentiated as follows:

1. Check on the dismantling of the temporary works and restoration of the state of the locations;
2. Start up and organisation of *post operam* environmental monitoring activities;
3. Check on the restoration of the Olympic mountain site areas.

1.4.1 CHECK ON THE DISMANTLING OF THE TEMPORARY WORKS AND RESTORATION OF THE STATE OF THE LOCATIONS

In this first post-Olympic phase, part of the activities were concentrated on checking the dismantling of the temporary works at the Olympic mountain venues. These were mainly tensile structures covered with PVC tarpaulins, containers, pipes and telephone and electric wires, fencing and various service materials for the structures which were still present at the Olympic venues.

Furthermore, in conjunction with a Security structure of the Arpa Piemonte Department of Torino, a check was carried out with regard to the presence of any abandoned waste or potentially dangerous material in the areas subject to dismantling and/or in the immediate vicinity.

Checks were also carried out with regard to the restoration of the temporary parking lots and dirt areas for the installation of the previously described temporary works.

1.4.2 START UP AND ORGANISATION OF POST OPERAM ENVIRONMENTAL MONITORING ACTIVITIES

They were arranged in agreement with the Golder Company, which organised and coordinated the environmental monitoring of the Olympic mountain sites and the execution of the post operam monitoring activities on behalf of Agenzia Torino 2006. The monitoring activities regarded certain areas previously monitored during the *ante operam* phase or which showed particular criticalities during the works in progress.

The monitoring campaigns were carried out in May and June 2006 in order to compare the results obtained in the same periods during the *ante operam* phase (May and June 2003). The parameters examined were: asbestos (MOCF and SEM analyses), dusts (PM_{10} and TSD), air quality (nitrogen oxides, sulphur dioxide, carbon monoxide, ozone, benzene and volatile organic composts), site noise, traffic noise, surface water (on-site: capacity, average current speed, air and water temperature, colour, conductibility, pH, Redox potential, dissolved oxygen; in the laboratory: suspended solids, hardness, ammoniac nitrogen, nitric nitrogen, nitrous nitrogen, chlorides, sulphates, BOD_5, COD) and underground water (on-site: static water table, temperature, pH, colour, conductibility, Redox potential, dissolved oxygen, volatile organic substances; in the laboratory: total dissolved solids, carbonate alkalinity, chlorides, ammoniac nitrogen, mineral oils, organic solvents and chloride solvents, total coliforms, faecal coliforms, faecal streptococci, total hydrocarbons, aromatic polycyclic hydrocarbons).

Figure 1.19 - Restoration operation

At the end of the monitoring campaigns the database of the monitoring results was updated and a report was drawn up containing a critical analysis of the results of the monitoring activities, both those related to the *post operam* phase and those related to other phases of the Olympic period (ante and during work in progress).

1.4.3 CHECK ON THE RESTORATION OF THE OLYMPIC MOUNTAIN SITE AREAS

During the design of the various Olympic works, the measures for environmental restoration and mitigation were defined (figure 1.19). These included all the measures necessary to restore the state of the locations in the site areas (grassing of surfaces worked on, consolidation of piles of land using naturalistic engineering techniques) and to favour the environmental installation of the Olympic works (grassing of the slopes, plantation of trees, drainage works).
During the Service Conference, the Arpa Piemonte EIA/SEA structure was assigned the task of checking the actuation of the above measures for the following Olympic mountain sites:

- "Amphitheatre" programmed snow cover system (Sestriere)
- "Clotes" and "Sportinia area " programmed snow cover system (Sauze d'Oulx)
- "Colomion" programmed snow cover system (Bardonecchia)
- "Melezet" programmed snow cover system (Bardonecchia)
- "Serra Granet Area" and "Sagnalonga Area" programmed snow cover system (Cesana T.se)
- "Sansicario Area" programmed snow cover system (Cesana T.se)
- "Pattemouche-Amphitheatre" programmed snow cover system (Pragelato)
- New "Baby Sansicario" four-passenger chair lift (Cesana T.se)
- Replacement of the Clotes two-passenger chair lift with the new "Nuova Sauze d'Oulx - Clotes" four-passenger chair lift (Sauze d'Oulx)
- "Chesal-Selletta" two-passenger chair lift with fixed toothing (Bardonecchia)
- New "Melezet-Etarpà-Chesal" two-passenger chair lift with automatic toothing and intermediate station (Bardonecchia)
- New "Nuovo Garnel" four-passenger chair lift with fixed toothing (Sestriere)
- "Sestriere-Fraiteve" eight-passenger single cable telecab with intermediate station (Sestriere)
- New "Trebials" four-passenger chair lift with fixed toothing (Sestriere)
- "Pra Reymond" four-passenger chair lift with R17 fixed toothing (Bardonecchia)
- New "La Coche-Serra Granet-Colle Bercia" four-passenger chair lift (Cesana T.se)
- New "Fraiteve 3" double skilift (Cesana T.se)
- New "Sky Lodge-La Sellette" four-passenger chair lift (Cesana T.se)
- Cesana-Sansicario cable way (Cesana T.se)
- "Bardonecchia–Fregiusa" eight-passenger single cable telecab (Bardonecchia)
- Cross country skiing venue and hydraulic works for the Chisone stream (Pragelato)
- Organisation of the ski runs for the Women's Downhill and Giant Slalom Alpine skiing competitions (Cesana T.se)
- Organisation of the ski runs for the Men's Downhill Alpine skiing competitions (Sestriere)
- Organisation of the "Kandahar - G. Agnelli and Sises" Slalom and Giant Slalom ski run (Sestriere)
- Half Pipe and Giant Slalom Snowboard runs (Bardonecchia)
- SS 23 "del Sestriere" – Modernisation and works to improve safety on the road from Perosa Argentina to Cesana Torinese
- SP 161 of the "Valpellice" Pinerolo - Torre Pellice: adaptations
- SS 589 – construction of variant outside Osasco from km. 35+700 to km. 37+100
- SS 23 and 24 – Adaptation of the road and organisation of areas for use as parking lots in Cesana T.se
- Adaptation of the Sansicario municipal road (Cesana T.se)
- Construction of the fourth (service) lane of the A32 motorway between the Frejus Tunnel and the Savoulx junction. Completion of the Bardonecchia junction
- SS 589 of the Laghi di Avigliana – Variant project "dei Laghi di Avigliana" at Avigliana and Trana
- SS 24 "del Monginevro" – Adaptation of the Cesana Torinese-Claviere stretch, including construction in the town of

Claviere (Cesana Torinese, Claviere)

- Biathlon – Creation of competition track and shooting range – Competition service building (Cesana Sansicario)
- Ski jump ramps (Pragelato)
- Venue for the bob, luge and skeleton events (Cesana T.se)
- Freestyle event runs (Sauze d'Oulx)

Due to the presence of snow coverage and low temperatures until the middle of May 2006, the checks on the environmental restoration of the Olympic sites began in late spring, starting with the works carried out on the roads, these being at a lower altitude, and continuing through the summer to the Olympic sites at higher altitudes.

1.4.4 CHECK ON COMPENSATION WORKS

As established by the SEA, compensation works were built for various Olympic venues (figure 1.20). These were operations aimed at compensating for the negative environmental impacts deriving from the construction of the Olympic works in the valleys, with positive environmental effects on the territory. There were different types of operation: consolidation of slopes, drainage of slopes, reforestation, water-related works (transversal dikes, consolidation of riverbanks). As with the environmental restoration operations, the compensation works involve the use of naturalistic engineering works and eco-compatible materials.

As with the restorations, during the Service Conference the Arpa Piemonte EIA/SEA structure was assigned the task of check the construction of the compensation works in observance of the prescriptions.

Figure 1.20 - Check on compensation works

1.4.5 CRITICALITIES

During the post Olympic phase, in the context of the Olympic mountain sites, the implementation of the environmental restoration operations and the compensation works represented an exceptionally interesting and innovative aspect. There were a considerable number of operations which made it possible to mitigate the impacts of the Olympic works, facilitate their inclusion in the territory and, in some cases, also to compensate for environmental criticalities with improvements in the quality of the territory. Furthermore, the implementation of such a high number of naturalistic engineering operations in a restricted geographic area represented a unique case of considerable interest for the Italian territory. The criticalities found in this context, with regard to the checking activities carried out by Arpa Piemonte, were:

- the overlapping of some sites and therefore difficulty in apportioning responsibility for restoring the locations;
- the implementation of site operations in areas which had already been restored, mainly due to the construction of temporary works and operations carried out immediately before the Olympic event to enable television coverage;
- the restoration of the numerous site roads built by the various bodies involved in the Olympic event, with difficulty in establishing responsibility and deadlines.

1.4.6 CONCLUSION

As can be understood while reading the previous paragraphs, the role played by Arpa Piemonte in the various phases was rather complex and highly diversified. Wishing to presents a points summary, the first activity of the Olympic event was:

- the check and verification of the SEA procedures and decision-making processes of the Service Conferences to ensure observance of the sectorial laws and principles of environmental sustainability;
- verification that, for all the works designed, all the possible instruments had been considered for the mitigation and

compensation of the impacts of the works;
- definition of the technical site monitoring specifications and verification of their correct application;
- check on the results of monitoring activities and definition of measures to solve and/or mitigate the criticalities;
- application of parallel monitoring activities alongside those carried out by Agenzia Torino 2006 in situations of particular criticality in order to verify the effectiveness of the measures taken by the firms to reduce the impacts on the components interfered with.

During the Olympic event, the main tasks were planning for emergencies and checking environmental management and venue management, terminating, with the end of the event, with the check on the environmental restoration works still underway.

The management and implementation of all these activities required the involvement of a significant number of people from the Agency, which contributed to pursuing the protection of the quality of the territory during all the preparatory phases of the Olympic event, which was run in a constantly monitored and controlled environmental framework. Furthermore, the commitment of Arpa Piemonte did not end with the end of the event, but continues with the aim of guaranteeing that the restored areas and adequate compensation will be returned to the area concerned.

2 The nivo-meteorological service

2. The nivo-meteorological service

2.1 THE NIVO-METEOROLOGICAL SERVICE FOR THE XX OLYMPIC WINTER GAMES TORINO 2006

Within the context of the specialist services performed to favour the success of the Torino 2006 Olympic and Paralympic Games, the meteorology and nivology service, commonly known as the weather and snow service, was fundamental to the management of numerous activities, carried out by various organisational functions, primarily those linked to with competitions, the preparation of the slopes, the removal of new snow and transport. The weather conditions during the Games were the only variables which could be forecast and measured but not controlled, that altered the scheduling and progress of the competitions.

The presence of a nivo-meteorological service throughout the areas where the competition were held, operational 24 hours a day, closely coordinated and capable of simultaneously measuring all the weather and snow parameters in different locations and at different altitudes in real time, equipped with avant-garde observation and forecasting instruments tested and adapted for local use, enabled the attainment of a high standard of quality in terms of characterisation of the phenomena underway and expected, timing and intensity of the phenomena, with sufficiently early forecasting to allow all the competitions and collateral events scheduled to go ahead in compliance with a new schedule if necessary.

The weather, companion of every phase of the event, favoured both the opening and closing ceremoniess, with fair conditions, no precipitation and no wind, and was characterised by temperatures which, as correctly forecast, posed no problems with regard to the operation of the more exposed technological equipment, nor uncomfortable conditions for the spectators. The fast-moving downhill skiing disciplines scheduled for the initial days of the event, and particularly sensitive to atmospheric conditions, took place in excellent meteorological conditions.

Figure 2.1 - At the start of the men's downhill on February 12th 2006

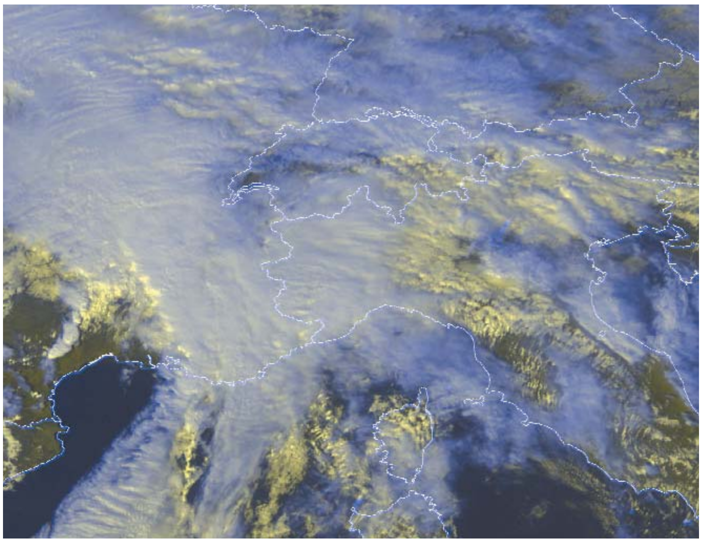

Figure 2.2 - Satellite picture of February 19th at 13.30 UTC

On the evening of Wednesday February 15th, the weather deteriorated, with two quite unusual phenomena for the season: the first was the passage of an organised frontal system, which generated very unsettled conditions, typical of the summer period, determining a lowering of the snowfall to 800 metres below freezing level, exceeding even the most pessimistic forecasts, leaving the city of Torino under heavy snowfall for the whole evening, accompanied by thunder and lightening while the cold front passed.

The subsequent persistent flow of damp air from the east, caused by a closed perturbation over the Mediterranean, blocked to the north by a huge mass of cold air, caused frequent sleet and poor visibility at the outdoor venues, leading to the postponement of several events.

2.1.1 THE AGREEMENT

The nivo-meteorological service for the Olympic event was assigned exclusively to Arpa Piemonte by the TOROC – Organising Committee of the XX Olympic Winter Games – with an agreement entered into in December 2001, which established, in addition to the reciprocal commitments, the working methods, ensuring the involvement of both bodies in every phase of progress of the service: from the initial planning to the provision of the service during the Games.

The agreement acknowledged the Agency as having the skills, expertise and potential for the development of services and products aimed towards the user, as well as the organisational capacities and reliability. These were the strengths that guided the Arpa Piemonte Environmental Monitoring and Forecasting Area along the challenging route that led to the organisation of the complex nivo-meteorological assistance system.

On the basis of the agreement, Arpa Piemonte arranged the activation, coordination and management of a specialised operating structure dedicated to nivo-meteorological assistance for the Games which satisfied the demands presented by the Organising Committee, installed the monitoring instruments and trained the staff to provide support. On its part, the TOROC, besides establishing the demands to be satisfied by the service, was responsible for providing logistic support, setting up the meteorology offices, the hardware, software and connections necessary, as well as the selection and recruitment of staff to provide support, in accordance with a mutually established plan.

ARPA PIEMONTE	TOROC
Activate, coordinate and manage an operational structure to supply nivo-meteorology support to the Games.	Define the requirements and aims of the nivo-meteorology service and cooperate with Arpa Piemonte to individuate the methods for its implementation.
Supply data and forecasts for the weather and snow conditions, as well as climatological information, in agreement with the requirements expressed.	Ensure the recruitment of the backup staff according to the pre-set plan.
Equip the venues with technical instrumentation for measuring the nivo-meteorology parameters.	Supply logistic support and operating structures (Weather Offices).
Train and manage staff to issue the service and back-up staff.	Supply hardware, software and connections required.
Feed the Internet and Intranet sites of the Games according to specifications.	Ensure the logistics of the weather staff (uniforms, transport, accommodation).
Implement and manage the network of weather offices at the service of the Games.	Guarantee the dissemination of the nivo-meteorology information in special information spaces in the Olympic venues, the production of paper and web publications.

Figure 2.3 - The tasks of Arpa Piemonte and the TOROC as regulated by the 2001 agreement

This service, with the forecasting and monitoring component, as well as the technological support, successfully satisfied various needs: with regard to programming, with the definition of the competition calendar and the contribution of the climatologic analysis to the definition of the insurance premiums, with regard to the organisation of the events, with certain technical indications useful to the final details of the projects for the venues (position in relation to the wind and exposure to the sun) and the sizing of the temporary infrastructures in relation to the meteorology parameters, with regard to support for athletic training and the international sporting federations, both during the Games and the preparatory phases, with the provision of the climatologic data processed and the organisation of specific measuring campaigns, with regard to the management of viability, scheduled snow coverage, information for the media and tourists and the aspects aimed at guaranteeing the protection of the whole district against the risk of avalanche.

THE NUMBERS OF THE GAMES	
785 weather reports	10 weather offices
65 measuring stations on the ground	75 weather staff members
869040 observations of weather parameters	8 weather venue teams
29989 messages to feed INFO2006	4400 man hours involved in issuing the service

Figure 2.4 - The "numbers" of the Games

Interview with Stefano Bovo, manager of the Arpa Piemonte Environmental Monitoring and Forecasting Area, who organised the XX Olympic Winter Games Torino 2006 nivo-meteorological assistance service.

1. What was your specific role in the various planning, implementation and delivery phases of the service?

Right from the outset, the public role of Arpa Piemonte imposed a clear separation of the Olympic assistance activity from the Agency's institutional activity, in terms of destination of human and financial resources: attention to the observance of this rule was paramount to the management of the project. As far as the first are concerned, permanent members of the Agency's staff were assigned the functions of project definition, technical guide, transfer of know how and coordination of the personnel made available by the Organising Committee. Similarly, the Agency's resources were dedicated exclusively to stable investments, the effects of which have been acquired by the Agency on a permanent basis (improvement of monitoring systems, advanced IT support, specialist qualification of staff members). For the 1992 Games held in Albertville, Météo France employed 68 of its own technicians, while Arpa Piemonte employed 37 for Torino 2006; with a total budget of 17 million French francs (about 2,000,000 euros) net of long-tern investments, the percentage of outside financing did not reach 50%, while in Torino, with a total of 3,000,000 euros, the outside financing percentage is higher than 80%.

2. Were you ready for the event on time? Was everything under control?

The event was prepared meticulously. The Sports Events in 2005 made it possible to test the services prepared for each location and discipline under real conditions. The extremely high levels of service required by the various functions of the Organising Committee left no room for any failure by the system, which was organised with the necessary provision of additional excess support for management and reserves. We were the first to set up operation in Sestriere and our services were operational from the very beginning of February, offering a complete service right from the initial approach to the Olympic Community as it settled in.

3. What makes a weather service for the Olympic Games different from that for other events?
Definitely the organisation of numerous events, requiring customised approaches which are very different from one another, in a very short space of time, all of which have to be managed as part of a single information system created for a variety of users. The experience of the MeteoGames website was a perfect example.

4. Did you experience moments of particular stress or outside pressure during the Games?
The consolidated experience of the Environmental Monitoring and Forecasting Area in the field of forecasting and preventing natural risks, managing alert systems, specialist assistance for critical situations and hydrogeological and environmental emergencies proved fundamental to coping calmly and professionally with potentially critical situations linked with the extreme variability of the weather during the second week of the Games. All the competitions, those held at the initially established times and those which were rescheduled due to the weather, went ahead precisely on time.

5. What was the main strength of the service you provided?
The choice of a decentralised service: a special multidisciplinary team, specialised in the characteristics of the competition, linked by extensive working experience together and the reciprocal exchange of technical knowledge and practical experience, was organised for each venue. Naturally, the success of this choice was based upon the authoritative action of direction and surveillance exercised by the coordinators of the weather, snow and instrumental-technical teams operating in the Centre of Torino. I believe that this is also the strength of the success of the post-Olympic management of the systems.

6. Would you like to be involved in a similar experience again? What would you do differently?
Only an edition of the Summer Olympics could present similar conditions to those faced for the Torino 2006 event in terms of stimulation and commitment. I would be very happy to do it again, re-proposing the same system, obviously in the light of the experience acquired and with the scientific-technical progress made in the meantime: for example, a technological delay made it impossible to use, as intended, the potential of the transportable meteorology radars for the very short-range forecasting of the weather. The experience and the structure are however readily available to guarantee nivo-meteorological assistance services for the most varied tourism and sporting requirements that should occur, staring with next winter's Universiade (University Games).

2.2 THE OPERATIONAL SERVICE

2.2.1 NIVO-METEOROLOGICAL ACTIVITIES FOR THE OLYMPIC GAMES

The nivo-meteorological assistance service involved a range of activities, which can be divided into two main phases: the preparatory – **pre-Games** – phase and the operational – **Games time** – phase during the Games. The first phase was characterised by the development of infrastructures (meteorology offices, hardware and connections) and included the completion of the installation of the monitoring instruments, the implementation of measuring campaigns, staff training, the implementation and testing of the procedures and hardware and software systems necessary to the service.
The operational phase during the Olympic and Paralympic Games ensured the full capacity operation of a complete

weather forecasting system, comprising dedicated products for all the venues, products to satisfy the requirements of the various users, supply of the data measured in real time and information on the weather and snow to the Competition management, the Main Operation Centre, the Sport Coordination Centre, the INFO2006 intranet system, the systems of distribution of information on the venues (On Venues Reports and Commentator Information System), to the Olympic family and, last but not least, the official Olympic Games website (figure 2.5).

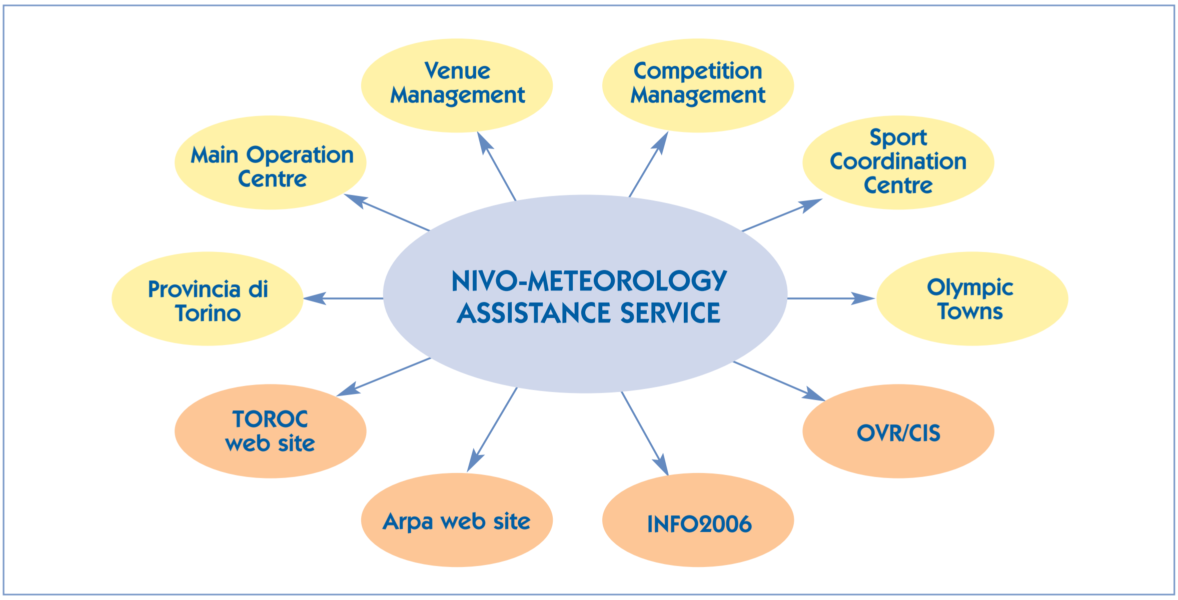

Figure 2.5 - Distribution of weather data and information towards users for the purposes of decision making support (highlighted in yellow) and towards the dissemination and informative systems (highlighted in orange)

The organisation of the service was based upon certain fundamental aspects:

- the distribution of the operational tasks among different operating units (Weather Operation Centre in Torino, Weather Local Centre in Sestriere, six peripheral offices at the venues known as Weather Information Centres, a weather desk at the Sport Coordination Centre and the Main Technological Centre, situated in Torino, at the Organising Committee headquarters) in constant communication with one another;
- the complete availability, for all the offices, of the meteorology data obtained, the satellite pictures and output of meteorology models at all units, with up to 10 minute updates;
- the strength and excess availability of the communication systems and hardware at the basis of the production and distribution of the services;
- the development of ad hoc software for the management, display, formatting and distribution of the data.

2.2.2 THE WEATHER FORECAST

The weather forecast took un a fundamental role in the context of the nivo-meteorological assistance service for the Games. It was articulated in space, with a degree of detail which, starting from the large scale, increased to concentrate on the individual venue where, from the general trend of the weather for the period of a week, the forecast was refined to the value acquired by the single parameters, temperature, wind and humidity, hour by hour. We can distinguish three main typical space-time scales on which the weather products at the service of the Games were defined:

- the medium – long-range (7-10 days): the forecast focused on the large atmospheric structures that concerned the area where the Games were held and, with a good degree of reliability, it was possible to formulate a trend, a change compared with the current situation, macroscopic effects on the single parameters throughout the area in general, with uncertainty in terms of time varying by as much as 12-24 hours;

- the short-range (2 days): venue forecasts with a high level of time-space detail were formulated, being particularly precise for the first 12 hours in situations characterised by gradual variability;
- nowcasting: the forecast for the next few hours, fundamental for sports competitions and in the case of phenomena underway, such as snow or poor visibility, in which a constant update is a useful tool to aid decision-making.

The predictability of weather phenomena depends heavily on the time-space scale that characterises them, usually in an inversely proportional way, so, for example, the forecasting of the hourly change in temperature at the biathlon venue is significant 1 or 2 days in advance, while the arrival of a warm front, capable of increasing temperatures by several degrees across a vast area, can be forecast up to 4 or 5 days in advance.
It should be pointed out that, in the case of the Games, the outdoor competitions took place in an area of complex orography, where the competition venues were at high altitudes, between 1200 and 2500 metres, where there is the confluence of two valleys towards the French border, featuring numerous mountains, some of which higher than 3000 metres, where the dominant westerly winds accompany the passage of cold fronts from the Atlantic.
The interaction of the fronts with the orography is one of the causes of the difficulty in predicting the weather in mountainous areas: their deformation by the mountains changes the effects on the ground, intensifying the wind, creating stau-foehn effects which are more or less advanced at the Italian border, transforming gentle snowfall into a storm, accelerating the effects of the warm front and, often, determining the exhaustion of associated phenomena much quicker than on the plain.
The main ingredients of nowcasting, i.e. the weather forecast for the next few hours, are the data observed and its constant availability, the capacity to interpret it and the knowledge of the local evolution of the weather, as well as the experience and capacity to link the often swift evolution of the data measured on the ground with the configuretion of the weather on a larger scale. The monitoring network set up by Arpa Piemonte for the Games, together with the experience of the single forecasters, enabled the attainment of a good level of reliability of this type of forecast.
For the 24-hour or 48-hour forecasts it is necessary to use mathematic numeric forecasting models, good post-processing procedures and, once again, the forecaster's experience and capacity for synthesis.

To provide the weather assistance service for the Games, Arpa Piemonte operatively used the forecasts of the generally circulated model of the International Forecast System (IFS) of the European Centre for Medium Range Weather Forecast (ECMWF), distributed by the Ufficio Generale Spazio Aereo e Meteorology (USAM – Aerospace and Meteorology Office) of the Italian Air Force.
The general circulation models, also known as global models (GCM), are the foundation of the weather forecasting process. They simulate the evolution on planetary scale, i.e.: all over the globe, for a vertical extension reaching up to 100 km from the earth's surface. It is necessary to include the whole atmosphere in the model because in medium-range time scales (for the IFS model 10 days after the forecasting date) the forecast area can be influenced by masses of air from very distant regions.
Having the entire globe as their dominion of integration, GCM are characterised by low spatial resolution and, specifically, the ECMWF IFS model has a horizontal resolution of approximately 20 km at our latitudes.
Arpa Piemonte had two runs (00 UTC and 12 UTC) of the ECMWF global model every two days: the ranges of the model are proposed to operative forecasters in weather maps to gain an overall view of the synoptic behaviour of the atmosphere. The atmospheric structures (like anticyclones, depressions and fronts) that concerned the Olympic area

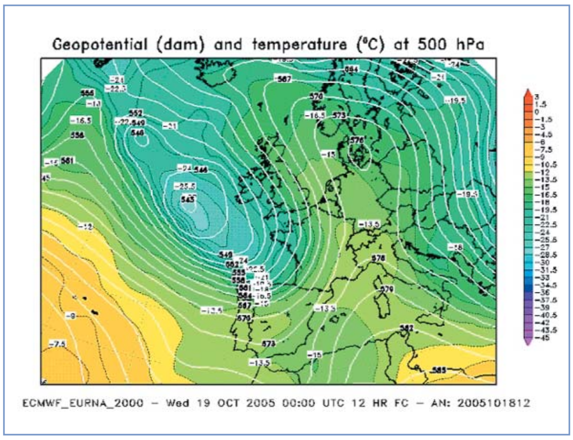

Figure 2.6 - Temperature (colours) and geo-potential heights (lines) at the pressure level of 500 hPa provided for by the ECMWF model
A cyclone moves over Eastern Europe, approaching the Alpine chain and undermining a weak anticyclone over the Central Mediterranean.

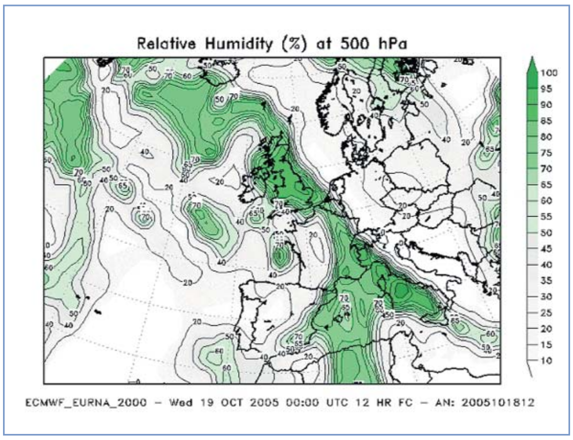

Figure 2.7 - Relative humidity at 500 hPa provided for by the ECMWF model
Associate with the cyclone shown in figure 2.6, a cold front is moving over North-West Italy. A second front is moving from the Western Mediterranean and approaching the Alps.

could be easily observed on the North-Atlantic and European areas (see figures 2.6 and 2.7 for example).

The ECMWF global model produces highly reliable forecasts of these large-scale structures, enabling the forecaster to make a very good estimate of the timing and intensity of the interaction of the structures with the North-West Alpine chain where the Olympic area was situated.

Alongside the deterministic approach, there is the probabilistic approach too, which tackles the problem of predictability by setting the forecast in terms of probability, using the so-called EPS (Ensemble Prediction System) method, which takes into consideration the chaotic component of the atmospheric motion, not contemplated by the numeric models due to their deterministic nature. The models are highly sensitive to slight variations in the initial conditions, due to errors in the observations and their overall representation by way of analysis, and tend to diverge from one another very quickly with the increase in the forecast time, amplifying the errors until they negatively influence the reliability of the forecast.
Other sources of uncertainty come from the errors and from the approximations within the model itself. Through the EPS a high number of simulations with differing initial conditions are produced, obtained by slightly altering the operative simulation, with the application of differences comparable to those of errors in observation.
Considering all the simulations obtained, which can differ greatly, a probability is associated to different possible scenarios: for instance, if 25 simulations out of 50 envisage more than 20 mm precipitation in a given area, this event will be assigned a 50% probability of actually happening.
ECMWF operatively manages an EPS system with a team of 51 members and provides probabilities of scenarios for the precipitation and temperature ranges used especially for medium-range forecasts (four to seven days). An example is shown in figure 2.8, which refers to the probability of having a temperature anomaly at 850 hPa higher or lower than 4 and 8 °C in relation to the climatology: it is possible to highlight a probable increase in temperature south of the Western Alps associated with the transit of a warm front which also affected the Olympic area during the Sports Events of 2005.
For a forecast with a high level of time-space detail such as that required for the Games, it is necessary to use a model which covers a limited area capable of providing a more detailed forecast of the weather parameters on a high resolution dominion.

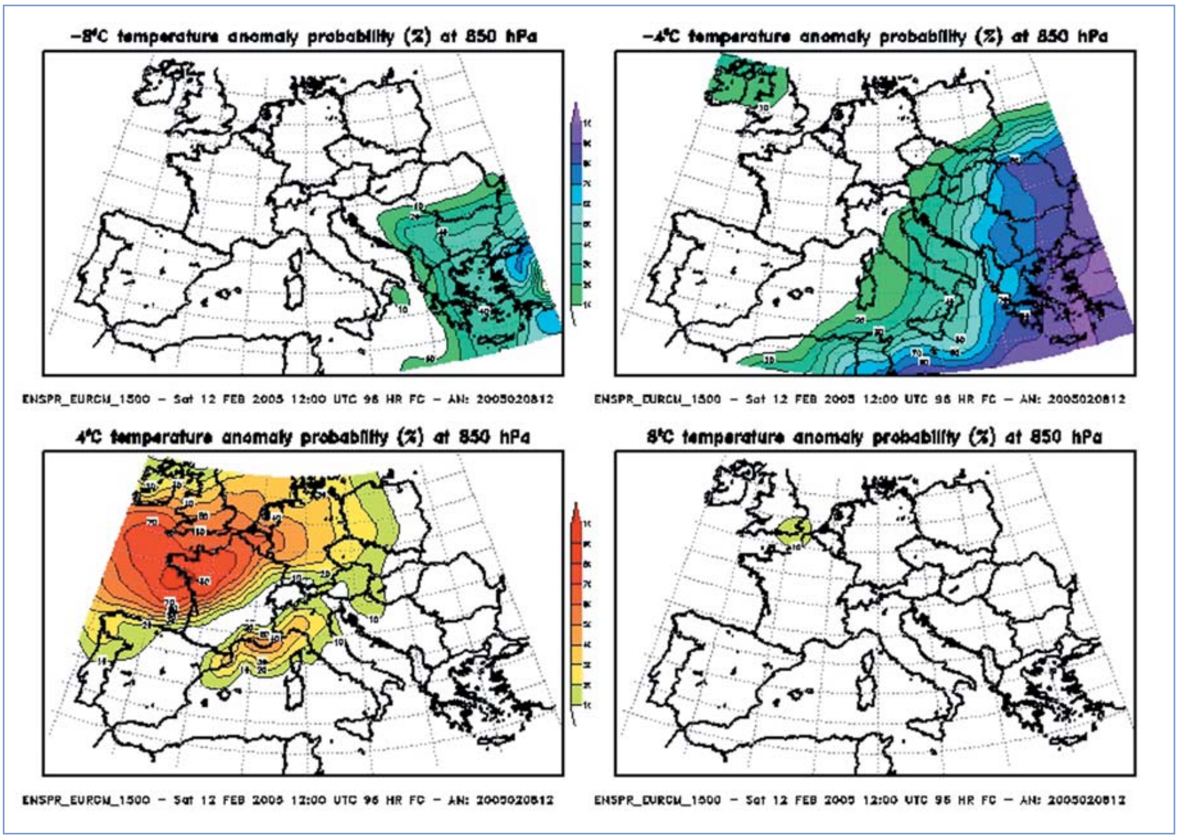

Figure 2.8 - Probability of temperature anomaly at 850 hPa: foreacst issued on 08/02/2005 in relateion to the expiry +96h (12/02/2005)

Reducing the dominion of integration, there is a reduction in the amount of calculations by the computer and it becomes possible to increase the spatial resolution of the model (below 20 km), making it possible to describe phenomena which occur in smaller space and time scales.

Arpa Piemonte operatively uses the Lokal Modell (non-hydrostatic limited area model) in its Italian version, called LAMI (Local Area Model Italy) which is developed in the context of the COSMO project (COnsortium for Small-scale MOdelling, http://cosmo-model.cscs.ch), involving the national weather services of Italy, Germany, Switzerland, Greece and Poland, plus some regional services including Arpa Piemonte and Arpa SIM (Emilia Romagna).

Simultaneously, close co-operations with MeteoSwiss and Deutscher Wetterdienst were carried out at Arpa Piemonte within the context of research and development in the limited area model field: the Swiss version (known as alMo) and the German version (LM-DWD) of Lokal Modell were used for study purposes, to analyse sensitivity to changes in dominion and physical parameterisations and for applications and statistical processing (post-processing) for the improvement of the forecasts.

The operative LAMI configuration is characterised by a dominion (figure 2.9) which includes the whole Italian national territory with a grid of 7 km of horizontal resolution and a vertical extension of 40 levels, starting with the lowest level of about 34 m from the ground and reaching the top of the atmosphere at an altitude of 22,000 m. Two operative runs are made a day (00 UTC and 12 UTC) and take from the German global model GME both the initial conditions and those around the outside.

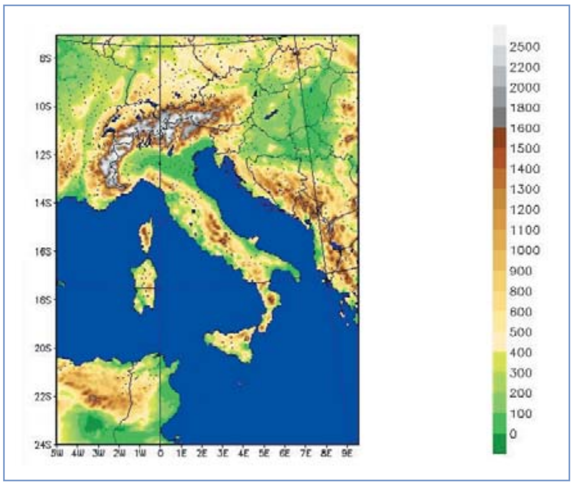

Figure 2.9 – Dominion of the LAMI with heights of the orography

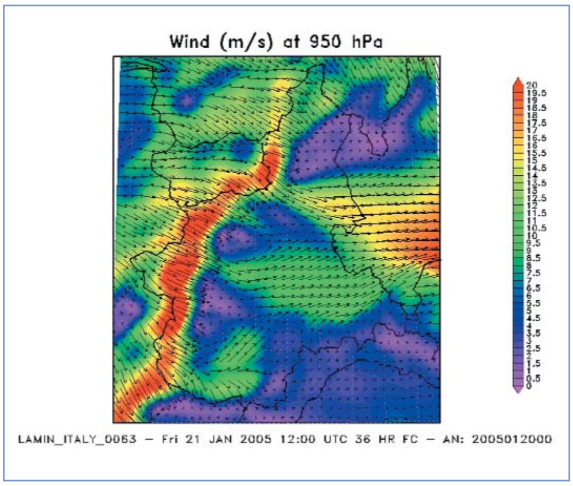

Figure 2.10 – Wind range forecast by LAMI over Piedmont at altitudes of about 1000 m in a typical case of foehn (+36 hour forecast)

A typical example of application of a limited area model is the forecasting of the wind range, which increases in importance in relation to the increase in accuracy of the definition of the orographic surveys, as can be seen in the example shown in figure 2.10.

The LAMI model was operatively used during the Games both for the production of meteorological range maps for use by forecasters, and for the production of precise numeric forecasts for the various parameters (temperature, humidity, wind, precipitation and pressure) in the Olympic venues, often using adaptive filters.
The direct outputs of the models often show errors compared with the values effectively measured due to imprecise representation of the local characteristics or incorrect parameterisation of the physical phenomena on a smaller scale than that of the model. In fact, surface meteorological parameters present variability at lower time and space scales than those provided by general circulation or limited area models, especially in mountainous areas. Therefore, the physical processes that describe their evolution cannot be explicitly calculated using the model, but have to be parameterised off-line using appropriate schedules.
This is why the direct output of the models in the Olympic area was often unsuitable for use, due to the extremely uneven orography characterised by two very narrow valleys which weren't processed correctly by the models.
Arpa Piemonte used two different post-processing methods which, starting with the data provided by the models and the observations recorded in the previous days by the meteorology stations, enabled the correction of the forecasts according to their behaviour in the previous days.
Both the methodologies (Kalman Filter and Multimodel SuperEnsemble) were adapted and developed for the Olympic area by Arpa Piemonte and were subject to a long test period before the Games.
The Kalman filter was applied to the data of the ECMWF model and the LAMI, while the Multimodel SuperEnsemble was used on the ECMWF, LAMI, aLMo and LM-DWD models.
The application of the post-processing procedures enabled a satisfactory correction of the detailed weather forecasts for temperature, humidity, wind intensity, precipitation and pressure (see figure 2.11 for example). More information on post-processing can be found in paragraph 5.1.

Another important application of the meteorology models in the context of operations to strengthen the forecasting systems and those for the prevention of natural risks, was the forecasting of the formation of ice on roads.

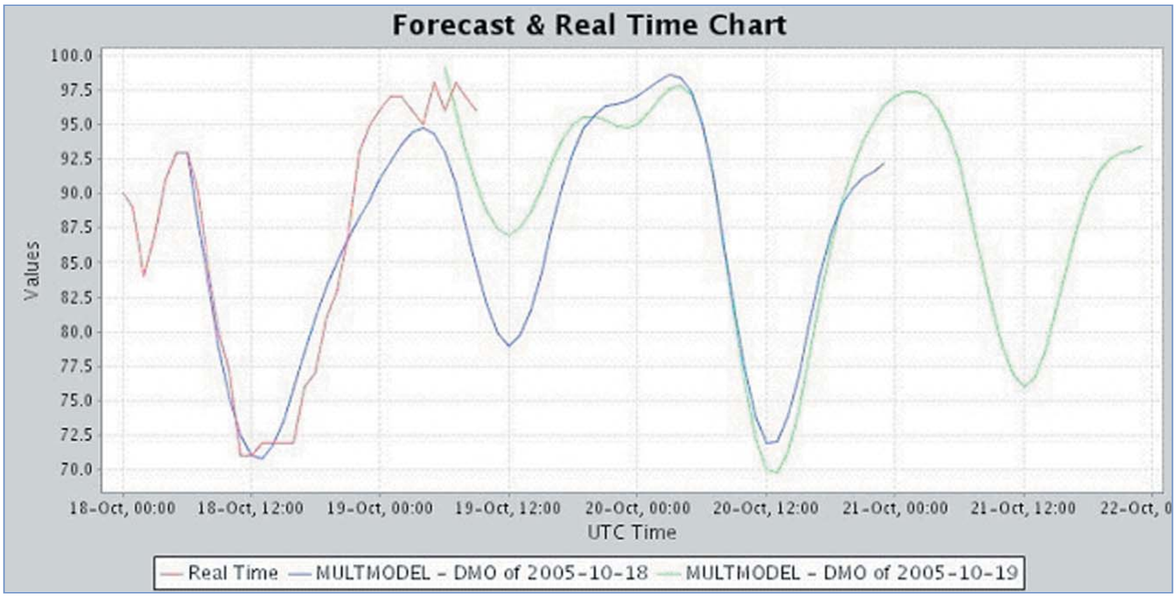

Figure 2.11 - Relative humidity forecasts for the Medal Plaza in Torino obtained using the Multimodel SuperEnsemble
Red line: data observed. Blue and green lines: data forecast with two different expiries.

Arpa Piemonte took care of the implementation and perfection of a deterministic model used to obtain a 24-hour numeric forecasting product for temperature and the state of the road surface. The model automatically receives from the weather station, installed near a stretch of road considered to represent a broader climatic dominion, the data observed for the site in question; it uses forecasts with three-hourly expiry of the air temperature, the dew point, relative humidity, cloud coverage, wind velocity and precipitation and, lastly, elaborates a forecast for each site, considering the specific characteristics of the stretch of road in question. Next, the forecast was extended to the entire road network subject to thermal mapping during winter 2003 on the motorway stretches concerned and, as far as directly concerned Arpa Piemonte, to about 100 km of the main State Roads and Provincial Roads of the Olympic valleys.

During winter 2004-2005 a test period was carried out for the monitoring and forecasting of the conditions of the road surface at medium and low altitudes in Val Chisone, thanks to the installation of a first monitoring station at Roure (TO). To complete the System and provide the most reliable possible ice formation monitoring and forecasting service, two more monitoring stations were installed in the remaining two climatic dominions: the first in Cesana Torinese on the S.R. 23 and the second in Oulx on the S.S. 335.

As explained thus far, the effort made by Arpa Piemonte to perfect the best technological instruments available for weather forecasting was outstanding. However, we ought to drawn attention to the fact that the real added value of the weather service for the Games was the subjective contribution of the forecasters and their extensive practical experience, acquired in the years prior to the event, which enabled them to gain details of the local conditions and the behaviour of the outputs of the weather models in relation to each venue.

The decisive contribution of the forecasters to the formulation of the local forecasts is evident in the improvement compared with the (good) forecasts supplied automatically by the models and the post-processing methods, as shown in paragraph 5 of this publication.

2.2.3 FORECAST OF THE NIVOLOGY PARAMETERS

An innovative snow forecasting service was provided during the Olympic and Paralympic Games, completing the weather service described earlier, specific to every single ski run.

Figure 2.12 - Measuring data on course

The product supplied, known as the Courses Report, used graphs and texts to describe the conditions of the ski run monitored during the day and proposed the evolution expected over the next 24 hours, focusing particular attention on the time of the competition itself (figure 2.12).

The nivology parameters considered for the forecast were:

- Ts - Snow surface temperature
- Q - Humidity of the snow
- SNC - Snow conditions according to a qualitative classification of the conditions of the ski run

While the forecast only regarded the parameters required to determine the preparing of skis in terms of slipperiness and grip, the development of the forecast required the constant analysis of other nivology parameters too, as well as some meteorology parameters.

- FF – form of the crystals that make up the top layer
- EE – size of the crystals
- Ta 0.1 – Temperature of the air 10 cm from the snowpack
- RH%0.02 – Humidity in the air in direct contact with the snow surface
- SKC – Sky conditions, qualititative description of the cloud cover, wind or precipitations

SNOW CONDITIONS								
DESCRIPTION								
PW	PP	P	HP	H	GR	I	WP	W
Poco compatta	Da poco compatta a compatta	Compatta	Da dura a compatta	Dura	Granulosa	Ghiaccio	Bagnata e poco compatta	Bagnata
Powder	Packed powder	Packed	Hard packed variable	Hard	Granular	Icy	Wet and powder	Wet

Table 2.1 - Classification of SNC snow conditions

The shapes of the crystals were defined on an empirical basis, using the international crystal classification known as the "The International Classification for Seasonal Snow on the Ground", published by *The International Commission on Snow and Ice of the International Association of Scientific Hydrology*.

On a ski run, programmed snow mixed with natural snow undergoes different transformations compared with the snowpack outside of the course, largely influenced by mechanical processes due to compression by the machinery used to prepare the course and the passage of the skiers. To adapt the types of crystals indicated in the international classification to the snow characteristics of the course and to better characterise the shapes of the crystals upon which the friction angle of the bottom of the skis and consequently abrasion and slipperiness depend, two new subclasses were used for class 3 "monocrystals", known as 3d "fine and pointed monocrystals on course" and 3e "fine and roun-

Grain shapes FF	1	Particles of precipitation
	2	Particles of precipitation decomposed and broken down
	3d	Fine and pointed monocrystals
	3e	Fine and rounded monocrystals
	6	Polycrystals
	7	Surface frost
	8	Ice
Grain sizes E	A	$e < 0,2$ mm
	B	0,2 mm $< e <$ 0,5 mm
	C	0,5 mm $< e <$ 1 mm
	D	1 mm $< e <$ 2 mm
	E	2 mm $e <$ 5 mm
	F	$e >$ 5 mm

Table 2.2 - Classification of the shapes of crystals used for the nivology service at the Games

ded monocrystals on course" (table 2.2).

These parameters were monitored on the flatter areas of the ski runs, considered to be the most critical point for the slipperiness of the so-called "fast" events, i.e.: all the Alpine skiing events apart from the special slalom and all the snowboard events apart from the half pipe.

Piano Paradiso for the Borgata course, Piano Alpette at Sestriere Colle, Piano Soleil Boeuf for San Sicario Fraiteve and Piano Intemedio of Course 23 at Bardonecchia were monitored every half-hour by experts who, every February and March for the last five years, regularly and continuatively participated in the measuring campaigns on the same ski runs.

The text of the Courses Report also took into consideration the air and snow temperature, wind, humidity, conditions of the top snow and sky conditions, measured at the Start and Finish from an hour before the competition, at the start of the competition and every fifteen minutes until the end of the competition.

Lastly, as the evolution of top snow is highly sensitive to even the slightest change in weather conditions, including the change in cloud coverage, the absence/presence of wind, oscillations in humidity, the freezing level, the possible presence of thermal inversion, the courses report had to be linked to the weather forecast. Consequently, the courses report was the result of the combined contribution of different skills which, by carefully analysing the snow conditions, enabled indication, with a good percentage of precision, of the evolution of the course over the next 24 hours.

The snow forecasting activity supplied to the Organising Committee also comprised the assessment of the top snow temperature for every outdoor venue for the next three days, on an hourly basis on the first day and every three hours on the second and third days.

2.2.4 MANAGEMENT OF THE AVALANCHE RISK

The activity carried out by Arpa Piemonte in relation to the management of the avalanche risk was organised during a data measurement phase (figure 2.13), an avalanche risk assessment phase and a phase to analyse evolution in rela-

2

tion to the weather conditions, information which was all gathered in the "Avalanche Report for the Alpine Olympic Area", issued every day during the Games.

Figure 2.13 - Measuring on the snowpack for the preparation of the Avalanche Report

The analysis and assessment of the avalanche risk refer to three areas with similar orography, morphology and nivo-climatology conditions. The three areas were identified as a south-west area on the border with France, stretching from Cesana to Claviere, a north-west area comprising the Bardonecchia basin, and a third, more internal eastern area, comprising Pragelato on the Val Chisone slope, Oulx - Sauze d'Oulx - Salbertrand on the Valle Susa slope and Sestriere as the area forming the barycentre and connection point between the two valleys. A specific degree of avalanche risk was assigned to every one of these sub-areas.

The daily reports were based upon the analysis of the data supplied by the network of automatic nivo-meteorological stations, the manual data from the regional network of observers and, above all, those resulting from a specific snow measuring activity carried out by a group of Alpine Guides associated with the TOROC.

In accordance with a standard AINEVA method, 20 measurements were taken, divided among the sub-areas as follows:

- 8 measurements in the Sestriere-Pragelato-Oulx area
- 5 measurements in the Cesana-Claviere area
- 7 measurements in the Bardonecchia area.

Under the coordination of the Arpa Piemonte snow experts, who permanently manned the Weather Local Centre in Sestriere on a shift basis, a complete itinerant measurement was carried out every two days, including a stability test, in accordance with a pre-scheduled programme, modified to suit the changes in the nivo-meteorological conditions. Moreover, direct measurements and tests were carried out directly with the Arpa Piemonte technicians appointed to prepare the reports.

In order to focus the forecasting activity on the specific problems that possible avalanche situations could have determined for mobility during the Olympic and Paralympic events, the Arpa Piemonte Environmental Monitoring and Forecasting Area carried out a specific preliminary study of the avalanche risk on the roads in the Alpine Olympic Area.

This study was one of the activities of the "XX Olympic Winter Games Torino 2006 safety planning team", set up by Torino Police Department, within which the Provincia di Torino – Civil Protection Service – was responsible for defining the risk scenario consequential to intense and prolonged snowfall.

The study carried out provided in-depth information to enhance the knowledge of avalanches available in the Charts of probable localisation of avalanches in the high Valle Susa and high Val Chisone and contained in the Avalanche Information System (SIVA - Sistema Informativo Avalanche) shared by Arpa Piemonte and the Provincia di Torino.

The study aimed to provide, by appropriately processing the knowledge available on past avalanches and the morphological predisposition of the territory to the break-off of avalanches, the individuation of the stretches of valley floor roads most

exposed to the risk of avalanche in critical snow conditions.
The consequent scenario was used by the bodies and authorities responsible for traffic safety on the roads in the Alpine area involved in the Olympic Winter Games, to optimise the preventive road closure procedures necessary in order to guarantee public safety, with the aim of quickly restoring normal road conditions when the emergency situation was over.
In this prospective the study was also carried out with the aim of assessing, venue by venue, the applicability of the programmed break-off of avalanches using explosives, in order to have a useful support for the decision and therefore facilitated management of the emergency.

The work was organised in three phases: the first phase was developed with the bibliographic collection of the documental and cartographic data on file.
To gain a climatic characterisation of the area, a probabilistic-statistic analysis of the daily snowfall data for some nivometric stations in the Val Chisone, Val di Susa and Val Germanasca was carried out, culminating with the definition of critical threshold values.
The second phase was developed with a measuring campaign on the ground, venue by venue, to check and, where necessary, correct the previous data and collect data on unknown avalanche sites or those insufficiently characterised by the bibliography.
This phase was also supported by the collection of verbal evidence, provided mainly by the staff responsible for snow clearance on the roads, to optimise the outlining and characterise the frequency of phenomena at the single avalanche sites.
The ground analysis procedure was accompanied by the stereoscopic photo-interpretative analysis of colour aerial photographs taken between 1979 and 2000.
The third phase was developed with the cartographic and conceptual processing of the data collected in the first two phases.
The matching of each individual venue with a probability class (high, moderate or low) of avalanche break-off in determined snow conditions of critical threshold was defined on the basis of geomorphologic and topographic elements and of vegetation coverage of the venue (figure 2.14); the assessments made were checked by comparison with the historic documentation available and with the events of a snowfall of moderate criticality which, at the beginning of March 1993, caused avalanches of a certain importance on the roads in the Val Chisone, the effects of which are presented in a detailed report.
As far as the more important and dimensionally vaster avalanche sites, characterised by extensive linear development of the stoppage zone before the roads, are concerned, the modelling of the avalanche dynamics was carried out using a one-dimensional mathematic model (AVAL-1D – developed by the Davos Federal Institute for Snow and Avalanches – SLF) to individuate the stoppage distances of an avalanche to determine depths of snow in the break-off area.

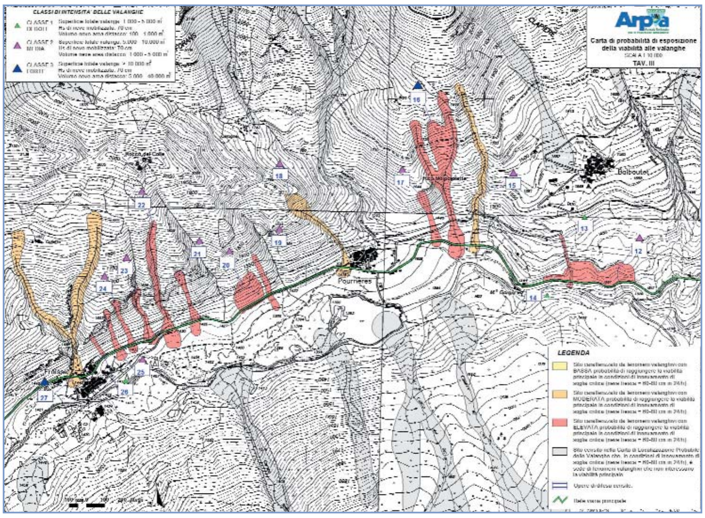

Figure 2.14 - Avalanche probability and intensity chart

The historic data of snowfall in 24 hours of four stations in the Olympic area, subject to probabilistic processes according to the Gumbel "exponential double distribution" model, provided an average value of snowfall expected in 24 hours with a return time of 10 years of about 73 cm. This value was taken as the critical threshold value for triggering avalanches which might concern the roads linked with the Alpine Olympic system.

Each of the 57 avalanche sites studied was represented graphically in a Territorial Information System using the ESRI©-ArcView 3.3 application, which enables the management of all the geo-referred documentation in a single IT environment.

Every site was attributed a probability value with regard to avalanches which might occur in the snow conditions considered reaching the roads. The same hypothetical avalanche was also attributed a degree of intensity, based on the dimensional parameters of the avalanche and the effects expected.

The chart produced represents a useful instrument for highlighting potential sectors of Olympic roads exposed to the risk of avalanche, but only if associated to a correct assessment of all the factors that contribute to creating a situation leading to avalanche break-off.

The operative use of the study took place through a specific emergency management plan which, in the planning of mobility during the Olympic period, was based upon the actuation of the alerting procedures, defined consistently with those implemented in the regional alert system for the purposes of civil defence, approved with D.G.R. n° 37-15176 dated March 23rd 2005.

The alert system provides for the issue of avalanche warnings; the criticality scale is divided into two levels: moderate (level 2) and high (level 3). The distinction between level 2 and level 3 situations is based upon the number of avalanches expected, their dimensions and the area of land involved.

Specifically for the Olympic mountain area, 26 avalanche reports were issued during the pre-Olympic and Olympic period, 23 of which characterised by a degree of risk referred to the European unified scale of 3 – marked (88%) (table 2.3).

During the Paralympic period, 10 reports were issued, 6 of which characterised by a degree of avalanche risk of 3 – marked (60%).

AVALANCHE RISK - PERIOD OF THE OLYMPIC AND PARALYMPIC WINTER GAMES TORINO 2006		
PRE-OLYMPIC AND OLYMPIC PERIOD		
LEVEL OF RISK	NUMBER OF DAYS ISSUED	%
1 - Weak	0	0
2 - Moderate	3	12
3 - Marked	23	88
4 - Strong	0	0
5 - Very strong	0	0
PARALYMPIC PERIOD		
LEVEL OF RISK	NUMBER OF DAYS ISSUED	%
1 - Weak	0	0
2 - Moderate	4	40
3 - Marked	6	60
4 - Strong	0	0
5 - Very strong	0	0

Table 2.3 - Summarised diagram of Avalanche Reports produced during the Games

An intense and protracted Aeolian activity strongly influenced the snow conditions, determining frequent situations where the snowpack was likely to break off in sheets; however there was no need to issue an avalanche warning with regard to the roads during the whole Olympic Winter Games.

2.2.5 THE WEATHER OFFICE NETWORK

One of the innovative aspects of the service performed by Arpa Piemonte, which distinguished it from the services provided for previsions editions of the Olympic Winter Games, was the distribution of the activities and products throughout the outdoor competition venues, with the creation of an authentic network of coordinated but independent weather offices (figure 2.15).

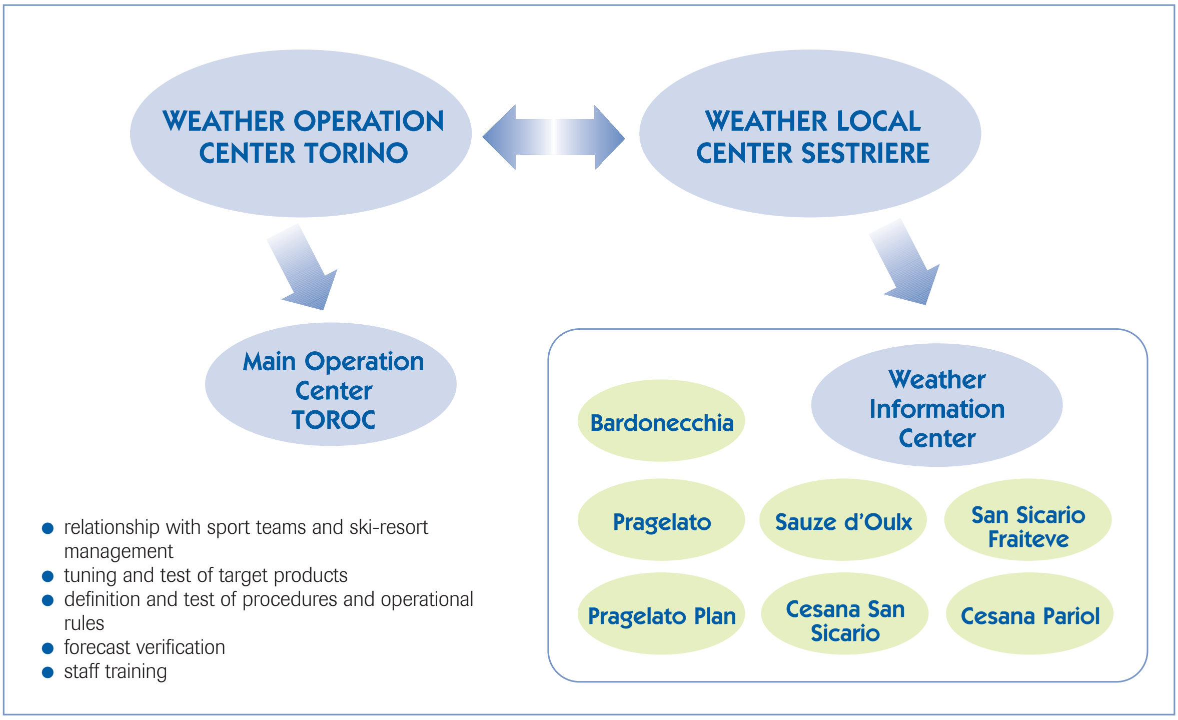

Figure 2.15 - The network of Weather Centres for the Games

The snow and weather assistance at the Games was organised by two main weather offices, one in Torino (Weather Operation Centre or WOC) (figure 2.16) and a second in Sestriere (Weather Local Centre or WLC) (figure 2.17), joined by seven peripheral offices at the venues (Weather Information Centre or WIC) (figure 2.18).

The Weather Operation Centre was dedicated to the regional forecasts and monitoring and the coordination and support of the activities of the MOC (Main Operation Centre) and was the main source of weather information and data distribution for the intranet system of the Games INFO2006.

In the Weather Local Centre in Sestriere, opened on December 12th 2003 and active since then, local weather forecasts were produced and nowcasting activities performed, along with activities related to monitoring, organisation and centring of the local measurements and the local weather and snow forecasts. The weather forecasts dedicated to transport and access road conditions were also produced at the WLC which, being in a barycentric position compared with most of the competition venues, also guaranteed the coordination of the activities carried out at the venues.

The Weather Information Centres (WICs), located in the temporary infrastructures of the outdoor competition

venues, enabled close collaboration with the management of the venue and the sports, the team leaders and all the staff. Maximum attention was devoted to the identification of the service among the staff at the venue, both by introducing the meteorologists to the colleagues who worked at the venue and using special signs (figure 2.19).
Operation of the WOC and WLC during the Games was guaranteed 18 hours a day, while the offices in the WIC venues were operational 12-13 hours a day. Each centre guaranteed 24-hour intervention in the case of adverse weather conditions. During the preparation for the Olympic event, at the WLC in Sestriere, from 2003 onwards, meteorological support was supplied through the production and divulgation of weather information in the form of the Olympic system weather report (in Italian, English and French) and special reports for important sporting events, as well as the dissemination of information on the state of the snowpack and its evolution. This activity allowed the training of staff and drawing up of operating procedures for the Games on the one hand and the establishment of a relationship of trust with the local administration, managers of the skiing district, shops and other public exercises, structures for the promotion of tourism, schools and the territory on the whole, on the other.

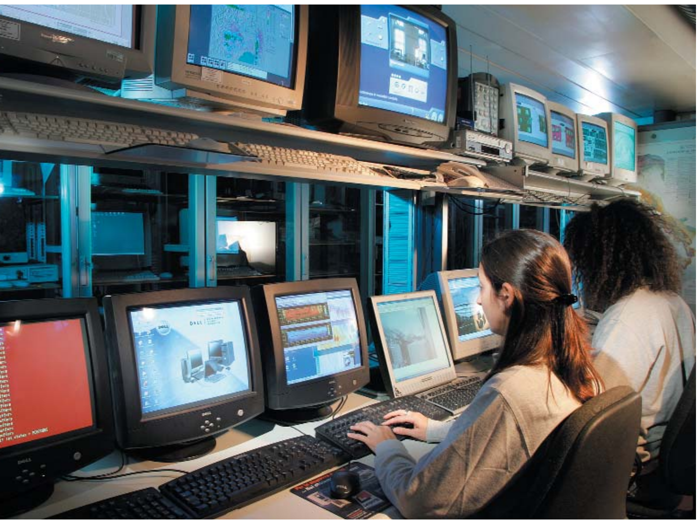

Figure 2.16 - Weather Operation Centre, Torino

Figure 2.17 - Weather Local Centre, Sestriere

Figure 2.18 - Weather Information Centre, Cesana Pariol

Figure 2.19 - The internal signs at the Pragelato venue: the weather office was in close contact with the ski jump judges office

2.2.6 WEATHER STAFF

The entire staff employed for the operative weather and snow assistance during the Games comprised 75 people, including meteorologists, nivologists, IT specialists and technical personnel to provide support (figure 2.20). The latter guaranteed both assistance for the delivery of the services and the preparation and control of the correct operation of the complex IT and communication architecture, which enabled the management of the weather system distributed throughout several centres, also guaranteeing the flow of information towards all users of the service: the games and media intranet, sport, transport and the logistics of the single venues, together with the management of buying-in stocks and public services.

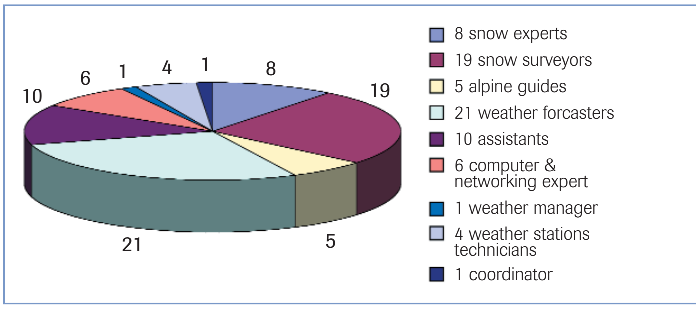

Figure 2.20 - Subdivision of the Weather staff into their different operating roles

Nineteen qualified operators, including staff from the Val Troncea Park and the Alta Valle di Susa Forestry Consortium, manually measured the parameters related to the characteristics of the surface layer of snow (figure 2.21). Five alpine guides contributed by regularly taking specific measurements of snow data useful for the assessment of the avalanche risk in the Olympic district and particularly in relation to the roads leading to the outdoor competition venues (figure 2.22).

In support of the more operational staff, other professional figures were employed in the preparatory phase, especially for preparing informative material, taking care of relations with the Organising Committee in the various areas of skill, carrying out climatology analyses and preparing all the documentation, while the Press Office staff guaranteed contacts with the media. The completion of the team was aided by the activation of a recruitment plan, comprising 15 people, in the agreement between the TOROC and Arpa Piemonte (figure 2.23).

Figure 2.21 - Measuring the temperature of the top snow

Figure 2.22 - Execution of slide block test - Rutschblock - to assess the resistance of the snowpack to cutting

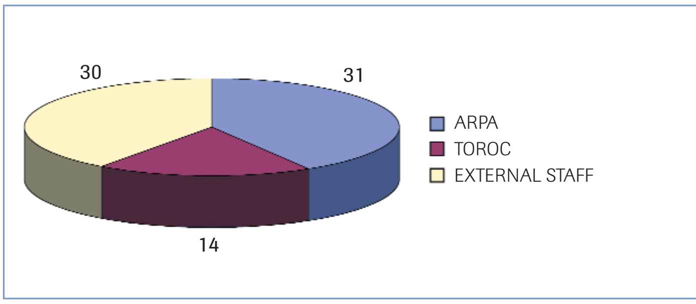

Figure 2.23 - Affiliations of the weather staff

As of 1997 the staff was involved in a weather forecasting activity and in the execution of experimental measures on-site within the Olympic area. Moreover, an intense learning plan and continuous operational training enabled the younger members of the staff to prepare for the performance of all the activities required by the weather service.

Some members of staff were involved at central level, at the Weather Operation Centre in Torino, at the Weather Local Centre in Sestriere and in the offices of the Organising Committee (Sport Coordination Centre and Main Technological Centre), while every outdoor venue had its own team of meteorologists, nivologists and assistants capable of operating in an integrated and autonomous way, satisfying all the needs of the single venue, in accordance with an individual and pre-set operating plan.

The organisational diagram of the service before the Games had the classic hierarchical structure, as can be seen from the table below (diagram 2.1):

General Coordinator				
Weather Service Coordinator	Snow service Coordinator		Logistic and Infrastructures Coordinator	
Weather forecasters	Snow experts	Snow surveyors	Technical experts	Assistants

Diagram 2.1 - Organisational diagram before the Games

During the Games the organisation changed significantly in order to guarantee autonomy to every venue team (diagram 2.2) according to a process, known as "venuisation", which identified all the organisation functions of the TOROC. This operational organisation was extremely functional during the Sport Events in winter 2005, when a good capacity for making decisions quickly and in stressful conditions was demonstrated.

Weather Service Manager at Sport Coordinator Centre (MOC)				
MOC Meteorologists	WLC / WOC Meteorologists	Venue Weather Coordinators	WLC Snow coordinator	Logistic and Infrastructures Coordinator at WLC
		Venue Meteorologists Venue Snow Experts Snow surveyors	WLC Snow experts Alpine Guides	MTC, WOC and WLC technical experts WLC assistants Weather stations technicians

Diagram 2.2 - Organisational diagram during the Games

2.2.7 THE PROCEDURES

One of the starting points for the definition of the procedures was an in-depth climatology study of the Olympic area, carried out to highlight potentially critical or favourable weather conditions during the Olympic period (figure 2.24).

The main aim of this study was the assessment of the weather conditions which could have influenced the competitions and ceremonies, causing delays and rescheduling. The best conditions for the production of artificial snow were also assessed.

The impact of new snow was also studied in terms of management of transport, clearance of snow from the roads

VENTI A 700 HPA SU W ALPI

day/year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
10	NW	NE	SW	WNW	S	N	SW	NW	SE	NNW	SW	W	W	S	N	NW	N	N	E	NW	NNE
11	NW	NE	SW	NW	SE	W	SSW	W	SSE	NNW	W	W	W	S	N	NW	N	N	SE	N	WSW
12	W	NE	SSW	W	SE	W	NW	SW	E	NNE	NE	W	NW	W	NE	NW	NW	NE	NE	N	NW
13	NW	NNE	S	NE	NW	NW	NW	NW	SE	NNW	SSW	NW	NW	NNE	NE	NW	NNW	NE	NE	N	WNW
14	NW	SW	SE	NNE	NW	NNW	NW	WNW	SE	SSW	NW	NE	NW	W	NE	NNW	E	SE	E	NW	N
15	W	SW	SW	NE	NE	NW	NW	NW	NE	SW	W	NE	N	NE	NE	NW	E	SE	SE	N	NNE
16	NW	W	SW	NE	NW	NW	NW	NW	NNE	N	NW	NE	N	NW	NW	NW	SE	E	NE	SE	NNE
17	W	SW	NW	W	NW	NNE	NW	NE	NNE	N	W	NW	W	NE	NW	NW	NNW	NE	NE	SE	NE
18	NW	SW	NW	N	NW	WNW	SE	E	NE	NW	NW	NW	NW	N	N	NW	SE	WNW	N	S	NW
19	NW	SW	SW	NW	NW	SW	S	NE	NW	NW	NW	NW	NW	W	NW	NW	NE	N	N	SE	NW
20	NE	NE	SE	NE	W	SW	SE	E	NNW	W	W	NW	NW	SW	NW	N	NNE	N	NE	SE	NE
21	NNE	NW	NE	NE	WSW	SW	SE	NE	N	SW	W	NE	NW	SW	NW	N	N	NW	E	SE	NE
22	NE	NW	SW	N	W	SW	NW	N	N	W	SW	N	SW	SW	NW	NW	NW	NW	E	SW	NE
23	NE	W	NE	NW	SW	SW	NW	N	NNE	W	W	NW	SW	NE	NNW	N	NW	NW	E	W	NE
24	N	WNW	NW	NW	SW	W	NW	SW	NE	W	NW	NE	W	NE	NW	NNE	NW	N	NW	NW	ENE
25	S	NW	NW	N	SW	W	SW	SE	NE	NW	NW	SW	W	NE	N	WNW	NW	NW	SE	WSW	NNE
26	SW	N	NW	NE	W	W	SW	S	NW	WSW	NW	S	NW	NE	SE	NW	N	W	S	SW	N

POTENTIALLY	
(light blue)	SUNNY DAYS
(pink)	SNOWY
(green)	CLOUDY
(blue)	HIGH HUMIDITY, FOG
(yellow)	WINDY

Figure 2.24 - Types of weather experienced during the Olympic period on the Western Alps, from 1985 to 2005

and systems for the controlled release of avalanches, which might influence access by athletes and spectators to the venues, the safety and comfort of everyone at the venues, the timing of emergency medical assistance, the protection of temporary structures and electronic equipment and the stocking up of food and drinks.
As far as specifically concerns the health, safety and comfort of the spectators, who were going to spend a long time at the outdoor venues, intense snow or rainfall, extreme wind chill conditions and the presence of ice or snow on the pavements and walkways were all considered.
The climatology study, in addition to the planning of the competition calendar, the sizing of temporary infrastructures and the highlighting of potentially critical situations, contributed to determining the insurance premiums for the Games.

A fundamental activity in the preparatory phase was the definition, together with the TOROC management, of a system of shared thresholds for the meteorology parameters which enabled quick decision-making regarding any criticalities regarding the sports competitions and non-sporting aspects of the event (tables 2.4 and 2.5).

The second phase of preparation consisted in testing the procedures of the WLC in Sestiere and in all the venues, in particular during the sport events during the 2004-2005 season, during which the weather teams were able to gain specialised skills, combining the knowledge of the local climatology and meteorology of the venue with the individual features of the sporting discipline.

The on-site monitoring and forecasting activities carried out in the years before and during whole period corresponding to the Olympics and Paralympics, were useful in order to perfect, also from an organisational viewpoint, the measuring, transmission and data processing procedures: it was also possible to try out innovative measuring instruments and build up a database for the Olympic and Paralympic period.

To ensure the success of all the activities provided for during the Games, accurate work plans were drawn up for each venue (figure 2.25), considering the specific organisational requirements and those of the events

WEATHER IMPACTS	WEATHER CONCERNS								
	Rain	Snow	Low temperature		High temp.	Wind chill	Wind	FOEHN	Visibility
			Mountain	Plain	Mountain	Plain			
In door competition	yes/no								
Snow making			?		Tw > -2°C		6m/s (20km/h)		
Freestyle	yes/no	yes/no				-25°C	Wind> 7m/s	yes/no	<30m
Biathlon							Wind>5m/s		
Alpine ski - DH, SG	P>15mm/6h (moderate)	<30cm (snowcats)					Constant until 70 km/h (race postponed)		<20 m on the whole course (race postponed)
	Mixed snow	>15cm and >30cm (snowcats team)					Constant until 40km/h (race delay)		<20 m on part of the course (race Delay)
	yes/no	> 5 cm (courses put off)					Gusts over 50km/h (Race interruption)		
Alpine ski - GS, SL	P>15mm/6h (moderate)	<30cm (snowcats)					Constant until 70km/h (race postponed)		<20 m on the whole course (race postponed)
	Mixed snow	>15cm and >30cm (snowcats team)					Constant until 40km/h (race delay)		<20 m on part of the course (race Delay)
	yes/no	> 5 cm (courses put off)					Gusts over 50km/h (Race interruption)		
Jump		How many (48-60 hours before)	T<-20°C		Tmin>0°C or sharply increasing temperatures (48-60 hours before)		>4 m/s (no official limit)	yes/no (48-60 hours before)	
Cross-country skiing			T<-20°C						
Snowboard									
Bobsleigh, skeleton, Luge	no	se > 30-50 cm/12h se > 15-25 cm/6h	If medium T h= dew point and rh> 65%	no	If daily medium T > 4c and rh < 30%	yes	If 13 m/s< velr<15m/s Velr > 15 m/s		no

Alert
Restoring Activities
Weather condition considering

Table 2.4 - Criticality thresholds for the sports competitions

WEATHER IMPACTS	WEATHER CONCERNS									
	Rain	Snow	Low temperature		High temp.	Wind chill	Wind	Fog	Ice	Avalanche
			Mountain	Plain	Mountain	Plain				Mountain
Health emergency			T < -20°C	T < -6°C		WC<-25				4-5 risk lev.
Electronic equipment			T < -25°C	T < 0°C						
Transport		40cm/12h					20m/s (70km/h)	VIS < 100m	YES	4-5 risk lev.
Snow removing		30cm/12h								
Spectator comfort			T < -10°C	T < -4°C		WC<-25				
Staff comfort			T < -10°C	T < -4°C		WC<-20				
Temporary structures		50 cm ($300 kg/m^2$)					28m/s (100km/h)			
Signs		30 cm					14m/s (50km/h)			
Electrical energy production			T < -30°C							
Food and Drink supplying			T < -10°C	T < -4°C	T > 10°C	WC<-10				
Opening and closing ceremonies	15 mm	15 cm		T < -4°C		WC<-20	6m/s (20km/h)	VIS < 100m		

Alert
Restoring Activities
Weather condition considering

Table 2.5 - Criticality thresholds for non-sporting aspects

scheduled for each day.

The working timetable and consequently the operational plans of the activities to be carried out at the single venues, were established in relation to the competition and training calendars and were such as to guarantee the issue of products to feed the intranet site INFO2006 at preset times.

To guarantee operation of the WOC and WLC 24/7 during the Games and ensure the respect of the issue of the products in the single venues, staff operated on a shift basis and provided 24-hour standby for intervention in the case of adverse weather conditions.

Every weather venue team was autonomous in the organisation of its own work, with precise attribution of roles and responsibilities for the issue of the products and methods of relating with the venue organisation.

A complex organisation, comprising coordination actions, guarantees consistency of the forecasts in each venue, with the frequent use of multiuser calls (using a conference call system). Only in the case of adverse weather conditions capable of jeopardising competitions did the central operation staff take a more important role, while continuing to rely on the total support of the weather staff of the single venues.

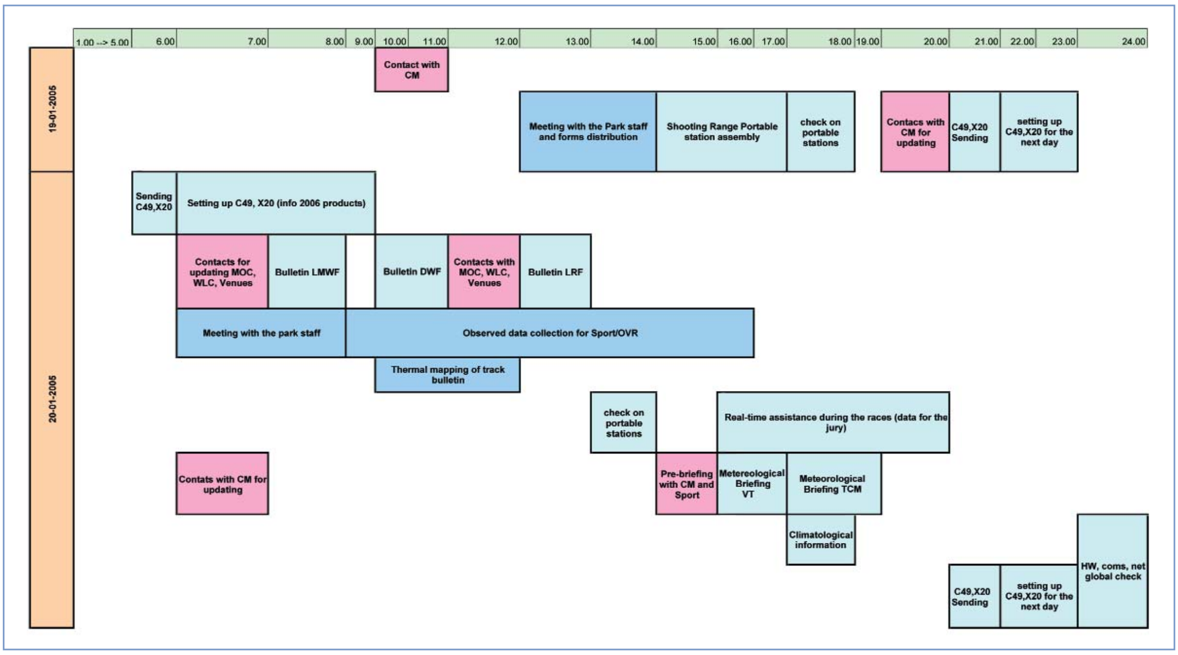

Figure 2.25 - Work plan for the Cesana San Sicario venue for the 19th and 20th of January 2005 during the sports events

2.2.8 THE INFORMATION SYSTEM

The aim of the information communication system for the nivo-meteorological assistance at the Games was double:

- to enable to creation of weather-snow products (medium-range forecast, real time meteorology measurements and their dissemination) for the sports competitions connected with the Olympic event and destined mainly for use in a sporting context and for venue management, particularly in the case of weather conditions requiring the implementation of contrast measures;
- to feed the TOROC, INFO2006 internal information system, on a daily basis, with detailed information on the current situation and the weather-snow forecast for the entire Olympic system, destined to the media and the various functions of the organisation.

To guarantee the operation of the whole system, the following measures were taken, in conjunction with the Sport management and Technologies management of the TOROC:

- upgrade of the hardware needed for the processing, dissemination and storage of the meteorology and nivology products;
- new acquisition of hardware and network resources, on the basis of cost/efficiency optimisation and usability criteria;
- integration of the hardware and network infrastructures acquired within the existing information system.

To build up the system, certain essential system requirements in terms of efficiency and security were defined together with the TOROC.

In detail, the requirements that had to be satisfied by the system during the Games were:

- guaranteed operation of the service 24/7;
- absence of "point of failure" (condition reachable through the provision of excess hardware, backup hardware and network equipment);

- high scalability;
- simple and modular implementation of the systemic parts;
- centralised scenario with a backup centre;
- integration of different technologies (MICROSOFT, LINUX, UNIX).

The design phase began at the beginning of 2004, together with the TOROC, and the first operational test of the whole communication system took place in the early months of 2005 during the Sport Events.

On the whole, the information system appears schematically as shown in figure 2.26, which highlights the type of IT connection and the access points of the network between the various meteorology product issue centres and between these and the final user, the TOROC.

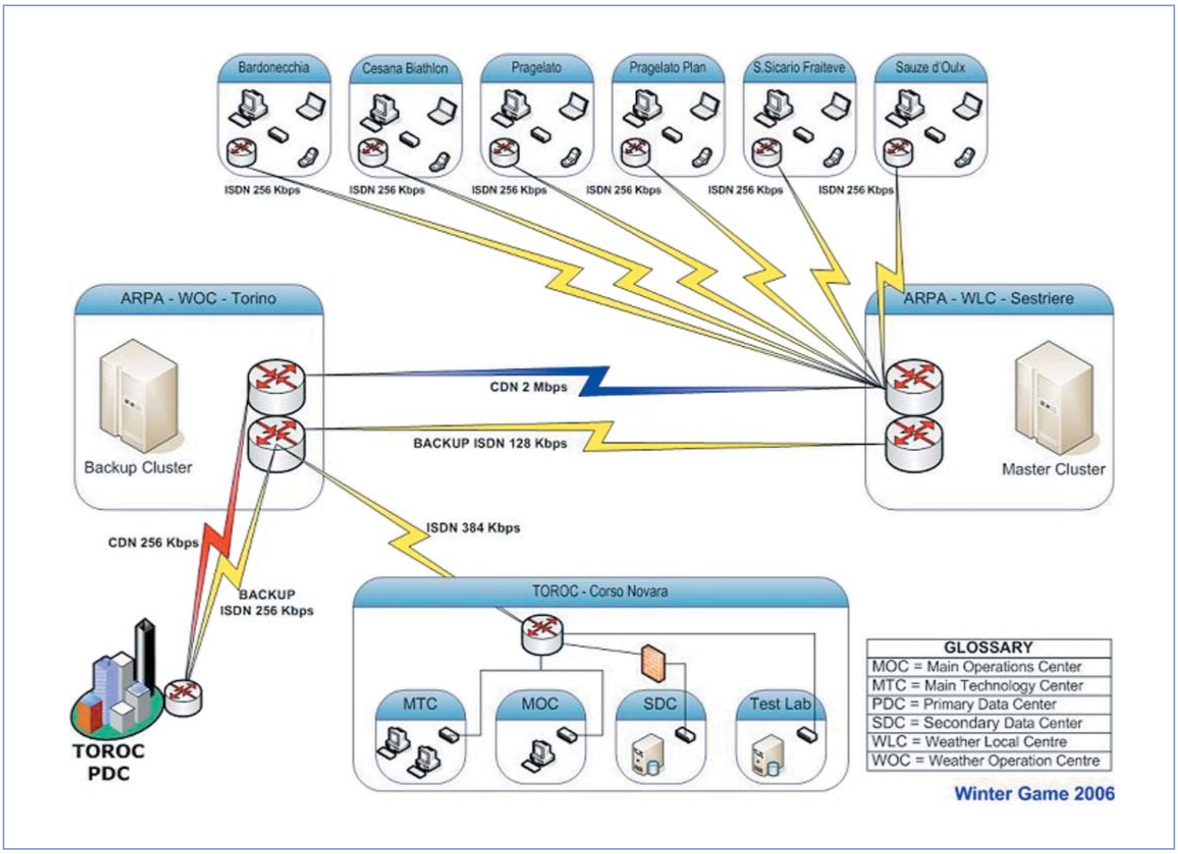

Figure 2.26 - The information system to support the weather and snow assistance at the Games

The sizing of the communication line was decided on the basis of the network traffic expected, both towards the TOROC and between the WOC in Torino and the WLC in Sestriere.

2.2.8.1 IT set-up of the weather offices

In order to favour the direct exchange between the nivo-meteorological service staff and the users of this service and for the dissemination of the information and latest data measured, independent forecasting units called Weather Information Centres were set up at the single outdoor competition venues. Moreover, the WLC in Sestriere which, during the Games, also provided backup to the WICs of the single venues, was strengthened from the IT viewpoint, with the acquisition and upgrade of the hardware needed to fulfil the aims of the IT system.

The hardware set-up at the WICs at the venues (figure 2.27), despite being smaller than that of the main centres, offered use of 3 simultaneous workstations, for displaying the data observed, both at the single venue and in the surrounding area, the model data forecast, satellite pictures and for the issue of the products.

TYPE	TECHNICAL CHARACTERISTICS	USE	TOTAL
PC	Lenovo Type 1 KTS600	Tecnical and nivo-meteorological	1
Screen	Monitor flat 17"		1
PC Notebook	Lenovo Type 1 E290	Tecnical and nivo-meteorological	1
Printer	Laser Printer Postscript A4	Printing of bulletins and other products	1
PC Notebook	Pentium M 735 (1.7 Ghz, 400Mhz, 2MB), 15.0" XGA LCD (1024x768) Screen - HD 60 GB - 512 MB RAM	For portable stations	1
PC Notebook (*)	2,0 Ghz Athlon processor with 256-KB L2 cache 15.0" XGA (1024x768) LCD display - HD 40 GB - 256 MB RAM	Thermal mapping	2
Internal and external instrumentation bags (*)	electronics device	Thermal mapping	2

* only in biathlon and cross-country venues

Figure 2.27 - The hardware of the WICs at the venues

All the hardware used for the nivo-meteorological assistance service was equipped with specialised software, consumables and assistance.

2.2.8.2 The INFO2006 Intranet system

Arpa Piemonte also designed and built a dedicated web application, called OLIMPIA 2006, which enables the management and distribution of meteorology data, with the creation of 6 specific meteorology products:

- Corridor Conditions (X25)
- Venue Accumulated Snowfall (X23)
- Venue Alerts (X21)
- Venue Conditions (X22)
- Venue Detailed Forecast (C49)
- Venue Forecast (X20)

These products were the result of automatic observations and forecasts by the meteorologists at the venue and were highly reliable due to the support of the mathematic models and post-processing procedures, and the complex network of weather stations on the ground set up for the Games at all the competition venues.

Every product was created and sent by ftp, at set times arranged with the TOROC (figure 2.28), in XML format.
This data was then displayed on the Games Intranet system INFO2006, in the way established by the Organising Committee and shared during the system design period.

<table>
<tr><th></th><th>VENUE FORECAST</th><th>VENUE ALERTS</th><th>VENUE CONDITIONS</th><th>VENUE ACCUMULATED SNOWFALL</th><th>CORRIDOR CONDITIONS</th><th>VENUE DETAILED FORECAST/SHORT TERM OUTLOOK</th></tr>
<tr><th></th><th>X20</th><th>X21</th><th>X22</th><th>X23</th><th>X24</th><th>C49</th></tr>
<tr><td>01.00</td><td rowspan="6">M</td><td>O</td><td>M</td><td>O</td><td>O</td><td rowspan="6">M</td></tr>
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<tr><td>11.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>12.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>13.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>14.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>15.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>16.00</td><td>O</td><td>O</td><td>M</td><td>M</td><td>O</td><td>O</td></tr>
<tr><td>17.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>18.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>19.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>20.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>21.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td>O</td></tr>
<tr><td>22.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td><td rowspan="3">M</td></tr>
<tr><td>23.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td></tr>
<tr><td>24.00</td><td>O</td><td>O</td><td>M</td><td>O</td><td>O</td></tr>
</table>

M = Mandatory
O = Optional
X20 = Mandatory Once a Day - Before 06,00
X22 = Mandatory Every Hour
X23 = Mandatory Twice daily - First mandatory message of the day before 08,00 - Second mandatory message of the day before 16.00
C49 = Mandatory Twice daily - First mandatory message of the day before 06,00 - Second mandatory message of the day before 23.59

Figure 2.28 - Scheduling of the issue of products for INFO2006

The Olimpia 2006 application, originally developed by Arpa Piemonte, offered the possibility to consult the data of the models and their post-processing procedures, also with graphics, imported by the special loaders that populate a database, comparing it with the data from the weather stations located throughout the territory. The user – in this case the meteorologist who had to prepare the end products – was able to choose the venue, the parameter to check, the forecasting model and the weather station of reference for the data measured.

In addition to these products, Olimpia 2006, enabled the generation of PDF reports for distribution at the venue and information products dedicated to sport (Long Range Weather Forecast, Detailed Weather Forecast and Last Minute Weather Forecast) and the local management of the various functions.

The application managed the security policies and roles of the authorised users with a Username and a Password. In this way, every user was able to use and see only the parts of the application for which he was authorised and only the venues to which he was assigned.

Figure 2.30 shows an example of the interface for the creation of a weather product, the Venue Detailed Forecast,

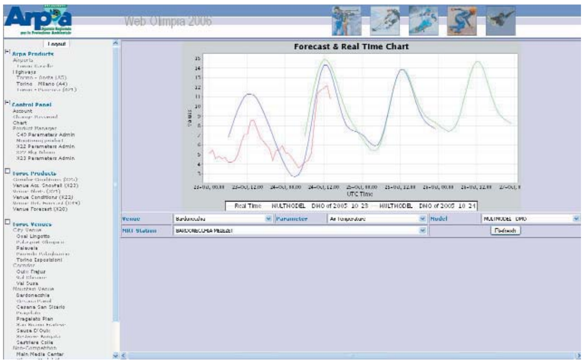


Figure 2.29 - Interface to display forecasting models and actual data registered by the weather stations decentralised throughout the territory

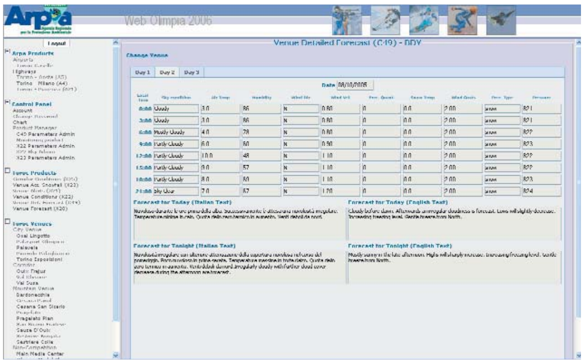


Figure 2.30 - Interface of the Detailed Venue Forecast

which represented an hourly forecast for the current day and a three-hourly forecast for the following two days, containing forecasts on the sky conditions, air temperature, humidity, wind direction, wind velocity, precipitation, now temperature, gusts of wind and pressure.

The initial values proposed by the application are loaded by the preset model or processed by the post-processing algorithms. The meteorologist intervenes to check the forecast data and, if necessary, to change every single value. For every day's forecast, there is a text forecast for the day and one for the night.

A utility was installed to monitor the dispatch of the products according to an arranged schedule. For every venue, if the xml file was not sent by the preset time, the "Monitoring Product" interface displayed a table with the missing venue and the name of the meteorologist assigned to that particular venue in order to activate the contact and check the delay.

A Service Level Agreement was signed with the TOROC to establish the quality levels of the service required (tables 2.6 and 2.7) as well as the response times for solving problems.

SEVERITY 1					
RESPONSE TARGET			FIX TARGET		
%		Mins	%		Mins
			95	within	30
100	within	5	98	within	40
			100	within	60

SEVERITY 2					
RESPONSE TARGET			FIX TARGET		
%		Mins	%		Mins
			95	within	160
100	within	15	98	within	200
			100	within	240

SEVERITY 3					
RESPONSE TARGET			FIX TARGET		
%		Mins	%		Mins
90	within	20	90	within	360
95	within	25	95	within	420
100	within	30	100	within	480

SEVERITY 4					
RESPONSE TARGET			FIX TARGET		
%		Mins	%		Mins
90	within	40	90	within	420
95	within	50	95	within	450
100	within	60	100	within	480

Table 2.6 - Response and fix time targets

<table>
<tr><th></th><th>SITE</th><th>PRESENCE</th><th>PHONE SUPPORT</th><th>PEOPLE</th></tr>
<tr><td rowspan="3">Human Resource</td><td>WLC - Sestriere</td><td>07 - 24</td><td>24 - 07</td><td>4</td></tr>
<tr><td>WOC - Turin</td><td>24 hrs</td><td>-</td><td>6</td></tr>
<tr><td>WICs</td><td colspan="2">24 hrs with phone support</td><td>2/3</td></tr>
<tr><td rowspan="4">Hardware Equipment & Support</td><td colspan="4">2 Cluster High Availability
Primary in the WLC (Sestriere)
Backup in the WOC (Turin)</td></tr>
<tr><td colspan="4">Cluster Hardware Support 6h 24x7 Call To Repair</td></tr>
<tr><td colspan="4">2 PC in every Venues</td></tr>
<tr><td colspan="4">Pc Venues Hardware Support by Lenovo</td></tr>
<tr><td rowspan="3">Software Support</td><td>ARPA</td><td colspan="3">24 hrs phone support + on site support asap</td></tr>
<tr><td>CSI</td><td colspan="3">TBD</td></tr>
<tr><td>RED HAT</td><td colspan="3">24 hrs phone support + on site support asap</td></tr>
<tr><td rowspan="3">Network & Support</td><td rowspan="2">TOROC
(Telecom)</td><td>WOC to WLC</td><td>WOC to PDC</td><td>WIC to WLC</td></tr>
<tr><td>High level 2 Mbps
+ bck 256 Kbps</td><td>High level -
256 Kbps</td><td>Medium level -
only 256 Kbps</td></tr>
<tr><td>CSI</td><td colspan="3">TBD</td></tr>
<tr><td rowspan="3">Ground Weather Stations System</td><td colspan="2" rowspan="3">TBD (CAE)</td><td colspan="2">3 ground stations dedicated for every Venue</td></tr>
<tr><td colspan="2">Failure station fixed within 4 hrs</td></tr>
<tr><td colspan="2">Staff of maintenance company
ready 24 hrs in WOC & WLC</td></tr>
</table>

Table 2.7 - Service Level Agreement

2.2.9 PRODUCTS

Beside those dedicated to feeding the INFO2006 system, numerous other products were issued by Arpa Piemonte during the Games, some of which were subject to experimentation during numerous important sport events in recent years, particularly during the Sport Events in 2005.
The reports were prepared using specific software which enabled transmission in xml format, for the real time updating of the website dedicated to the Olympics by Arpa Piemonte, and saving in pdf format for printing and transmission by e-mail to the Competition Office, which produced copies for all the teams to be distributed during the Team Captains Meetings in the afternoon.

All the products were used to feed the Arpa Piemonte website, the TOROC website and the INFO2006 intranet system, and were disseminated inside the single venues, in particular those for sport-related use.

Figure 2.31 - Olympic System Weather Report

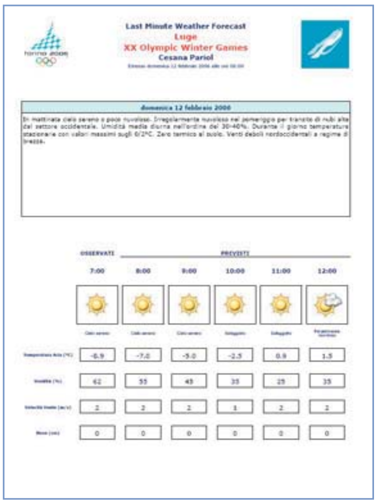


Figure 2.32 - Last Minute Weather Forecast for Cesana Pariol venue

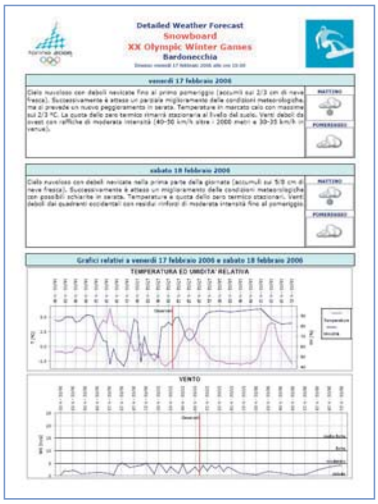


Figure 2.33 - Detailed Weather Forecast for Bardonecchia venue

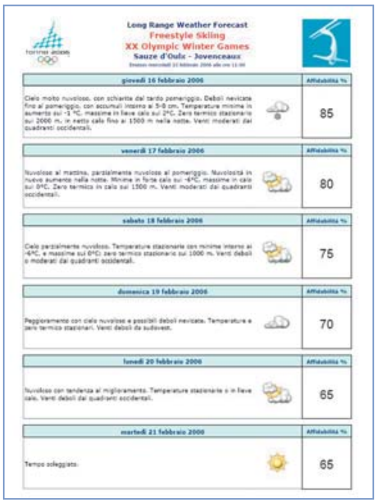


Figure 2.34 - Long Range Weather Forecast for Sauze d'Oulx venue

Figure 2.35 - Course report processed at Sestriere Colle during the Paralympic Games

The contents of the product were summarised during briefings at the daily Team Captains Meetings and the venue meeting.

Olympic system weather forecast

This contained a general weather forecast for the whole Olympic system. It was issued every day by the meteorologist at the WLC in Sestiere, in Italian, French and English. It was produced by the meteorologists of Arpa Piemonte at the WLC in Sestriere from winter 2002, to provide weather information on the Olympic system and for the website of the Olympic Committe (figure 2.31).

Last Minute Weather Forecast

Detailed quantitative weather forecast on every venue for the current day, in Italian and English (figure 2.32).

Detailed Weather Forecast

Detailed quantitative weather forecast on the venue for the next two days, in Italian and English (figure 2.33).

Long Range Weather Forecast

Text weather forecast for every venue for the next five days, in Italian and English (figure 2.34).

Courses Forecast

Forecast for the next 24 hours covering snow conditions on the competition course, presented in Italian and English, drawn up from three days before the Downhill training session until the day before the last of the “fast” competitions, i.e.: the Giant Slalom for the alpine skiing and the Giant Parallel Slalom for snowboarding (figure 2.35).

Thermal mapping

Monitoring of the snow surface temperature using a specially designed infrared thermometer fitted to a specific support transported on a snowmobile.

This product was conceived and built for the Nordic Skiing speciality, in the Nordic Combined during the Olympics, the Biathlon during the Paralympics and Cross Country in both sports events (figure 2.36).

The mapping operations were carried out three hours before the start of every competition and the results were available an hour before the competition on the big information panels for the athletes, as well as being delivered to the Competition Office for distribution to all the teams.

The same mapping was then published on the Arpa Piemonte website and explained in detail during the team captains meeting in the evening.

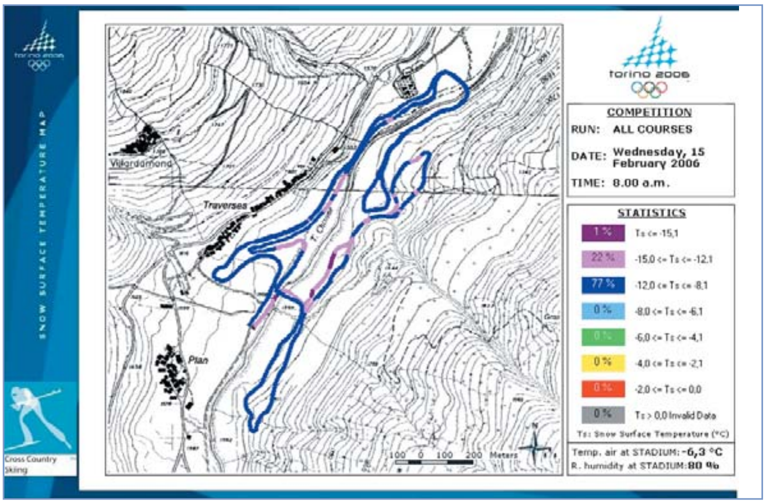


Figure 2.36 - Example of thermal mapping

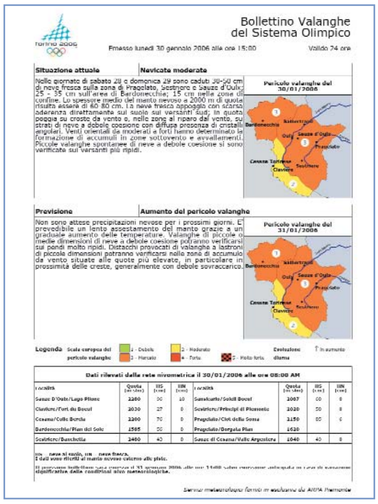


Figure 2.37 - Avalanche Report

Avalanche Report

Document for the analysis and forecasting of the conditions of the snowpack and the correlated avalanche risk, written in Italian, English and French, every day from the 1st to the 26th of February and from the 9th to the 19th of March. The report, which presented details of the regional report, contained an analysis of the current situation and that forecast for the following 24 hours in relation to the snow conditions, the state of the snowpack and the assessment of the avalanche risk in the Olympic mountain area.

The avalanche risk forecasting service was supplied from the end of December, every week, with the dual aim of following the evolution of the conditions of stability and consolidation of the snowpack from the very first snowfalls and of providing a nivology assistance service during the venue preparation phase. The same service was continued until the middle of April to provide assistance for the avalanche risk during the dismantling of the venues (figure 2.37).

Data observed

A summary of the data observed from the fixed and portable weather stations and the activity of the observers on the courses was transmitted every quarter of an hour to the venue's Result System service. The same data was also supplied every half-hour to the teams, displayed on panels (figure 2.38). In the evening, the data for the day was supplied to the team captains during the briefing.

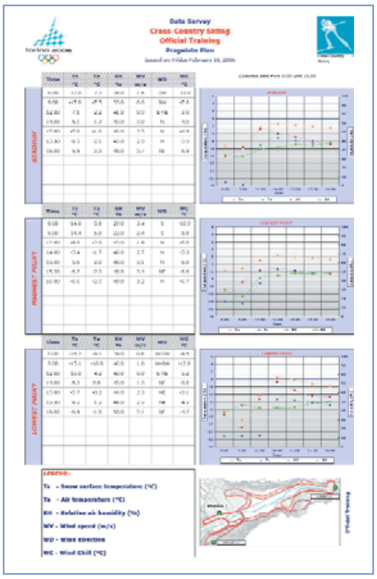


Figure 2.38 - Data observed for the Pragelato Plan competition office

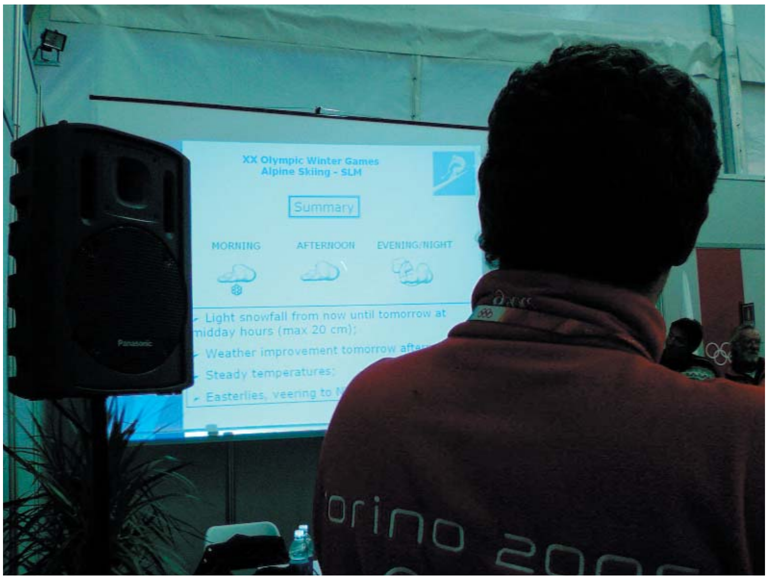


Figure 2.39 - A picture of the weather briefing at Sestriere Colle

Briefing

At the Team Captains' Meetings, the meteorologist offered a briefing with the forecasts for the next days, while the nivologist supplied the thermal mapping data in the venues requiring this service (figure 2.39).

Forecast of ice on roads

With the application of a specially developed deterministic model, it was possible to obtain, starting with the data observed from stations in the most critical points of the road system concerned, both of meteorological nature and measured directly on the road surface, a 24-hour numeric forecast of the temperature and the state of the road surface.

The table below (Tab. 2.8) summarises the number of reports issued during the Olympics and Paralympics for each type of forecast, as well as the 29989 xml messages which fed the INFO2006 Intranet system.

REPORT	PRODUCTS ISSUED DURING THE OLYMPIC GAMES	PRODUCTS ISSUED DURING THE PARALYMPIC GAMES	TOTAL
Olympic System Weather Report	17	10	27
Last Minute Weather Forecast	187	10	197
Detailed Weather Forecast	187	40	227
Log Range Weather Forecast	187	40	227
Courses Reports	42	12	54
Thermal Mappings	16	0	16
Avalanche Reports	29	12	41
TOTAL	675	124	789

Table 2.8 - The reports issued by the Weather Service during the Games

2.3 THE MONITORING SYSTEM

Alberto Olivero

In preparation for the nivo-meteorological assistance activity at the Games, in order to allow constant control of the meteorology parameters in the Olympic area and guarantee the nowcasting activities, Arpa Piemonte carried out extensive operations to strengthen its monitoring systems, coordinated by the manager for the Meteo-hydrographical Network Area, Alberto Olivero.

In the Olympic area, Arpa Piemonte managed a network (figure 2.40) of 66 automatic stations (10 of which can be relocated for the monitoring of meteorology parameters in the more sensitive points of the courses as regards slipperiness), 2 radio-survey systems, 2 radar dopplers and a wind and temperature profiler in the urban area of Torino.

2.3.1 THE NETWORK OF STATIONS ON THE GROUND

The 66 automatic stations mentioned above were divided as follows:

- fixed stations (figure 2.41), already operational and located within the Olympic area, some of which were equipped not only with the classic weather sensors, but also with special sensors (e.g. weather present sensors to measure visibility and a nephoipsometer, i.e. cloud gauge, to estimate the base of the clouds) pertinent to the Olympic monitoring and forecasting activities;
- transferable stations (figure 2.42) positioned in strategic points of the competition courses. The structure of these stations required simpler supports than those for the fixed stations, with no base plinths, making them easier to reuse in another location at the end of the Games. The sensorial equipment of the transferable stations was very similar to that of the fixed stations, but due to their particularly decentralised position, they were chosen for the installation of special sensors (e.g. infrared thermometer for the constant measurement of the surface temperature of the snowpack);
- portable stations (figure 2.43), small stations with certified instrumentation, mounted on portable supports. The data was transmitted either by direct connection between the station and a portable PC, or using the GSM telecommunication system.

Of all the nivo-meteorological parameters (figure 2.44) measured by the three types of stations belonging to the measuring network on the ground, we want to look at:

Figure 2.40 - Measuring network on the ground of the Olympic area

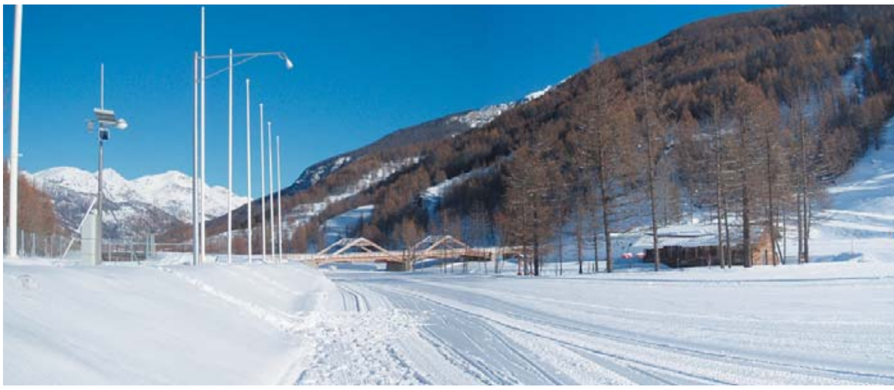


Figure 2.42 - Transportable measuring station at Pragelato Plan Stadium

- air temperature. This was monitored constantly, with data updates every 10 minutes and in 66 different points of the territory involved in the event;
- relative humidity, measured in 57 points;
- wind, monitored in 46 points with classic velocity and direction measurements. In addition to this instrumentation, two triaxial sonic anemometers were installed next to the ramps at the Pragelato venue for the ski jumping competitions. These sensors allow the continuous 3-D measurement of the wind;

Figure 2.41 - Fixed measuring station at Sestriere Alpette

Figure 2.43 - Portable measuring station at Pragelato Plan

- snow surface temperature, measured using 10 infrared thermometers, which detect the slightest change in snow surface temperature.

METEOROLOGICAL PARAMETERS		REGIONAL MONITORING NETWORK	SPECIAL NETWORK FOR OLYMPICS	TOTAL
P	precipitation	45	7	52
Ta	air temperature	48	18	66
RH	relative humidity	39	18	57
B	atmospheric pressure	14	4	18
RADD	global radiation	20	4	24
RADRsw	reflected radiation	7	6	13
Tn	snow temperature	4	-	4
Tnir	surface snow temperature	3	6	9
Hn	snow heigth	21	2	23
VV	wind velocity	35	11	46
DV	wind direction	33	11	44
VV sonic	sonic anemometer	-	4	4
DV sonic	sonic anemometer	-	2	2
CC	cloud cover	3	-	3
LLCH	lowest level clouds height	3	-	3
PW	present weather	4	1	5

Figure 2.44 - Weather parameters measured by the weather stations

2.3.2 THE AUTOMATIC RADIOSONDE SYSTEM

Two radiosonde systems are managed in Piedmont by Arpa Piemonte, one at Levaldigi Airport (CN) and the other near the Cesana Pariol venue.

Radiosondes measure the vertical profiles of pressure, temperature, relative humidity, wind direction and intensity up to the maximum useful altitude of 28000 m. The measurement of these atmospheric parameters takes place using electric capacity sensors contained inside the radiosonde, a box measuring 55x147x90 mm with a total weight of 220 g, while the measurement of horizontal wind at altitude is obtained on the basis of the speed at which the radiosonde moves horizontally as it rises in the atmosphere, analysing its positive in relation to fixed points on the earth's surface using a GPS system.

The systems installed for the launch of the balloons are completely automatic, capable of performing 24 radiosondage operations without the intervention of an operator. To rise in the atmosphere, the radiosonde is tied to a latex balloon weighing 600 grams and filled with helium. Every launch line is also equipped with a safety parachute for the balloon's return to the ground after it bursts upon reaching its maximum altitude.

Figure 2.45 - Radiosonde launch system at Cesana Pariol

The data is transmitted via radio in real time from the radiosonde to the launch station. By way of remote control systems the two systems can be managed from the WOC and the WLC.

During the Games the two systems supplied four radiosondage results a day, measured at the main synoptic times. It would also have been possible, in the event of critical weather conditions, to programme extra launches.

Using radiosonde data, it was possible to assess the characteristics of the planetary boundary layer and particularly unsettled conditions, the type of atmospheric stratification and the rotation of the wind in the lower strata. Radiosondage procedures can also be used to estimate the height of the freezing level and the isotherm at –10 °C, fundamental for the assessment of the type of precipitation that could affect the venues: rain or snow.

The values measured by the radiosonde are presented on thermodynamic diagrams which make it possible to gain useful information on the thermodynamic structure of the atmosphere and its implications for the effects in the lower strata, which mostly influence human activity.

Figure 2.46 is an example of representation of the radiosondage data acquired at Cesana Pariol on the 13th of February 2006. The red profile represents the temperature measured, while the blue profile represents the dew temperature, the green profile represents the trend in relative humidity and the light blue profile represents the dry adiabatic with the damp pseudo-adiabatic.

Between the 12th and 13th of February 2006, a polar depression crossed Central-Eastern Europe, bringing cold dry currents from the north. The radiosondage carried out at Cesana-San Sicario for Monday the 13th of February at 00 UTC shows, corresponding to the explanation above, a ground humidity value of less than 50% and, in general, the air column up to an altitude of about 4000 m presents little humidity (green vertical profile for relative humidity). The winds observed blew from the southeast on the ground and from the northern quadrants above 3000 metres. The freezing level observed was also affected by the cold air associated with the polar depression, which remained below 1000 metres.

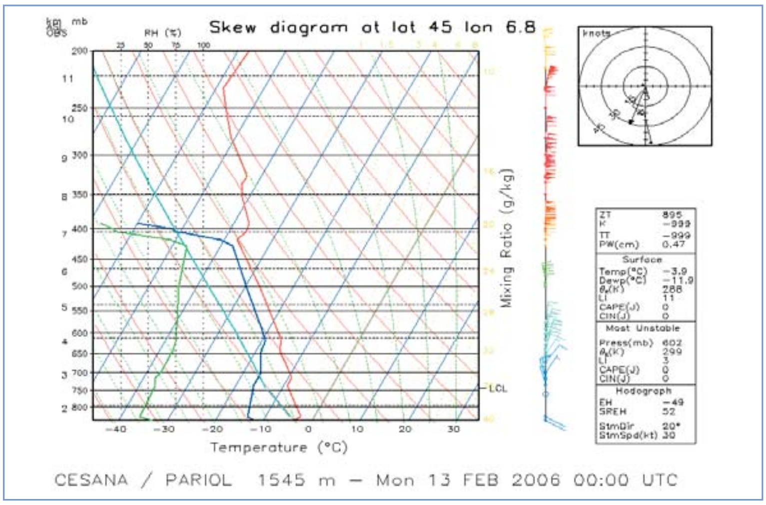


Figure 2.46 - Vertical profile of temperature, relative humidity and wind on a thermodynamic diagram
Measurements referred to the 12/02/2006 at Cesana Pariol

2.3.3 THE RADAR SYSTEM

The weather radar is a very important operating instrument for monitoring and forecasting very short-range conditions. From this very short-range forecasting viewpoint (up to six hours) the radar system made up of two C band Doppler radars was used during the Olympic period.
C band Doppler radars installed at Bric della Croce, on the summit of the Turin hill, and the summit of Monte Settepani in the Apennines, in the province of Savona sent (and continue to send) their data every 10 minutes to the Natural Risk Situation Room (which housed the WOC).
The real time processing of the radar measurements enables the estimate of some significant meteorology parameters for the whole regional territory, particularly the restricted Olympic area.

The instrument was used for the following applications:

- real time monitoring of precipitation intensity, wind velocity and presence of hail within a range of 230 km of the radar site and with a definition of 1 square km;
- very short-range forecasts (up to six hours) of storm phenomena associated with intense precipitations, snow, hail, etc.

2.3.4 WEB-CAMS

Five web-cams, two of which at the start of the Alpine skiing courses, enabled the remote monitoring of the local weather conditions and provided direct information regarding visibility along the courses.

Figure 2.47 - Radar picture from Mount Settepani on the border with Liguria

Figure 2.48 - Picture from the web-cam at Rio Nero, near the women's downhill start point

2.3.5 SNOW SURFACE TEMPERATURE MONITORING SYSTEM FOR THE CROSS COUNTRY COURSE

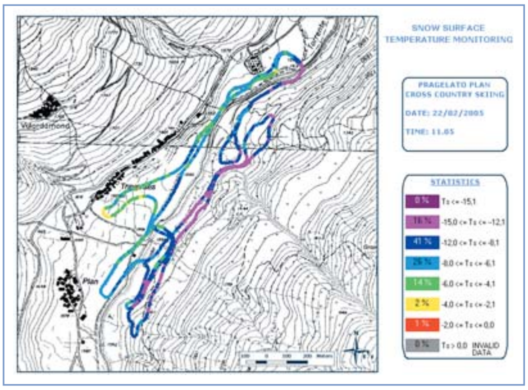


Figure 2.49 - Mapping of the snow surface temperature of the Cross Country Skiing course at Pragelato Plan

Arpa Piemonte implemented a system to monitor the surface temperature of the snowpack along the course in support of the Olympic Cross Country Skiing and Nordic Combined competitions. This system supplied the Olympic teams with a "Map of the snow surface temperature".
The system was made up of mobile peripheral station connected to an infrared thermometer (Accuracy ± 5 °C, Resolution 0.1 °C, Range from –40 °C to +100 °C) transported by a snowmobile at a constant speed of about 10 km/h. The station registered the data collected by the sensor every second (at about 3m) georeferencing them using a GPS system. The data was then transmitted via radio to a portable PC portative, recorded, process and displayed.
The end product consists in a thematic map (figure 2.49) in which the snow surface temperature is represented every 3 metres on a topographic map and using 8 colours to represent 8 classes of temperature.

2.3.6 MANUAL MONITORING OF THE NIVOLOGY PARAMETERS ON THE COURSES

Manual measurements, taken by qualified observers, completed the measurement of the characteristics of the top layer of snow for the Alpine and Nordic skiing competitions.
The daily monitoring of the nivo-meteorological parameters was aimed at assessing the snow conditions on the course and changes in these conditions during the different competition times scheduled.

For every course, different measuring points were individuated: in addition to the start and finishing lines, intermediate areas of particular significance in terms of athletic activity, slipperiness and stress caused to the surface of the course (flat stretches, changes in gradient, channels, etc.), were also considered.
The courses monitored were:

- Kandahar Banchetta run (G. Nasi) in Sestriere Borgata,
- Sises run in Sestriere Colle,
- Giovanni A. Agnelli run in Sestriere Colle,
- San Sicario Fraiteve run,
- Sauze d'Oulx Jouvenceaux,
- Pragelato Plan,
- Cesana San Sicario,
- Bardonecchia (runs 23 and 24).

The measuring activity was carried out at least three times a day, to perform continuous monitoring of the physical characteristics of the snow, paying particular attention to the surface layer.
The nivology parameters measured were selected specifically in relation to their importance at athletic level, without neglecting the different weight that every single nivo-meteorological parameter acquires in the preparation of materials for Alpine skiing or Nordic skiing.
These parameters measured on the courses are shown in the table below.

	MONITORED PARAMETERS	Alpine skiing	Biathlon	Nordic combined	Cross-country	Luge	Skeleton	Bobsleigh	Ski jumping	Snowboard	Freestyle
Meteorological parameters	Air temperature	■	■	■	■				■	■	■
	Air relative humidity	■	■	■	■				■	■	
	Visibility	■	■	■	■	■	■	■	■	■	■
	Sky conditions	■	■	■	■				■	■	■
Snow parameters	Snow conditions	■	■	■	■				■	■	■
	Snow surface temperature	■	■	■	■				■	■	■
	New snow depth	■	■	■	■				■	■	■

Figure 2.50 - Parameters measured manually on the competition courses

Air temperature: expressed in °C and °F and measured at 1.5 m or 10 cm above the snowpack, using portable digital thermometers. This temperature value at 10 cm was used to prepare the courses reports.
Relative air humidity: expressed in % and measured with digital hygrometers 1 cm above the snowpack.
Visibility: assessed on the basis of reference points within the surrounding territory.
Sky conditions: expressed in cloud classes.
Snow conditions: expressed in standard classes used in competitions.
Snow surface temperature: expressed in °C and °F measured using digital thermometers in contact with the surface of the snowpack.
Depth of new snow on the ground: expressed in cm and measured as new snow over the last 24 hours.
The monitoring of the nivology parameters on the courses supplied useful data for preparing the report on the course conditions and for forecasting the evolution of the snow surface temperature.

2.4 ACTIVITY OF THE VENUES AND PECULIAR PHENOMENA

The following chapter explains the activity performed by the weather venue teams for the nivo-meteorological assistance for the various sporting disciplines: as already described, the "distributed" character of the service was a strong point. This organisation was also used to write the chapter. Each team wrote a report on its own activity, following a general coordinated scheme. Consequently, every paragraph is influenced by the peculiarities of the team, specific experiences and the factors to be measured.
Intervention is purposely incomplete to present the contents and styles in an impersonal way and to highlight the spirit and passion that fuelled our operators, even in their reporting activities, maintaining some repetitions which are useful to understand the interpretations and solutions of problems of common origin applied to the different operating contexts of the venues.

2.4.1 PRA

2.4.1.1 The organisation of the nivo-meteorological service at the Pragelato venue

The municipality of Pragelato hosted all the Nordic skiing disciplines, with cross-country skiing at Plan, ski jumping at Rivets and the Nordic Combined in both competition venues. The cross country skiing course was situated in the loca-

lity of Plan, on the valley floor just a few kilometres from Sestriere, between the hamlets of Pattemouche and Granges, while the ski jumping system was situated on the right side of the Chisone stream opposite the hamlet of Rivets. The respective stadiums are 2.5 kilometres apart but the venue perimeters are just 200 metres apart at the closest point.
Initially, given the closeness of the two venues and the shared nature of the Nordic Combined event, the idea was to supply the nivo-meteorological service using just one team of nivologists and meteorologists based in Pragelato Plan. During the World Ski Jumping Championships held from the 11th to the 12th of February 2005 it became obvious that a weather team would have to be dedicated exclusively to the ski jumping event, remaining permanently at that particular venue; this was immediately obvious to both Arpa Piemonte and the Venue Team and particularly to the Sport Management. During the competitions and official training sessions of the Test Events, the jury requested the presence of a meteorologist in the jury tower to provide a nowcasting service.

Figure 2.51 - The Pragelato weather team

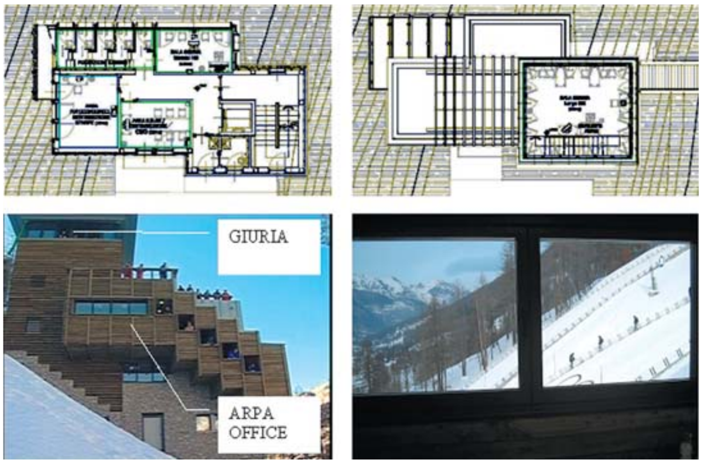


Figure 2.52 - The Weather Office housed in the Judges Tower

Figure 2.53 - Workstation

Figure 2.54 - Sonic anemometers installed along the ridge between the two ski jumps

At the end of the Test Events, the decision was made to split the Pragelato nivo-meteorological team: Serena Poncino and Andrea Piazza (the latter being a meteorologist from the Autonomous Province of Trento) were picked out as the forecasters of the meteorology teams dedicated to the Pragelato venue, where all the Ski jumping and Nordic Combined competitions were held.
The new team set to work immediately on reorganising the service in close collaboration with the sport management, and particular with the sport manager Sandro Pertile and his assistants Barbara Perri, Michela Elia and Franco Desogus, in order to optimise the service and adapt it to the specific needs of the Olympic discipline.
On the basis of the requests made by the jury during the Test Events, the Pragelato weather office was installed on the 1st floor of the Jury Tower. This position was strategic because it allowed the forecasters to remain constantly in close contact with the jury, competition managers and results manager, these being the main users of the nivo-meteorological service.
Despite the small number of people dedicated, the weather sta-

tion at the Pragelato venue was equipped with 3 workstations, two of which mobile, used to display the forecasting models, satellite and radar pictures (particularly useful for nowcasting) to prepare the forecasts. From the 3 workstations it was possible to read, in real time, the data picked up by the two sonic anemometers positioned on the ridge between the two ramps near the LH take off and the NH take off, as well as all the data recorded by all the Arpa Piemonte weather stations, particularly those of "Trampolino a Monte" and "Trampolino a Valle" situated at the departure and arrival of the lift system used by the athletes to reach the start. The data observed, as well as being useful for the nowcasting activity, was supplied to the result manager and the coaches and displayed on INFO2006.

The technical delegate (TD) Joe Lamb contacted the Pragelato Sport Manager about a month before the Games to check that the meteorologists were sufficiently fluent in English and highlighted the importance of having correct and clear forecasts. As it was possible to see during the XX Olympic Winter Games, and as explained in further detail in this document, the decisions of the TD often depend not only on the weather conditions underway, but those forecast. Before every training session or competition, before every Team Captains Meeting, the TD asked for a weather update, but in critical weather conditions, by express request of the TD, the forecaster had to flank him and supply constant updates on the evolution of the weather conditions.

The weather team was always a reference point, not only for the jury but for the entire staff, also thanks to the cooperation that was created with the continuous participation of the weather team in all the venue team meetings, including those in the months leading up to the Olympics. The planning of the venue activities could also be determined by the weather forecasts. For instance, the coverage of the spectator stands with canvas only took place when snow was forecast. Similarly, more volunteers were recruited in the morning when it might be necessary to clear snow from the venue. Activities were planned to remove ice from the spectator walkways when frost was expected and grit was spread on the roads and pedestrian areas when the temperatures forecast were such as to cause the snow to melt considerably, causing the formation of big puddles. Even the distribution of hot drinks and hand warmers among volunteers was planned in accordance with the weather forecast.

Attendance of the team venue meetings was of fundamental importance: it enabled the weather staff to be aware of all the criticalities at the venue and to be constantly updated with regard to the activities scheduled for the following days, allowing them to target the forecast not only on the competition periods but also on the other venue activities which remained behind the scenes but were fundamental to the success of the event.

Every day, both through the issue of reports and verbal communications, the ski jumping and Nordic combined competition managers received updates, as did the ramp manager and the manager of the in run: the information supplied was used to plan the activities to prepare the in run and the landing area.

Other users of the weather service, but by no means of lesser importance, were the teams, who received three weather reports - LMWF, DWF, and LRWF (figure 2.32, 2.33, 2.34) - every day; at every Team Captains Meeting there was a briefing on the weather conditions expected during the competitions and/or training sessions, and one hour before the cross-country skiing and Nordic combined competitions, the thermal map of the course was issued, this service being supplied in conjunction with the nivologists at Pragelato Plan and used mainly to help choose which type of ski wax to use. Furthermore, thanks to the cooperation with the Val Troncea Park and particularly with Enrico Boetto and Nanni Martin, during all the official ski jumping and Nordic combined trai-

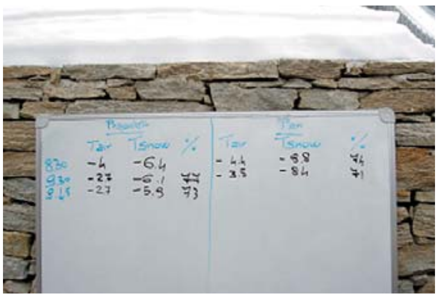


Figure 2.55 - Board where the data observed was posted

Figure 2.56 - Coaches' stand

ning sessions and competitions, data related to the air and snow temperature and relative air humidity measured at the take off of the ramp and in the cross-country stadium at Pragelato Plan were delivered to the coaches' stand.

In short, the weather service was polyvalent and aimed at all the organising staff, athletes, coaches and jury.
In order to supply the best possible service and satisfy all the needs, the working timetable during the Games was longer than 10 hours every day. The activities performed on a typical day are listed briefly below:

FEBRUARY 20TH	
07.30	Check-in
08.00	Check products for INFO2006
09.00	Update on the weather conditions forecast for the training sessions to the Technical Delegate (TD)
09.15	Issue Last Minute Weather Forecast for NC training sessions
09.30	First T, Ta, RH, VV, dirV data observed to OVR
10.30	Training starts. Every 15 min the weather data observed must be sent to OVR
12.00	Issue Detailed Weather Forecast
13.00	Training ends. Data will be sent to OVR every hour
13.15	Issue Long Range Weather Forecast
13.30	Lunch break
15.00	Issue Last Minute Weather Forecast for SJ competitions
15.30	Prepare briefing for Team Captains Meeting
16.30	Competition starts. Every 15 min the weather data observed must be sent to OVR
17.00	Team Captains Meeting
20.00	Competition ends. Last data observed for the day to OVR
21.00	Issue product for INFO2006
21.30	Venue Team meeting
22.30	Check-out

The working timetable was extensive and intense, especially if you consider the constant interruptions caused by the numerous updates supplied to the staff and the distribution of the data observed at the Office Venue Result (OVR).

2.4.1.2 Nivo-meteorological aspects characteristic to the ski jumping competitions

The importance of the weather conditions, and therefore their forecasting, for the preparation and success of the competitions is reiterated again and again *in the rules of the international special ski jumping competitions, flying competitions on skis approved by the 44th international ski federation (MIAMI – USA – 2004).*
At paragraph 417 *Snow Preparation*, it says:

417.1 Requirements for the In run and Take off.
The preparation of the snow must be such that it is completely level and at the exact height of the profile boards. This profile must allow a snow depth of minimally 20 cm. The necessary snow density is achieved through packing.
The tracks must be prepared with a help of technical equipment (track cutter, with boards or similar) according to the following measurements:
- Distance between the centres of the tracks: 30 - 33 cm
- Tracks width: 13.0 - 13.5 cm
- Tracks depht: at least 2 cm for normal hills and 3 cm for large and flying hills.
The preparation of the in run and take off must provide all competitors with the same conditions throughout each competition round. If it is necessary to change or prepare the in run during the competition because of snowfall, falls, or long holds, there must be a sufficient number of trial jumps before the competition can continue. In the case of poor and hazardous conditions, the Jury will base its decision on the performance of the forerunners and the effects

of the weather on them.
If the length or inclination of the take off is changed during one official round of competition, the round must be cancelled and restarted.
It is the Jurys responsibility to decide at the conclusion of a day of jumping whether the in run track shall be left in or taken out and the in run prepared anew.
In exceptional cases the Jury is entitled to decide to use an artificial in-run track.

A foehn event during the Test Event of the World Ski Jumping Championships in 2005 (11-12 February '05) highlighted the importance of the early forecasting of katabatic winds, not only for the safety of the athletes during the competitions but especially for the preparation of the launch ramp in accordance with the requisites of the above regulation. Temperatures above zero on the night before the competition made the preparation of the tracks of the launch ramp, which must be completely smooth and frozen, very difficult.
The foehn event in question made it necessary to use chemical additives to pack the snow which was soaking wet due to high daytime and nighttime temperatures. The staff responsible for preparing the launch ramp managed to intervene swiftly thanks to the early forecasting of the event.
The experience acquired during the Test Events turned out to be fundamental to individuate the correct solution to the problems related to high temperatures. Chemical additives take effect immediately but after a few hours they release the humidity absorbed and make the snow unusable, making it necessary to remove the snow and cover the launch ramp anew. While the use of additives was possible during the last competition of the World Ski Jumping Cup 2005 their use during the Games would have been impossible other than for the last competition in the calendar. For this reason the Sport Manager Sandro Pertile insisted that the Large Hill launch ramp be equipped with a cooling serpentine for activation in the case of excessively high temperatures.

Figure 2.57 - Cooling serpentine along the LH ramp

In the same paragraph (417.1 Requirements for the In run and Take off) reference is made to snowfall: *If it is necessary to change or prepare the in run during the competition because of snowfall, falls, or long holds, there must be a sufficient number of trial jumps before the competition can continue. In the case of poor and hazardous conditions, the Jury will base its decision on the performance of the forerunners and the effects of the weather on them.*
Even gentle snowfalls can pose a risk for the athletes. Whenever too much time passes between the jump of one athlete and the next, the snow could settle on the in runs reducing their uniformity and deteriorating the conditions of slipperiness, but, more importantly, the snow could settle on the jumper's skis, preventing him from entering the correct flying position: if the athlete were to jump with the tips of the skis pointing downwards, he would inevitably tip and his safety would be put at considerable risk.

On the afternoon of the 17th of February, during the Ski Jumping training sessions it snowed lightly. Initially, to prevent the snow from depositing on the tracks and the consequential problems, 2 or 3 forerunners were sent out in quick succession between one athlete and the next, but as the snow continued to fall, the use of the forerunners ceased to be sufficient to guarantee the safety of the athletes and the training session was suspended.
The problems related to the snow didn't just concern the safety of the athletes but, as mentioned earlier, the preparation of the in run and landing slope too, as well as the preparation of the venue for the arrival of the spectators. On the 19th of February, a deep area of Atlantic depression caused unsettled weather conditions, with light snowfall from mid-

morning, gradually becoming heavier and heavier during the afternoon and particularly in the evening. The next morning the whole venue was covered in a soft blanket, about 15 cm deep, which was extremely pretty but also meant a lot of hard work as everything had to be ready for the morning training sessions and especially for the competition in the afternoon. The weather forecast made it possible to plan the snow clearance operations and the preparation of the course, making the best possible use of time. In particular, on the afternoon of the 19th, the manager of the ramp came several times to ask for updates on the weather forecast, needing to know the quantities of snow expected. As the regulations state, the course has to be marked use spruce twigs and coloured tapes or banners at the sides.

417.3 The Marking of the Landing Hill.

The Hill Size (HS) has to be marked on the landing hill by a crossline of spruce twigs or equivalent. This crossline should be marked with red ink colour at each side of the landing slope for a distance of appr. 5 meters.

Furthermore, on both sides of the landing slope it is recommended that banners with different colours shall be laid down as follows:

- *between the construction point (K) and the Hill Size (HS) a red banner on each side;*
- *from the K-point towards the P-point a blue banner on each side in an equivalent length of the distance between K and HS, as well as*
- *from the fall line towards the HS a green banner on each side in an equivalent length of the distance between K and HS.*

For the orientation of the measurers, Jumping Jury and spectators regarding distances reached and for calibrating the video-distance measuring, crosslines also have to be placed on the landing slope from 10 m bifore P-point to the Hill Size (HS) for the Jumping lengths at intervals of five m (e.g. 60 m, 65 m, 70 m, 75 m ...). If needed, the Jury is entitled to add additional markings.

But in the regulations at 417.2 Requirements for the Landing Slope and Outrun, it also says: *The snow must be prepared so that it possesses the necessary density and firmness. … For sites hosting OWG, WSC, WSFC, JWSC and WC competitions, it is mandatory that the preparation, grooming and packing of snow can be accomplished through the use of an appropriate on-site snow grooming machine...*

Given the forecasts, the competition director was fully aware that it would be necessary to use the snow grooming machine to pack the snow the next day, or during the night. In order to optimise times and improve the work for the preparation of the run, it was vital for staff to immediately remove the spruce twigs, signalling tapes and banners from the run. It was a hard night for the team that prepared the run, but the next day, the outrun and landing slope conditions were perfect.

The heavy snowfall required the efforts of the whole venue team and volunteers to clear the snow from the spectators' stand, the VIP stand and coaches' stand, walkways and roads.

On the 20th of February during the last jumping competition, the ramp area was crossed by an isolated low cloud which quickly reduced visibility, leading the TD to suspend the test jumps. The phenomenon was extremely localised, the high resolution satellite did not see the cloud and the webcams at Pragelato Plan clearly showed that there was nothing further downhill. It was only thanks to the experience acquired over the years in relation to the local phenomena in the valley that it was possible to reassure the jury that the fog would clear in time for the start of the competition jumps. The mountain breeze would come and blow the cloud down towards the valley, leaving the in run and restoring sufficient visibility for the athletes to compete and the spectators to fully enjoy the entertainment.

So far we have looked at different weather phenomena, but we still haven't commented on the most important phenomenon for the jumping competitions: wind.

In the FIS regulations, in the paragraph on the responsibilities of the jury, it says: *"The Jury must decide: in which* *sphere of the wind condition (velocity) the jumper is allowed to start".* Furthermore, in subparagraph ***415.3 Wind Velocity and Direction*** related to *The Installation of Measuring Devices* it says: *The wind measuring instruments must be placed alongside the landing slope at the height of the optimal flight trajectory. The measurement data for these devices must be available to competition officials in the Judges Tower and shown in the most consolidated, readable form possible. Measuring instruments must be placed in two locations on normal hills (at approximately 10 m from the edge of the take off and at 70% of the distance to the K-Point), and in three locations on large hills (at approximately 10 m from the edge of the take off as well as at approximately 50% and approximately 100% of the distance to the K-Point). …In addition, at least 8 wind flags or wind socks must be placed along each side of the landing hill at the height of the flight trajectory.*

The jumping discipline is based largely on aerodynamic properties. The athlete's position during flight is such as to favour the air resistance which prevents falls. To guarantee that all the athletes jump in the same aerodynamic conditions, very strict rules have been laid down with regard to the features of the equipment. However the wind intensity and direction may considerably affect the performance of an athlete even when all the other conditions are the same: it is easy to imagine how a frontal wind favours the athlete's jump, unlike a wind from behind. This is why the wind is the parameter to which the regulations devote most attention.

The jury has to guarantee that all the teams jump in the same surrounding conditions: on the basis of the atmospheric stability forecast, particularly with regard to the wind, the TD decides the three spheres of wind in which the athletes are authorised to jump. The more stable the conditions, the more the TD is able to choose narrower spheres of wind to guarantee the success of the competition (the wind effectively observed lies within the spheres chosen) and the greater the uniformity of the jumping conditions for the athletes. The TD chooses three spheres of wind in which he considers the wind in the three directions: frontal, lateral and vertical. A gentle wind has the opposite effect on the athlete's performance depending on where it comes from: for example, a wind with a positive vertical component, blowing from downhill upwards, will tend to support the athlete, favouring him in the competition, while a wind with a negative vertical component, blowing from uphill downwards, will tend to weigh the athlete down.

For the wind to remain inside the chosen spheres, both intensity and direction must remain constant. On the 16th of February, the venue was hit by light precipitation. Due to the high temperatures, the precipitation took on the form of fine drizzle. Thanks to the presence of the serpentines, the high temperatures caused no problems in relation to the stability of the tracks and the drizzle that fell on them froze immediately without ruining the tracks and without settling on the athletes' skis. However, despite being very gentle (rarely above 2 m/s), due to the perturbation underway, the winds quickly changed direction, causing the TD considerable problems and leading to the suspension of the jumps and postponement of the competition. The decision was particularly worrying due to the deterioration in the weather conditions forecast for the days ahead. Just half an hour later, a meeting was called to decide, in agreement with the Main Operation Centre (MOC) when to hold the competition. After carefully assessing the weather forecast, the decision was made to repeat the competition the morning after, an hour earlier than on the previous days. The competition start was brought forward to avoid the gentle snowfall forecast for later. The choice of the date and time of the postponed competition turned out to be perfect: the winds remained gentle and their direction sufficiently stable and sleet began to fall only in the last round, intensifying only at the end of the competition.

On the afternoon of the 16th of February however, as expected, moderate foehn conditions were established causing worries related to the temporary structures at the venue. In particular, the Venue Manager, Paul Freudesprung, asked several times for updates on the winds expected and their intensification over the hours ahead: he was worried about a giant screen and needed to be informed of the arrival of wind travelling at more than 90 km/h, which would have required the removal of the tensiostructures from the venue.

Another wind-related event occurred on the 21st of February. Gentle winds were forecast, but during the morning the arrival of easterly currents was expected with a gradual rise in humidity from the valley leading to an increase in cloud, especially during the afternoon. The athletes began jumping with a gentle south-westerly wind. After the first 10 athletes had jumped, the wind direction became variable, eventually coming from the east, and the competition had to be suspended. By now the easterly wind had settled in. After a brief consultation with the forecaster, Joe Lamb, the TD of the Nordic Combined, decided to continue with the competition and have the first athletes, who had already jumped in different wind conditions, repeat their jump. By this time the wind direction and intensity were stable and the jumps followed one another in rapid succession: the ski jumping competitions of the XX Olympic Winter Games had been successfully completed to the immense satisfaction of all the athletes and staff, arousing a considerable amount of emotion.

2.4.2 PRP

2.4.2.1 The organisation of the nivo-meteorological service at the Pragelato Plan venue

On the 31st of January 2006, at the end of a two-year process characterised by various preparatory and training phases for the XX Olympic Winter Games Torino 2006, some of the most significant and educational of which were the FIS World Cup finals in 2004 and the Test Events in 2005, the Snow-Weather team assigned to the Pragelato Plan venue settled in at the Weather Information Centre (WIC). The team, which supplied the Nivo-meteorological assistance service for the Pragelato Plan venue was made up of: Salvatore Martorina and Pancrazio Bertaccini (Meteorologists), Paolo Costa (Specialised technician), Enrico Olivero and Claudio Boggiatto (Nivologists).

The experiences of previous years created a close knit team, skilled and capable of responding in the best way possible to the needs related to the exclusively sporting aspect and, more generally speaking, to the complex management of a venue. This made it possible to live the Olympic experience to the full, despite the long work shifts. The commitments of Snow-Weather Team meant getting up at dawn: the typical day usually began at about 6.00 a.m. for the Nivologists and the Technician who, after setting up and preparing everything necessary, carried out the Thermal Mapping of the competition course, analysed and checked the quality of the data recorded, printed the Thermal Maps obtained and distributed them to the various people concerned (Coaches, Ski wax specialists, Jury and Media Centre), for a total of 16 Maps of the surface snow temperature on the competition courses during the Olympic period.

Figure 2.58 - The Pragelato Plan snow-weather team with Cristian Zorzi, gold medal winner in the 4x10 km relay
(from left: Enrico Olivero, Paolo Costa, Claudio Boggiatto, Salvatore Martorina, Pancrazio Bertaccini)

The two Meteorologists usually went on duty at about 7 a.m.: after an initial analysis of the previous day's situation and the data registered by the weather stations, a quick look at the satellite pictures, radar maps and various webcams located throughout the Olympic area, the forecasting phase began, with the issue of the first report, the Last Minute Weather Forecast, followed by all the other products.

During the pre-Olympic, Olympic and Paralympic periods, the Snow-Weather team issued various products related to the evolution of the nivo-meteorological parameters. These products were made available to the various functions at the venue, from Sport to OVR (Official Venue Results), from the coaches of the National teams to those responsi-

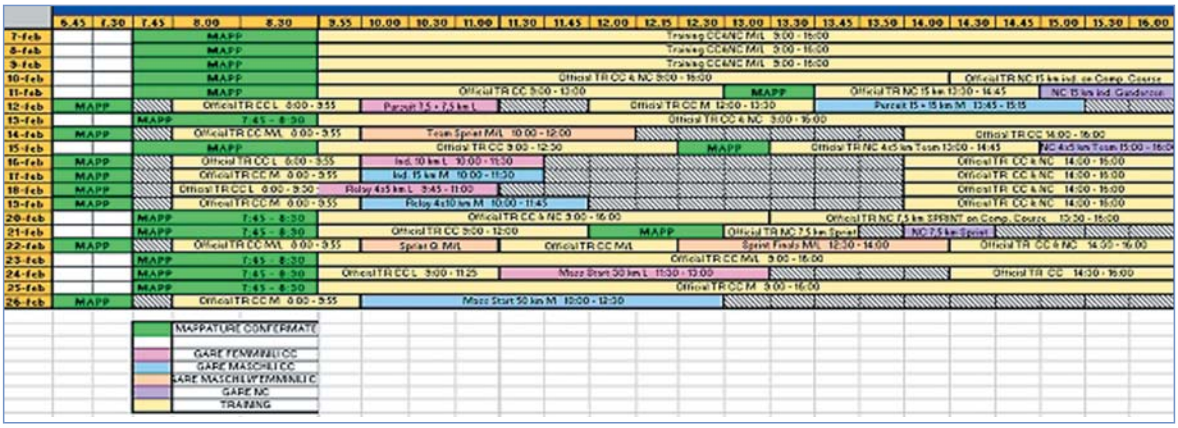


Figure 2.59 - Programme of the Thermal Mappings carried out during the Olympics

DATE	TIME	ACTIVITY	NOTE
21 Feb	by 6.00 a.m.	X20	INFO2006 product
21 Feb	by 6.00 a.m.	C49	INFO2006 product
21 Feb	by 8.00 a.m.	Last Minute Weather Forecast report	Possible update for the NC competition from 3.00 p.m. to 4.00 p.m.
21 Feb	by 11.00 a.m.	Detailed Weather Forecast report: 21/02/2006 - 22/02/2006	
21 Feb	by 1.00 p.m.	Long Range Weather Forecast report: 22/02/2006 - 27/02/2006	
21 Feb	by 5.00 p.m.	Prepare Briefing for TCM	
21 Feb	6.00 – 7.00 p.m.	TCM	Team Captains' Meeting
21 Feb	after 9.00 p.m.	C49	INFO2006 product

Figure 2.60 - Daily programme of the two Meteorologists involved in the issue of the various products

ble for waxing the skis, from Transport to TOBO (Torino Olympic Broadcasting Organisation), and also sent to the MOC (Main Operation Centre) in Torino.

As of the 16th of January '06, before the effective start of the Games and the arrival of the national teams, to give an indication of the weather conditions ahead to all those who would be preparing the competition courses and setting up and managing the venues in general, long range weather reports were produced (6-day written reports), for a total of 38 Long Range Weather Forecasts issued until the until the end of the Olympics and 13 Long Range Weather Forecast issued during the Paralympics as of the 7th of March.

From the 30th of January to the 26th of February, 28 Detailed Weather Forecasts were issued every day, reporting the conditions for the next 48 hours and comprising, in addition to text, the numeric forecasts for certain atmospheric parameters considered relevant for the venue, such as air temperature, relative humidity and wind intensity. During the Paralympic period, as of the 8th of March, 12 Detailed Weather Forecasts were issued.

Lastly, on the days of the official training sessions and competitions, first thing in the morning, the Last Minute Weather Forecast, providing details on the forthcoming hours of the competition and/or official training session, was issued, with a total of 23 reports during the Olympics and 10 during the Paralympics. Furthermore, the Snow-Weather team was involved in the Team Captain's Meetings, held every afternoon before the competitions, during which the weather and snow conditions forecast for the next day were presented, with a total of 11 snow-weather briefings during the Olympics and 7 during the Paralympics.

On the official training and competition days, the Weather Information Centre supplied 31 Reports of data observed for the Olympic period (as of the 1st of February '06) and 10 Reports for the Paralympic period (as of the 7th of March '06).

The daily monitoring of the atmospheric parameters and the snow, thanks also to the use of manual detectors near the lowest point of the course, was carried out at 30-minute intervals on competition days, starting three hours before the start of the competition, while during the official training sessions and in the pre-Olympic period in general, monitoring activities were carried out in five moments chosen as significant and representative of the competition times (8.00 a.m., 9.00 a.m., 12.00 a.m., 2.00 p.m., 4.00 p.m.).

The parameters measured were:

Ts	snow surface temperature (°C)
Ta	air temperature (°C)
RH	relative humidity (%)
WV	wind velocity (m/s)
WD	wind direction
WC	wind chill (°C)

According to that established beforehand with the Sport Manager, there were three monitoring points; the Stadium, the highest point and the lowest point of the competition course.

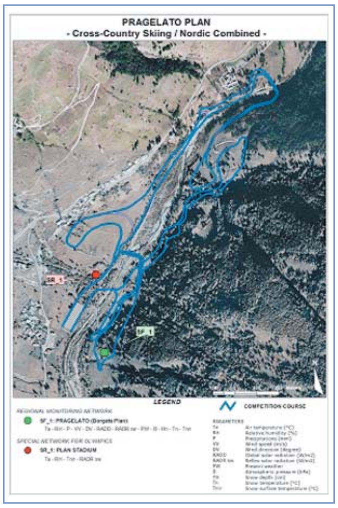


Figure 2.61 - Monitoring along the competition course

Figure 2.62 - "Pragelato Plan" fixed station at the highest point

Figure 2.63 - "Plan Stadium" transportable station at the Stadium

Figure 2.64 - Portable weather station at the lowest point of the course, *which varied depending on the competition course, requiring the movement of the portable station as and when necessary*

2.4.2.2 Nivo-meteorological aspects characteristic to the Cross-Country Skiing and Biathlon competitions during the Olympics and Paralympics in Pragelato Plan

For the Cross-Country Skiing competition held in Pragelato Plan during the Olympics, and the Biathlon competitions,

held in Pragelato Plan during the Paralympics, the International Federations established thresholds for certain atmospheric parameters which might have influenced the success of a competition: as far as the Cross-Country Skiing was concerned, the critical threshold established was for air temperature, which hadn't to fall below -20 °C, while for the Biathlon, critical conditions were considered those in which the wind intensity exceeded 5 m/s, as this could create considerable problems for the athletes involved in the event at the shooting range.
In general, during the Cross-Country Skiing and Biathlon competitions, there were never atmospheric conditions such as to have to consider moving or postponing a competition: only during the first week of the Paralympics, dedicated mainly to the Biathlon, did wind intensity values approach the threshold established, but fortunately, during the competition, the situation never became so critical as to prevent the competitions scheduled from going ahead.

A week by week analysis of the weather conditions which characterised the pre-Olympic, Olympic and Paralympic periods in Pragelato Plan is presented below, accompanied by a series of graphs related to the values observed for certain indicative atmospheric parameters.

Olympic period

Week from the 1st to the 5th of February: in the first two days, the weather situation was characterised mainly by stable weather conditions, favoured by the presence of the Anticyclone of the Azores over Central-Southern Europe with pleasant daytime temperatures; on the 3rd and 4th of February, northerly currents kept the weather conditions good, but the gradual descent of a polar depression towards the Mediterranean caused a gradual drop in temperature and of the freezing level. On the 5th of February, moderate north-westerly currents determined the formation of low-lying cloud along the Val Chisone with uneven cloud coverage, more consistent in the middle of the day.

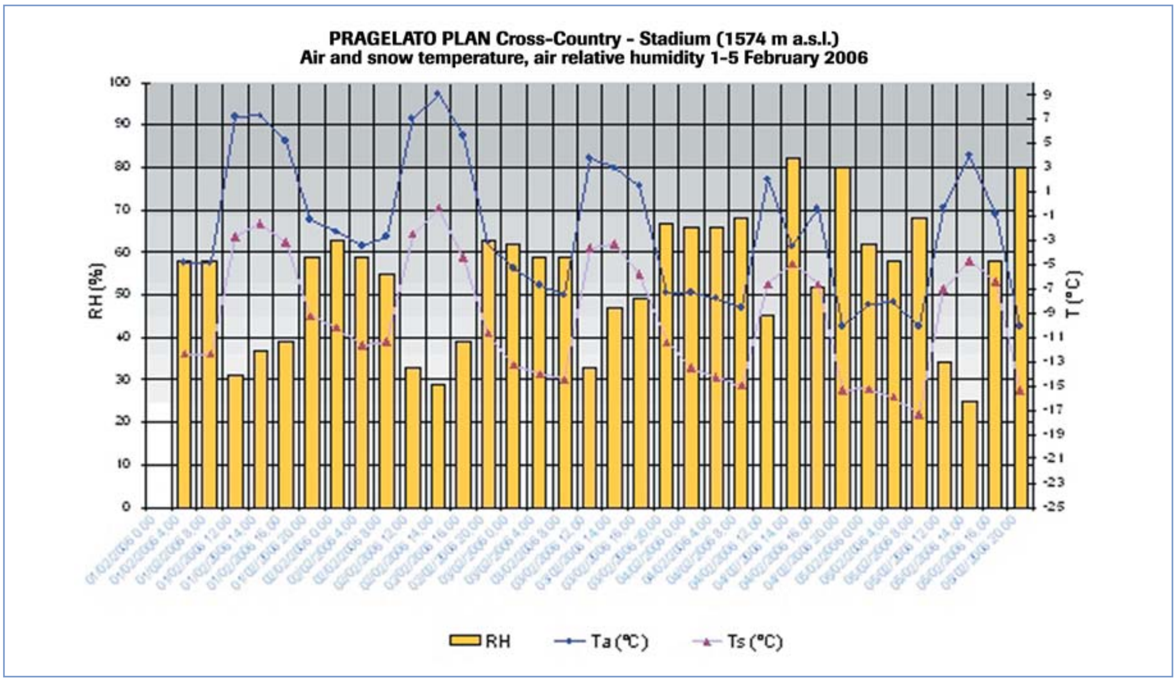


Figure 2.65 - Trend of air temperature, relative humidity and snow temperature

Week from the 6th to the 12th of February: the beginning of the week was characterised by the expansion of an anticyclone area over Western Europe and the consolidation of settled, sunny weather which lasted until the first part of the 8th of February, when the descent of a deep Polar depression towards the Alps intensified the winds, bringing foehn conditions associated with uneven cloud cover.

This situation continued through the 9th of February. On the 10th, the Polar depression moved off towards southwest and an anticyclone area expanded over Western Europe, favouring the mitigation of the winds and the return of stable and prevalently sunny weather conditions for the whole weekend, but with temperatures falling considerably with the conclusion of the foehn event.

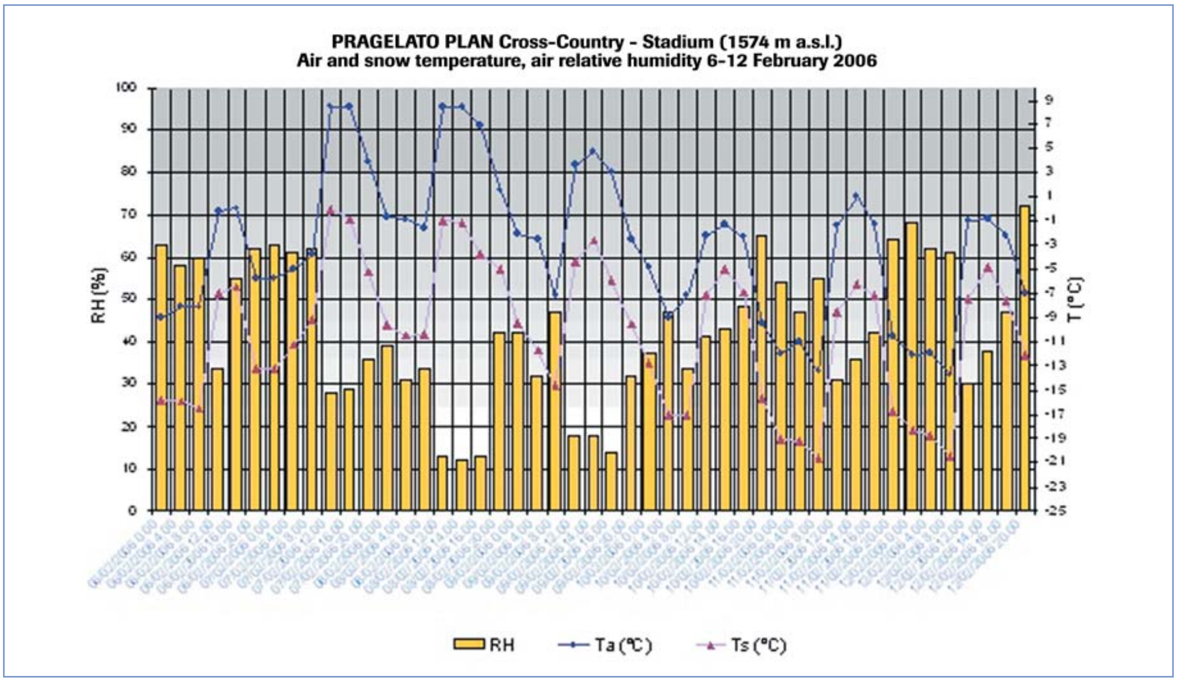


Figure 2.66 - Trend of air temperature, relative humidity and snow temperature

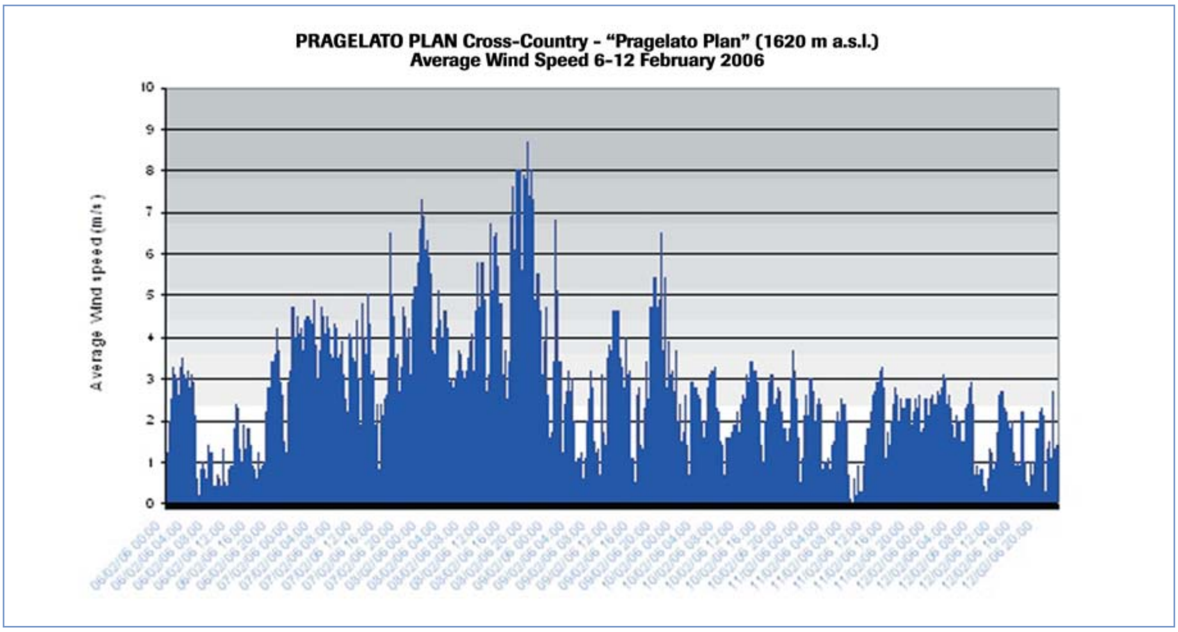


Figure 2.67 - Trend of scalar wind intensity

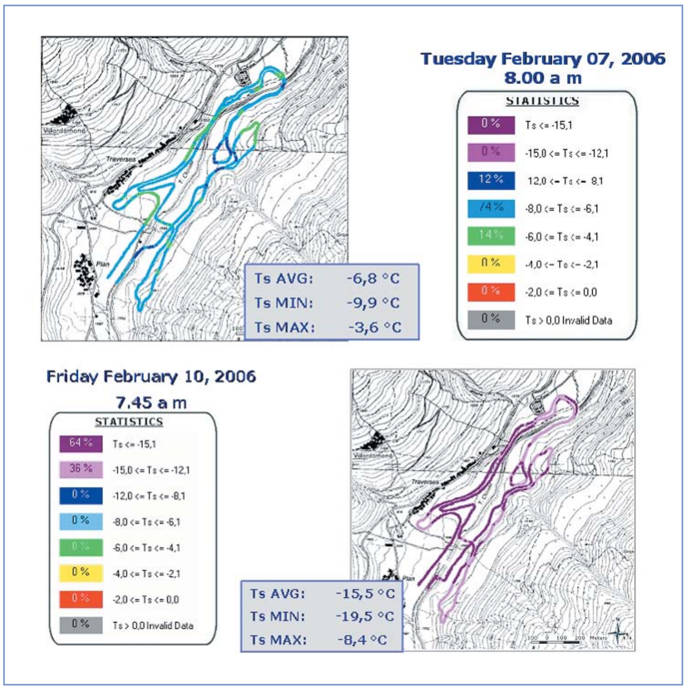


Figure 2.68 - Comparison between the Thermal mappings carried out on the 7th and 10th of February

As far as snow temperature was concerned, the maximum values were reached on the 7th and 8th, with temperature close to 0 °C and "wet" snow conditions along most of the course during the sunniest hours. As of the 9th, temperatures fell considerably: this cooling along the competition course is highlighted if we compare the thermal maps produced on the 7th and 10th of February.

Week from the 13th to the 19th of February: the third week of the month was undoubtedly the most critical for the weather conditions. On the afternoon of Wednesday the 15th of February there was a stable situation, favoured by an anticyclone promontory over Western Europe, but this was followed by the rapid transit of Atlantic frontal systems which caused fairly perturbed weather conditions: initially the area was affected by the passage of a warm front, which determined an increase in cloud cover and a marked rise in temperatures with soft drizzle during the night between the 15th and 16th of February. On the 16th, the Olympic area was crossed by a series of fronts, warm in the morning and cold in the evening: Pragelato was on the limit of the wall of the foehn, with consequent uneven cloud coverage associated with gen-

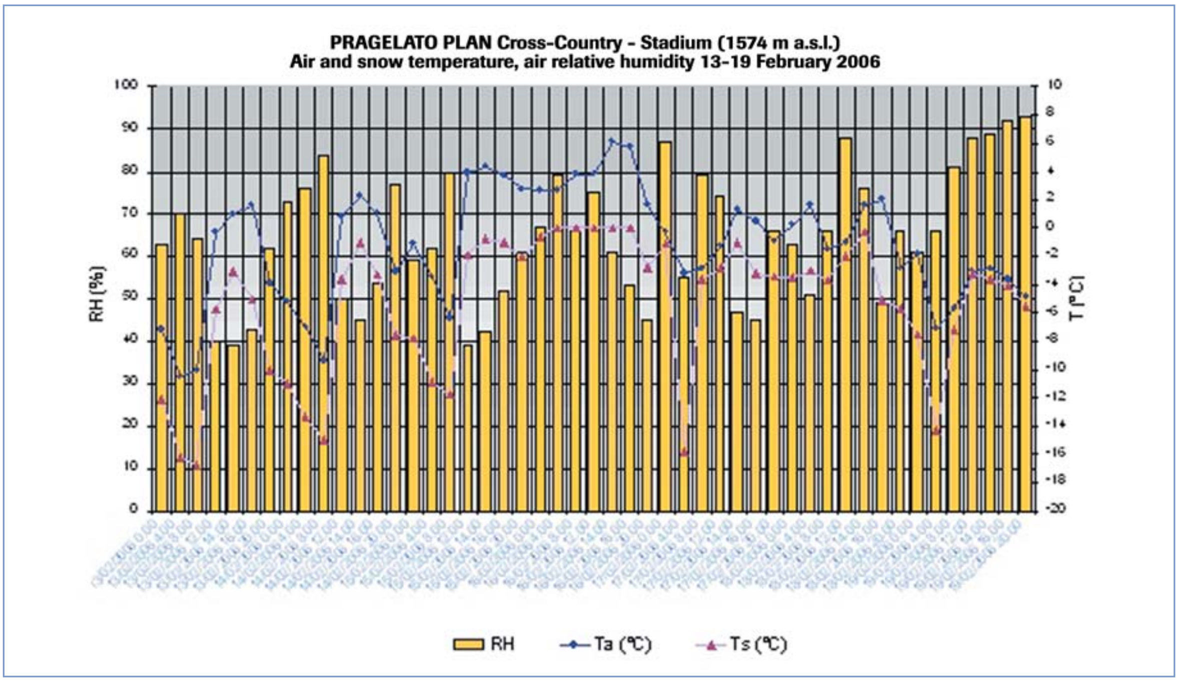


Figure 2.69 - Trend of air temperature, relative humidity and snow temperature

tle rain in the morning and generally moderate winds with strong gusts throughout the day. During the afternoon there was a temporary improvement and disappearance of the phenomena. From the evening, the passage of a cold front determined a sharp drop in temperatures and the return of precipitation, but this time in the form of snow. Perturbed weather continued through the 17th and part of the 18th, due to the rapid transit of a cold-warm frontal system, with snow and winds of moderate intensity. The movement of these structures away to the east favoured an improvement, limited to the second part of Saturday the 18th of February. On the 19th in fact, a deep depression of Atlantic origin caused perturbed weather conditions with snow from mid morning, gradually becoming heavy as the afternoon progressed.

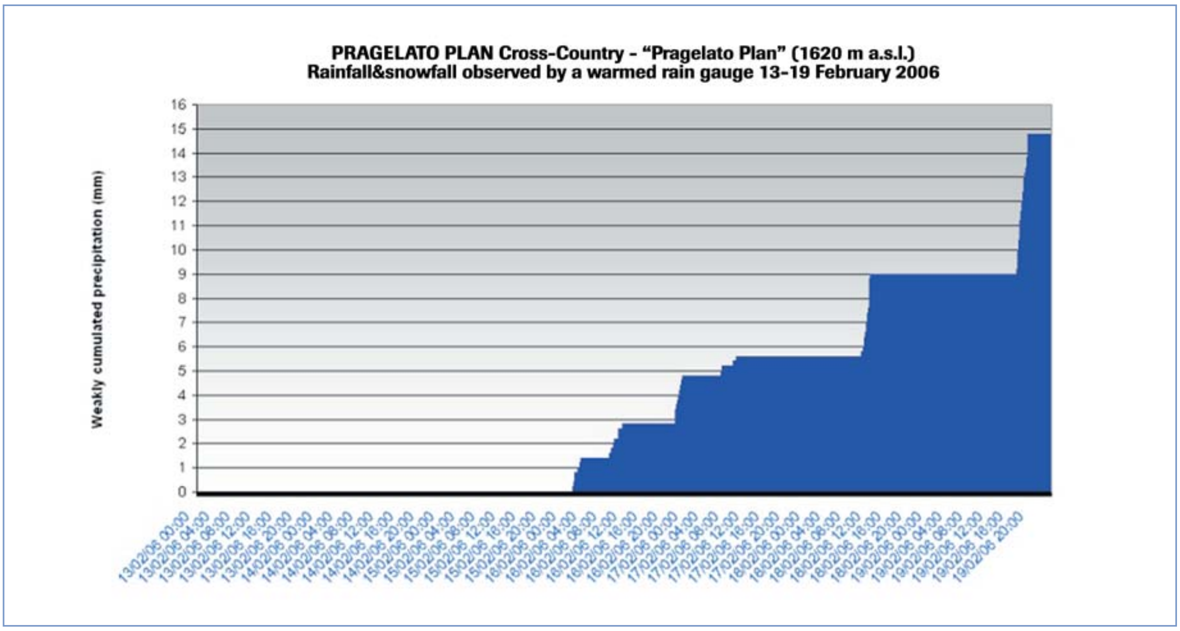


Figure 2.70 - Precipitations observed

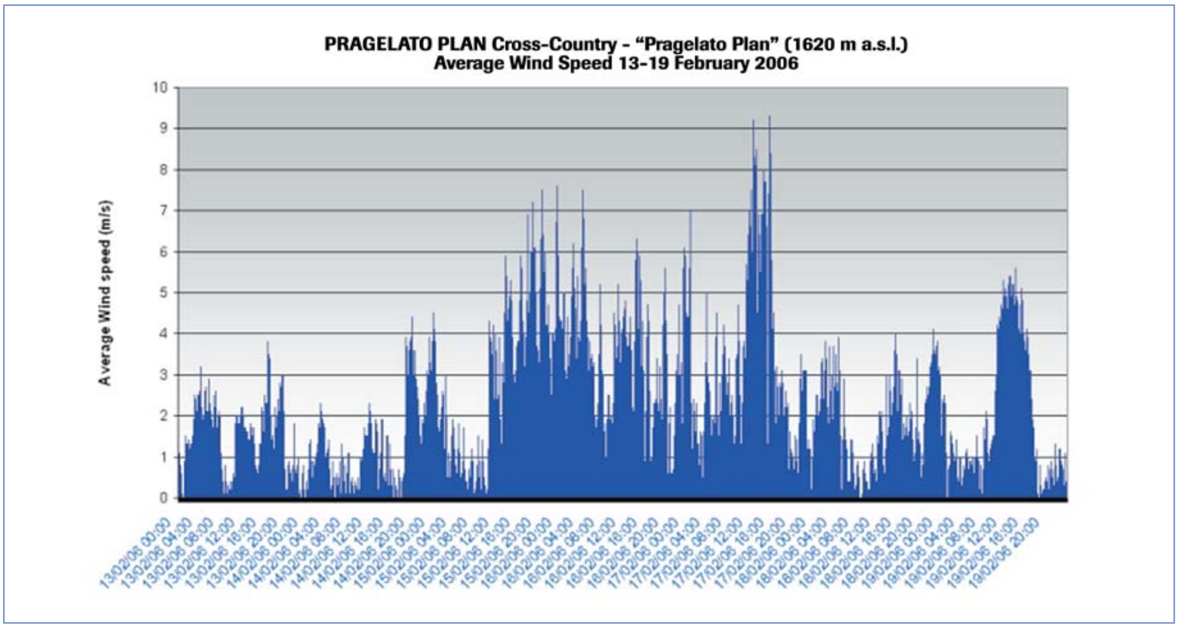


Figure 2.71 - Trend of scalar wind intensity

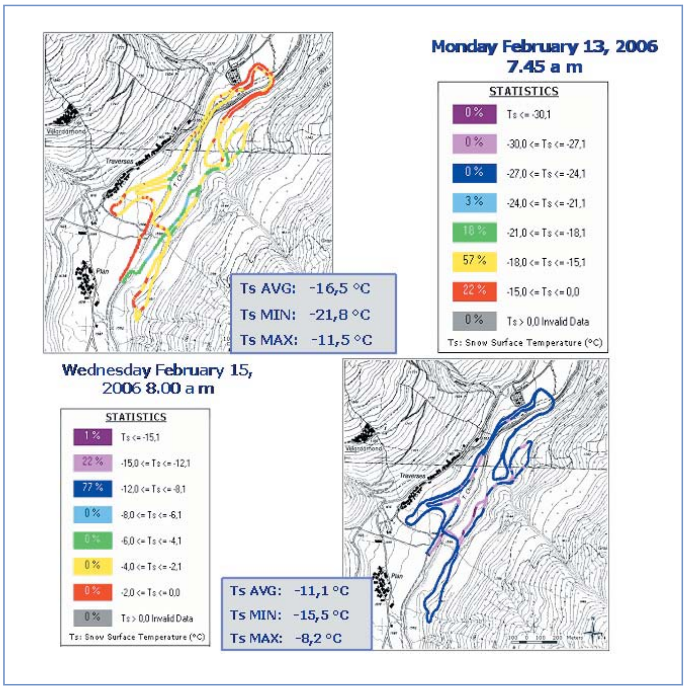


Figure 2.72 - Comparison between the Thermal mappings carried out on the 13th and 15th of February

As far as snow conditions were concerned, the passage of the warm front on the 15th and the associated light rain in the evening determined a marked increase in humidity, with temperatures on the 16th remaining at around 0 °C all day. This heating was clear from the comparison between the data recorded on the Thermal Maps drawn up on the 13th and 15th of February.

Week from the 20th February to the 26th of February: during the night between the 19th and 20th of February, the depression moved away to the east, enabling a gradual return to substantially stable weather conditions. On the 21st, 22nd and 23rd of February, easterly currents at all altitudes determined the formation of low-lying cloud along the Val Chisone with occasional sleet on the 21st and the afternoon of the 22nd and the 23rd. On the 24th and in the early part of the 25th, the joint action of low pressure on the Central Adriatic and low pressure on the Bay of Biscay determined a flow of damp eastern currents over the area, with cloudy skies and snowfall which intensified during the 24th. The low pressure over the Central Adriatic moved away to the east from the afternoon of the 25th, enabling the entrance of north-westerly currents which favoured a gradual improvement in the weather conditions, becoming more evident from the evening, with fine weather for the last day of Olympic competition.

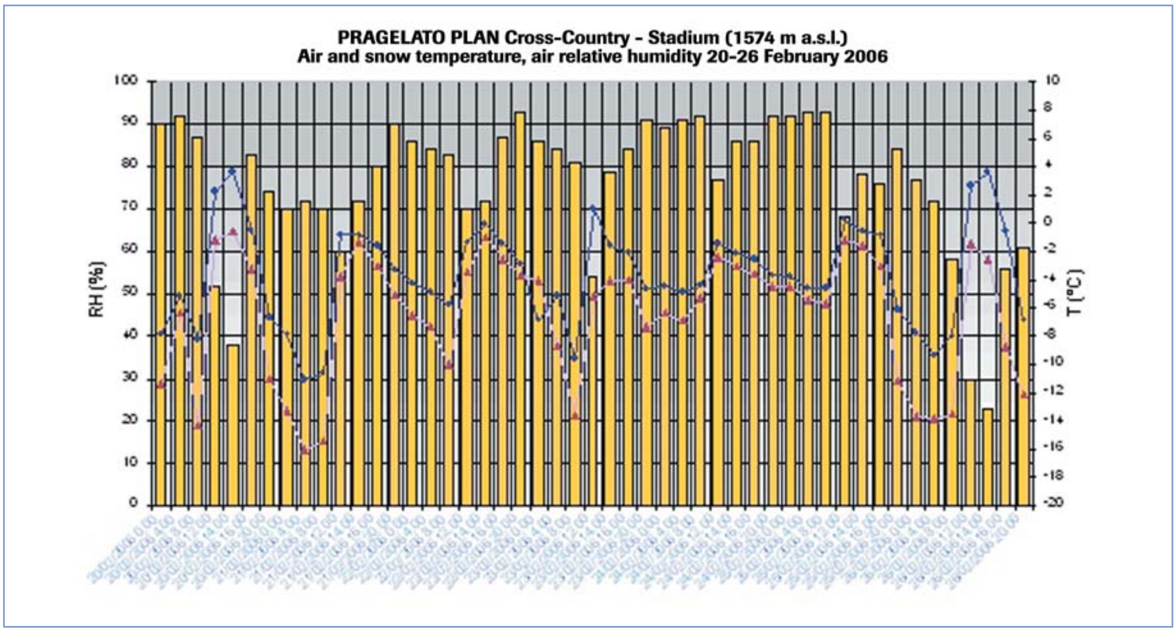


Figure 2.73 - Trend of air temperature, relative humidity and snow temperature

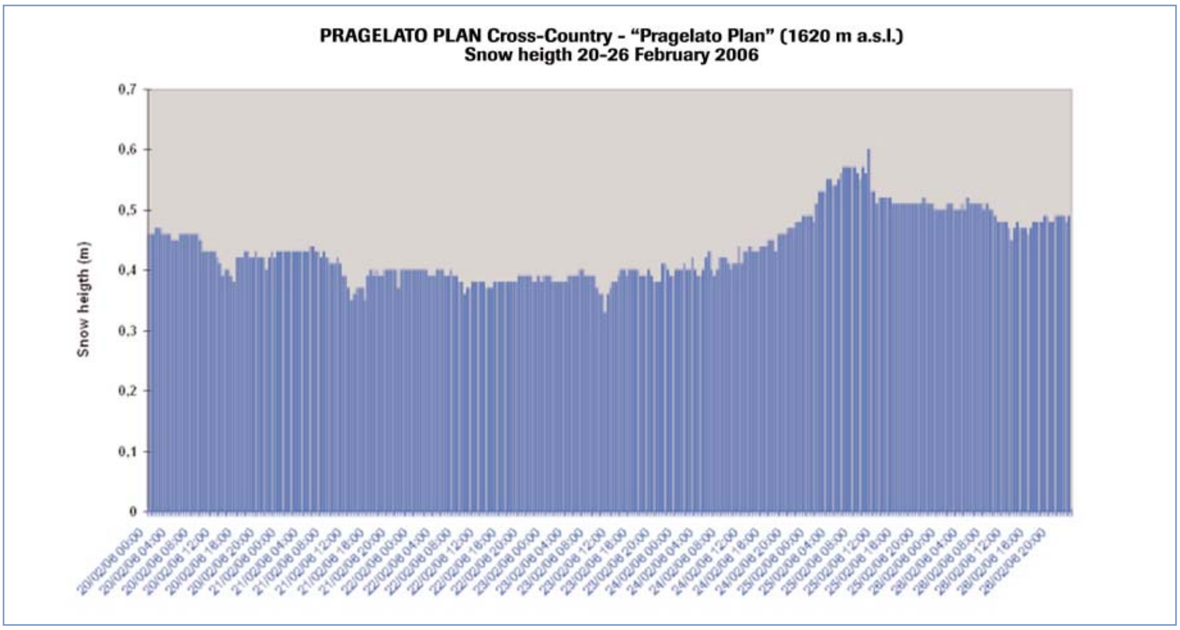


Figure 2.74 - Depth of snow on the ground

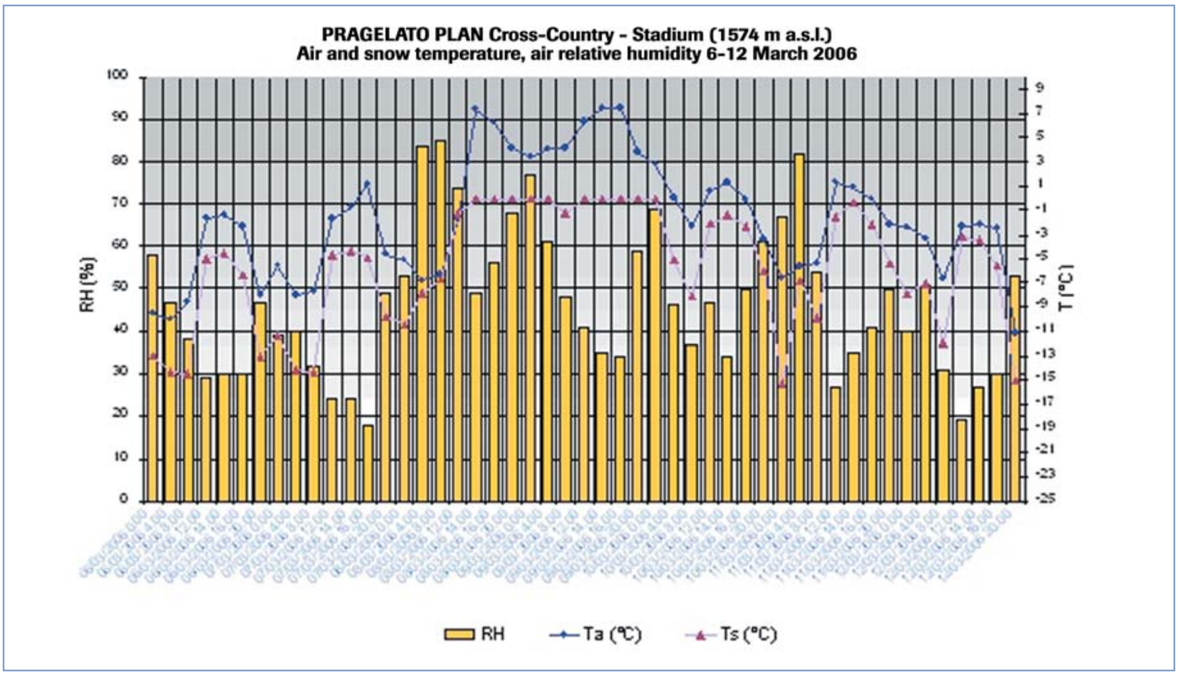


Figure 2.75 - Trend of air temperature, relative humidity and snow temperature

Paralympic period

Week from the 6th to the 12th of March: the first two days of the week were characterised by fine weather conditions, favoured by cold and intense northerly currents. The passage of a warm Atlantic front from the early hours of the 8th of March determined an increase in cloud cover and temperatures, with gentle rain during the warmer hours of the day. The rest of the week was characterised mainly by moderate winds which touched the Pragelato area on several occasions, determined by an intense baric gradient near the Alps.

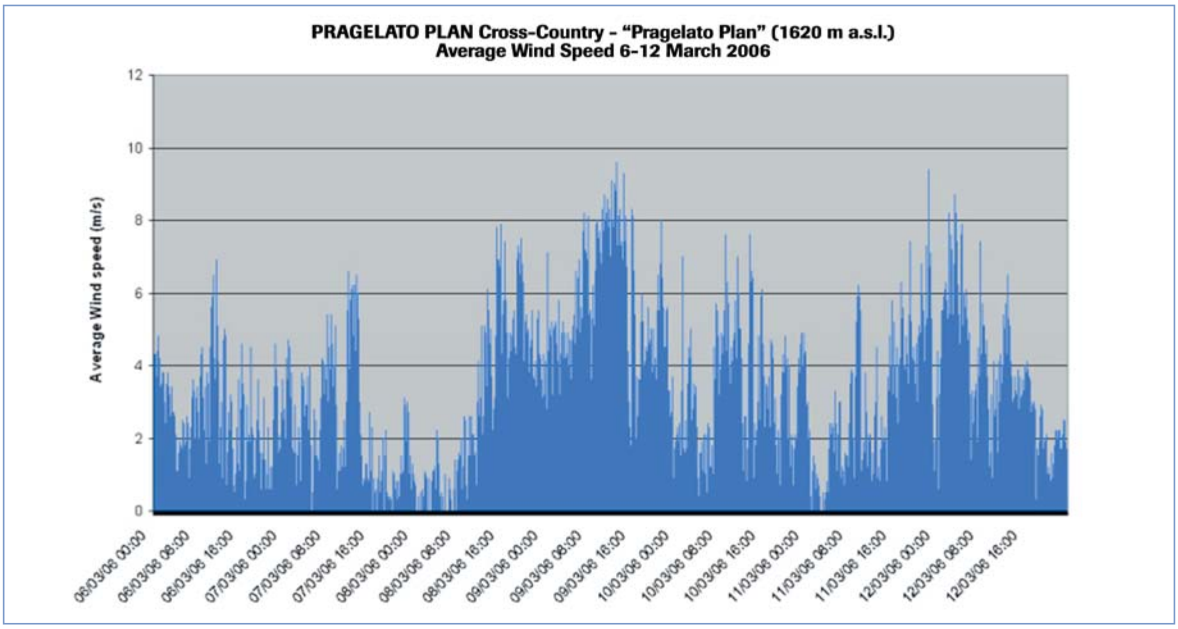


Figure 2.76 - Trend of scalar wind intensity

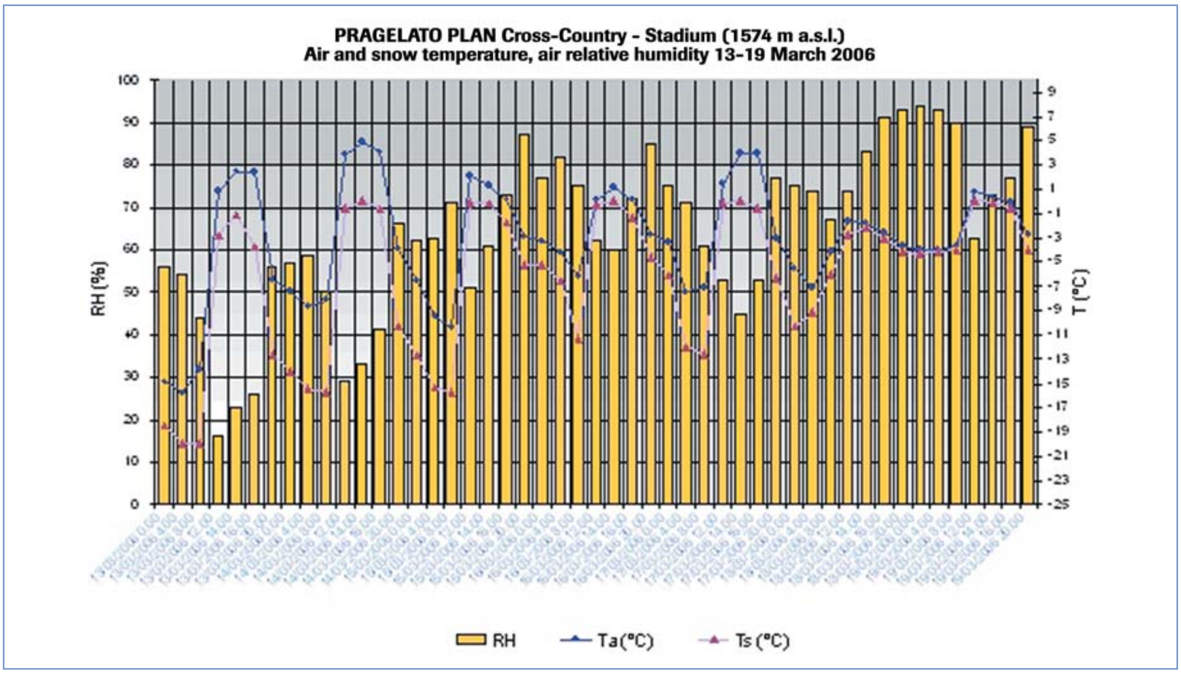


Figure 2.77 - Trend of air temperature, relative humidity and snow temperature

Week from the 13th to the 19th of March: until the afternoon of the 15th the weather conditions were stable and sunny, favoured by an area of high pressure over the western basin of the Mediterranean. This was followed by damp easterly currents in the lower strata of the atmosphere, determining uneven cloud coverage.

These conditions remained largely unchanged until the 18th of February: in the two final days of competition, the passage of a warm front, associated with a depression over the Iberian Peninsula, determined more consistent cloud coverage with light snowfall from Saturday afternoon until Sunday morning.

2.4.2.3 Weather Vs Climate (Olympic period)

As the automatic weather station at Pragelato Plan was only installed in December 2002, the following details do not provide comparison between climatology data in the real sense and the data observed during the Olympics, but more of an analysis of the data observed in recent years.

Temperature analysis

The results of the analysis of the mean and extreme temperatures recorded from the 10th to the 26th of February 2006, compared with temperature data for the same period in the years from 2003 to 2005, are shown in the following tables:

MEAN TEMPERATURE (°C)			
YEAR	Mean T	Min $_{mean}$T	Max $_{mean}$T
2003	-6,7	-10,5	-3,1
2004	-1,9	-8,7	3,5
2005	-5,5	-10,7	6,6
2006	-3,4	-7,7	3,2
Mean	-4,4	-9,4	2,6
Minimum	-6,7	-10,7	-3,1
Maximum	-1,9	-7,7	6,6
St. Dev.	2,1	1,4	4,1

MINIMUM TEMPERATURE (°C)			
YEAR	Absol. $_{min}$T	Mean $_{min}$T	Max $_{min}$T
2003	-15,1	-10,9	-8,4
2004	-12,4	-6,2	-1,4
2005	-14,7	-9,8	4,1
2006	-12,3	-7,5	-0,8
Mean	-13,6	-8,6	-1,6
Minimum	-15,1	-10,9	-8,4
Maximum	-12,3	-6,2	4,1
St. Dev.	1,5	2,1	5,1

MAXIMUM TEMPERATURE (°C)			
YEAR	Absol. $_{max}$T	Mean $_{max}$T	Max $_{max}$T
2003	4,3	0,1	-8,6
2004	12,4	3,8	-5,0
2005	9,0	0,1	-6,0
2006	6,5	2,0	-2,5
Mean	8,1	1,5	-5,5
Minimum	4,3	0,1	-8,6
Maximum	12,4	3,8	-2,5
St. Dev.	3,5	1,8	2,5

Figure 2.78 - Summarised table of mean and extreme temperatures

Mean Temperature

The average of the mean temperatures for the 4 years was –4.4 °C, with a mean minimum temperature of –6.7 °C in 2003 and a mean maximum temperature of –1.9 °C in 2004. The minimum value (-10.7 °C) was recorded on the 22nd of February 2005; the maximum value (6.6 °C) was recorded on the 12th of February 2005. The percentage of days with an average temperature below 0 °C (86%) is higher than the percentage of days with an average temperature above 0 °C. Considering all the days with an average temperature lower than 0 °C, it is highly likely that the temperature is less than or equal to –2 °C (87%).

Minimum Temperature

The mean of the average minimum temperatures for the 4 years is –8.6 °C, with a mean minimum temperature of –10.9 °C in 2003 and a mean maximum temperature of –6.2 °C in 2004.
The extreme minimum value (-15.1 °C) was recorded on the 13th of February 2003; the extreme maximum value (4.1 °C) was recorded on the 12th of February 2005. The percentage of days with an average temperature below 0 °C was 98%; considering all the days with an average temperature lower than 0 °C, it is highly likely that the temperature is less than or equal to –2 °C (96%).

Maximum Temperature

The mean of the average maximum temperatures for the 4 years is 1.5 °C, with a mean minimum value of 0.1 °C observed in 2003 and in 2005, and a mean maximum value of 3.8 °C in 2004. The extreme maximum value (12.4 °C) was recorded on the 14th of February 2004; the extreme minimum value (-8.6 °C) was recorded on the 17th of February 2003. The percentage of days with an average temperature below 0 °C was 42%; considering all the days with an average temperature lower than 0 °C, it is highly likely that the temperature is between –2 °C and 0 °C (84%).

Wind analysis

Comparing the wind classes, calculated using the Munter classification (1992) based on recognisable effects in the mountains (effect on snow on the ground, on people and objects), in relation to the 2003/2005 period (figure 2.175) with the wind classes in relation to the 2006 Olympic period (figure 2.81) we can see that, while in the three previous years the probability of having calm winds or winds of gentle intensity was 98% and, consequently, that of having winds of moderate intensity was 2%, during the Olympics the percentage of calm or gentle winds was 95% with 5% moderate winds. As far as wind direction was concerned, shown in graph form here, calculated using the "compass chart", the differences are minimal, the main directions during the day being north – north-east, particularly during the warmest hours of the day, with the southerly component taking over after sunset and lasting until the early hours of the morning (the distinction shows diurnal hours considered from 7.00 a.m. to 6.00 p.m.).

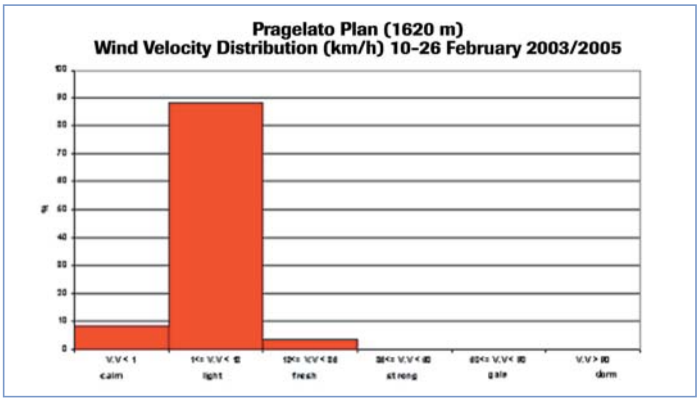


Figure 2.79 - Wind velocity for Olympic period 2003/2005 distributed in classes according to the Munter classification

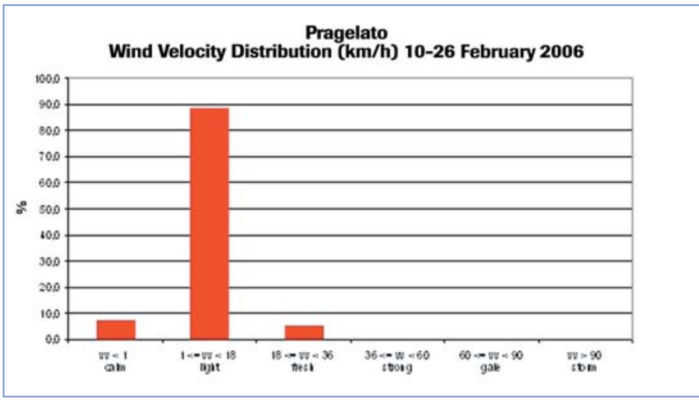


Figure 2.80 - Wind velocity for Olympic period 2006 distributed in classes according to the Munter classification

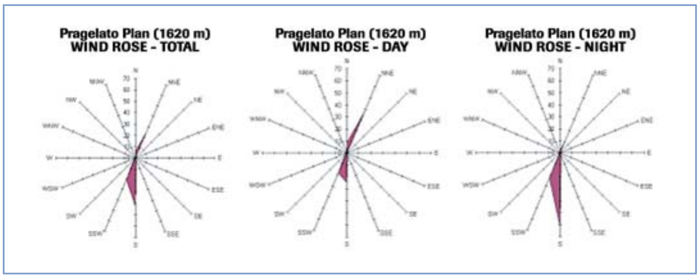


Figure 2.81 - Distribution of the wind direction during the Olympic period for 2003/2005

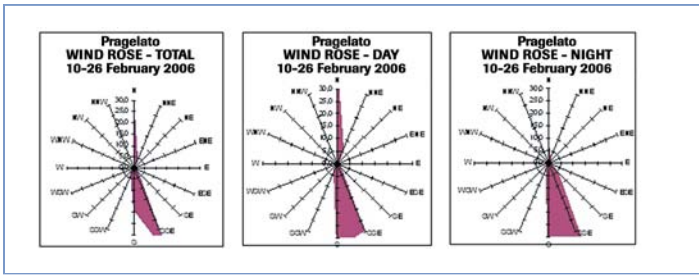


Figure 2.82 - Distribution of the wind direction during the Olympics

Snowfall analysis

The data observed in relation to snow was processed considering the values supplied by an automatic weather station. The table below summarises the values for snow depth on the ground and intensity of snowfall during the last 4 years during the Olympic period. The comparison with the previous three years shows a maximum value during the Olympics both for new snow on the ground and intensity of snowfall.

YEARS	HsM (cm)	Hsm (cm)	Hn (cm)	Gn	G + n	Hn/Gn
2003	21	10	11	2	17 - Feb	6
2004	31	0	35	5	21 - Feb	7
2005	6	0	2	2	22-25 - Feb	1
2006	57	31	41	5	25 - Feb	10

Figure 2.83 - Table summarising the values of depth of snow on the ground and intensity of snowfall during the Olympic period of the last 4 years

where:

HsM = maximum snow depth

Hsm = minimum snow depth

Hn = new snow on the ground during the period from the 10th to the 26th of February

Gn = number of snowy days

Hn/Gn = intensity of snowfall

G+n = day with the highest intensity of snowfall

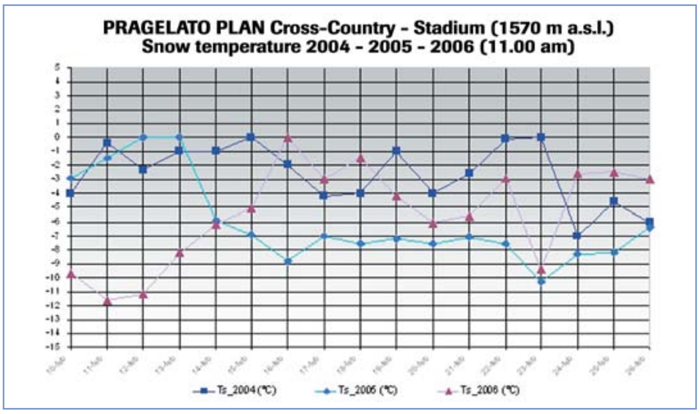


Figure 2.84 - Trend of snow temperature during the Olympic period of the last 4 years

Snow temperature analysis

From the comparison between the snow surface temperature recorded at Plan Stadium at 11.00 a.m. during the Olympic period of the last three winter seasons, we can see how, during 2006, the values of the first 4 days are much lower than those recorded in the previous 2 years.

2.4.2.4 Weather Vs Climate (Paralympic period)

Considering the short space of time covered by the data observed was insufficient to enable a significant analysis from the climatology viewpoint, all we can do is make a comparison with the previous years exclusively for data related to snow and snowfall.

Snowfall analysis

The data observed in relation to snow was processed considering the values supplied by an automatic weather station. The table below summarises the values for snow depth on the ground and intensity of snowfall during the last 4 years during the Paralympic period.

YEARS	HsM (cm)	Hsm (cm)	Hn (cm)	Gn	G + n	Hn/Gn
2003	5	0	5	1	15 - Mar	5,0
2004	27	3	16	3	11 - Mar	5,3
2005	7	0	0	0	-	-
2006	34	30	10	2	11 - Mar	5,0

Figure 2.85 - Table summarising the values of depth of snow on the ground and intensity of snowfall during the Paralympic period of the last 4 years.

where:

HsM = maximum snow depth

Hsm = minimum snow depth

Hn = new snow on the ground during the period from the 10th to the 19th of March

Gn = number of snowy days

Hn/Gn = intensity of snowfall

G+n = day with the highest intensity of snowfall

Snow temperature analysis

From the comparison between the snow surface temperature recorded at Plan Stadium during the Paralympic period of the last two winter seasons, we can see generally lower values during the Paralympics with better snow conditions than in 2005, when, especially after the 14^{th} of March, the snow temperature was close to 0 °C with "wet" snow conditions even during the early hours of the morning.

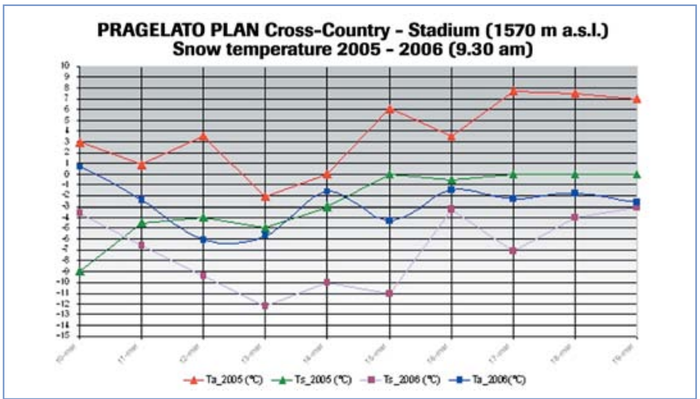


Figure 2.86 - Trend of snow temperature measured at 9.30 a.m. during the Olympic period of the last 2 years

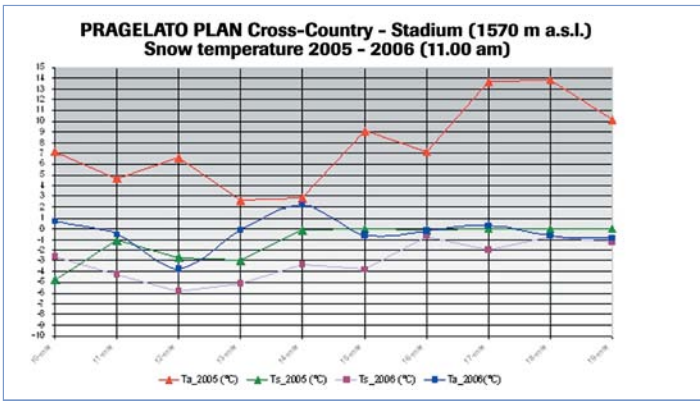


Figure 2.87 - Trend of snow temperature measured at 11.00 a.m. during the Olympic period of the last 2 years

2.4.3 SCB

2.4.3.1 The organisation of the nivo-meteorological service at SCB

The men's and women's alpine skiing competitions (excluding the women's speed disciplines) took place at the Sestriere Colle (STC) and Sestriere Borgata (STB) venues, just a few kilometres apart, but characterised by different local climatic conditions linked especially to the different geographic position (altitude) of the finishing lines of the respective competition courses.

The table shows the technical characteristics of the competition courses for the various disciplines.

DISCIPLINE	LOCALITY	START ALTITUDE	FINISH ALTITUDE	VERTICAL DIFFERENCE	LENGTH
Downhill	SES. BORGATA	2800 m	1886 m	914 m	3299 m
Super-G	SES. BORGATA	2536 m	1886 m	650 m	2325 m
Giant Slalom	SES. COLLE	2480 m	2030 m	450 m	----
Special Slalom	SES. COLLE	2210 m	2030 m	180 m	----

In order to provide the most complete and satisfactory nivo-meteorological assistance possible, in terms of sporting aspects and the logistic organisation of the two venues, the teams included two meteorologists dedicated to weather forecasting, Christian Ronchi and Fabrizio Di Lernia, two nivologists, Cristina Prola and Silvia Musso, dedicated to forecasting snowfall and monitoring the snow data, as well as coordinating the groups of collaborators from the CFAVS and the Val Troncea Park (Federico Kurchinski, Diego Girardi and Carlotta Scampini from the CFAVS and Luca Maurino, Valter Peyrot and Bruno Usseglio from the Park), employed every day on the competition courses to measure nivo-meteorological data for the OVR and the Competitions Office. The SCB venue team was also able to rely, when necessary, on colleagues at the WLC in Sestriere, including nivologists Marco Cordola and Andrea Bertea, who were responsible for drawing up the English version of the daily courses report.

Figure 2.88 - The high part of the Kandahar Banchetta course in Borgata (right) and the G.Agnelli and Sises course (left)

Figure 2.89 - SCB weather team (from left Fabrizio di Lernia, Christian Ronchi, Cristina Prola and Silvia Musso)

The "on the job" training course taken by the members of the Weather Venue Team lasted more than three years, with a series of intermediate sporting appointments, such as the World Cup finals in 2004 and the Test Events in December 2004).

Participation in these events was fundamental to test the experience acquired by the team in terms of knowledge of the local weather conditions in the mountains and to refine the working methods in order to gauge them to the needs of the TOROC and to create a close knit team conscious of the enormous amount of pressure that an event of international acclaim like the Olympic Winter Games brings with it.
The professional skills of the meteorologists and nivologists were trained not only from a technical viewpoint, but also and especially in terms of communication with the managers of the various sporting and logistic activities of the venue, so that they would be able to make decisions with regard to the methods and times of the snow-weather information to release, minimising the risk of "false alarms" and optimising the quality of the weather forecast.
The collaborators from the Val Troncea Park and the Alta Val di Susa Forestry Consortium were involved in the monitoring campaigns on the competition courses during the years leading up to the Games, each one acquiring specialisation in specific disciplines. This gave them in-depth knowledge of the competition venues in relation to logistics, access and the best position to occupy in terms of safety during the competition itself, but also in relation to

more technical aspects linked with the evolution of the snow characteristics on the basis of the weather conditions, this being an indispensable factor for becoming aware of any instrumental problems while carrying out measurements, due to the severe climatic conditions in which they operated.
The weather operation office for the SCB competitions was housed in the WLC in Sestriere, in the immediate vicinity, but outside, of the STC venue.

Figure 2.90 - The weather office for the SCB venue inside the WLC

This choice, which differed from the situation in the other Olympic venues, was dictated by the fact that it was naturally uneconomic to set up two snow-weather offices just a few hundred metres apart. Obviously this strategy created a series of advantages and some disadvantages regarding the effectiveness of the work. The positive aspects included the possibility to make use of the technical resources of an advanced and solid structure like the WLC, the possibility to concentrate exclusively and constantly on snow and weather forecasting and monitoring without being involved in the ordinary activities of the venue and the relative isolation which provided a first filter of the weather information supplied to the operators. On the other hand, the position of snow-weather office physically outside of the venue created the dual risk that the service would be perceived as extraneous to the functions supplied by the organisation and that the weather information would not reach those responsible for the various venue activities in a sufficiently effective way with regard to time and quality.
In the final balance of the Olympic experience, this logistic strategy turned out to be extremely useful, especially in a venue like that dedicated to alpine skiing, where environmental pressure is very high and has to be filtered. This is why it was crucial to have in-depth knowledge of the decision-making dynamics within the venue and to maintain a constant working connection between the snow-weather office and all the organisational functions which used the weather forecast (sport, transport, snow removal, etc.), promptly responding, and anticipating where possible, the various requests for information. Furthermore, the credibility acquired by the weather team during the training years prior to the Olympic event turned out to be fundamental, offsetting potential delegitimisation due to the fact that it was not physically and constantly in the heart of the venue's decision-making heart.

The activities offering snow-weather support to the venue began in reduced form from Torino at the end of January 2006 to satisfy the requirements of the organisers who needed long-range weather forecasts in order to plan the preparation of the competition courses (production of reports known as Long Range Weather Forecast, with a total of 52 issues during the Olympic and Paralympic period). From the beginning of February 2006, the SCB weather-snow office moved to Sestriere, beginning all the activities and services planned in the months leading up to the

Olympic event. The philosophy observed in the distribution of staff throughout the month of the competition was based on two needs: the first was to use the staff with most experience in those moments considered to be more delicate for the forecasting and communication phases (nowcasting during the competitions and evening weather briefing) simultaneously guaranteeing constant back-up: the second was to plan a physical presence in the office of staff in echelon formation where possible, to grant everyone a fundamental period of physical and mental rest, avoiding the counterproductive accumulation of stress.

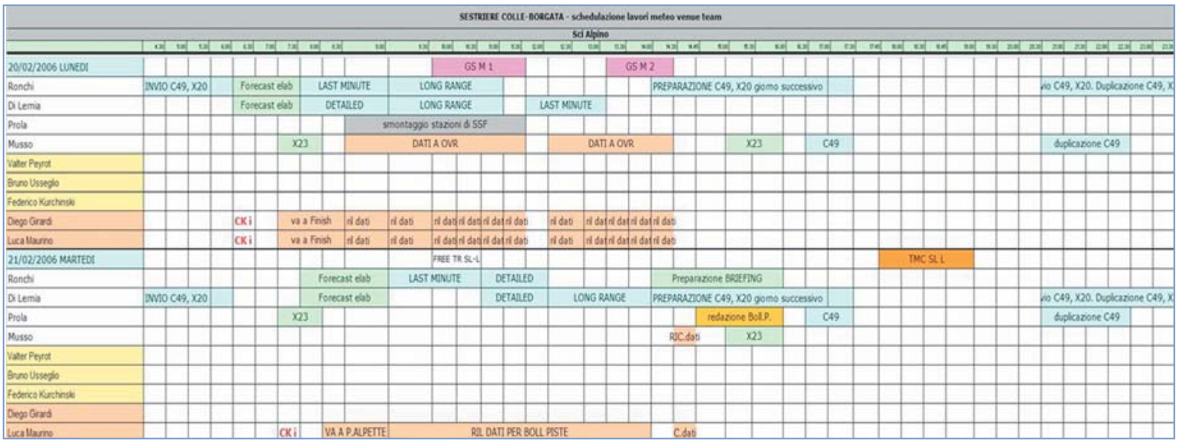


Figure 2.91 - Example of a diagram of the use of snow-weather staff at the venue

Figure 2.92 - A weather briefing at the Captains meeting in the evening

SESTRIERE Colle Borgata	Sabato 18 febbraio 2006	
Check list prodotti		
Prodotti da fare	**Ora prevista**	**Ora effettiva**
✓ X22 Set Sky Condition	07.30	
✓ X 23 HN	07.45	
✓ Aggiornamento MOC (mail e telefono)	08.20	
✓ Aggiornamento Gianni Poncet (mail e telefono)	08.20	
✓ DWF per meteogiochi (fare import da X20 e salvare)	08.45	
✓ DWF Borgata (spedizione)	09:30	
✓ DWF Sestriere (spedizione)	09.30	
✓ LRWF (spedizione)	10.30	
✓ X20 (più eventuale Invio aggiornamento)	13.00	
✓ Mail con bollettini a Elisa e Barbara	15.00	
✓ X23 HN	15:45	
✓ C49 (Elaborazione)	18.00	
✓ Aggiornamento MOC e Poncet	21.30	

Figure 2.93 - Daily check-list for the 18th of February 2006

As far as the production of snow-weather forecasts in agreement with the organisation was concerned, from the 29th of January information was supplied to feed INFO2006, generating xml files on the C49, X20 and X22 products (see paragraph 2.2.8.2) – restricted to the "sky condition". For INFO2006, the nivologists issued hourly forecasts of the snow surface temperature for C49 and X23, in which, twice a day for all the outdoor venues, the amount of new snow fallen during the last 24 hours was indicated.

From the 1st of February, the Weather Team processed medium range forecasts every day (Detailed Weather Forecast), with a total of 67 reports during the whole period, and, on competition days only, 11 short-range reports (Last Minute Weather Forecast). From the 7th to the 23rd of February and from the 11th to the 16th of March, courses reports were issued every day, with a total of 17 reports.

All the reports were disseminated by the Competition Office to the FIS delegates and those responsible for preparing the competition courses and distributed by e-mail to a mailing-list of venues comprising all the function managers and the media, pinned up in points with a high level of passage within the venue (VOC, Press), transmitted by fax to the police operating at the venue.
On the 19th of February, the activities for the collection of data observed in relation to the conditions of the snowpack began, required to prepare the Courses Report. This report indicated the air temperature measured 10 cm from the snowpack, the snow surface temperature, the relative humidity of the air measured 2 cm from the snowpack, the snow conditions and the weather conditions observed during the day underway, together with the evolution of the conditions of the snowpack along the courses expected for the next day (totalling 11 issued during the whole period).
During the competitions and official training sessions, the nivologists also collected the data observed in relation to temperature and air humidity, snow temperature, wind velocity and direction, sky conditions and snow conditions, measured both automatically and manually by the side of the course. The measurements were taken every 15 minutes during the competition and sent to the OVR (Official Venue Result).
All the products listed above were written in Italian and English.

2.4.3.2 The characteristic nivo-meteorological aspects of the Sestriere Colle and Borgata venues

To be able to issue a forecast capable of identifying any potentially critical situations for the competitions, official training sessions or preparation of the courses, the weather variables of impact and a series of sensitive thresholds were identified in conjunction with the Competition and Course managers of the TOROC sport functions. For the Alpine Skiing, these variables were mainly the amount of new snow, wind and visibility, the critical thresholds and corresponding operational reactions of which are defined in the following table:

WEATHER IMPACTS	WEATHER CONCERNS		
	NEW SNOW	WIND	VISIBILITY
Alpine skiing DH, SG	> 30 cm (snow grooming equipment)	Constant up to 70 km/h (postpone competition)	< 20 m on the WHOLE course (postpone competition)
	> 15 cm and < 30 cm (snow grooming teams)	Constant up to 40 km/h (delay competition)	< 20 m on PART of the course (interruptions/delay to competition)
	> 5 cm (postpone laying course)	Gusts above 50 km/h (interruptions during competition)	
Alpine skiing GS, SL	> 30 cm (snow grooming equipment)	Constant up to 70 km/h (postpone competition)	< 20 m on the WHOLE course (postpone competition)
	>15 cm and < 30 cm (snow grooming teams)	Constant up to 40 km/h (delay competition)	< 20 m on PART of the course (interruptions/delay to competition)
	> 5 cm (postpone laying course)	Gusts above 50 km/h (interruptions during competition)	

Alert situation
contrast actions
take account for weather

As shown by the colours of the table, three different levels of alert were identified, corresponding to different contrasting actions by the organisation. It is worth highlighting the importance of the two levels of criticality shown in the table:

- the arrival of more than 30 cm of new snow involved the use of snow grooming machinery to restore the original competition course, requiring a very long time to restore the course to optimal conditions;
- for the speed disciplines, either a constant wind in excess of 40 km/h or an average wind below this threshold but with gusts in excess of 60 km/h, required postponement.

Given the spatial extension of the Sestriere venue, with the 1900 metres of Borgata and the 2020 of Colle, and the considerable vertical difference covered by the courses, with the start at 2800 metres for the downhill, it was fundamental to have in-depth knowledge of the local orography to forecast the impact of the snow, wind and visibility along the courses. These weather aspects which characterised the two venues during the Olympic and Paralympic period are analysed below, with particular focus on the competition days.

Olympic period

Period from the 1st to the 11th of February 2006 (free and official training sessions for STB)

February was affected by a series of weather configurations which placed importance first on one and then on the next variable.

During the first 7 days of the month, the presence of an area of high pressure over Central Europe guaranteed sunny weather, with low temperatures from the 4th of February onwards. Thanks to these climatic conditions, it was possible to prepare the courses, complete all the sites and make the venue completely operational in time for the opening of the Games.

Over the next three days, the simultaneous presence of a depression over Central-Eastern Europe and an anticyclone promontory over the Western Mediterranean created intense flows at high altitude from northwest, with a moderate pressure gradient over the Western Alps. On Thursday the 9th of February, a cold front passed to the north of the Alps, the main effect of which was the intensification of winds in the Olympic area, with gusts reaching up to between 80 km/h and 90 km/h at high altitudes.

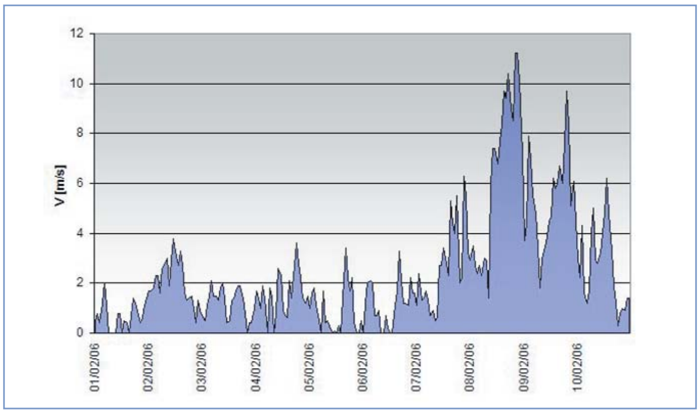


Figure 2.94 - Trend of the wind velocity recorded by the Banchetta station in the days before the start of the competitions

Figure 2.95 - The wind blows the crests of Mount Rognosa (2940 m) on the afternoon of the 9th of February 2006

On the same day the first official trials of the men's downhill were scheduled, and these went ahead as planned.

On the 10th, movement of the Polar depression away to the southeast and the expansion of an anticyclone area across Western Europe favoured the calming of the winds and a return to settled weather conditions for the following days, joined by a general drop in temperatures.

Sunday the 12th of February 2006 - Men's Downhill 12.00 a.m.

The Alpine skiing debut at the XX Olympic Winter Games enjoyed excellent weather conditions: fairly clear sky due to the passage of modest, fine, high-level cloud in the middle of the day, temperatures remained below zero along most of the course all day long, reaching a maximum of 1 °C at the finish line in Borgata, and winds were generally gentle.

Tuesday the 14th of February 2006 - Men's Downhill and Combined Slalom

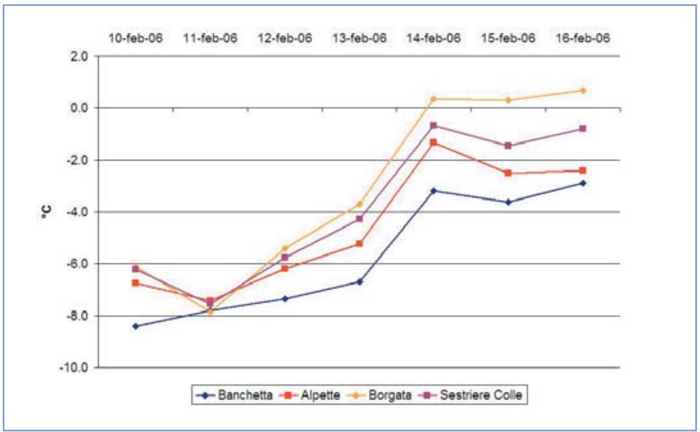


Figure 2.96 - Trend of the daily mean temperature at the highest point and lowest point of the STC and STB competition courses from the 10th to the 15th of February 2006

An intense day of competition with the men's downhill valid for the combined scheduled at 12.00 a.m. on Mount Banchetta and the two rounds of the special slalom at Sestriere Colle in the afternoon/evening. From the weather viewpoint, an anticyclone promontory positioned over Western Europe guaranteed settled, sunny weather conditions on the one hand, but favoured a rise in temperatures of about 3-4 °C compared with the previous days on the other, but this did not influence the preparation of the competition courses.

Period from the 16th to the 20th of February 2006

The weather scenario changed drastically from the evening of the 15th of February. The collapse of the high pressure over Europe enabled the passage over the Olympic area of a series of rapid hot and cold Atlantic frontal systems which caused fairly perturbed weather conditions alternating with brief improvements until the 19th, when a deep Atlantic depression brought masses of damp air from southwest due to a marked deterioration of the weather, with snowfall beginning mid-morning and becoming heavier and heavier during the afternoon and evening, only petering out in the early hours of the 20th of February. During these 4 days, the amount of new snow accumulated reached about 40 cm on the high part of the downhill course and about 25 cm in Sestriere Colle.

On Friday the 17th of February 2006 - Men's Super-G Free Training (11.00 a.m.) POSTPONED - Ladies Combined Slalom (5.00 p.m. and 7.30 p.m.)

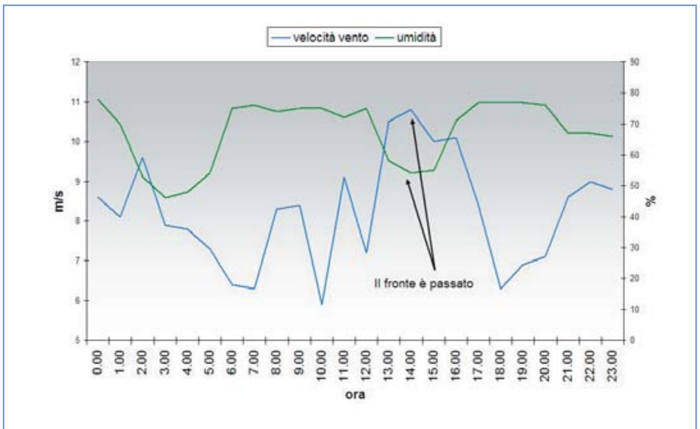


Figure 2.97 - Trend of the hourly mean wind velocity and humidity recorded near the start of the men's Super-G on the 17th of February 2006: note the considerable increase in the winds immediately after the passage of the cold front

Between the evening of Thursday 16th and Friday 17th, a cold front transited across the Olympic area causing moderate snowfall on the high and intermediate parts of the competition course where the men's Super-G was scheduled, with very poor visibility. The wind became stronger to moderate with gusts, while temperatures fell about 3 °C compared with the day before, settling at about -8 °C at 2500 m and -4 °C at 2000 m. The programme for the 17th of February included the trials of the Super-G on the Banchetta course and the ladies Slalom valid for the Combined at Sestriere Colle in the evening.

The main worries of the organisers were focused on the accumulations of new snow expected on the Super-G course and on planning the course of the competition itself, considering the new deterioration forecast for the evening and the next day.

In this situation it was fundamental to have an accurate weather forecasts in terms of time and quantities: this is why, on the morning of the 17th, the competition office organised a meeting with the FIS delegates, the TOROC psort function managers, the media, the course officials and the SCB Weather team, during which to plan all the day's activities on the basis of the indications and weather forecasts. As far as the entity of the snowfall was concerned, the amounts forecast (20-25 cm at the most) led the organisation to abstain from using snow grooming equipment, which would have required the complete "reconstruction" of the competition course, but to organise shifts for the human resources, who levelled the course without ever stopping over the following 24 hours. Also, and most importantly, on the basis of the indications provided by the SCB Weather team, an arc of time during the day (from 2.00 p.m. to 5.00 p.m.) in which a partial improvement in the weather was forecast, was established in which to create the competition gates.

The time arc concept was extremely useful to supply weather indications for easy use by the organisation. The cold front moved away from the Olympic area in the early afternoon of the 17th, favouring a quick but brief improvement in the weather conditions with broad clear patches accompanied by strong winds at high altitudes (gusts around 80 km/h) which did not allow the men's Super-G trials to go ahead but made it possible to arrange the course for the competition the next day. During the evening, a new warm front approached Sestriere, increasing cloud but without precipitations and with good visibility, allowing the Special Slalom valid for the ladies Combined to go ahead.

Saturday the 18th of February 2006 - Men's Super-G (12.00 a.m.) POSTPONED

On the morning of the 18th we woke up to bad weather once again, with initially gentle snowfall caused by a new closed frontal system moving over the Olympic area and with reduced visibility in patches. The work to clear the course carried out during the night did however make it possible to start the competition on schedule, despite the forecast return of the bad weather within the following hour with the post-frontal part of the perturbed system. Between 12.00 a.m. and 1.00 p.m. the snowfall increased in intensity and the simultaneous effect of snow and wind associated with a drastic drop in visibility led the organisers to stop the competition and decide to postpone it, to protect the physical safety of the athletes. In this space of time, the constant satellite monitoring and weather radar systems proved fundamental for forecasting, allowing the SCB Weather Team to estimate the time required for the

Figure 2.98 - The weather situation at 12.30 on the 18th of February 2006

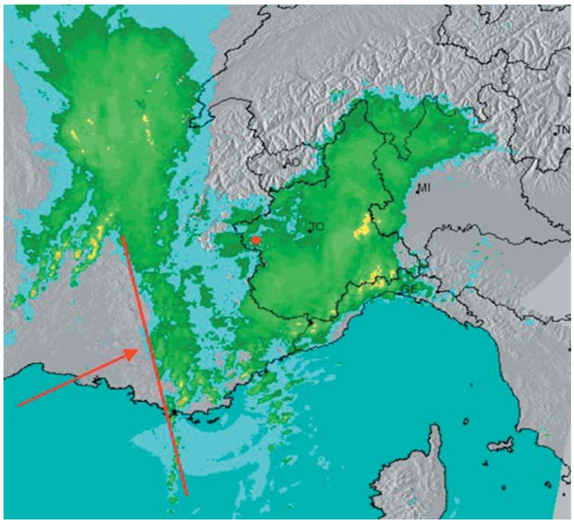


Figure 2.99 - The passage of the cold front between 12.00 a.m. and 1.00 p.m. on the 18th of February, seen through the weather radar pictures

passage of the front and the end of the snowfall, expected for around 2.00 p.m. and followed by a quick, albeit brief, improvement.
Thanks to continuous contact between the TOROC, FIS delegates and SCB weather office, the competition start was rescheduled for 4.00 p.m. to enable the course staff to free it from the newly fallen snow.
Unlike the previous day, the different nature of the perturbed system made it possible to expect post-frontal winds below the risk threshold. The forecast was correct and the Super-G started again at the scheduled time and was completed according to plan.

A new cold front approached the Olympic area during the evening, causing heavy snow showers the next day, February 19th 2006.

Monday the 20th of February 2006 - Men's Giant Slalom (9.30 a.m.-1.00 p.m.) POSTPONED

The last snowfall in this weather phase characterised by the series of perturbed Atlantic systems, petered out in the early hours of the 20th of February, leaving about 20 cm of new snow on the ground. The snow that fell forced the organisation to delay the start of the competition in order to permit the clearance of the snow accumulated on the course during the night. However, the movement of the front away to the east made room for more settled and sunny conditions, apart from a modest amount of uneven cloud in the afternoon. The temperatures tended to climb 1/2 °C despite remaining below zero along the whole G. Agnelli course at Sestriere Colle, where the men's Giant Slalom event went ahead in excellent conditions.

Period from the 20th to the 25th of 2006

On the 21st, 22nd and 23rd of February, a flow of easterly currents at all altitudes characterised the weather conditions in Sestriere. In this configuration, low-lying cloud formed along the Val Chisone, sometimes reaching as far as Colle, causing occasional sleet carried by the wind on the 21st of February and on the afternoon of the 22nd and 23rd. The ladies Slalom was scheduled for the evening of the 22nd of February, and the competition went ahead as planned despite reduced visibility at the start.

Figure 2.100 - Effect of the cloud rising from the Val Chisone on visibility at Colle del Sestriere, under the thrust of easterly currents: the sequence was created in the space of 2 min, on the 24/8/2004

Friday the 24th of February 2006 - Ladies Giant Slalom (9.30 a.m.-1.00 p.m.)

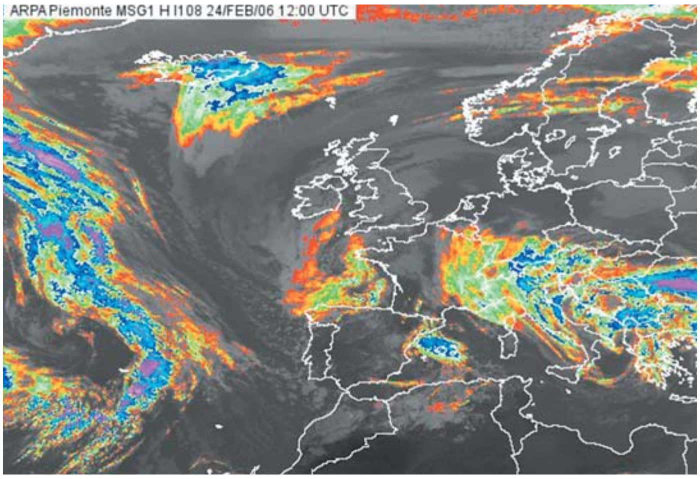


Figure 2.101 - The passage of the front, seen through the satellite pictures in the infrared channel

The joint action of two areas of low pressure positioned respectively over the Bay of Biscay and Northern Adriatic, caused an intensification of the flows of damp air already preset during the previous days, with new snowfall, intensifying during the afternoon. The nature of the winds meant that strong gusts were not registered and cold continental air kept temperatures down. The ladies giant slalom went ahead as planned in the first rounds and the snow intensified immediately after the end of the competition.

Saturday 25 February 2006 - Men's Special Slalom (5.30 p.m.-7.30 p.m.)

Snow continued to fall until mid-morning with an accumulation of 35 cm of new snow over the 24 hours. North-westerly currents arrived at high altitudes in the middle of the day, blowing away the majority of the clouds with clear skies in the afternoon too. In the evening the sky was characterised by uneven cloud cover with occasional sleet transported by the wind, but this did not affect the progress of the men's Special Slalom, the last Alpine Skiing competition at the XX Olympic Winter Games Torino 2006.

Paralympic period

Week from the 6th to the 12th of March

The first two days of the week were characterised by stable and sunny weather conditions, favoured by cold and intense northerly currents. The passage of a warm Atlantic front from the early hours of the afternoon of the 8th of March determined an increase in cloud coverage and temperatures, with light snowfall during the day. The rest of the week was characterised by moderate winds with strong gusts at high altitudes, determined by an intense baric gradient near the Alps.

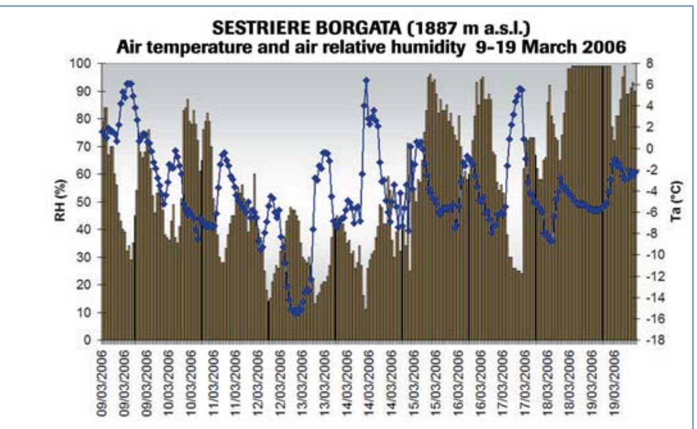


Figure 2.102 - Trend of the air temperature and relative humidity at Borgata in the Paralympic period

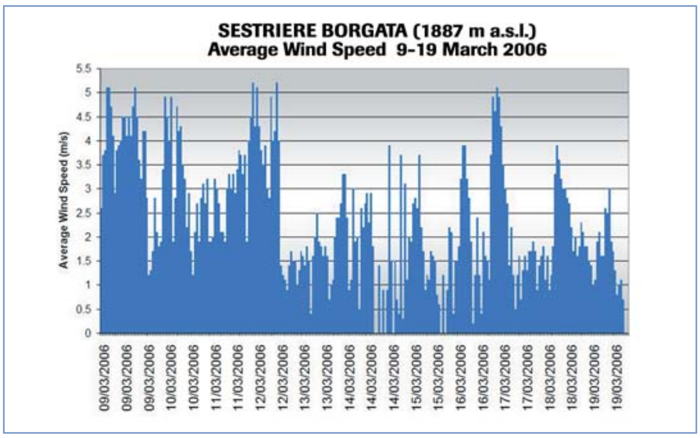


Figure 2.103 - Scalar wind velocity recorded at Borgata in the Paralympic period

Week from the 13th to the 19th of March

Conditions of fine weather prevailed until the afternoon of the 15th, thanks to an area of high pressure over the Western Mediterranean basin, which protected the Paralympic area from the arrival of damp Atlantic perturbation on the final days of the competitions. On the 18th and 19th of March, the passage of a warm front, associated with a depression over the Iberian Peninsula, determined more consistent cloud with light snowfall from the afternoon of Saturday until Sunday morning.

2.4.3.3 Weather Vs Climate (Olympic period)

The weather stations used as climatology reference for the SCB venue were Sestriere Principi di Piemonte (2020 m above sea level) for Colle and Banchetta (2480 m above sea level) for the speed disciplines held at Borgata.

The climatology period of reference was 9 and 5 years respectively, so the analyses reported below are related basically to the average trend in recent years.

Temperature analysis

The results of the analysis carried out on the mean and extreme temperatures recorded from the 10th to the 26th of February 2006, compared with the temperature data for the same period of the previous years, are shown in figures 2.104 and 2.105.

SESTRIERE PRINCIPI	CLIMATE	OBS
Average Daily Temperature	-2,7	-5
Average Daily RH	53	64,3
Average Minumum Daily RH	25	47,8
% T<=0 °C (med)	67	100
% T<=-2 °C (med)	77	82,4
% -2<T<=0 °C (med)	23	17,6
% T<=0 °C (min)	89	100
% T<=-2 °C (min)	83	100
% -2<T<=0 °C (min)	17	0

Figure 2.104 - Table summarising the temperatures and relative humidity for Sestriere Principi

SESTRIERE BANCHETTA	CLIMATE	OBS
Average Daily Temperature	-7,7	-7,2
Average Daily RH	53	54,8
Average Minumum Daily RH	36	38,2
Average Maximum Daily RH	69	72,8
% T<=0 °C (med)	91	100
% T<=-2 °C (min)	100	100

Figure 2.105 - Table summarising the temperatures and relative humidity for Sestriere Banchetta

Mean temperature

Sestiere Principi di Piemonte

In the Olympic period, the average of the mean temperatures of the climatology comparison was -2.7 °C, with a probability of 67% of days with an average temperature below 0 °C.

The summary table 4.3.3.1a shows how, during the Olympic period from the 10th to the 26th of February 2006, the temperatures recorded were well below the reference average with particular days on which the mean temperatures were 100% below zero.

Banchetta

In the Olympic period, the average of the mean temperatures of the climatology comparison was -7.7 °C, with a probability of 91% of days with an average temperature below 0 °C. Figure 4.3.3.1b, shows how the Olympic period from the 10th to the 26th of February 2006 recorded mean temperatures substantially in line with the climatology values of reference, even though, in all three weeks, the thermometer remained constantly below zero.

Wind analysis

Comparing the wind classes for the Banchetta station, calculated using the Munter classification (1992) based on recognisable effects in the mountains (effect on snow on the ground, on people and objects), in relation to the period of reference (figure 2.106) with the wind classes in relation to the 2006 Olympic period (figure 2.107) we can see how the Olympic period of February 2006 was a slightly windier period compared with the climatology mean.

In fact, the percentage of events with winds of moderate intensity was higher than average and the percentage of days without wind was clearly lower.

As far as wind direction was concerned, shown in graph form here, calculating the distribution of mean wind velocity as a function of wind direction and using the "compass chart", the differences are evident during the day and during the night. The 2006 Olympic period shows a more obvious southerly component compared with the climatology mean, contrasted by a much weaker northerly and easterly component at night (the distinction shows diurnal hours considered from 7.00 a.m. to 6.00 p.m.), in line with the climatology trend.

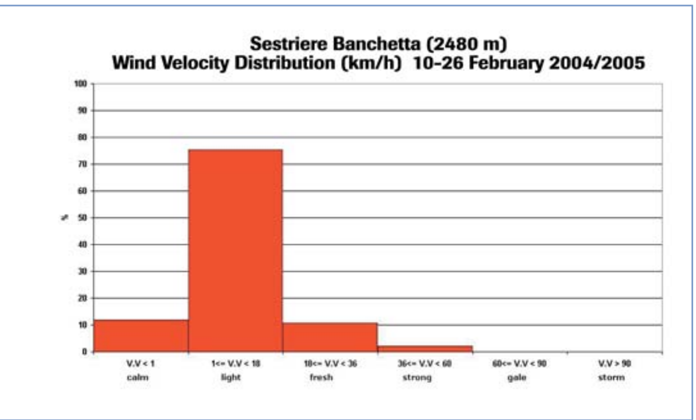


Figure 2.106 - Wind velocity for Olympic period 2004/2005 distributed in classes according to the Munter classification

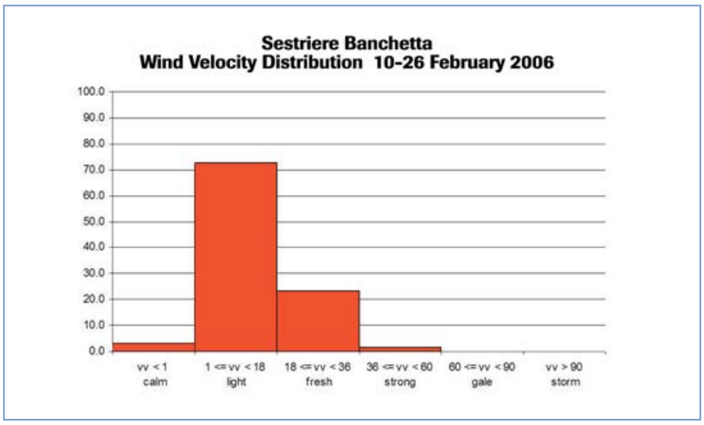


Figure 2.107 - Wind velocity for Olympic period 2006 distributed in classes according to the Munter classification

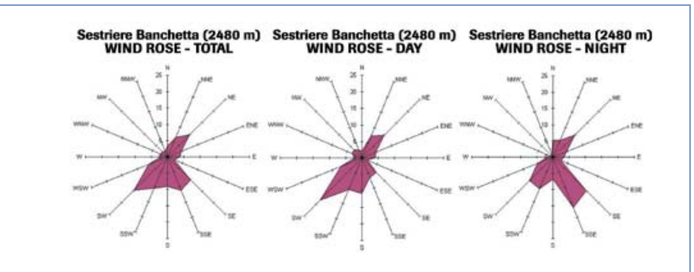


Figure 2.108 - Distribution of the wind direction during 2004/2005

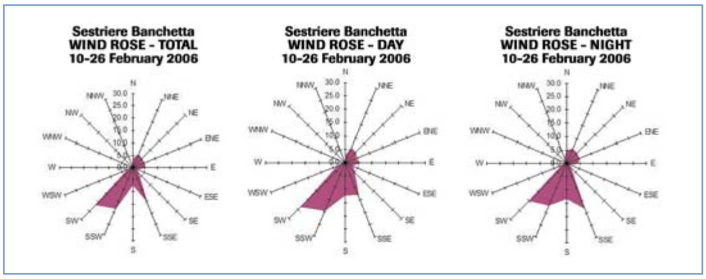


Figure 2.109 - Distribution of the wind direction during the 2006 Winter Olympics

Snowfall analysis

The data observed in relation to snow was processed considering the values supplied by an automatic weather station. The table below summarises the values for snow depth on the ground and intensity of snowfall during recent years during the Olympic period. The comparison (figure 4.3.3.6) shows how the Olympic period of February 2006 was one of the snowiest periods in recent years, with higher than average new snow and snowfall intensity than recorded in previous winters.

SESTRIERE PRINCIPI

YEARS	HsMax (cm)	Hsmin (cm)	Hn (cm)	Gn	G + n	Hn/Gn
2003	96	86	10	2	16 - feb	5,0
2004	123	108	42	5	21 - feb	8,4
2005	45	42	4	4	21 - feb	1,0
2006	82	49	47	7	25 - feb	6,7

BANCHETTA

YEARS	HsMax (cm)	Hsmin (cm)	Hn (cm)	Gn	G + n	Hn/Gn
2004	161	144	28	5	20 - feb	5,6
2005	68	48	26	8	26 - feb	3,3
2006	89	39	73	7	25 - feb	10,4

Figure 2.110 - Tables summarising the values of depth of snow on the ground and intensity of snowfall during the Olympic period of the last 4 years

2.4.4 SSF

2.4.4.1 The organisation of the nivo-meteorological service at the San Sicario Fraiteve venue

The ladies alpine downhill, downhill combined and Super-G speed skiing competitions were held in San Sicario Fraiteve during the Torino 2006 Winter Olympics.
The course used for the competitions started from the highest point of Mount Fraiteve and crossed half the slope of the region known as Soleil Boeuf, ending near the village of San Sicario.
The table shows the technical characteristics of the competition courses for the three disciplines.

DISCIPLINE	START ALTITUDE	FINISH ALTITUDE	VERTICAL DIFFERENCE	LENGTH
Downhill	2538 m	1738 m	800 m	3202 m
Downhill Combined	2400 m	1738 m	662 m	2822 m
Super-G	2286 m	1738 m	548 m	2358 m

The enormous extension of the courses is obvious, both in terms of length and vertical difference and this factor represented one of the greatest criticalities from the forecasting viewpoint.
The snow-weather team assigned to the Weather Information Centre of the SSF venue was made up of: Maria Elena Picollo and Annarita Altavilla (weather forecasters), Daniele Moro (nivologist from the Friuli Region), Flavio Remolif, Carlotta Scampini and Rinaldo Gros (nivology measurers from the Alta Val Susa Forestry Consortium).

The nivo-meteorological assistance service in support of the activities in relation to the venue and the Sport Team began on the 23rd of January with the daily production of long-range weather forecasts, with a total of 27 reports during the whole period. The reports were processed in Torino and sent by e-mail to those concerned, allowing better planning of the venue arrangement and competition course preparation work.
From the 19th of January, information began to feed INFO2006, with the supply of the C49, X20 and X22 products

(for sky condition only).
From the 2nd of February, the Weather Team took up permanent residence at the venue; in addition to the products already described, daily detailed weather forecasts were issued, with a total of 27 reports during the whole period.
All the reports were disseminated through the Race Office to the FIS delegates and those responsible for preparing the course, sent by e-mail to the whole Venue Team, posted in strategic positions in the venue (VOC, Press) and transmitted by fax to the police operating at the venue.
On the 9th of February, the activities for the collection of the data observed in relation to the conditions of the snowpack began, required to prepare the Courses Report. This report indicated the air temperature measured 10 cm from the snowpack, the snow surface temperature, the relative humidity of the air measured 2 cm from the snowpack, the snow conditions and the weather conditions observed during the day underway, together with the evolution of the conditions of the snowpack along the course expected for the next day (totalling 11 issued during the whole period).

Figure 2.111 - The course at San Sicario Fraiteve


Figure 2.112 - The SSF snow-weather team
From left: Annarita Altavilla, Maria Elena Picollo, Flavio Remolif, Carlotta Scampini, Rinaldo Gros, Daniele Moro

During the competitions and official training sessions, the nivologists also collected the data observed in relation to temperature and air humidity, snow temperature, wind velocity and direction, sky conditions and snow conditions, measured both automatically and manually by the side of the course. The measurements were taken every 15 minutes during the competition and sent to the OVR (Official Venue Result).
All the products listed above were written in Italian and English.
The stations of the monitoring network used as reference for the venue were Monte Fraiteve (2700 m), significant for the high part of the course, Soleil Boeuf DH-W (2029), used for the intermediate part, and San Sicario Highest Point (1677) not far from the finishing line. Two portable stations were also used, one positioned at the start point and the other at the finish point, in order to better monitor such a long course.
The Chief of Race, the Race Office, the FIS delegates and the Competition Manager asked the weather team for practically constant assistance, with the constant monitoring of the situation in real time and nowcasting, especially in more critical conditions, using state of the art radar and satellite equipment (available on the Arpa

Piemonte intranet).

During the Team Captains Meeting, which was held the evening before every competition or training day in Sestriere (total of 9 in the whole period), the weather conditions expected for the next day were outlined, answering the questions of the captains of the teams involved in the competitions.

An excerpt of the table of the daily activities plan of the Venue Team is printed below.

SAN SICARIO FRAITEVE - schedulazione lavori meteo-nivo venue team

Sci Alpino

	07.00	07.30	08.00	08.30	09.00	09.30	10.00	10.30	11.00	11.30	12.00	12.30	13.00	13.30	14.00	14.30	15.00	15.30	16.00	16.30	17.00	17.30	18.00
16/02/2006 GIOVEDI										TR DHK-L (h 12.00-13.45)													
Piccolo	Forecast elab					LAST MINUTE			DETAILED		LONG RANGE					Preparazione BRIEFING							BRIEFING
Altavilla	Forecast elab					LAST MINUTE			DETAILED		LONG RANGE					PREPARAZIONE C49, X20							
Moro			verifica stazione portatile						RiC e Trasm Dati_OVR 1h prima e poi ogni 15 min						rio dati		redazione boll piste						
Gros							Va al finish		dati per OVR 1h prima, e poi ogni 15 min														
Scampini				va a Start, Verifica Stazione porta					dati per OVR 1h prima, e poi ogni 15 min														
Remolif				va al piano			raccolta dati per boll piste a Piano S.B infer								comu dati								
Dotta																							
Girardi																							
17/02/2006 VENERDI										DHK-L (h 12.00-13.30													
Piccolo	Forecast elab					LAST MINUTE			DETAILED		LONG RANGE												BRIEFING
Altavilla	Forecast elab					LAST MINUTE			DETAILED		LONG RANGE					PREPARAZIONE C49, X20 giorn							
Moro			verifica stazione portatile						RiC e Trasm Dati_OVR 1h prima e poi ogni 15 min						ric dati		redazione boll piste						
Gros				va a Start, Verifica Stazione porta					dati per OVR 1h prima, e poi ogni 15 min														
Remolif				va al piano			raccolta dati per boll piste a Piano S.B infer								comu dati								
Scampini							Va al finish		dati per OVR 1h prima, e poi ogni 15 min														
Dotta																							
Girardi																							

Figure 2.113 - Scheduling of the snow-weather team activities at the San Sicario Fraiteve venue

2.4.4.2 Meteorological aspects characteristic to the venue

In agreement with the Competition Management and taking advantage of the experience acquired during the Test Events in 2005, the critical variables for the competitions were identified, with the relative critical thresholds.

	WEATHER CONCERNS		
	NEW SNOW	WIND	VISIBILITY
Alpine skiing Down Hill Super-G	> 30 cm (snow grooming equipment)	Constant up to 70 km/h (postpone competition)	< 20 m on the WHOLE course (postpone competition)
	>15 cm and < 30 cm (snow grooming teams)	Constant up to 40 km/h (delay competition)	< 20 m on PART of the course (interruptions/delay to competition)
	> 5 cm (postpone laying course)	Gusts above 50 km/h (interruptions during competition)	

alert situation

contrast actions

take account for weather

For the Downhill and Super-G disciplines, snowfall represented a criticality whether it occurred before the competition, because large amounts of new snow make it hard to clean and prepare the course, or, obviously, during race-time, as it would drastically reduce visibility; rain or sleet also jeopardise the technical characteristic of the course which, to make the competition as fast as possible, must be very smooth and frozen. Wind begins to be critical when it exceeds mean values of 40 km/h, but strong, uneven gusts can also lead to interruption or cancellation of the competition.

During the week when the Ladies Alpine Skiing competitions were scheduled, there were frequent critical situations and it was just as well that criticality thresholds had been established. However these were slightly adjusted now and then to suit needs.

Weather analysis of competition days

The competition days on the Fraiteve course were concentrated between the 15th and 19th of February, while from

the 12th to the 14th, the first official training sessions were scheduled.
From the start of training until the first part of Wednesday 15th, the weather situation was characterised by the presence of an anticyclone promontory over Western Europe, which favoured stable and sunny weather conditions. Temperatures remained very cold but the gradual increase in the daily trend was evident until the morning of the 15th.

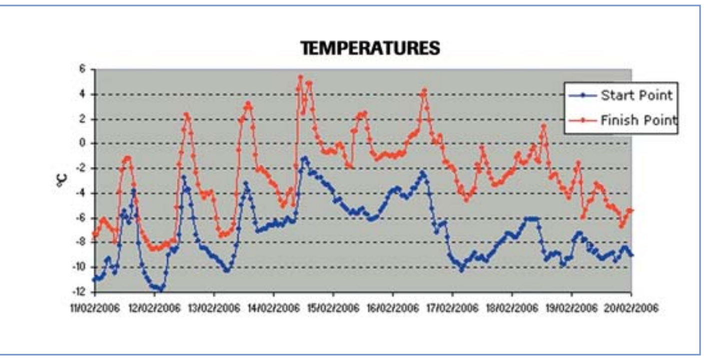


Figure 2.114 - Trend of the temperatures in the Olympic period on the competition track

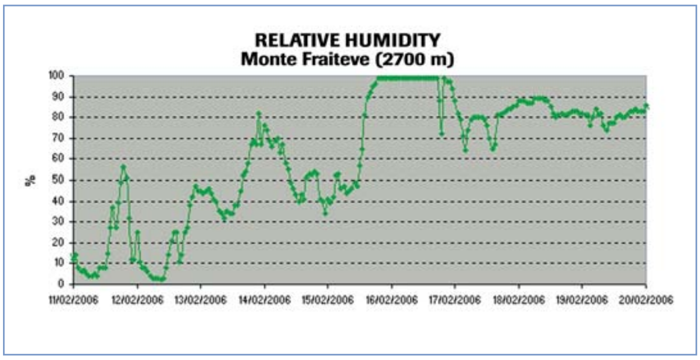


Figure 2.115 - Trend of relative humidity observed from the Mount Fraiteve station during the Olympic period

Subsequently, westerly currents brought numerous Atlantic frontal systems to the Olympic area, causing moderately perturbed weather conditions with widespread cloud cover alternated with clear patches, occasional snow showers and stronger winds at high altitudes. The relative humidity measured at the Monte Fraiteve station (2700 m) considerably increased as of the second part of February 15th, remaining at values higher than 80% between the 16th and 20th of February.
The chronicle of the competition period between the 15th and 20th of February is printed below.

Wednesday the 15th - Downhill 12.00 a.m.
The first competition scheduled was the Downhill. The weather conditions during the race-time remained acceptable: partial cloud cover was caused by high cloud, with maximum temperatures dropping drastically (by as much as 3-4 °C) compared with the day before and moderate winds mainly at the top of the course. The competition went ahead as planned.

Thursday the 16th - Downhill combined - Official Training 12.00 a.m.: Cancelled
The downhill combined official training session was scheduled for the 16th of February, but cloudy skies and snowfall caused reduced visibility on the course so the session was cancelled.

Friday the 17th - Downhill combined 12.00 a.m.: Postponed
After a night of cloudy skies and light sleet, the morning began with bad weather, but the forecast created some hope that it would clear during the time scheduled for the competition.
The *chief of race* and FIS judge were in constant contact with the venue weather office to postpone the competition if necessary and receive prompt information regarding the evolution of the situation. The forecasts were extremely complex: the flow from southwest brought masses of damp air from the French slope; the only way out was to keep an eye on the satellite and radar and estimate the time it would take for the clouds to move off. A first indication of some clearance arrived: a cold sector should have reached San Sicario Fraiteve and the whole Olympic area in the late morning. Those responsible for preparing the course and the organisers took heed of the indication and decided, on the basis of the forecast, to postpone the competition by an hour. Until just before the new start time, the situation showed no

signs of improving and the pressure on the weather office became heavier and heavier. At long last, with perfect timing, the cold arrived to scatter the clouds: the competition was on!
Unfortunately, the cold and dry air not only "dried" the atmosphere and blessed us with a few rays of sunshine, it also strengthened the winds and a very strong gust hit an athlete as she flew over a jump, making her fall. It was impossible to continue because such irregular and intense gusts of wind would affect the classification too much: the competition was off.
The pressure was back on the weather office. It isn't easy to forecast gusts of wind and there was not much hope of an improvement in the afternoon.
So the first attempt at the DHK-L failed and the competition is postponed until the next day.
The graph shows the trend of the mean wind velocity and the gusts recorded by the portable station positioned at the start point (2500 m) on the 17th of February.

Between 10.00 a.m. and 12.00 a.m. the strengthening of the winds was clearly visible: the mean values were around 40 to 60 Km/h, while the gust values even exceeded 100 Km/h at 10.00 a.m., continuing to remain above 80 Km/h at 11.00 a.m. and 12.00 a.m.. From 1.00 p.m. onwards, the wind seemed to gradually die down but continuing gusts along the competition course were so irregular as to be almost invisible from the data recorded.
The temperature trend for the 17th shows a clear drop in maximum temperatures compared with the day before. The arrival of cold air higher up causes a drop of more than 6 °C at the start point and about 5 °C at the finish point.

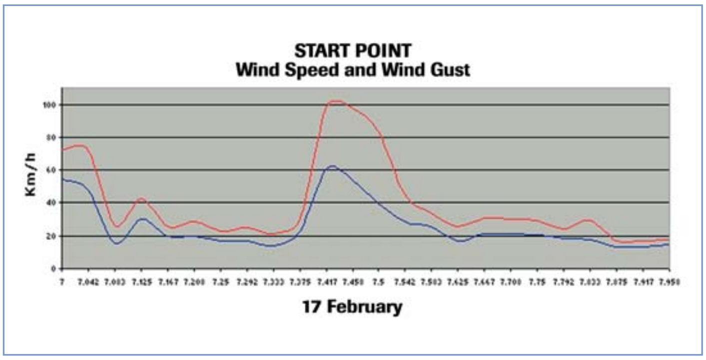


Figure 2.116 - Wind velocity at the Start Point (blue: mean velocity; red: gust velocity)

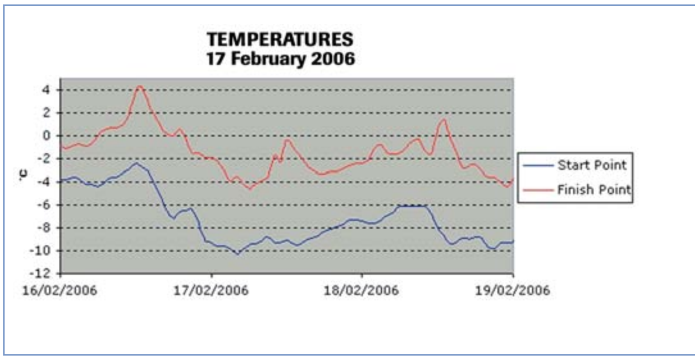


Figure 2.117 - Trend of the temperatures observed at the Start Point and Finish Point during the days of competition 16-19 February 2006

Saturday the 18th - Downhill combined 3.30 p.m.

The passage of a warm front during the night caused widespread snow over the whole Olympic area until the morning. The amounts of new snow on the course at San Sicario Fraiteve reached up to 15-20 cm on the highest part of the course, so the operations to clean and prepare the course were slowed down and the start of the competition was postponed, initially from 12.00 a.m. to 1.00 p.m. and then again and again until 3.30 p.m..
The approach of a cold front in the late morning caused the snowfall to peter out and the clouds to disperse, despite favouring a slight intensification of the winds. The gusts recorded at the top of the course did not exceed 40 Km/h so there were no critical situations to prevent the competition from going ahead. The Downhill combined is on!

The arrival of cold air also affected the trend in high altitude temperatures: the maximums at the top of the course occured mid-morning, starting to fall again by 10.00 a.m. The situation was different at the finish point where, in

Figure 2.118 - Two moments during the thick snowfall of 19/2
The tables indicated the cancellation of the competition.

conjunction with clear skies the sun brought temperatures above 0 °C in the early afternoon.

Sunday the 19th - Super-G 12.00 a.m.: Postponed

For days, the weather forecasts had been announcing the arrival of a well structured perturbation on Sunday. The satellite picture for Sunday at 12.00 a.m. shows the deep area of low pressure over France and the facts did not dispute its eastward movement. The sky clouded over in the early hours of the day and the snow began to fall mid-morning, gradually intensifying from the early afternoon.

The new snow accumulated during the day amounted to over 30 cm at the top of the course (2400 m) with about 20 cm lower down. During the race-time, conditions were very critical: poor visibility due to the thick snow and abundant amounts of new snow on the course ante. After a first postponement until 12.30, the competition was cancelled.

The weather forecast for the days ahead played a fundamental

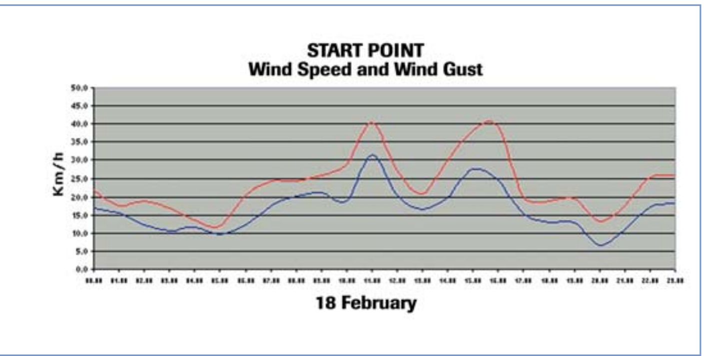


Figure 2.119 - Wind velocity observed at the Start Point (blue: mean velocity; red: gust velocity)

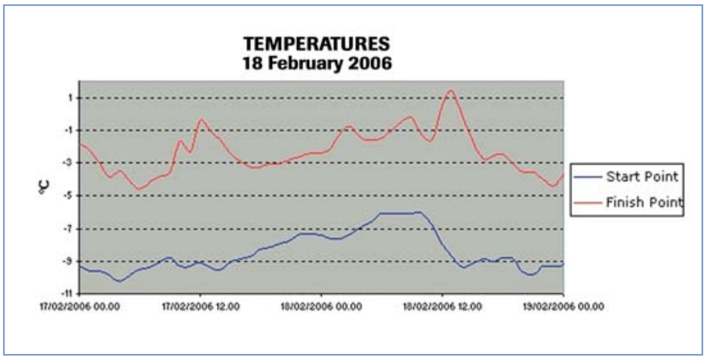


Figure 2.120 - Trend of the temperatures observed at the Start Point and Finish Point during the days of competition 17-19 February 2006

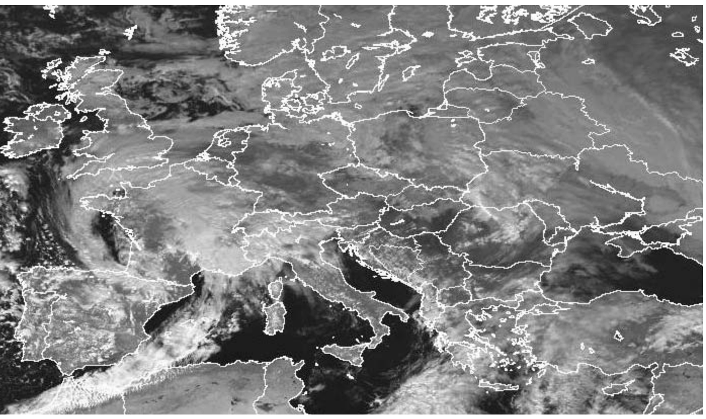


Figure 2.121 - Weather situation observed by the MSG satellite in the infrared channel

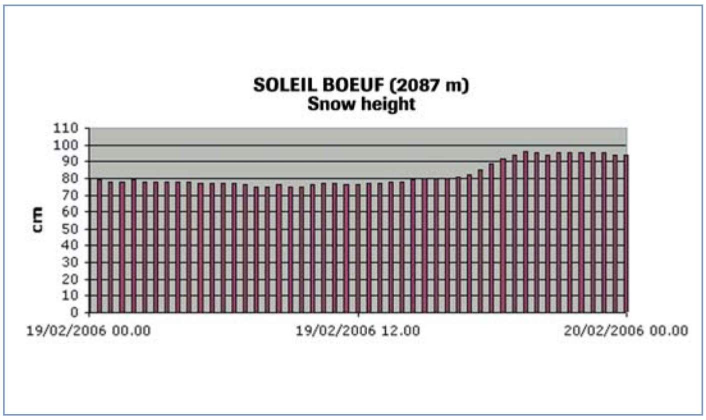


Figure 2.122 - Trend of the depth of the snowpack during the 19th of February, the snowiest day of the Olympic period

role in choosing the new competition date. The meteorologists were called to the jury meeting, usually reserved exclusively to FIS delegates and the Competition Team, in which they played a determinant role: days of bad weather and the postponement of two out of three competitions had made the team particularly sensitive and attentive to the weather forecast, so the weather forecasters were asked to speak before anyone else and the whole meeting was based upon the forecast for the days ahead. The competition was postponed until the next day.

Monday the 20th - Super G 12.00 a.m.

The weather conditions were more settled at last, with uneven cloud, rising temperatures and gentle winds allowing the competition to go ahead.

2.4.4.3 Comparison with the climatology values

The table below shows the comparison between the values of the most significant variables observed during the two Olympic weeks and the respective climatology values.

SAN SICARIO FRAITEVE	CLIMATE	OBS
Average Daily Temperature (°C)	-7.3	-9.1
Average Daily RH (%)	54	64.4
Max snow height (cm)	109	100
Min snow height (cm)	97	58
Intensity of snowfall (cm/day)	3	8.9
Snowy days	3	7
vv < 1 Km/h	4	2
1 <= vv < 18 Km/h	38	50.2
18 <= vv < 36 Km/h	42	38.7
36 <= vv < 60 Km/h	13	5.6
60 <= vv < 90 Km/h	3	0
vv > 90 Km/h	0	0

We can say that the games-time was colder, damper and snowier than the climatology mean.

Compared with the climatology mean, the snowy days between the 10th and 26th of February 2006 were more than twice the average number, while the daily intensity of snowfall reached almost 300% more. The mean wind velocity remained within values comparable with the climatology.

2.4.5 CEP

2.4.5.1 The organisation of the nivo-meteorological service at Cesana San Sicario

The Olympic venue that hosted the Bob, Skeleton and Luge competitions is easily recognisable at Pariol Greniere, a hamlet of the municipality of Cesana Torinese. An Olympic venue with a highly technological content due to the presence of a futuristic track, built in less than four years. The weather support guaranteed to the TOROC was represented by a meteorologist (Fiammetta Orione), who supervised the construction of the track and its test in 2005. This made it possible over the preparatory years to individuate the main characteristics of the venue's microclimate, processing special documents during the progress of the works. During the Olympic period, the meteorologist supplied remote weather reports as there was no on-site office.

The reports were used by the Sport organisation office, the track technicians, the OVR system, the teams and the transport sector. They were pinned on the notice boards in the main venue offices and distributed to the team managers. There were three reports with the possibility of updates.

The weather station of reference was the MILOS station in Cesana Pariol. MILOS is a fixed weather station also used as support for the radiosonde system which, for the Cesana venue, was particularly important. To avoid technical difficulties it was often necessary to use this station during the Games and, to gain a more panoramic view, the portable stations of the CSS venue, situated at a higher altitude than the Bob track, where the vehicle started, were also used. The "Lowest Point" was particularly useful for monitoring the microclimate of the Pariol. Situated near the rocky ridge which separated the venues, positioned on the two slopes of the hill, it supplied indicative

Figure 2.123 - Moment of joy at the finish of the Bob track

thermal values compared with those simultaneously measured at the bottom of the course by MILOS. The possibility of questioning the stations via modem and via GSM in real time was fundamental for the monitoring of the competition situation.

The Long Range Weather Forecast contained the weekly forecast, described with text and a summarising symbol day by day. The Detailed Weather Forecast contained the forecast for the same afternoon and the next day. The forecasts in this report had to be as precise as possible in terms of temperature and humidity, wind intensity and direction, as well as, naturally, supplying precise indications on the cloud coverage and precipitations. This report was formulated with a text part, two summarising symbols and two graphs. The updated forecast (Last Minute Weather Forecast) included the forecast for the current day, with a text part, a descriptive part using symbols and data. This forecast was presented at hourly level. All the products were processed in English and Italian and simultaneously distributed throughout the venue and on the INFO2006 system. They were filled in according to the specific requirements of the discipline and the venue, and issued in the morning, according to a programme developed with the Sport managers. The venue organisation and weather service represented a highly satisfactory example of autonomy, dynamics and reciprocal cooperation. This synergy made it possible to tackle and overcome the logistic difficulties deriving from the dual location of the service with a remote technical station, at the CSS weather office at Cesana San Sicario, and a temporary station on-site.

Figure 2.124 - Weather reports issued for the Cesana Pariol venue

The meteorologist was present at the venue in the second part of the day to offer direct assistance during the official training sessions and competitions, guaranteeing more than 12 hours' constant coverage. The afternoon station was housed in the OVR tower. Speed and precision of the weather information passed during race-time between the service, the OVR managers and the jury was indispensable. The technical assistance offered spontaneously by the Telecom team at the venue was extremely helpful in solving the usual problems linked with the heavy-duty use of portable hardware and telephone lines. The presence of the service was requested at the briefings only at times of greatest risk, between the 7th and 10th of February and between the 16th and 18th of February. The meteorologist remained in constant phone contact with the Sport and OVR managers.

2.4.5.2 Meteorology aspects characteristic to the BSL track

The ice inside the track played a fundamental role and was kept at the ideal temperature by a complex cooling system. The role of the weather service was extremely important in terms of monitoring and forecasting the atmospheric variables. The deterioration of the ice depended on the trend in temperature, humidity and wind.

Gusts of wind for example caused the cancellation of the official training sessions between the 7th and 9th of February, with considerable inconvenience for the athletes and organisers.

The dry atmosphere tended to produce unexpected cracks on the surface of the ice, deteriorating the track and altering the friction of the blades. The cold atmosphere on the 23rd-25th February created considerable difficulties for the bob descents. Two sleighs overturned unusually and suffered consequent damage due to the difficulty in maintaining the track in optimal conditions.

Figure 2.125 - The start of the bob track

Heavy snow and frost on the surface caused problems especially at the start. Naturally, we cannot ignore the heavy snowfall on the 19th of February which, besides making the venue inaccessible, especially to spectators and sleigh technicians, caused considerable difficulties with the competition.

Nivo-meteorological analysis linked with the sporting events

Throughout the whole of February, we can identify two synoptic phases which characterised the first and second fortnights of the period. The first phase was characterised by the presence of a vast anticyclone area west of France. This determined generally stable and sunny weather conditions over the whole Olympic valley in the early days of the month, with temperature and freezing level climbing compared with the climatology. The humidity and temperature ratio remained well below critical limits and posed no difficulty to the training sessions.

On the 3rd of February, a Polar depression moved down towards the Mediterranean basin. The temperatures and freezing level returned to the expected values. Over the next few days, the depression shifted towards the Balkans, favouring the entrance of cold and relatively dry currents from north - northeast. On the 5th on particular, the flow in the medium-lower strata climbed from east along the Valle Ripa, thus determining an increase in cloud cover. Having said this, the hill of San Sicario is in a more protected position than other venues. It is near the French border and on westward facing slope. The re-entry from east can determine perturbed weather conditions when the flow is intense both in medium-low strata (1500-1600 m) and those which are medium-high (2800-3000 m).

From the 6th to the 9th of February, a new Polar depression approached the Alps, causing intense currents from northwest and triggering foehn winds in the valleys. Graph 2.127 shows the change measured at the foot of the track by MILOS. In this situation, the training sessions were affected because the strong gusts were close together and lifted soil inside the circuit, making the passage of the luge impossible. Training was interrupted on the 8th of February towards half past five, and from the graph we can see an average intensification of currents between four and seven p.m.. The intensity of the gusts was measured by the only sensor in the weather station of Soleil Boeuf. The experience at this venue as consistent with the situation at Pariol.

The gusts at the bottom of the track were of sustained intensity throughout the foehn episodes due to the particular exposure of the slope, facing the confluence of the Alta Valle Susa with the Valle Ripa. The currents rising from the confluence area generated considerable turbulence, combined with northerly currents coming down from the San Sicario Soleil Boeuf slope.

On the days between the 10th and 14th of February, an anticyclone expansion determined stable, sunny weather with moderately dry and cold currents from north. The delicate balance between temperature and humidity required considerable compensation efforts by the track technicians and concentration by the athletes.

Figure 2.128 shows the hourly daytime temperature and humidity trends recorded at the Lowest Point station for this second period. The increase in humidity, observed between the 13th and 14th, can be linked to the frontal systems associated with the area of high pressure expanding over the Mediterranean. Temperatures remained low, slightly below average.

The 15th was characterised by a clear change in the weather conditions: the flow of the currents was from west, favouring the arrival of damper, more unsettled air from the Atlantic. During the second fortnight of the month, there was a continuous succession of perturbations with numerous snowfalls.

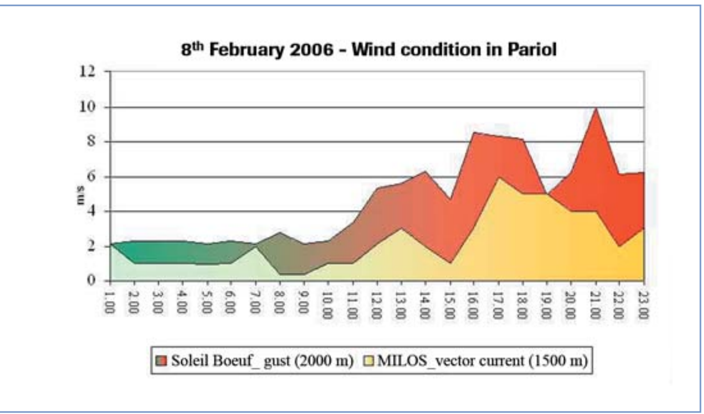


Figure 2.126

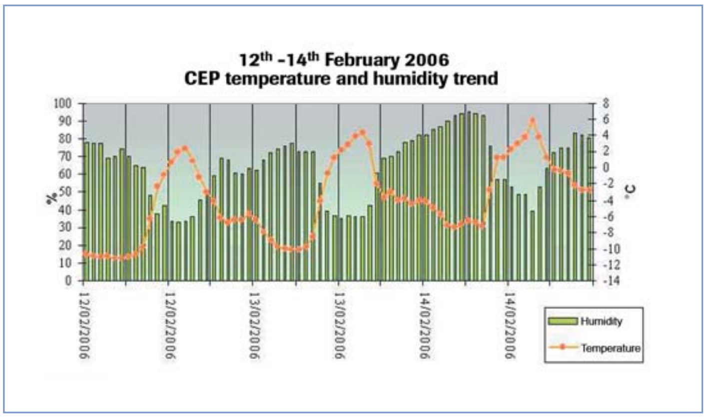


Figure 2.127

On the 16th, 17th and 18th in particular, there was an alternating situation of bad weather in the night and morning, with clear skies in the afternoon. A total of about 10 cm of new snow was measured on the ground. The skeleton competitions experienced no particular problems.

The most intense event was definitely that on the 19th of February, when the nucleus of an Atlantic depression, positioned over France, directed damp, southwesterly currents at high altitudes and easterly currents on the plain over Piedmont, determining perturbed weather conditions and widespread, heavy snowfall. About 30 cm were measured in 36 hours. Graph 2.128 represents the accumulation of new snow on the ground from 12:00 a.m. on the 18th of February to 6.00 a.m. on the 20th of February.

From the 22nd of February, the depression over Central Italy determined a damp return from east to Piedmont, partial-

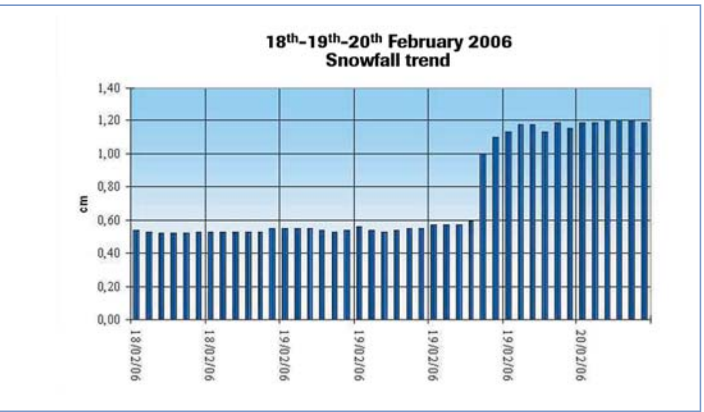


Figure 2.128

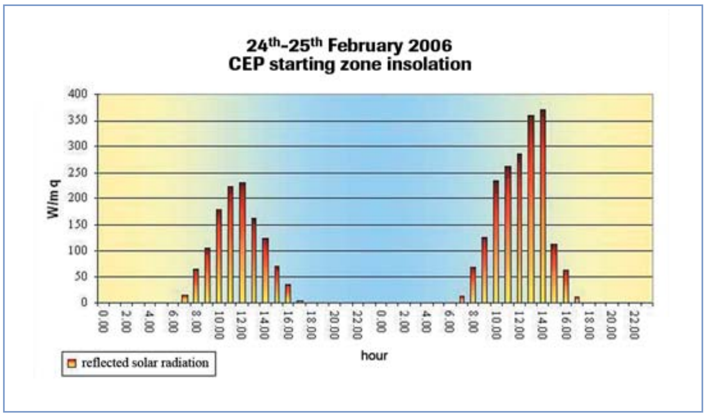


Figure 2.129

ly involving the Pariol area with very uneven cloud in the morning and thick mist in the afternoon. The bob competitions were not affected but the normal logistics of the venue were. Graph 2.129 shows the mean solar radiation recorded by the radiometer from the Lowest Point station, at the top of the track, to the finish. The marked drop in afternoon radiation as of the middle of the day on the 24th and 25th of February was considerable.

The 24th in particular, was characterised by another deterioration in the weather, when a vast cyclone area with the main minimum over the Bay of Biscay, favoured a flow of damp currents from southwest over the whole region, combining with the aforementioned easterly flow, bring more cloud and snow to the Olympic valleys. The sky was cloudy over the San Sicario area too and snowfall was moderate, especially in the early hours of the 25th, with 18 cm of new snow on the ground. Dreadful visibility can be observed from the webcam pictures for the 24th of February, the first directed towards the top of the hill and the second directed towards Monte Chaberton (figures 2.130 and 2.131).

Figure 2.130 - Webcam picture of Cesana San Sicario finish point

Figure 2.131 - Webcam picture of Cesana San Sicario start point

As of the afternoon of the 25th, the minimum gradually moved eastwards, favouring the arrival of dry north-westerly currents which determined a decisive improvement in the weather conditions.
In conclusion:

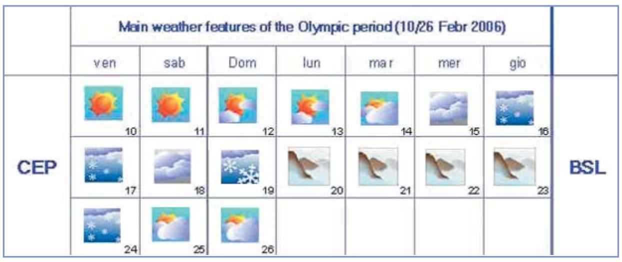


Figure 2.132 - The weather at Cesana Pariol during the Games

From the logbook, Sunday February 19th 2006.
The meteorologist thoughtfully said: "Judge, considering the difficult and persistent conditions of the snow, do you think it would be best to call off the competition?".
The judge answered vehemently and with a strong German accent: "NO!"

2.4.6 CSS

2.4.6.1 The organisation of the nivo-meteorological service at the Cesana San Sicario venue

The Olympic Biathlon competitions were held at Cesana SanSicario, situated between 1620 and 1680 m above sea level. The competition venue comprised a system of different length courses (2-4 km) and a shooting range with 30 targets positioned 50 m from the shooting line. The building, the former Italsider colony, was already present and was renovated and made suitable to house the Olympic family and part of the workforce and staff involved in the competitions.

After the experience of the Test Events in 2005, which involved the snow-weather staff for the assistance of the World Cup competitions with the supply of a weather forecasting service and measuring and monitoring of the data observed, the Arpa Piemonte staff worked all year round in close collaboration with the Toroc Biathlon tram, attending meetings, practice runs and critical event simulations. This determined improved knowledge of the various functions operating in the organisation of the venue and enabled improved management and coordination of the weather assistance service during the Olympic event.

About ten days before the official start of the supply of INFO2006 (29th of January 2006) the real weather assistance began, with the daily dispatch of the long range sport report (Long Range Weather Forecast), with a total of 33 reports for the whole Olympic event. As of the 29th of 29 January and until the 26th of February, INFO2006 was fed with the daily dispatch of products C49, X20 and X22 (see paragraph 2.2.8.2) – exclusively for the "sky condition", and the short range sport report (Detailed Weather Forecast), with a total of 29 dispatches for each product type. During the "games time", from the 10th to the 26th of February, 8 very short range reports (Last Minute Weather Forecast) were issued exclusively for the competition days, while, as of the 5th of February, 20 "Data Survey" reports were issued with the collection of the data observed during the training sessions (official and free) and during the competitions. Lastly, 5 briefing weather briefings were held during the Team Captains Meetings.

The logistic part linked with the organisation of the weather office and the installation of the portable stations required particular care and attention concerning the hardware and software components and, last but not least, linked with telecommunications, involving the technicians also during the months leading up to the Olympic event.

During the actual sport phase the weather office was in direct contact with the Competition Office, the VCC (Venue Communication Centre) and the OVR (Official Venue Results), for which it supplied reports and data. All the nivo-meteorological information was transmitted as and when necessary to the team captains and disseminated throughout the venue to all the functions. Relations of communication with the Competition Manager were particularly important and delicate, especially in critical weather situations in terms of the competition and the integrity of the course, such as strong gusts of wind, heavy snowfall, sharp increases in temperature, etc.

For everything concerning the problems linked with the structure and management of the venue, reference was made to the Venue Manager who, during the daily Venue Team Meetings held in the evening, always reserved a space for the weather forecast in order to organise the preventive measures to cope with any criticalities.

Every day the MOC contacted the WLC and all the decentralised venues to compare forecasts ad discuss any problems.

The snow-weather staff was made up as follows:

- 2 meteorologists: Umberto Pellegrini and Elena Oberto
- 1 technician: Fabio Antonini
- 2 nivologists: Alberto Cotti and Lucia Caffo (Alta Val Susa Forestry Consortium)
- 2 measurers: Mario Roppolo and Mario Manzon (Alta Val Susa Forestry Consortium)

In greater detail, a typical Olympic competition day's operation involved all the elements of the staff, each for his or own particular duties. The two meteorologists took care of the forecasting while the nivologists, the technician and the measures collected the data observed and the management of the portable stations.

The measuring points are shown in red in the figure below: the highest point and the lowest point were monitored with a transportable weather station while the data observed at the shooting range was measured both manually and electronically by questioning a portable station. The data was supplied every half hour starting three hours before the competition and for its entire duration.

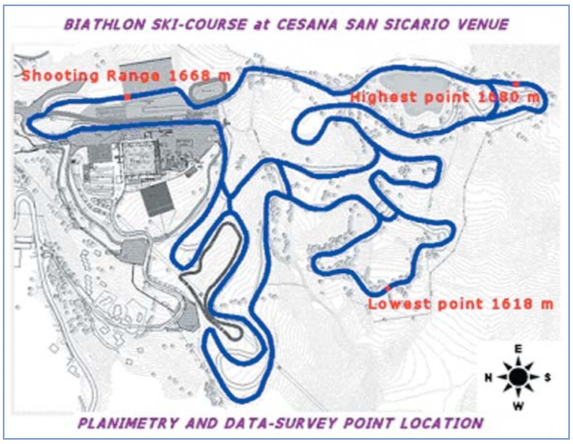


Figure 2.133 - Plan of the Biathlon venue with tracks used in the various competitions and measuring points

The Highest point and the Lowest point were monitored using transportable weather stations, while the Shooting range was monitored using a portable weather station and a measurer.
The parameters considered were:
Ts: Snow surface temperature (°C),
Ta: Air temperature (°C),
RH: Relative humidity (%),
WV: Wind velocity (m/s) (at the Shooting Range),
WD: Wind direction (at the Shooting Range),
WC: Wind chill (°C),
SC: Snow conditions (at the Shooting Range).

The data was supplied to the Sport and OVR (Official Venue Results) functions, disseminated using a USB flash memory key and volunteer runners made available by the aforementioned functions.
The data observed and the forecasting products were printed and displayed in five strategic places inside the venue, at the waxing cabins, changing rooms and on the competition field. The data delivered to OVR, besides appearing in the official registers, was communicated to the public and athletes on the Official Board on the competition field at the Shooting Range.

The figure below shows the calendar of the 13th of February (women's individual 15 km) as an example of an organisational diagram for a competition day: for each member of the team, the scheduling of the various products is highlighted, along with the times of issue, contacts within the venue with OVR, Competition Manager and Competition Office and outside contacts with MOC, WLC and WIC.

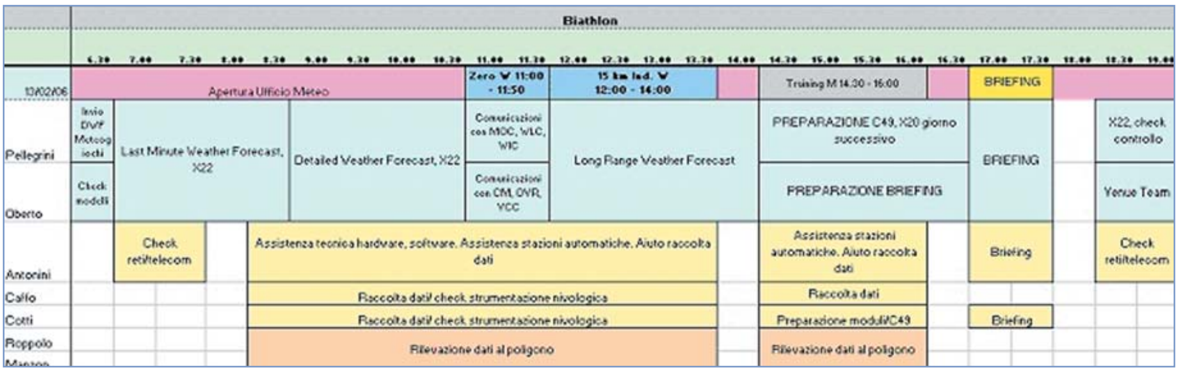


Figure 2.134 - Example of a diagram of activities in the venue related to the 13/02

2.4.6.2 Nivo-meteorological aspects characteristic to the Biathlon

The snow and weather parameters critical to the discipline

The international regulations of the Biathlon set a wind velocity threshold at the shooting range of 5 m/s, above which the competition is automatically suspended or cancelled. To guarantee real time monitoring of this weather parameter during competitions and training sessions, a portable station was installed near the shooting line at the shooting range in agreement with the Competition Manager.

The International Regulations do not set other official limits for others snow and weather parameters, but particularly critical situations were communicated immediately to both the Competition Manager and the Venue Manager.

While biathletes can compete in any weather conditions, both the course and the whole competition site must be meticulously managed in relation to the atmospheric conditions: the stands and walkways must be kept clear of snow, the course requires extra maintenance (mainly at night) in the event of snow, especially when intense, in the case of strong costs of wind which might not be critical for the shooting but might damage the course by littering it with leaves and twigs in the areas where there are more trees… The issue of air temperature and the snowpack is particularly delicate: the information is definitely useful for athletes and captains and is fundamental for the choice of wax. Considerable attention was devoted to the forecasting of this parameter, as requested specifically during the briefings.

Figure 2.135 - Photos and celebrations of the Biathlon and Bob team
From top left: Elena (meteorologist), Umberto (meteorologist), Fabio (technician), Lucia (nivologist), Alberto (nivologist); bottom left: Camilla (Competition Office volunteer) and Fiamma (meteorologist for the bob)

Figure 2.136 - Portable station installed at the shooting range

Nivo-meteorological analysis linked with the sporting events

Throughout the whole of February 2006, we can identify two synoptic phases which characterised the first and second fortnights of the period. The first phase was characterised by the presence of a vast anticyclone area west of France. This determined generally stable and sunny weather conditions over the whole Olympic valley in the early days of the month, with temperature and freezing level climbing gradually and dispelling the initial worries of the Competition Manager with regard to the snow conditions which, during the sunniest hours, gradually began to melt. The graph below shows the daily hourly trends of temperature and relative humidity (San Sicario Highest Point): see how the first days were characterised by both maximum and minimum temperatures above zero.

On the 3rd of February, a Polar depression moved down towards the Mediterranean basin. The temperatures and freezing level returned to the usual values for the period (see who in figure 5 the temperature values drop). Over the next few days, the depression shifted towards the Balkans, favouring the entrance of cold and relatively dry currents from north - northeast. On the 5th on particular, the flow in the medium-lower strata was decidedly

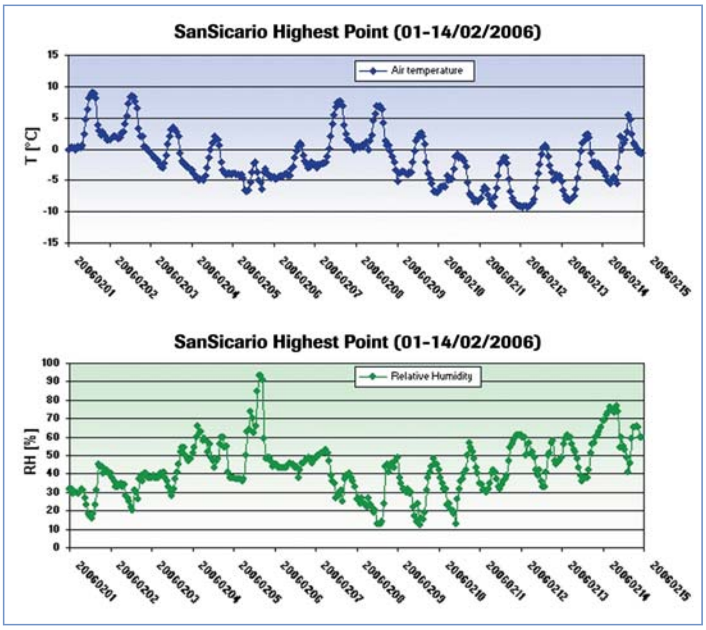


Figure 2.137 - Daily hourly series of temperature and relative humidity values recorded by the San Sicario Highest Point station from 1/02/2006 to 14/02/2006

easterly, determining an increase in cloud cover on the plain and rising into the Val Susa (see the peak in relative humidity on the 5th). Having said this, the hill of San Sicario is in a more protected position than other venues. It is very near the French border and on westward facing slope. The re-entry from east can determine perturbed weather conditions when the flow is intense both in medium-low strata (850 hPa) and those which are medium-high (700 hPa).

During the 8th and 9th another polar depression descended, favouring intense north-westerly currents with episodes of foehn in the valleys: at the shooting range, the average hourly values recorded were always below 5 m/s, while gusts reached peaks of about 8-10 m/s during the afternoon of the 8th and the night between the 8th and 9th. Thanks to its orographic position, San Sicario is usually less exposed to the effects of the favonius: it should be noted that, during the phenomenon it was very close to the foehn wall, at the beginning of the adiabatic compression (during the foehn temperatures never exceeded 1-2 °C, while lower in the valley, at Pragelato for example, temperatures were a good 5-6 °C higher!). At an altitude of 1600 m half up the slope in a frontal position in relation to the direction of the westerly flow, the wind intensity was also much lower than in places higher up, such as San Sicario Fraiteve which, despite being just a few kilometres away as the crow flies, on the same slope but almost on the crest of the mountain, registered higher wind values.

The morphology of the venue, changed especially during the course and shooting range design phases, helped in this sense: shaped into a basin, this portion of the slope was sheltered and the shooting range was extremely protected, not only from intense synoptic gusts of wind but also from the ascending (from E-SE) and descending (from N-NE) mountain breezes that occurred during the day.

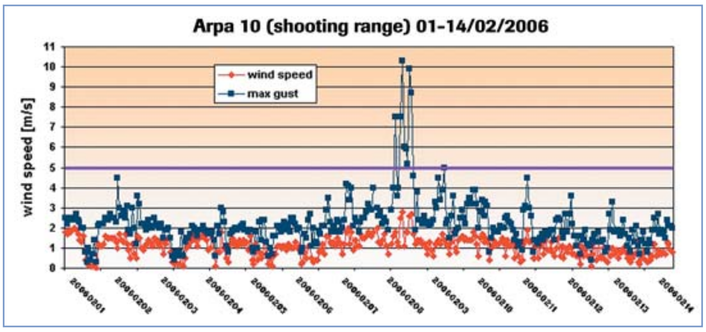


Figure 2.138 - Daily hourly series of wind velocity and maximum gust values recorded by the portable station at the shooting range from 1/02/2006 to 14/02/2006

Between the 10th and 14th of February another anticyclone expansion determined stable, sunny weather with moderately dry and cold currents from north which kept the shallow snowpack constant.

The 15th was characterised by a clear change in the weather conditions: the flow of the currents was from west, favouring the arrival of damper, more unsettled air from the Atlantic. During the second fortnight of the month, there was a continuous succession of frontal systems transiting over Piedmont and they determined perturbations with numerous snowfalls.

The first snow, in the night between the 15th and 16th, was slight and not even registered by the snow gauge at San Sicario Lowest Point (1600 m) while higher up, at 2000 m, the Soleil Boeuf station recorded 3 cm. On the 16th, 17th and 18th there was an alternating situation of bad weather, during the passage of various fronts in the night and morning, with clear skies in the afternoon. A total of about 10 cm of new snow was measured on the ground.

The figure below shows the daily hourly trends in temperature and humidity recorded at the Highest Point station for this second period considered: we can see the various frontal passages that arrived, observing the trend in relative humidity, while the temperature remained low, with maximum values close to zero for several days.

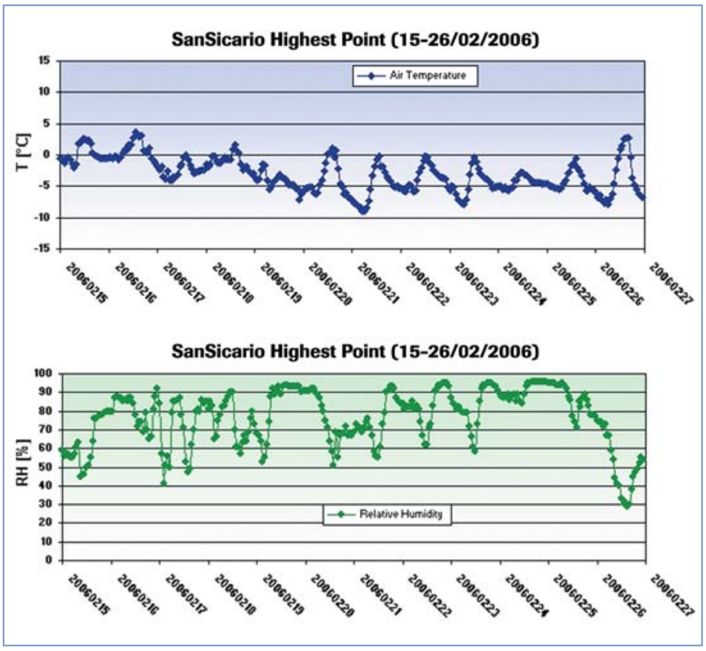


Figure 2.139 - Daily hourly series of temperature and relative humidity values recorded by the San Sicario Highest Point station from 15/02/06 to 26/02/06

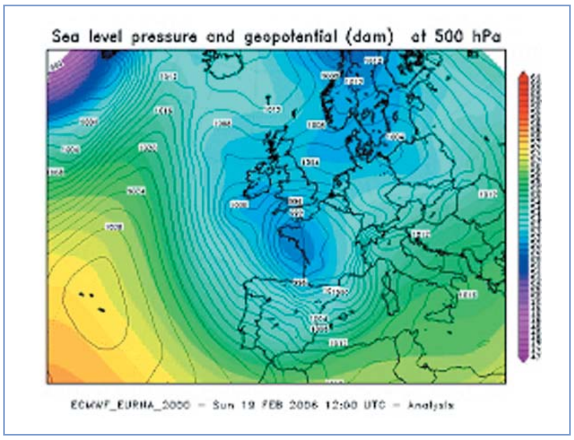
The most intense event was definitely that on the 19th-20th of February, when a deep Atlantic depression, positioned over France, directed damp, southwesterly currents at high altitudes and easterly currents on the plain over Piedmont, determining perturbed weather conditions and widespread, heavy precipitations. The associated snowfall was of moderate intensity with about 30 cm on the ground during the whole event.

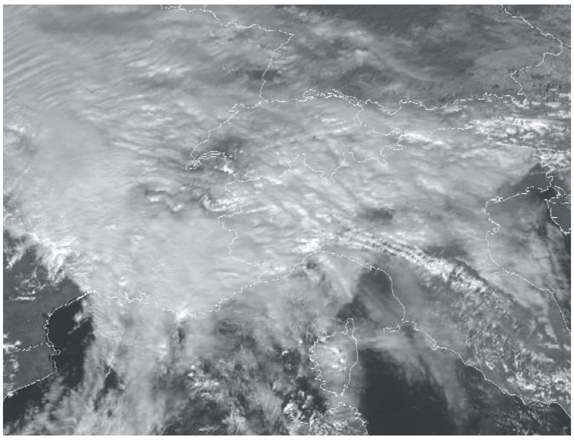
The figure below illustrates the SLP and the height of geopotential at 500 hPa of the 19th of February 12 UTC with relative high resolution satellite picture of the channel: the vast are of depression is clearly visible, extending from the British Isles to the Spanish Mediterranean Coast directing a damp south-westerly flow from the Mediterranean Sea towards Piedmont.

When the depression moved over Central Italy, it determined a damp re-entry from east which partially affected the San Sicario area without bringing snow. The following days (21st, 22nd and 23rd) were characterised by mainly stable weather conditions with very uneven cloud.

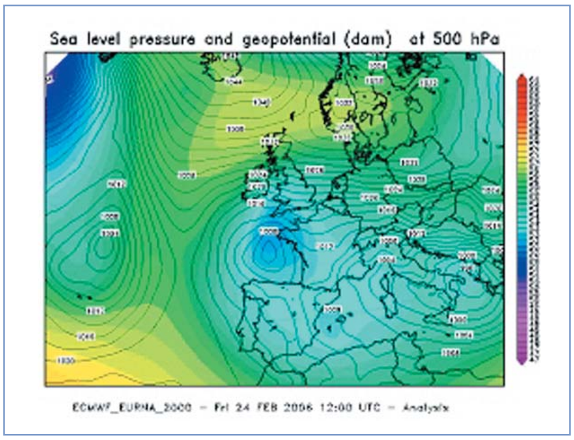
The 24th was characterised by another deterioration in the weather, when a vast area of depression with the main minimum over the Bay of Biscay, favoured a flow of damp currents from southwest over the whole region (figure 10). The sky was cloudy over the San Sicario area too and snowfall was moderate, especially in the early hours of the 25th, with 18 cm of new snow on the ground.

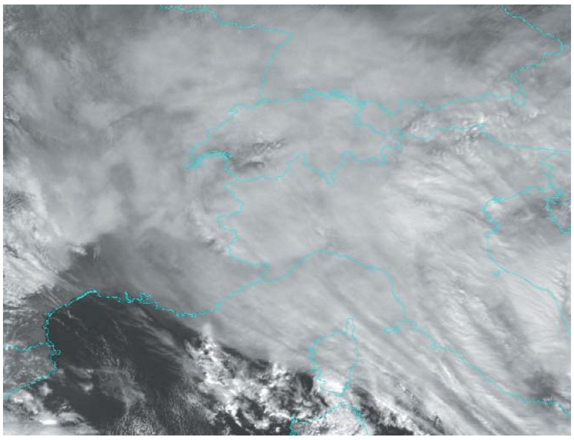
As of the afternoon of the 25th, the minimum gradually moved eastwards, favouring the arrival of dry north-westerly currents which determined a decisive improvement in the weather conditions.





Figures 2.140 and 2.141 - SLP analysis chart and geopotential height at 500 hPa on February 19th at 12 UTC and relative satellite picture (HRV)





Figures 2.142 and 2.143 - SLP analysis chart and geopotential height at 500 hPa on February 24th at 12 UTC and relative satellite picture (HRV)

2.4.7 SDO

2.4.7.1 Organisation of the nivo-meteorology service at the Sauze d'Oulx venue

Sauze d'Oulx was the Venue which held the Freestyle competitions during the Torino 2006 Olympic Winter Games. There are two freestyle courses: one dedicated to "jumps" ("aerials") and one to the "bumps" ("moguls") and they were set up in Jouvenceaux, an outlying area of Sauze d'Oulx, at an altitude of 1,400 metres in the high Val di Susa (see figure 2.145).

The Nivo-meteorology Group appointed to the Weather Information Centre of the Sauze d'Oulx venue was made up of weather forecasters Paolo Bertolotto and Marco Turco, technician Renzo Machetta and snow expert Zeno Vangelista.

The weather and snow service in support of the competitions and all the events related to the venue, began on the 2nd of February 2006, well in advance compared with the start of the competitions, in order to supply useful indications for those responsible for preparing

Figure 2.144 - The SDO meteorology group

From left: Marco Turco, Renzo Machetta, Paolo Bertolotto the courses and the staff appointed to set up the venue. The service included the daily issue of short-range (for the next 12 hours, only on competition and official training days), mid-range (for the next 48 hours) and long-range (6 days) weather reports.

In addition to the products listed above, the group supplied assistance and almost constant availability to the competition office staff and FIS delegates, adapting its products to suit the demands of the team.

Lastly, they attended the various Team Captains Meetings, held on the day before the competitions, presenting the weather conditions and any related criticalities, as well as answering the questions of the captains of the teams involved in the competitions.

Another service consisted in supplying to the OVR (Office of Venue Results), during the competitions and official training sessions, the air temperature, relative air humidity, wind velocity and direction, wind chill and snow temperature data observed, measured automatically and manually beside the course.

The venue monitoring network was made up of three stations: a fixed weather station near the course dedicated to the aerials (1373 m), a transportable weather station next to the start of the course dedicated to the moguls (1454 m) and a portable anemometer installed near the springboard of the aerials course.

In addition to the anemometer, several windsocks were installed along the aerials course, capable of supplying a signal visible to everyone, especially the athletes, captains and staff, indicating the wind velocity and direction.

As far as interaction with the venue organisation was concerned, it was decidedly satisfactory, inasmuch as both parties did their utmost to help; in particular, the flexibility of the Weather group in supplying special, constantly updated products was greatly appreciated. Probabilistic forecasts were requested with regard to the timing of precipitation, strengthening of the winds and diminishing of visibility, as well as personalised briefings with the FIS delegates, those responsible for preparing the courses and the press, and the weather group did everything possible within the limits of the potential available to make the forecasts. The sunset time and duration were also requested, sunset being a critical moment for visibility on the course.

An example of the group's workload is shown in figure 2.147.

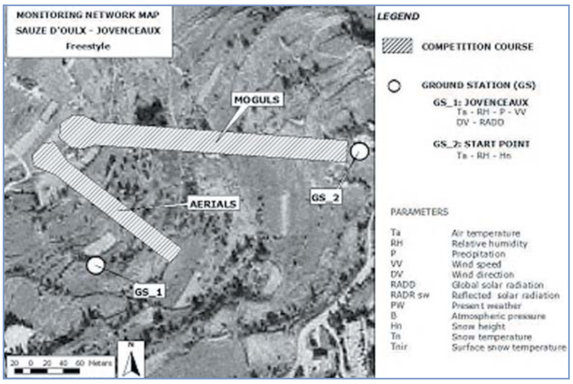


Figure 2.145 - Monitoring network for the Sauze d'Oulx venue

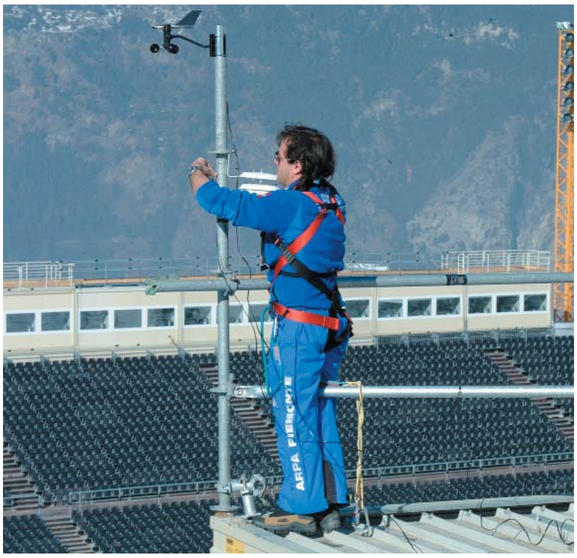


Figure 2.146 - Installation of anemometer on the summit of the judges cab

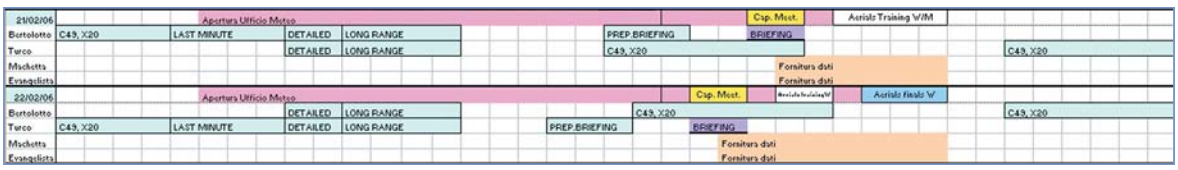


Figure 2.147 - Example of diagram of activities at venue

2.4.7.2 Characteristic Nivo-meteorology aspects for Freestyle

First off, in agreement with the discipline managers, possible criticalities were traced in the weather parameters which could have prevented the correct performance of the competitions.
As far as the moguls discipline was concerned, no critical weather conditions capable of preventing the competition from going ahead were individuated, apart from extreme and highly unlikely conditions.
As far as the aerials discipline was concerned, three types of possible problems linked with the weather were individuated: wind with values in excess of 7 m/s, reduced visibility (mainly with regard to spectator visibility, as the athletes are capable of jumping without any difficulty even when there is about 50 metres' visibility), heavy snow, capable of significantly slowing down the take off speed from the springboard and so making the evolution in the air much more dangerous or even impossible.

The weather conditions during the Olympic period varied, and, in hindsight, we can confirm that every one of these problematical aspects presented itself, although the strong winds did not last long and mainly concerned the early part of the Olympic period, when the moguls competitions were held.

Until the 14th of February the weather conditions were fairly settled, with a predominant anticyclone and mainly sunny weather. Only on the 8th and 9th of February did a polar depression approach the Alps, with consequent weak foehn conditions at the venue, which did not cause particular problems for the scheduled "moguls" training sessions.

The first critical situation arose with the passage of a warm front on the 15th and 16th of February, with light rain which caused one or two problems in preparing the course for the aerials competition.
On the 17th and 18th of February, the approach of a couple of cold fronts from the Atlantic caused snow showers and moderate winds, which did not however cause critical conditions.

The most problematic moment came on Sunday the 19th of February, during heavy snow caused by the approach of a deep Atlantic depression towards Northern Italy. The moment of maximum intensity, monitored hour by hour in constant communication with the FIS delegate, was forecast three hours earlier by the weather forecast model, resulting in the postponement of the qualifying heats for the men's aerials, after a series of subsequent delays, despite the fact that the weather forecast prepared on Saturday had been very accurate in terms of the amount of precipitation and the type of weather (see figure 2.148).


Detailed Weather Forecast
Freestyle Skiing
XX Olympic Winter Games
Sauze d'Oulx - Jovenceaux
Emesso sabato 18 febbraio 2006 alle ore 09:00

sabato 18 febbraio 2006

Nuvoloso al mattino con deboli nevicate. Nuvolosità in diminuzione netta nella tarda mattinata e nel primo pomeriggio fino a cielo poco o parzialmente nuvoloso la sera. Massime in lieve aumento sui 4°C, temperature in calo la sera sui -2°C. Zero termico stazionario sui 1500 m. Venti deboli occidentali con temporanei valori moderati nel primo pomeriggio.

MATTINO
POMERIGGIO

domenica 19 febbraio 2006

Cielo poco nuvoloso al primo mattino, nuvolosità in forte aumento nel corso della mattinata fino a cielo coperto nel pomeriggio. Diminuzione della nuvolosità in tarda serata e la notte. Nevicate moderate al mattino e nel pomeriggio, in esaurimento in serata (apporto massimo intorno ai 15 cm). Possibilità di visibilità ridotta durante le nevicate. Temperature in calo, con minime sui -3°C e massime sugli 1°C. Zero termico in calo sui 1200 m. Venti deboli da sudovest con possibili valori moderati fino al tardo pomeriggio.

MATTINO
POMERIGGIO

Figure 2.148 - Report (DWF) issued on 18-02-2006

On the 21st and 23rd of February, easterly winds at all altitudes brought low-lying cloud along the valley in the afternoon (from 3-4 p.m. until about 6-7 p.m.), with fog and extremely reduced visibility and occasional sleet. These conditions dissipated as the winds began to blow downhill from the mountain in the evening, restoring visibility to sufficient conditions for the competition to go ahead.

It should be remembered that the wind velocity at Sauze is strongly influenced by the location of the venue, halfway up a hill in a valley, so that the winds are mainly channelled in precise directions. When the weather is stable, the wind velocity is at breeze level, coming up from the valley floor during the day and down from the mountain at night: maximum intensity is reached in the middle of the afternoon, dropping during the training sessions or competitions, scheduled for the evening. For more details see paragraph 2.4.7.3.

Figure 2.149 - Reduced visibility on 21/02/2006

These characteristics of the venue, i.e. breeze velocities and channelling of the winds in precise directions, escape the predictive capacities of the models, which makes knowledge of the area by the forecaster extremely important.

2.4.7.3 Weather Vs Climate at Sauze d'Oulx

Introduction

To perform the climatology analysis in Sauze d'Oulx, the venue for the Olympic freestyle competitions (10-26 February), the station in Jouvenceaux at an altitude of 1373 m, installed in June 2003 was considered. For the depth of the snow in the 10-26 February 2006 period, reference was made to the data measured by the transportable weather station positioned at the start of the moguls course (1454 m). For the position of the two measuring stations, see figure 2.145. Reference is also made to the Lago Pilone station for the snowfall for the years prior to 2006; this station, despite being situated at a clearly higher altitude (2320 m), is the most representative for the venue considered because the nearest snowmeter, compared with the valley floor stations, is characterised by a similar nivometric trend.

We should however consider that snow coverage at the competition venue is systematically less than that registered at Lago Pilone and the snow that falls melts more. In fact, for the Test Event held in 2005, a year in which natural snowfall was particularly critical, artificial snow was used preventively during the months leading up to the event.

The data for the 10-26 February 2004/2005/2006 period was then analysed; the trends in temperature, wind velocity and direction and snowfall were observed.

The data acquired was registered with reference to UTC ("Coordinated Universal Time"), so for the passage from UTC to local time, in the 10-26 February period, all you have to do is add an hour.

Temperature in Jouvenceaux

The average daily temperature value was –1.4 °C; the daily thermal details registered showed a minimum of -11.3 °C and a maximum of 11.7 °C (see table below).

YEARS	MeanT (°C)	MaxT (°C)	MinT (°C)
2004	0,3	11,7	-8,6
2005	-3,1	10,5	-11,3
2006	-1,4	8,4	-7

Figure 2.150 - Table summarising the average and extreme temperatures

Despite being a limited data sample, we can state that in the 10-26 February period, temperatures tended to increase, while remaining extremely unsettled. Humidity is in opposition to temperature. Another aspect requiring consideration is that, being a middle valley station, the average daily temperature range is not extensive (between –2 °C and +6 °C): the minimum temperature occurs at about 6.30 UTC with the maximum occurring at 13.00 UTC.

Fresh snow and snow depth on the ground registered at Lago Pilone

The elaborations regarding snow were carried out using data measured automatically. The analyses are related to the snow depth on the ground and the amount of fresh snow daily in the 10-26 February period.
The following table summarises the depth of snow on the ground and the intensity of snowfall for each year considered.

YEARS	HsM (cm)	Hsm (cm)	Hn (cm)	Gn	SNOWIEST DAY
2000	63	51	12	3	19 - Feb
2001	141	103	58	5	18 - Feb
2002	97	34	65	4	15 - Feb
2003	106	93	13	2	16 - Feb
2004	172	123	64	5	21 - Feb
2005	53	47	6	6	23 - Feb

Figure 2.151 - Depth of snow on the ground and intensity of snowfall for the station at Lago Pilone (*)

With reference to the previous figure, it is important to observe that, in the 10-26 February period, the depth of snow has an average value of 116 cm with a minimum of 53 cm in 2005 and a maximum of 172 cm in 2004. During the period of the Games, four days characterised by snowfall are expected on average, equally distributed throughout the period, each of which brings an average of 9 cm/day of snow.

YEARS	HsM (cm)	Hsm (cm)	Hn (cm)	Gn	SNOWIEST DAY
2006	30	2	45	4	25 - feb

Figure 2.152 - Depth of snow on the ground and intensity of snowfall for the station at Jouvenceaux (moguls start) (*)

From the comparison of the previous two figures and remembering that snow coverage at the venue is systematically less than that registered at Lago Pilone and that the snow that falls melts more, we can state that in the 10-26 February 2006 period, the snow coverage was good.

(*)
HsM = maximum thickness of the snowpack
Hsm = minimum thickness of the snowpack
Hn = fresh snow accumulated in the 10/26 February period
Gn= number of snowy days

Wind

The following graphs show that the intensity of the wind is weak in 92% of cases (8% of which accounted for by calm winds) and moderate in 8% of cases. There are no cases of strong wind (in excess of 36 km/h). In particular, moderate values are more likely to be reached during the day than at night. The main wind condition is breeze: from the valley floor during the day (from north-east) and from the mountain face during the night (from south).

The distribution of the winds at the venue is shown below.

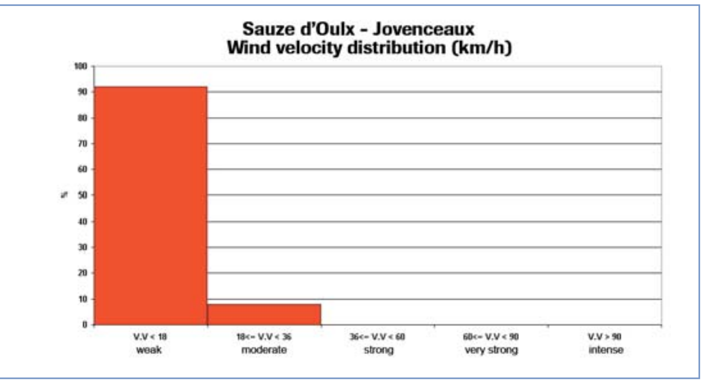


Figure 2.153 - Histogram of wind velocity measured from the Jouvenceaux station in 2004, 2005 and 2006

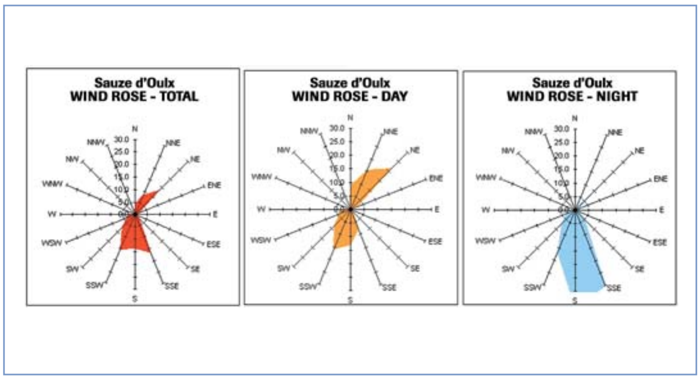


Figure 2.154 - Distribution of the average velocity in relation to the direction, using the "compass chart"
To this end, a distinction was made between daytime and nighttime velocity (the hours between 7 a.m. and 6 p.m. being classed as daytime hours)

2.4.8 BDY

2.4.8.1 The organisation of the nivo-meteorology service at the Bardonecchia venue

At the end of a long training programme at the Olympic venue of Bardonecchia, the Arpa Piemonte Nivo-meteorology team selected to offer support during the Olympic snowboard competitions, began its operational activity in the Nivo-meteorology operation room at the Bardonecchia Melezet venue at the end of January 2006.
The on the job training programme lasted a total of two years and included the 2004 World Cup final, the 2005 Test Events (leg of the Nokia FIS Snowboard Championship) and the 2005 Junior World Ski Championship.
The on the job activities performed during this training period were indispensable for the formation of a team with local meteorology and nivology skills in the mountains and to create a rapport between the members of the weather-snow team in order to tackle an event of international acclaim like the Winter Olympics.
The group in question, known as the BDY Weather Team, was made up of the following professional figures: Nicola Loglisci and Chiara De Luigi (weather forecasters and assistants for the manual nivo-meteorology measurements), Marco Lagorio (supporting technician) and Silvia Ambrois (snow specialist).

Figure 2.155 - The BDY weather team (from left: Nicola Loglisci, Chiara De Luigi, Marco Lagorio, Silvia Ambrois)

Figure 2.156 - The weather-snow boards in the weather room at Bardonecchia Melezet

The operating weather room was set up on the premises of the Sport offices at the completion venue and named WIC (Weather Information Centre).

During the pre-Olympic and Olympic period, the BDY Weather Team issued different products related to the conditions and evolution of the nivo-meteorology conditions. These products were made available to the various functions present at the venue, from Sport to OVR, from Transport to TOBO, and also sent to the MOC in Torino. All the products issued were published in Italian and English.

As of December 2005, in advance compared with the official start of the Games, it became indispensable to supply an indication of the evolution of the weather conditions at the Bardonecchia venue, due to the collapse of certain structures at the competition venue caused by an accumulation of snow on the 2nd of December 2005.
In operational terms, this was translated into additional daily comments in the weather report issued for the whole Olympic area (available on the Internet at the official website of Torino 2006). The aim of this comment was to translate the forecast for the whole Olympic Area in terms of local phenomena and phenomena of importance for the venue in question.

Subsequently, from the 28th of January 2006, the production of certain official weather forecast products began, in order to indicate the weather conditions on the following days, useful to all the operators working at the Bardonecchia venue (e.g.: preparation of the courses, arrangement and management of the venue, snow clearance, etc.). Long range weather reports were produced (6-day written reports), for a total of 27 Long Range Weather Forecasts issued until the 26th of February 2006.
From the 30th of January to the 26th of February, 28 Detailed Weather Forecasts were issued every day, reporting the conditions for the next 48 hours and comprising, in addition to text, the numeric forecasts for certain atmospheric parameters considered relevant for the discipline, such as air temperature, relative humidity and wind intensity.
During the official training sessions and competitions, as well as in critical conditions (e.g.: snowfall during the night with consequent mobilisation of staff to clear snow from stands and courses) in the early morning, the Last Minute Weather Forecast providing details in relation to next few hours of the competition and/or official training session, was issued, with a total of 13 reports.
As of the 8th of February 2006, 12 forecast and observation reports were issued in relation to the state of the snowpack on the courses.
Lastly, the BDY Weather Team was involved on a daily basis in the Team Captains Meetings, to discuss and prepare the competitions or training sessions for the next day. These meetings were held every evening and the role of the weather team was to present the weather and snow conditions forecast for the next day, with a total of 17 nivo-meteorology briefings.

In order to present the nivo-meteorology data in the best way possible, four pre-Olympic meetings were held with the managers of the Sport sector of the Torino 2006 Organising Committee. The aim of these meetings was to discuss the strategic nivo-meteorology points and variables for the monitoring activity during the Olympic snowboard training sessions and competitions.
From the 7th of February 2006, the Weather Information Centre supplied 15 reports on data observed.
These reports contained information related to certain nivo-meteorology variables of considerable interest with regard to the performances of the athletes involved in the Olympic competitions.
In accordance with that established with the Competition Manager of the Bardonecchia venue, the variables in question and their observation points are listed below, specifying whether the observations were manual or automatic.

Ts snow surface temperature (°C)

Ta air temperature (°C)

RH relative humidity (%)

WV wind velocity (m/s)

WD wind direction

These variables were measured using two portable weather stations and one fixed station positioned:

- at the start of the parallel giant course;
- at the start of the snowboard cross course;
- at the finish of the snowboard cross and parallel giant courses, representative of the half-pipe competition.

Furthermore, the snow surface temperature was manually measured in the following observation points:

- Start, 1/3, 2/3 snowboard cross (SBX), parallel giant (PGS) courses and finish;
- Right wall and left wall of the half-pipe (HP) course.

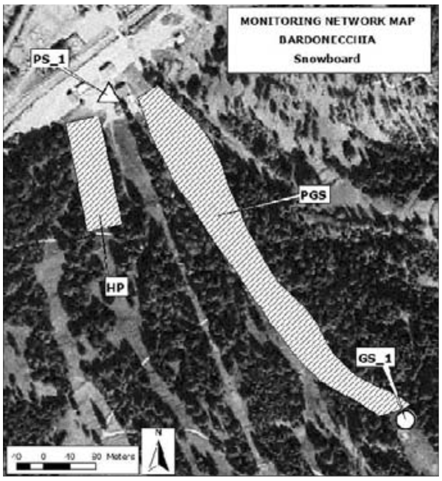


Figure 2.157 - Satellite picture of the Olympic venue of Bardonecchia

Figure 2.158 - Screen board with the weather data supplied by the BDY Weather Team

These measurements were taken every day, starting from one hour before the competitions and then every 30 minutes during the competition.

The only exception to this observation schedule was for the snow surface temperature measurements on the competition courses, decided with the Competition Manager to prevent obstructing the training sessions and competitions.

Figure 2.159 - "Bardonecchia" fixed station installed by the stat of the Border Cross discipline

Figure 2.160 - Bardonecchia competition venue (with the Border Cross course on the left and the half pipe on the right)

Figure 2.161 - Portable station at PGS start

Figure 2.162 - Portable station at the finish

2.4.8.2 Characteristic nivo-meteorology aspects for the Bardonecchia venue

In agreement with the Competition Management, no criticality thresholds were established for any of the different snowboard disciplines, having decided to analyse the weather situations that might affect the competitions on a case-by-case basis.
The significant aspects of the weather that characterised the Bardonecchia venue during the Olympic period are analysed below.

Period from the 1st to the 7th of February 2006 (start of the official training sessions)

The weather situation in the first seven days of February was characterised by a succession of two vast anticyclones over Central Europe, which determined mainly sunny weather conditions. Apart from the first two days, temperatures remained low, with minimums falling below 0 °C due to the arrival of cold air over Europe as a result of the descent of a depression from Scandinavia over the Eastern Mediterranean. This situation was of particular importance, as it facilitated the completion of works at the venue and the consequent transfer from site to Olympic venue. Furthermore, the low temperatures considerably facilitated the preparation and perfection of the courses before the official training sessions scheduled for the 7th of February.

The graph below shows the trend in the air temperature and snow surface temperature in the period considered.
In this period, the winds registered at the Bardonecchia venue were mainly weak westerlies, sometimes breezes, apart

from the 5th of February, when there was an intense flow of easterly currents in the lower atmosphere. The intensity of the easterly winds lifted the low-lying cloud towards the Val Susa to the Olympic area of Bardonecchia which, due to the local orography on the French border, is not usually affected by this kind of phenomenon. The picture that follows, registered during the afternoon of the 5th of February by the webcam at Jaffreau, shows how the whole Bardonecchia basin was affected by stratocumuli, while drier air characterised the high atmospheric strata.

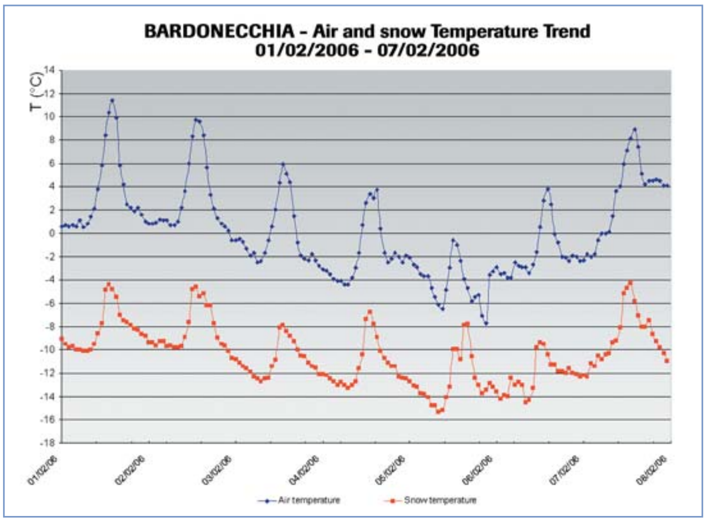


Figure 2.163 - Trend in temperature of the snowpack at the Bardonecchia venue from the 1st to the 7th of February 2006

Period from the 8th to the 11th of February 2006 (official Half Pipe and Border Cross training sessions)

On the 8th of February 2006 a deep depression from Scandinavia moved down towards Northern Italy, causing the north-westerly winds to intensify and encouraging the formation of foehn conditions in the Val Susa, continuing the next day. The weather situation in Bardonecchia was characterised by scattered cloud with rising temperatures and gusts of wind which reached up to 60 km/h over the competition venue. The correct forecasting of the foehn event, especially with regard to timing, was extremely important for the valid and efficient programming of the logistic works at the venue (e.g.: look and spectator services). The characteristic cloudiness of the foehn event is clearly shown by the following picture.

Figure 2.164 - View from Mount Jaffreau on the 5th of February 2006
(photo from www.bardonecchiaski.com)

Figure 2.165 - Wall of the foehn seen from the Bardonecchia Melezet competition venue of the 9th of February 2006

During the 10th and 11th of February 2006, the depression moved away to the east, allowing a gradual return of the anticyclone from the Azores over Western Europe, bring settled and sunny weather conditions and weak winds to the Bardonecchia venue. Temperature were no longer affected by the influx of the foehn and gradually fell, with maximum temperatures around 0 °C and minimums around –10 °C.

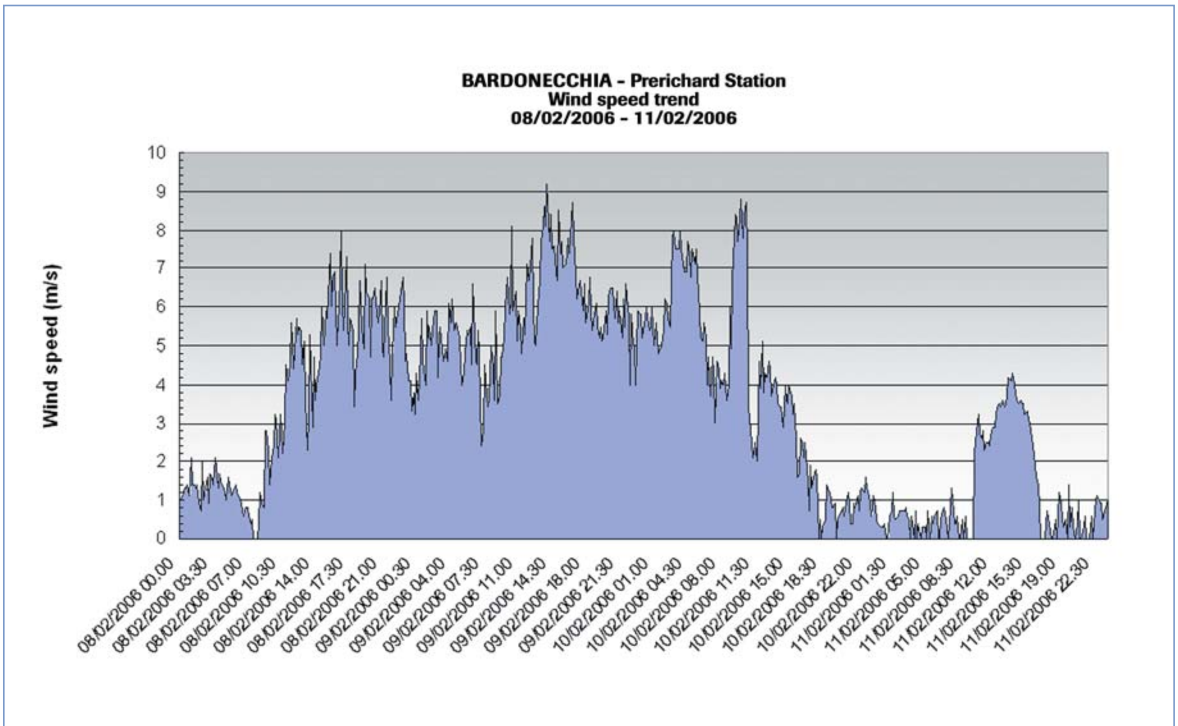


Figure 2.166 - Trend in wind velocity measured at the Prerichard station from the 8th to the 11th of February 2006

Period from the 12th to the 13th of February 2006 (Half Pipe heats and final)

The first day of competition took place in extremely good conditions. The absence of precipitation in the days before, together with severe temperatures made it possible to perfect the preparation of the half pipe course before the competition.

An area of high pressure over Western Europe guaranteed good weather conditions during the heats in the morning and the final in the early afternoon. Only towards the end of the competition did high, wispy clouds move in, associated with a warm front moving towards the Alps, which did not however affect the end of the competition in any way.

These clouds had been forecast by the BDY Weather Team, and this prediction proved to be a valid and useful element for the preparation of the bottom of the snowboards by the skimen of some of the countries competing.

The next day, the women's Half Pipe heats and final went ahead with clear, sometimes slightly cloudy, skies.

Figure 2.167 - Fog in transit during the men's Half Pipe final on the 12th of February 2006

Period from the 15th to the 17th of February 2006 (SBX heats and final)

Starting in the afternoon of the 15th of February a vast Atlantic depression caused the weather conditions to deteriorate due to the fast transit of the associated frontal systems over the Olympic area.

The start of precipitation was forecast for the night between the 15th and 16th of February on the Bardonecchia venue and was expected to last until the early afternoon on the 16th, the day of the men's SBX heats and final. Although the amounts forecast were of weak intensity, the Venue and Competition Management felt that it was indispensable to plan the clearance of fresh snow from the stands, access corridors and, above all, the course, before dawn, because even a few centimetres of snow can ruin the conditions and safety of a competition run against the clock.

One of the main criticalities of the forecast was the estimate of the freezing level and snow altitude. The criticality was created by the different location of the Olympic Village and the competition venue, one at an altitude of about 1300 m and the other at about 1600 m.

As shown by the graph below, the transit of a warm front in the night between the 15th and 16th of February raised the freezing level but caused snowfall above 1500 m.

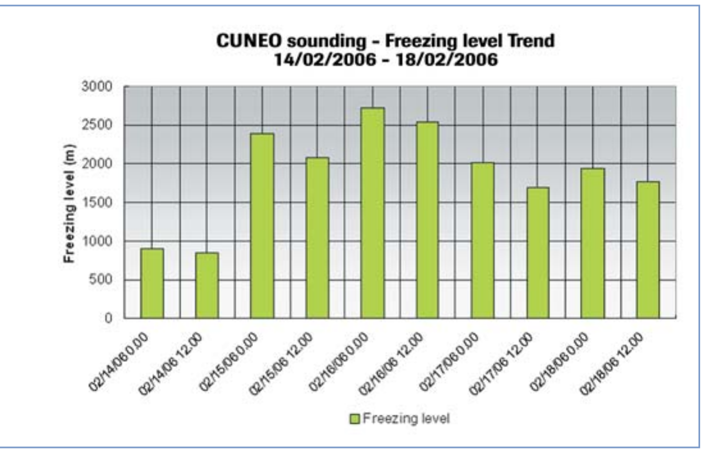


Figure 2.168 - Trend in the freezing level measured using the radiosonde at Cuneo Levaldigi

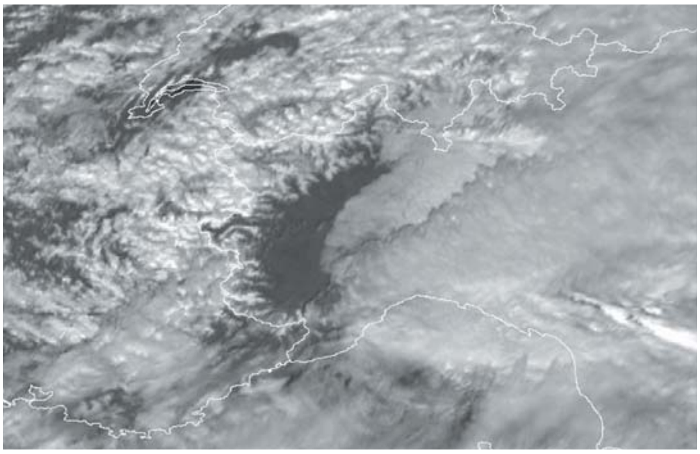


Figure 2.169 - MSG satellite picture of February 16th 2006

During the morning of the 16th, light snowfall was registered near the start of the SBX competition, with sleet at the finishing line. For this event an improvement in the weather conditions was forecast for the afternoon, with scattered cloud and no precipitation. In actual fact the fast passage of the cold front meant that post-frontal dryness reached the Olympic area in the middle of the day, stopping the precipitation and creating large clear patches of sky, providing excellent conditions for the final.

The photographs below show clear skies in the afternoon of the 16th of February 2006 (Meteosat MSG satellite channel) and the different weather conditions in which the Snowboard Border Cross heats took place from 10.00 a.m. to 11.00 a.m. and which characterised the final, from 2.00 p.m. to 3.00 p.m. (pictures published on the official Torino 2006 website).

Period from the 19th to the 21st of February 2006 (Official PGS training sessions)

On the 19th of February 2006, an Atlantic depression caused an intense flow of southerly currents at high altitude and easterly currents in the middle-low strata of the atmosphere, with clear deterioration of the weather at the

Figure 2.170 - Border Cross heats in the morning of February 16th 2006 (photo from www.torino2006.org)

Figure 2.171 - Border Cross final in the afternoon of February 16th 2006 (photo from www.torino2006.org)

Olympic venue of Bardonecchia Melezet and light snow, intensifying in the afternoon (freezing level registered on the ground by the radiosondage carried out in Cesana). This made it indispensable to provide an effective weather forecast for the event in question. In this case too, the weather forecast was correct, favouring, once again, the programming of all the snow clearance operations from the stands and courses, as well as the optimal management of the tensiostructures housing all the venue offices.

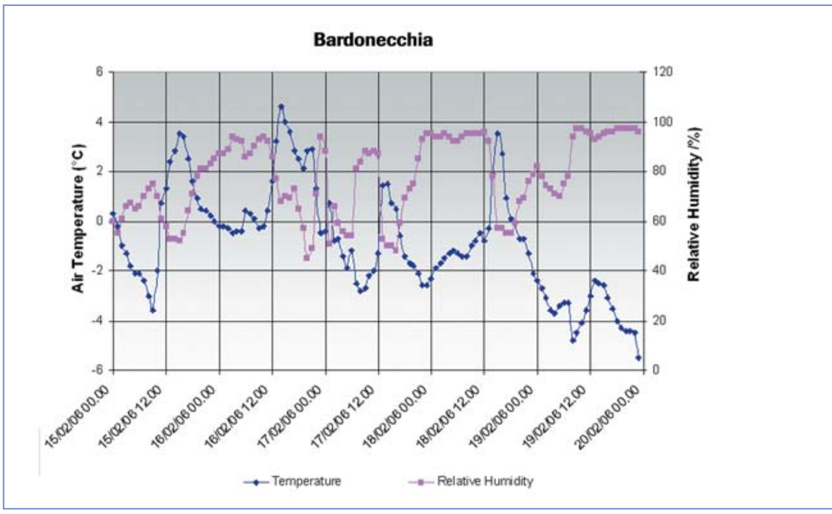


Figure 2.172 - Trend in temperature and relative humidity from the 15th to the 20th of February 2006

Period from the 22nd to the 23rd of February (PGS heats and final)

On the 22nd of February 2006 the weather remained unsettled, with variable cloud but an absence of precipitation. A second wave of damp air from the south subsequently affected the Bardonecchia venue, starting in the late afternoon of the 23rd of February 2006, when the weather suddenly deteriorated with the arrival of light snow. The weather forecast for these days predicted variable cloud for the 22nd of February 2006 and mainly sunny skies on the 23rd of February 2006. The cloud cover and snow temperature forecasts for these days were extremely helpful to those responsible for preparing the bottoms of the snowboards, especially on the 22nd (men's PGS final). The deterioration in the weather in the late afternoon of the 23rd was not forecast by the BDY Weather Team. This forecasting error did not however affect the day's competitions, which ended, fortunately, in the early afternoon on the 23rd of February 2006.

Figure 2.173 - Fresh snow on the Bardonecchia Melezet venues after the snowfall on the 19th of February 2006

2.4.8.3 Weather Vs Climate (Olympic period)

The Bardonecchia Prerichard station (1353 m) is the station with the most representative historic data for the Olympic venue of Bardonecchia. It was installed at the beginning of December 1990 and is still operating.

Temperature analysis

The result of the analysis of the average and extreme temperatures registered from the 10th to the 26th of February 2006, compared with temperatures for the same period from 1991 to 2005, are shown in figure 2.174 and the following analysis.

MEAN TEMPERATURE (°C)			
YEAR	Mean T	Min $_{mean}$T	Max $_{mean}$T
Climate	0,3	-4,6	5,4
2006	-1,1	-4,5	3,2

MINIMUM TEMPERATURE (°C)			
YEAR	Mean $_{min}$T	Min $_{min}$T	Max $_{min}$T
Climate	-3,9	-9,4	1
2006	-4,7	-8,8	0,5

MAXIMUM TEMPERATURE (°C)			
YEAR	Mean $_{max}$T	Min $_{max}$T	Max $_{max}$T
Climate	5,5	0,6	12,3
2006	3,4	-0,4	6,5

Figure 2.174 - Table summarising average and extreme temperatures

Average Temperature

The average of the average temperatures of the climatology period is equal to 0.3 °C, with an average minimum temperature of –4.6 °C in 2005 and an average maximum temperature of 5.4 °C in 1998. The Olympic period from the 10th to the 26th of February 2006 registered average temperatures below the climatology values of reference and, in particular, this result derives from the fact that the maximum average temperature values were about 2 °C below average.

Minimum Temperature

The average minimum temperature for the climatology period of comparison is –3.9 °C, with an average minimum value of –9.4 °C in 2005 and an average maximum value of 1 °C in 1998. The Olympic period in consideration registered average minimum temperatures just below average.

Maximum Temperature

The average maximum temperature for the climatology period of comparison is 5.5 °C, with an average minimum value of 0.6 °C observed in 2005, and an average maximum value of 12.3 °C in 1998. The Olympic period in consideration registered average maximum temperatures below average and well below the historic records. This shows how the slight negative temperature anomaly was mainly linked to diurnal radiation.

Wind analysis

Comparing the wind classes, calculated using the Munter classification (1992) based on recognisable effects in the mountains (effect on snow on the ground, on people and objects), in relation to the 1991/2005 period (figure 2.175) with the wind classes in relation to the 2006 Olympic period (figure 2.176) we can see how the Olympic period in February 2006 was a period characterised by little wind compared with the climatology average. In fact, the percentage of events of moderate intensity was well below average, while the percentage of events with calm winds increased.

As far as wind direction is concerned, shown here in graph form calculating the distribution of average wind velocity as a function of the wind direction, using the "compass chart", the differences are mainly concentrated in the distribution of winds during the day. In fact the 2006 Olympic period has a greater southerly component than the climatology average. Southerly currents are characterised by slight distribution during the night too, showing how the period in question was subject to greater influence by damp southerly currents. This result also clearly explains

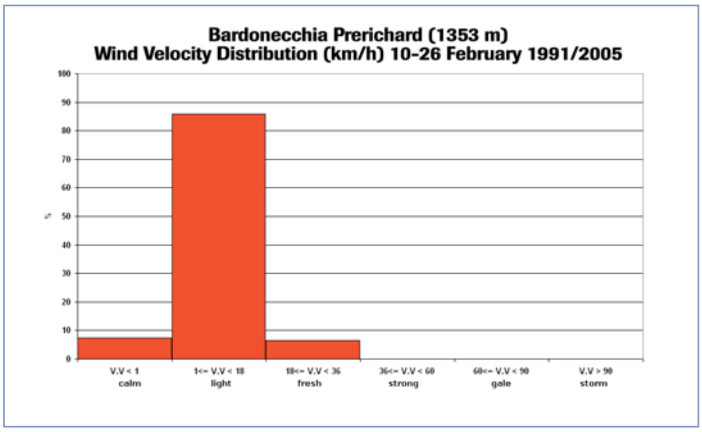


Figure 2.175 - Wind velocity in the 1991/2005 Olympic period distributed in classes according to the Munter classification

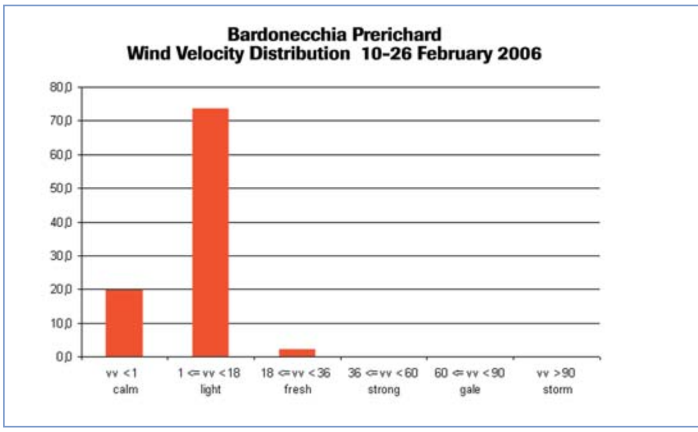


Figure 2.176 - Wind velocity in the 2006 Olympic period distributed in classes according to the Munter classification

the trend in temperatures, as southerly currents caused increased cloud cover, reducing the hours of diurnal radiation. The wind charts present as a further result the prevalence of north - north-easterly currents, particularly during the night, and the southerly component during the day, (the distinction shows diurnal hours considered from 7.00 a.m. to 6.0 p.m.), in accordance with the climatology trend.

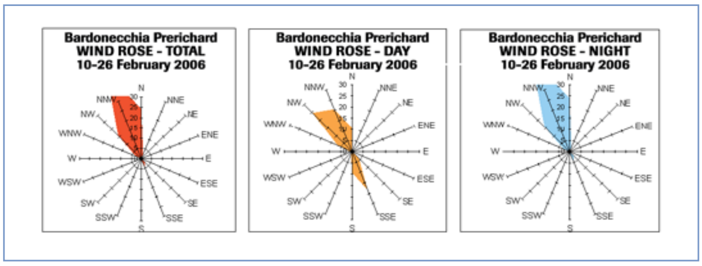


Figure 2.177 - Distribution of the wind direction during the 1991/2005 Olympic period

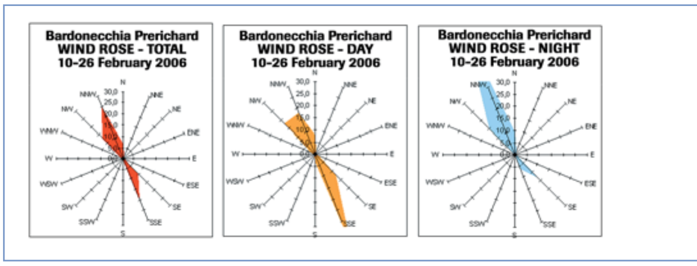


Figure 2.178 - Distribution of the wind direction during the 2006 Olympics

Snowfall analysis

The data observed in relation to the snow was processed in consideration of the values supplied by an automatic weather station. The table below summarises the values of snow depth on the ground and intensity of snowfall during the 1991/2005 climatology period, during the Olympic period. The comparison with this climatology period (figure 2.179) shows how the Olympic period of February 2006 was one of those with most snow in the last 16 years, with values of snow on the ground and snowy days above average.

YEAR	MAXIMUM DEPTH OF THE SNOWPACK (CM)	MINIMUM DEPTH OF THE SNOWPACK (CM)	INTENSITY OF THE (SNOW ON THE GROUND/NUMBER OF SNOWY DAYS)	NUMBER OF SNOWY DAYS
climate	36	13	8	4
2006	43	12	9	5

Figure 2.179 - Table summarising the values of snow depth on the ground and intensity of snowfall during the Olympic period of the last four years

2.4.9 SESTRIERE WLC

The Weather Local Centre or WLC in Sestriere, opened on December 12th 2003, produced the local weather forecasts and performed nowcasting activities, along with activities related to monitoring, organisation and centring of the local manual measurements and the local weather and snow forecasts, also providing logistic technical assistance for all the other venues. The WLC was operational from the 31st of January to the 26th of February and from the 4th to the 19th of March, every day from 6.00 a.m. to 22.20 p.m., with the presence of qualified staff, guaranteeing direct relations with the public, media and local authorities, as well as assistance for sports technicians and technical assistance according to set procedures.

Figure 2.180 - Weather local centre in Sestriere

The group was made up of Mauro Rava (coordinator), Daniele Cane (weather forecaster), Gabriella Arbia, Erika Solero and Giorgio Cogerino (supporting technicians) and Loredana Lattuca (Press Office). Moreover, the snow forecast and coordination of the Alpine guides (Alberto Bolognesi, Piermario Mattiel, Piero Bertotto and Eugenio Testa) in support of the nivology activities, were carried out by Marco Cordola (coordinator) and Andrea Bertea (nivologist).

Figure 2.181 - The General Manager visits the Sestriere WLC

From left: Anna Maria Gaffodio (Technical Manager), Marco Pasquero (Staff management), Renata Pelosini (weather manager), Vincenzo Coccolo (General Manager), Stefano Bovo (Manager of Environmental Monitoring and Forecasting Area), Alberto Olivero (Manager of monitoring network installation)

The meteorologist's activity at the Weather local centre in Sestriere concerned three different contexts:

1. Production of general weather reports for the whole Olympic Area.
2. Assistance for the venues, data flow check, weather procedures check, backup for venues unable to issue reports for technical reasons.
3. Media and public relations.

Coordination with the technical and nivology staff at the WLC and with the colleagues at the Sestriere Colle – Borgata venue was excellent and highly productive for the supply of an optimal nivo-meteorology service to the various users and for offering prompt solutions to the technical problems of the different venues.

2.4.9.1 Production of general weather reports for the whole Olympic Area

The meteorologist at the WLC handled the issue of all products not linked with the needs of a single sport, but refer-

ring generally to the whole Olympic Area. The main need to consider, obviously in addition to the best possible weather forecast, was the achievement of maximum coordination of the general forecasts with those specific to the different venues.
The daily exchange of e-mails with the various venues and with the MOC was extremely important, in order to obtain a forecast shared and drawn up by several forecasters and which highlighted the aspects common to the whole Area and the peculiarities of each single venue.
The meteorologist of the WLC, before issuing the products, also took into meticulous consideration all the products issued by his colleagues on the venues, aiming to achieve maximum harmonisation of the forecast in quantitative and qualitative terms.
The main products were the Olympic System Weather Report (disseminated on the TOROC website and on paper at the WLC), the forecast in XML format (symbols for weather, temperature,…) on the same TOROC website, the MontagneDoc website and the CONI website, the general weather forecast and evolution for the website meteogiochi.arpa.piemonte.it and the Report for the company Via Lattea, which operates the lift systems of the Alta Val Susa district.
A second group of products regarded the transport security and civil protection requirements with regard to the weather conditions: X25 corridor conditions on the Intranet INFO2006 of the TOROC (conditions of the main access routes to the mountain venues), Report for the Department of Civil Protection of the Provincia di Torino (which took care of snow clearance on the SP23), Report for the A21 and A4 motorways and the forecast for Caselle Airport.
Lastly, an Olympic System Weather Analysis was produced every day, describing the previous day's weather conditions and with an appropriate check on the relative forecasts.

2.4.9.2 Assistance at venues for weather procedures

The WLC meteorologist assisted his colleagues at the venues, checking the correct data flow, the correct operation of the IT procedures and supplying assistance at the venues unable to issue products for a variety of reasons. For this reason, his presence at the WLC required an extended working timetable, while 24/7 standby was provided thanks to a mobile phone line.
The weather service for the Games was characterised by a rather complex structure, with numerous weather offices requiring daily dispatches of the data observed, the outputs of the meteorology models and the results of the post-processing methods.
The number of products required daily for the forecast of a single venue was extremely high and the data distribution chain rather long, so a delay in one of the points of the chain had widespread consequences on all the subsequent nodes of the network.
A procedure was developed for the reacquisition of the data and to solve the problems related to the procedures in the single venues, with the clear definition of responsibility for each element in the acquisition chain, so that the problems could be solved as quickly as possible and ambiguities in relation to the reacquisition of the data could be avoided.
The cooperation between the meteorologist at the WLC and the colleagues at the Natural Risk Situation Room in Torino was excellent and enabled a quick and efficient solution to the problems related to the availability of the data. The WLC meteorologist informed his colleagues at the venues of the problems found and the solutions to them by sending multiple text messages. The number of operations for the reacquisition of data at the WLC was quite consistent, with an average of more than one operation a day.
The connection with the technical staff at the MTC was equally efficient, enabling the very fast solution of the few interface problems with the Web Olimpia 2006 application.
The operations regarding the IT procedures (usually carried out by remote connected on the machine at the venue or

the machines in Torino) of moderate, serious or very serious entity during the Olympic period were about 15.
The main ones were changes to the acquisition procedures for the passage of the IFS model of the ECMWF to a resolution of 0.25°, the operation on machines blocked due to hung procedures and software updates to local machines.
The backup intervention by the colleagues at the most significant venues was carried out during the block of the venue networks due to the power failure, with the coordination of the issue of products. The WLC meteorologist also sent out the products for INFO2006 during the load-in of the venues, when the colleagues were not yet physically present at the venue offices.
It is curious to note that the earliest morning assistance operation was carried out at 7.00 a.m., while it was once necessary to intervene at 11.00 p.m.

2.4.10 TORINO WOC

2.4.10.1 The organisation of the nivo-meteorology service at the Torino and Pinerolo venues

Apart from all the mountain venues, where the various outdoor Olympic competitions took place, all the indoor competitions were held in Torino:

- *Ice Hockey*, at the Olympic Palasport and Torino Esposizioni,
- *Figure Skating*, at Palavela,
- *Speed Skating*, at Oval Lingotto,
- *Short Track*, at Palavela,

and in Pinerolo:

- *Curling*, at Palaghiaccio.

The Torino city venue also hosted numerous outdoor events; the Opening and Closing Ceremonies of the Games at the Olympic Stadium, the evening medal ceremonies with the Olympic champions in Medals Plaza and various other shows for the public in the historical town centre.

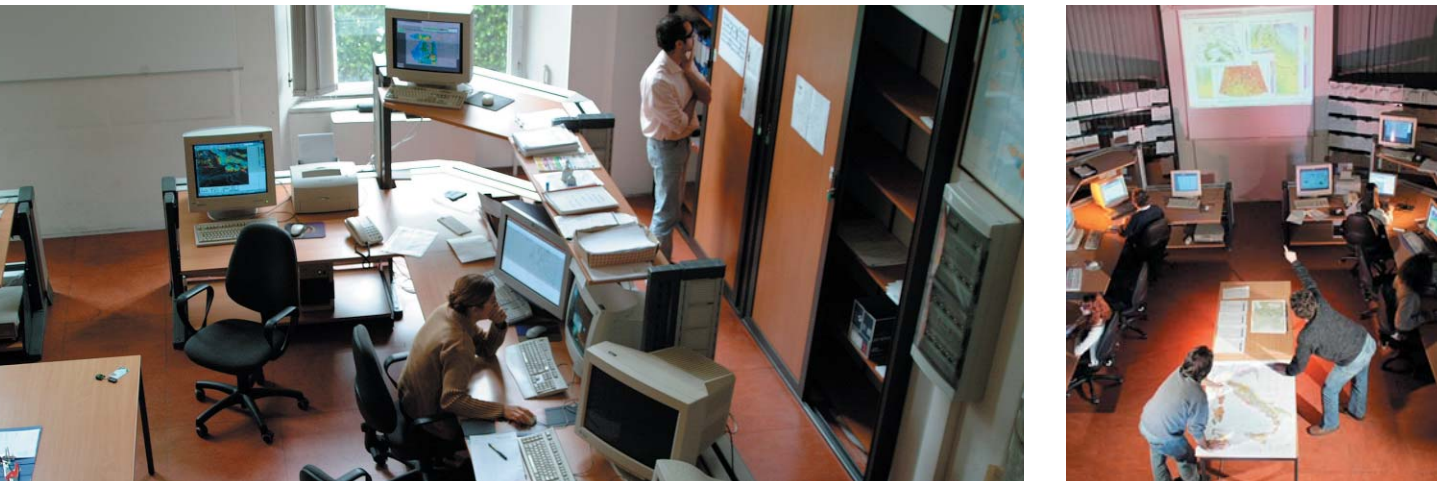


Figure 2.182 - The WOC office at the Arpa Piemonte Environmental Monitoring and Forecasting Area

At the end of a long training course, the Arpa Piemonte weather group was selected for the Olympic venue of Torino: its job was to provide support during the indoor Olympic competitions and the outdoor events in the Torino city venue, simultaneously preparing all the forecasting products for the Pinerolo venue, thus bringing together responsibility for the weather service for both city venues.
The *Weather Operation Centre* (WOC) was set up in the same offices as the local weather office of the Arpa Piemonte

Environmental Monitoring and Forecasting Area (figure 2.182).

The weather team assigned to the Olympic venue of Torino was made up of two forecasters: Giovanni Paesano and Antioco Vargiu, who formed the WOC *Weather Team*.

The on the job training course was able to rely on work experience with a duration of almost seven years and, in more specifically sporting terms, included the *Test Events* of the 2004-2005 winter season (*European Short Track Championships*).

The on the job activities performed during this training period were indispensable for the formation of a team with local meteorology skills and to create a rapport between the members of the team in order to tackle an event of international acclaim like the Winter Olympics.

The WOC team began its specific operating activity for the Torino venue at the end of January 2006. So much advance time was necessary because it had to meet the needs of the various users who, on all the days prior to the official start of the Games, worked on the lengthy preparation of the great Olympic event.

During the pre-Olympic phase and throughout the Olympic period (as well as the Paralympics), the WOC *Weather Team* issued different products in relation to the conditions and evolution of the weather parameters. These products were made available to the various functions present at the venue, from Sport to OVR, from transport to TOBO, and also sent to the MOC.

They were produced in electronic format for the INFO2006 website and for the "Arpa Piemonte Meteogiochi" website and in PDF format, sent by e-mail to the various users. All the products issued were published in Italian and English. Radio and television interviews were also carried out for the Italian and foreign press who made requests to such effect, with the support of the Arpa Piemonte Press Office, which guaranteed the presence of its staff at the WOC for the whole Olympic period.

As of the 30th of January 2006, the production of certain office weather forecast products began, in order to indicate the weather conditions on the following days, useful to all the operators working at the Torino venue (e.g.: preparation of the outdoor locations for various events, arrangement and management of the venue, snow clearance, etc.). Daily long range weather reports were produced (6-day written reports), for a total of 28 *Long Range Weather Forecasts* issued until the 26th of February 2006.

From the 30th of January to the 26th of February, 28 *Detailed Weather Forecasts* were issued every day, reporting the conditions for the next 48 hours and comprising, in addition to text, the numeric forecasts for certain atmospheric parameters considered relevant for the venue, such as air temperature, relative humidity, wind intensity and amount of precipitation.

During the subsequent Paralympic period, a further 22 *Long Range Weather Forecasts* and 22 *Detailed Weather Forecasts* were issued, from the 27th of February to the 19th of March, the last day of the Paralympics: for an overall total of 50 *Long Range Weather Forecasts* and 50 *Detailed Weather Forecasts*, issued during the whole Olympic and Paralympic period from the 30th of January to the 19th of March 2006.

Besides the production and distribution of the various official weather forecasts, it was necessary to constantly monitor the weather conditions present, in order to supply immediate updates of the forecasts issued, in the case of sudden weather changes.

Continuous contact with the various users (easier by

Figure 2.183 - The portable automatic weather station installed on the roof of the WOC office

telephone) was useful to answer questions on sudden weather changes in real time and offer reassurance and satisfaction.

The measurements of the meteorology variables, for the observation of the weather present, were carried out using several fixed automatic weather stations within Torino and Pinerolo, and a portable automatic weather station on the roof of the WOC (figure 2.183).

The fixed automatic weather stations, belonging to the Arpa Piemonte regional monitoring network were:

- Torino Giardini Reali,
- Torino Vallere,
- Torino Reiss Romoli,
- Torino Consolata,
- Pinerolo.

Furthermore all the monitoring instruments available were used: satellite, radar, radiometer, *wind profiler*, detectors for weather present, *webcam*, etc.

An example of the daily programme of the two meteorologists involved in the issue of the various forecast products is shown in the diagram of the list of activities in figure 2.184, with a commitment that lasted from morning until evening.

SERVICES SUPPLIED	VENUE	ISSUE TIME	NOTES
1. DWF	Torino	by 9.00 a.m.	Torino Esposizioni → Ice Hockey
(Detailed Weather Forecast)	Pinerolo	by 9.00 a.m.	Pinerolo Palaghiaccio → Curling
2. Check Sky condition	Torino	every hour	for INFO 2006
(data observed)	Pinerolo	every hour	for INFO 2006
3. Set up C49	Torino and	3.30 p.m.	Numeric report for INFO 2006
4. Set up X20	Pinerolo	3.30 p.m.	Numeric report for INFO 2006
5. LRWF (Long Range Weather Forecast)	Torino	by 4:00 p.m.	Send 2 PDF reports by e-mail (English+Italian)
			Printout for fax
6. Create tomorrow's C49	Torino	6.00 p.m.	Numeric report for INFO 2006
	Pinerolo	6.00 p.m.	
7. Create tomorrow's X20	Torino	6.00 p.m.	Numeric report for INFO 2006
	Pinerolo	6.00 p.m.	
8. Send today's C49	Torino	9.05 p.m.	for INFO 2006
	Pinerolo	9.05 p.m	
9. Send today's X20	Torino	9.20 p.m.	for INFO 2006
	Pinerolo	9.20 p.m	
10. Check Sky Condition	Torino	end of the evening	for INFO 2006
(data observed)	Pinerolo	end of the evening	for INFO 2006
UPDATES:			
A. update today's C49	Torino	every hour	for INFO 2006
	Pinerolo	every hour	for INFO 2006
B. update today's DWF	Torino	by 4.30 p.m.	for INFO 2006 and "Meteogiochi" website
	Pinerolo	by 4.30 p.m.	for INFO 2006 and "Meteogiochi" website
C. update today's X20	Torino	every hour	for INFO 2006 and various e-mail users
	Pinerolo	every hour	for INFO 2006 and various e-mail users

Figure 2.184 - Check list of daily operations of the two meteorologists of the WOC

2.4.10.2 Characteristic nivo-meteorology aspects for the Torino and Pinerolo venues

It was not necessary to identify fixed criticality thresholds for the meteorology variables, establishing a case-by-case analysis of the weather conditions that might affect the various events. As the competitions were all held indoors (Olympic Palasport, Palavela, Torino Esposizioni and Oval Lingotto in Torino; Palaghiaccio in Pinerolo), no

competition was delayed. However the weather conditions were very important for the Olympic Stadium outdoor venue which hosted the Opening and Closing Ceremonies of the Games, and for *Medals Plaza*, the square in the historical town centre of Torino where the evening medal ceremonies with the Olympic champions various other shows for the public were held; the Closing Ceremony of the Paralympic Games also took place at *Medals Plaza*.
The Opening and Closing Ceremonies of the Games were crucial moments for the Olympics from the image viewpoint, due to the enormous visibility offered at international level. It is easy to understand how the weather conditions were so important and deserved considerable attention in relation to phenomena which might have jeopardised the ceremonies in any way.
The most important meteorology variables for the venue of Torino, which could have had the most significant effect on the outdoor activities and influence the outdoor audience, were air temperature, humidity, wind and precipitation. Wind and precipitation had an impact on the work and the various activities being carried out outdoors for the arrangement and general preparation of the outdoor events. Temperature and humidity values were important for the comfort of the outdoor audience. These were the parameters on which the meteorologist of the WOC had to focus.
The significant meteorology aspects that characterised the city venues in the Olympic and Paralympic period, with particular reference to Torino, host of the most important Olympic events, are listed below.

Period from the 30th of January to the 5th of February 2006

(preparation of the Olympic Games Opening Ceremony)

The first week began with bad weather, due to the final effects of a depression, moving eastwards from Spain, which brought precipitation, also to the Torino and Pinerolo areas, in the last days of January, until the 30th. From the 31st of January to the 5th of February, a vast anticyclone area, stretching from Central Europe into Western Europe, quickly brought more settled conditions, with mainly sunny or partially cloudy skies, misted by fog in the colder hours due to atmospheric stability. After the troubled start, the beautiful days of the first week in February facilitated the preparatory activities for the Olympic Games Opening Ceremony, held outdoors, in the Olympic Stadium in Torino, as well as all the arrangement works for the Torino venues, in anticipation of the start of the great Olympic event.
Sunny weather brought daytime temperatures to maximum values above 10 °C. In the hours of darkness (from late evening to early morning) minimum temperatures fell to 0 °C, but the most intense cold came only at the end of the week when, as of the 5th of February, polar air began to move down from Scandinavia towards the east coast of Italy, taking temperatures, even at lower altitudes, to below zero.

Period from the 6th to the 12th of February 2006

(Olympic Games Opening Ceremony)

During the second week, the weather conditions remained largely stable on the plain, thanks to the area of high pressure over Western Europe. The sun was temporarily covered by wispy cloud or morning mists, lifting during the morning and thinning out in the afternoon, with temperatures that never managed to climb

Figure 2.185 - A moment during the Opening Ceremony at the Olympic Stadium in Torino
(photo from www.torino2006.org)

above 5-6 °C. The polar depressions descended over Eastern Europe towards the Italian Adriatic Coast, occasionally triggering strengthened foehn winds in Piedmont, which mainly concerned the first plains near the Alpine valleys: Pinerolo more than Torino. While the cold air, transported from Scandinavia towards Eastern Italy, kept minimum temperatures below 0 °C for most of the week on the plains of Torino and Pinerolo, the foehn winds which blew between Thursday the 9th and Friday the 10th of February favoured a sudden rise in temperatures which, at the maximum values, returned temporarily above 10 °C.
The Opening Ceremony on the evening of February 10th took place in stable weather conditions. The foehn wind, which only just touched Torino, gradually died out as the day went by. The clear sky favoured a broad temperature range, with a gradual drop in temperature during the night, from +3 °C to 0 °C between the beginning and end of the ceremony.
The correct forecasting of the foehn event, especially with regard to timing, was extremely important for the valid and efficient programming of the logistic works for the final preparation of the ceremony. Temperature was another parameter required for the duration of the ceremony, being important for the comfort of the audience, and was correctly forecast.

Period from the 13th to the 19th of February 2006

(Evening awards ceremonies at Medals Plaza)

The week from the 13th to the 19th of February saw the rapid evolution of the weather conditions, with subsequent sudden weather changes.
The anticyclone over South-West Europe continued to offer stable weather in the first two days of the week. As of Wednesday 15th, the gradual descent of low pressure from the North Atlantic towards Western Europe determined a drastic deterioration in the weather conditions, in alternating phases.
The rotation of the winds from the south initially brought widespread cloud, without precipitation. The only benefit was the rise in minimum temperatures which, from the -2 and -3 °C of the previous days, climbed to above 0 °C, thanks to the cloud cover due to damp, mild air from the south.
On Thursday the 16th, a swift improvement during the night favoured the sudden formation of thick fog on the plain in the morning, due to the humidity accumulated in the low strata by the south-easterly winds.
On Friday 17th, an intensification of the westerly currents strengthened the foehn winds again as far as the Pinerolo and Torino plains, with strong sun and a considerable rise in maximum temperatures to almost 15 °C.
On Saturday the 18th the quick passage of a frontal depression caused a light shower over the Torino venue, which caught us slightly by surprise, as the forecast had indicated cloud only, with no precipitation. The phenomenon, with characteristics more in keeping with Spring than Winter, was very brief however and almost negligible, without any effect on the evening medals ceremony at Medals Plaza (figure 2.186), dying out in the early afternoon in under half an hour.

Figure 2.186 - A moment during the evening award ceremonies held in Medals Plaza in Torino
(photo from www.torino2006.org)

On Sunday the 19th, the ulterior approach of the North Atlantic depression towards France caused the weather on the plain to deteriorate more significantly, with precipitations which started off as rain in the morning and became snow in the late afternoon. As shown by the vertical profile of the air temperature in figure 2.187, measured by the radiometer of the Arpa Piemonte regional monitoring network over the 24 hours of the 19th of February, during the afternoon there was a drastic drop in temperature with cold air which, together with the precipitation, descended from the higher strata of the atmosphere to he ground, turning the rain into snow between the late afternoon and evening.

The main criticality of the forecast was the estimate of the snow altitude. The sharp drop in temperature had been underestimated by the meteorology models, so the snow on the plain had not been forecast the day before (Saturday the 18th), when the report had announced "sleet". The snow came with lightening and this was a decidedly unusual phenomenon for the season and the location, proving the fact that the cold spell had been very severe and hard to predict. However a new update of the forecast on the same day (Sunday) was useful in informing users. Moreover, the forecast of the duration of the snowfall, which continued into the start of the evening medals ceremony at Medals Plaza but ended before the end of the event, was perfect. The snow on the city of Torino by night and on Medals Plaza, on the evening of the Olympic medals ceremony, created a wonderful atmosphere, greatly appreciated by organisers and audience alike.

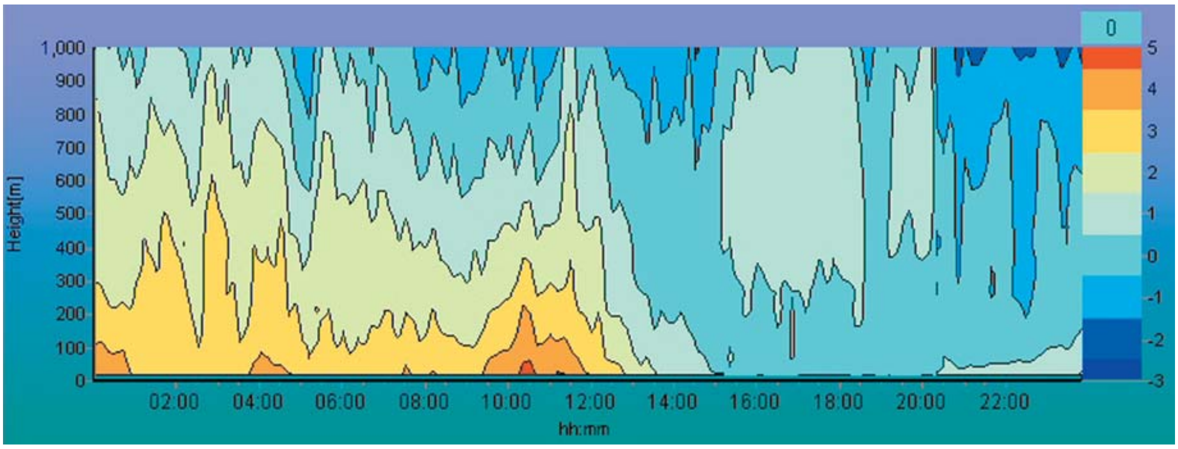


Figure 2.187 - Weather trend of the vertical profile of the air on Sunday the 19th of February, from the measurement of the radiometer in Torino in Corso Stati Uniti - (light blue indicates air at 0 °C)

Period from the 20th to the 26th of February

(Olympic Games Closing Ceremony)

In the last week of the Olympic period, the unsettled weather continued, mainly with cloud, but with rain only on Wednesday, Friday and Saturday.

Low pressure over South-West Europe maintained the extensive cloud cover practically all week. Minimum temperatures benefited, remaining constantly above 0 °C: damp and mild air from the south favoured minimum values between +2 and +3 °C. At the same time however, the clouds reduced the diurnal temperature range, with maximum values never rising above 6 or 7 °C.

The meteorological evolution, despite being negative, was "calmer" than the previous period and therefore easier to predict, with correct forecasts during the week.

After light rain on Friday 24th and Saturday 25th, the weather report issued for the forecast of the day of the Closing Ceremony (Sunday the 26th) reassured the show's organisers that good weather would return to the Torino venue. In fact, the Closing Ceremony took place in perfectly stable atmospheric conditions. Even the temperature, correctly forecast at about +4 °C for the ceremony, caused no problems for the comfort of the outdoor audience.

Paralympic period from the 10th to the 19th of March 2006

(Paralympic Games)

The Paralympic period was unaffected by problems.

The day of the Games Opening Ceremony (Friday the 10th of March) benefited from a sunny sky and temperate day-time temperatures (reaching over 15 °C). However the foehn winds intensified quickly during the afternoon, as correctly indicated by the weather forecasts well in advance, thus informing the opening ceremony organisers a few days ahead of time.

The strong foehn wind phase continued for several days, with gusts extending to the city venues, due to the arrival of a polar depression which moved down over Eastern Europe, also causing a sharp drop in temperatures on the days following the 10th of March.

From the 13th of March, the weather situation regained some tranquillity, with largely settled conditions, alternating with cloudier moments, with few relevant precipitations, but significantly extended to the Torino area, limited mainly to Pinerolo.

The final day, the 19th of March, was characterised by more or less extensive cloud, but without criticalities for the Closing Ceremony.

As mentioned in the previous paragraphs, the WOC weather service for the Torino venue was not limited exclusively to the period of the Olympic and Paralympic Games, but continued for a longer period, including all the days between the Olympic period and the Paralympic period, as the weather forecasts were vital to all the organisers of the various venues, both for preparation before the show and for the closure at the end of the great event. There were no criticalities with the weather service supplied by the WOC on the days between the 26th of February and the 10th of March.

2.4.11 TORINO MOC

A fixed weather station was present at the MOC (Main Operation Centre), situated in Torino at the TOROC headquarters, in Corso Novara 96. Here two Arpa Piemonte meteorologists (Renata Pelosini and Massimo Milelli) guaranteed an 18-hour service, every day from the 31st of January to the 26th of March and from the 4th to the 19th of March. When necessary, due to adverse weather conditions, the coverage could be extended to 24-hour. The job of the meteorologists at the MOC was to maintain constant contact with the TOROC, IOC and IF directors and managers at headquarters and with the meteorologists at the various competition venues.

Figure 2.188 - Visit of the Canadian weather delegation to the MOC: around the Weather Manager Renata Pelosini

From left: Vito Carambia, Marco Cordola, Al Wallace, Chris Doyle and Stefano Bovo

The MOC also hosted the Weather Manager, to answer to the organisation for any criticalities linked with the weather service or the weather itself and to satisfy specific demands, especially regarding relations with the Media, also taking official positions. At least one daily contact of the Weather Manager with the meteorologists responsible for the activities at the single venues, in the WLC and the WOC, was guaranteed so that the service could operate properly.

2.4.11.1 Role of the Weather Manager

The weather service was mainly involved in decisions regarding the delay or rescheduling of certain competitions and official training sessions. The excellent link with the offices at the competition venues enabled prompt and detailed communication of the weather conditions observed and forecast in order to enable the rescheduling of the competition calendar as quickly as possible.

The staff at the MOC also played a key role in the coordination of the weather forecasts for the various competition venues, especially in the event of adverse weather or preparation of the long range weather forecasts.

Another role of the MOC meteorologists was that of issuing special reports for the information departments or the Civil Protection Department in the event of particularly adverse weather conditions. Furthermore, a role of introduction and explanation of the service to colleagues from other weather services, members of the Organising Committee of the next Olympiad and the information departments (mainly foreign) who presented official requests to such effect, was played.

Weather Manager - Renata Pelosini

Renata graduated from Milan University with a degree in physics in 1990. Since 1991 she has worked on weather-related issues, initially for the ENEL, where she was responsible for research and development in the field of meteorology models, contributing in 1994 to the creation of the operating weather forecast service. In 1997 at the World Downhill Ski Championships in Sestriere, she coordinated the weather support activities. Since 1997 she has worked for the Regional Agency for Environmental Protection of Piedmont (ARPA), coordinating weather forecasting activities and connected development activities for Regione Piemonte. In August 2003 she was assigned the post of Weather Manager for the Organising Committee of the XX Olympic Winter Games Torino 2006, for which she oversaw the construction of the nivo-meteorology service for the Games.

2.4.11.2 Recommendations for the future

The decision to allocate the Weather Manager to the MOC was a winning move for the organisation. The most expert meteorologist was always there to guarantee the coordination of the offices at the competition venues, acting as an interface between the Organising Committee, the Olympic and Paralympic Committees, the federations, the press and the decentralised offices. The Weather Manager has to have a position at the MOC, which is the heart of the whole organisational machine, all the nivo-meteorology information and the data measured in real time with the same updating frequency available at the venues, particularly to carry on with the nowcasting activity together with the venue staff in the event that competitions were delayed. The weather station inside the MOC always has to be manned, must always have team products and priority access to the products issued by the venues. The authority of the MOC meteorologists must be such as to not create conflict with the meteorologists and operators at the venues. The MOC meteorologists must be able to make decisions in uncertain conditions and their decisions must be automatically shared by the staff operating in the decentralised offices.

2.5 ASSESSMENT OF THE WEATHER FORECAST

2.5.1 ANALYSIS OF THE FORECASTS OF THE METEOROLOGY MODELS AND POST-PROCESSING METHODS

Inside the database which formed the base of the Web Olimpia 2006 application, different types of data were introdu-

ced, such as the forecast proposal to the meteorologists of each venue.
The different forecasts proposed as first guess are summarised in the table below:

PARAMETER	DIRECT OUTPUTS OF MODELS	POST-PROCESSING PROCEDURE OUTPUTS
Temperature	ECMWF LAMI	Kalman filter on ECMWF Multimodel SuperEnsemble
Relative humidity	ECMWF LAMI	Kalman filter on ECMWF Multimodel SuperEnsemble
Wind velocity	ECMWF LAMI	Multimodel SuperEnsemble
Wind direction	ECMWF LAMI	
Pressure	ECMWF LAMI	Kalman filter on ECMWF
Precipitation	ECMWF LAMI	Multimodel SuperEnsemble

ECMWF: IFS global model of the European Centre for Medium range Weather Forecasts (ECMWF), interpolated on the station point.
LAMI: Lokall Model limited area model in the Italian version, interpolated on the station point.
Kalman filter: the direct output of the ECMWF model was corrected with the application of the Kalman filter. For each station and forecast expiry, the Kalaman gain is calculated progressively for each day of forecast, enabling the correction of the forecast starting with the data observed.
Multimodel SuperEnsemble: more complex post-processing procedure which combines the forecasts of several models. Besides the ECMWF and LAMI models, the outputs of the AlMo (Lokall Model in the Swiss weather service version, MeteoSwiss) and Lokall Modell in the German weather service version, Deutscher Wetterdienst, were also used. For each input model, for each station and for each operational expiry, the weights are calculated on the basis of the respective services compared with the data measured in a training period. The forecasts of the various models are then combined with the respective weights to obtain the so-called SuperEnsemble.

Each forecast was elaborated on all the parameters for each station of the Olympic Area. The forecasts related to the "virtual stations" of each venue were entered into the DB, combining the most significant observations for the venue taken from different stations, consistently with the observations entered in the Web Olimpia 2006 system.

Availability of forecast data

The demand for the supply of data during the Olympics regarded 28 days (from the 1st to the 28th of February), with 14 days during the Paralympics (from the 6th to the 16th of March).
The availability of several input sources for the database enabled, on 100% of the days of forecast, an automatic suggestion for preparing the weather product, with different levels of reliability depending on the different methods implemented:
ECMWF: always available, slightly late on 2 days out of 28 during the Olympic period.
LAMI: always available, despite being extremely late on a significant number of days (it was reacquired on about 7 days out of 28 during the Olympic period).
Kalman filter: always available, with slight delays linked with the ECMWF delay 2 days out of 28 during the Olympic period.
Multimodel: always available and perfectly on time.

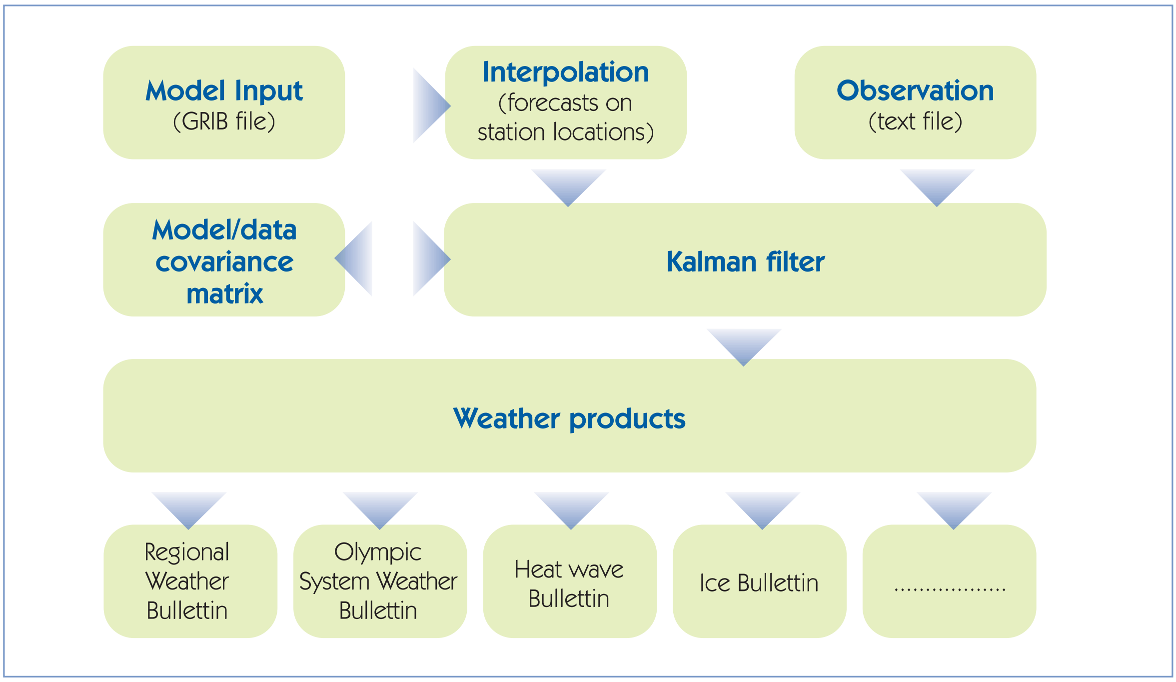


Figure 2.189 - Flow chart of the algorithm of the Kalman filter

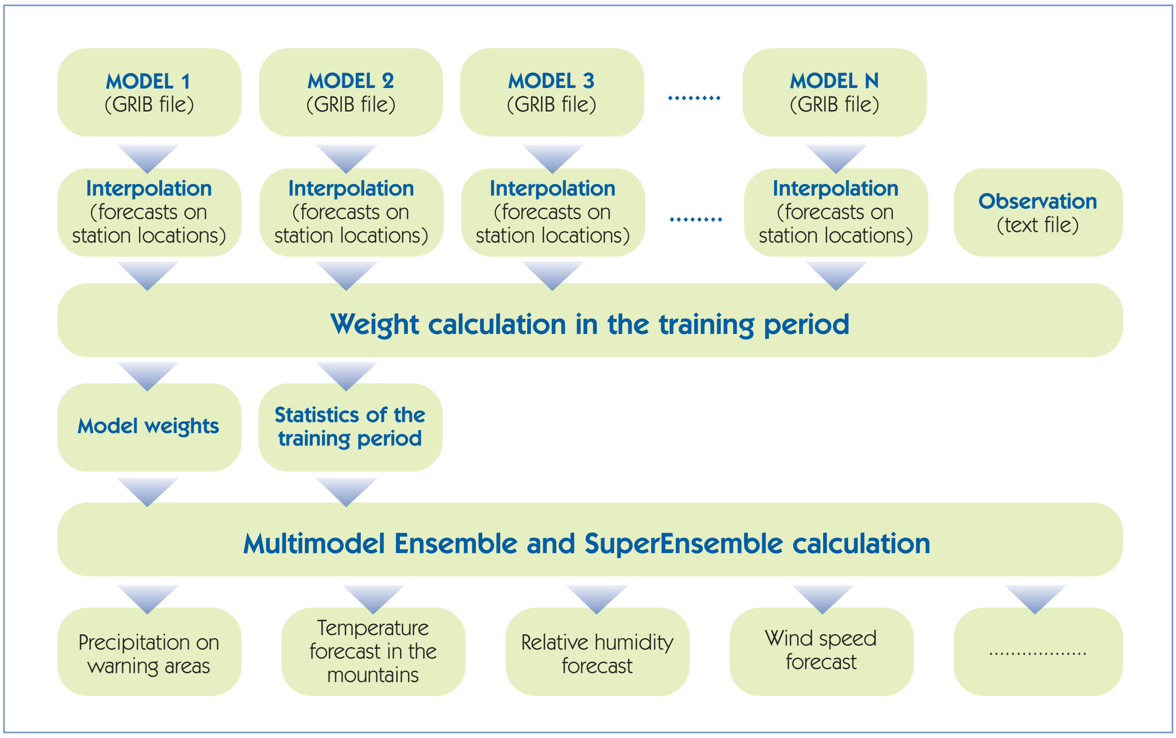


Figure 2.190 - Flow chart of the algorithm of the Multimodel SuperEnsemble

NOTE: the AlMo and Lokall Modell limited area models were supplied though a special agreement with Arpa Piemonte by MeteoSwiss and by Deutscher Wetterdienst. In accordance with the agreement reached, their use was limited to the Olympic (10-26 February) and Paralympic (10-19 March) periods. Due to the change in dominion of the Lokall Modell in the days leading up to the Games, the availability of forecast data of this model allowed for a very short trai-

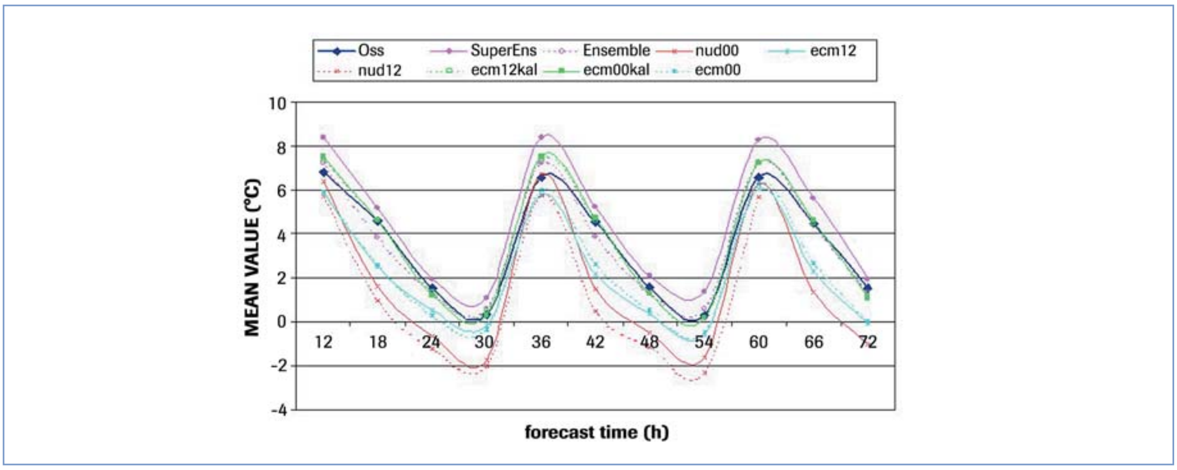


Figure 2.191 - Average value of the temperature forecast in the Olympic period for the Olympic Medal Plaza venue - Torino
SuperEns: Multimodel SuperEnsemble; Ensemble: Multimodel Ensemble; Obs: observations; nud00, nud12: LAMI model; ecm00, ecm12: ECMWF model; ecm00 kal, ecm12 kal: Kalman filter applied to ECMWF model.

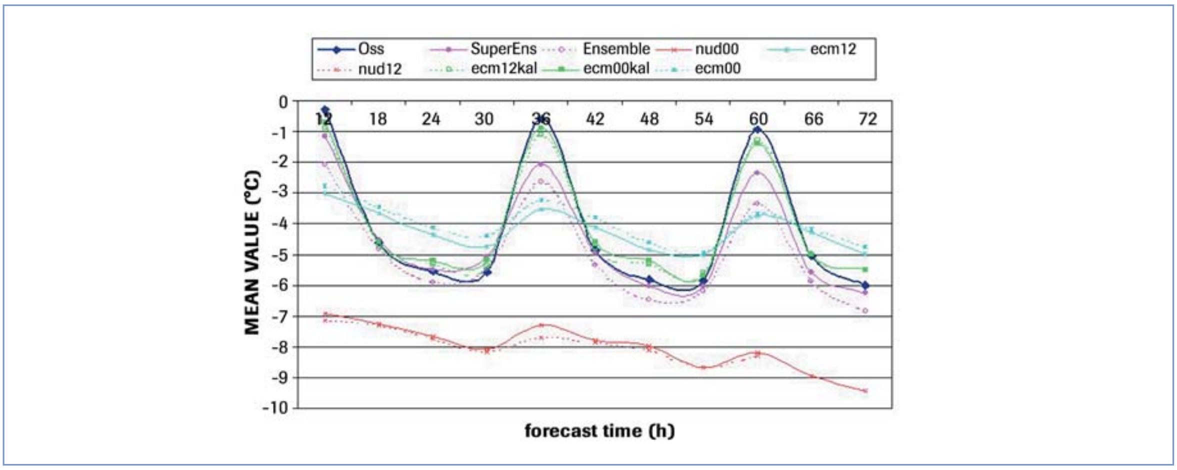


Figure 2.192 - Average value of the temperature forecast in the Olympic period for the Sestriere Colle venue
SuperEns: Multimodel SuperEnsemble; Ensemble: Multimodel Ensemble; Obs: observations; nud00, nud12: LAMI model; ecm00, ecm12: ECMWF model; ecm00 kal, ecm12 kal: Kalman filter applied to ECMWF model.

ning period, so the Multimodel SuperEnsemble supplied operationally to the forecasters was limited to the ECMWF, LAMI and AlMo models during the Olympic and Paralympic periods, with a suitable training period. The data supplied by the DWD was used for an experimental launch of Multimodel with a shorter training period.
The following analysis will therefore reflect the structure of the "virtual stations" for each Olympic venue. The services of the direct model outputs (DMO), Kalman filter and Multimodel are assessed for temperature, relative humidity, wind velocity and pressure.
For each value, the statistic parameters used were those commonly used for the variables that change constantly, such as the average value, the mean error (or bias), the mean absolute error and the root mean square error (RMSE). The period of analysis is the whole data supply period, i.e. 28 days for the Olympic period and 14 days for the Paralympic period.

Temperature

The direct outputs of the models present errors which are often very consistent, especially those of the LAMI model.

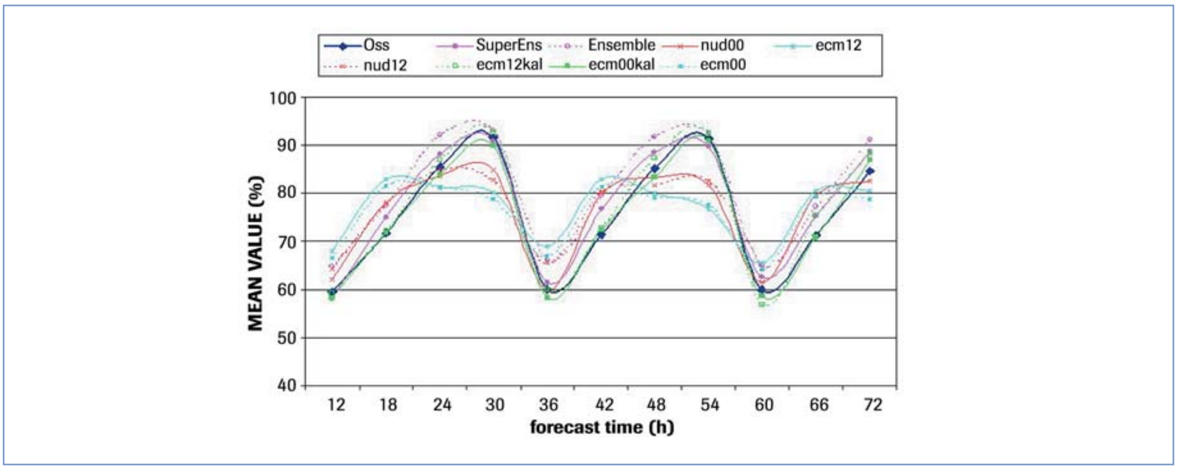


Figure 2.193 - Average value of the humidity forecast in the Olympic period for the Olympic Medal Plaza venue - Torino
SuperEns: Multimodel SuperEnsemble; Ensemble: Multimodel Ensemble; Obs: observations; nud00, nud12: LAMI model; ecm00, ecm12: ECMWF model; ecm00 kal, ecm12 kal: Kalman filter applied to ECMWF model.

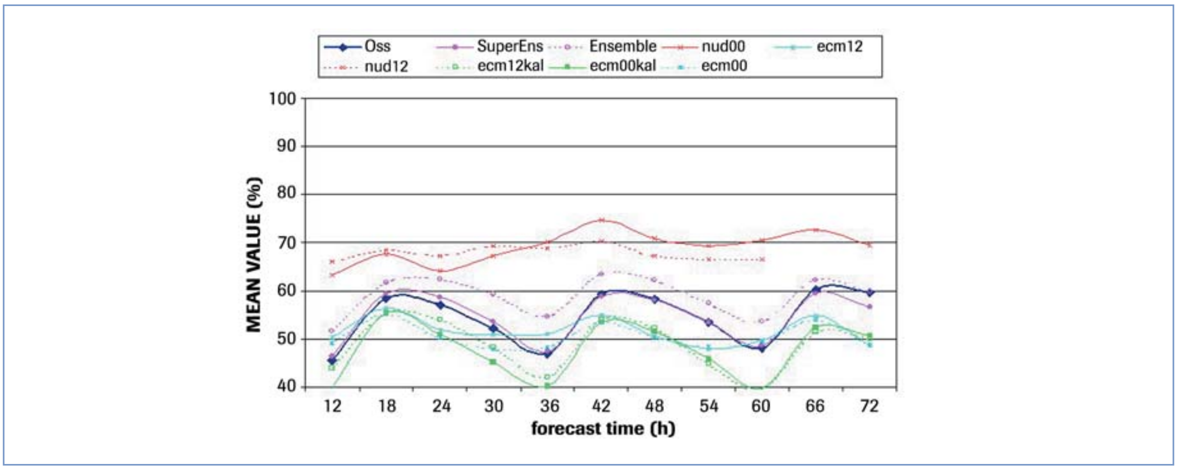


Figure 2.194 - Average value of the humidity forecast in the Olympic period for the Sestriere Colle venue
SuperEns: Multimodel SuperEnsemble; Ensemble: Multimodel Ensemble; Obs: observations; nud00, nud12: LAMI model; ecm00, ecm12: ECMWF model; ecm00 kal, ecm12 kal: Kalman filter applied to ECMWF model.

In the venues on the plains forecasts are acceptable, but in the mountains, mean errors of up to 6/7 °C occur.
The post-processing methods (Kalman, Multimodel) enabled a considerable improvement in the forecasts for all the venues considered. The improvement is particularly evident in the mountains, where the mean error was reduced everywhere to values below 1 °C, while the RMSE was usually below 2 °C. Even better values were achieved on the plain, with practically zero errors for all the expiries and RMSE lower than 1.5 °C.
The comparison between the two methods is however harder, because both reported comparable skills. In general, the Kalman filter was less "biased", with mean error values always close to zero, indicating that, in general, the values were neither overestimated nor underestimated. On the other hand, the Multimodel SuperEnsemble, despite slight bias, reported lower values for the RMSE, indicating smaller errors than the Kalman filter.
As regards the subdivision of the shares, there is a slight prevalence of the Kalman filter on the plains and of Multimodel at high mountain altitudes, while it hard to establish which behaves better at lower mountain altitudes (e.g.: Multimodel attained much better results than Kalman at CSS, while the opposite can be said for BDY).
During the Paralympic period, the performances of the models were comparable with those described earlier

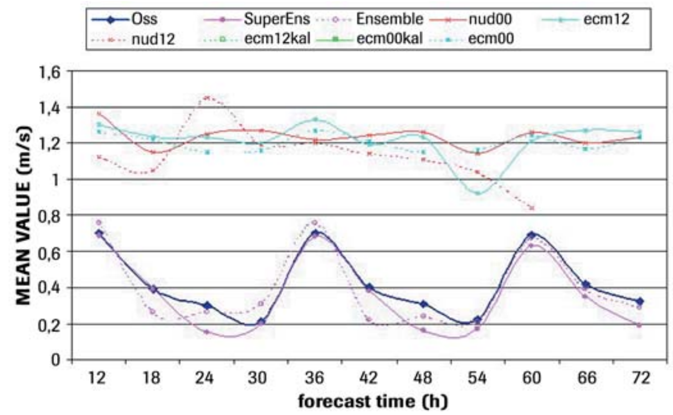


Figure 2.195 - Average value of the wind velocity forecast in the Olympic period for the Olympic Medal Plaza venue - Torino
SuperEns: Multimodel SuperEnsemble; Ensemble: Multimodel Ensemble; Obs: observations; nud00, nud12: LAMI model; ecm00, ecm12: ECMWF model; ecm00 kal, ecm12 kal: Kalman filter applied to ECMWF model.

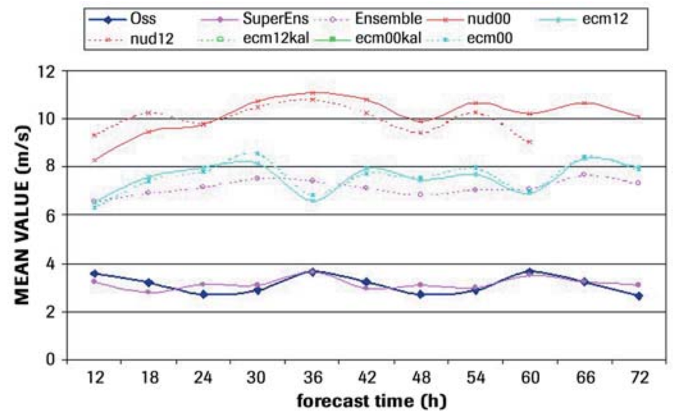


Figure 2.196 - Average value of the wind velocity forecast in the Olympic period for the Sestriere Colle venue
SuperEns: Multimodel SuperEnsemble; Ensemble: Multimodel Ensemble; Obs: observations; nud00, nud12: LAMI model; ecm00, ecm12: ECMWF model; ecm00 kal, ecm12 kal: Kalman filter applied to ECMWF model.

for the Olympic period. Only the Kalman filter seems to be less efficient than the Multimodel at the low altitude stations.

Relative humidity

The results of the direct outputs of the models were acceptable on the plains, fair at the high mountain venues and unacceptable at lower mountain altitudes.

The post-processing methods were unable to improve the forecast, especially at lower mountain altitudes, but at all altitudes they achieved performances, compared with the DMOs, with mean errors of about 5% and RMSE of about 10% on the plain and 15% in the mountains.

In this case too it is hard to discriminate between the use of the Kalman filter and the Multimodel SuperEnsemble. Both obtained good results in the reduction of the mean error and the RMSE, without either prevailing over the other.

In particular, it can be observed that the Kalman filter is slightly better than Multimodel every time the ECMWF model

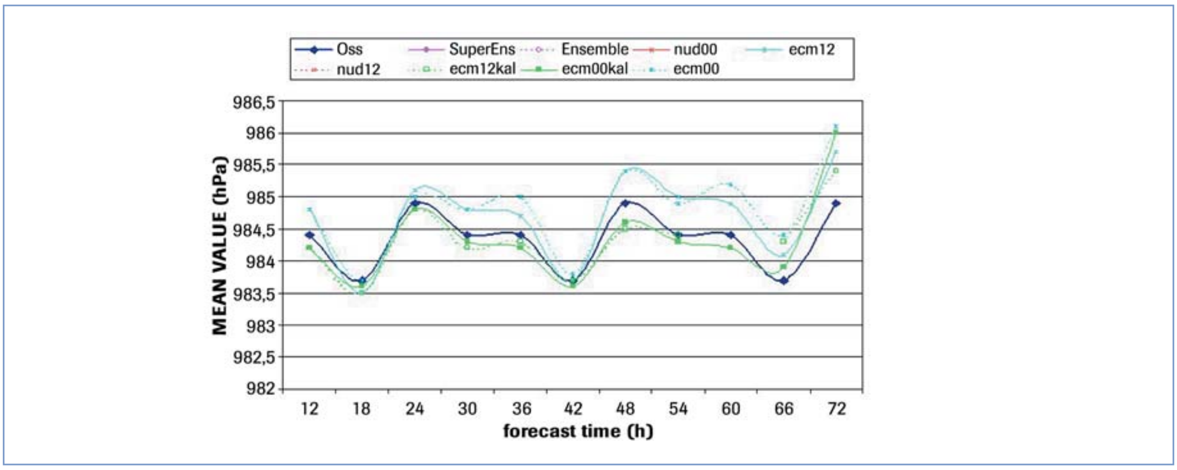


Figure 2.197 - Average value of the pressure forecast in the Olympic period for the Olympic Medal Plaza venue - Torino
SuperEns: Multimodel SuperEnsemble; Ensemble: Multimodel Ensemble; Obs: observations; nud00, nud12: LAMI model; ecm00, ecm12: ECMWF model; ecm00 kal, ecm12 kal: Kalman filter applied to ECMWF model.

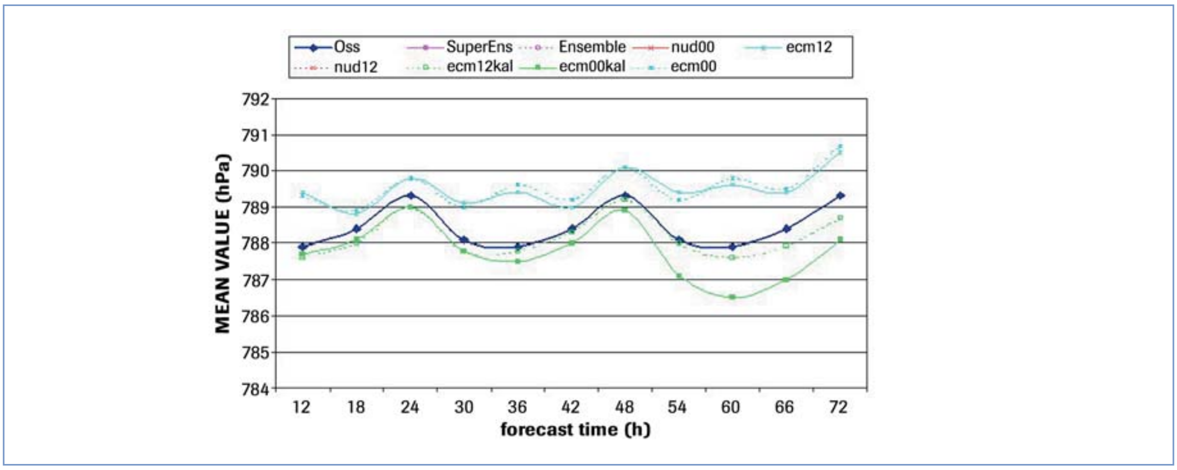


Figure 2.198 - Average value of the pressure forecast in the Olympic period for the Sestriere Colle venue
SuperEns: Multimodel SuperEnsemble; Ensemble: Multimodel Ensemble; Obs: observations; nud00, nud12: LAMI model; ecm00, ecm12: ECMWF model; ecm00 kal, ecm12 kal: Kalman filter applied to ECMWF model.

(used for calculation) presents relatively good forecasts. When the model is less acceptable however, the Multimodel SuperEnsemble, which also combines other models, despite probably having inferior performances, brings added value to the forecast.
The same considerations can be made for the Olympic period and for the Paralympic period.

Wind velocity

The direct outputs of the models are practically unusable as they overestimate the winds effectively measured everywhere especially at high mountain altitudes. From the forecasting experience we can observe that, in actual fact, the direct outputs of the models (particular of the LAMI) were more useful for estimating gusts of wind (also from the timing viewpoint) than average wind, which was usually overestimated. It is also possible to see that the models in general do not adequately describe the breeze condition in the mountains, which is characterised by a quite regular oscillation in wind velocity with higher values in the middle of the day. At some venues the models actually described a trend which was exactly the opposite of that observed.

The only post-processing method used for wind velocity was the Multimodel SuperEnsemble, which is usually more suitable than the Kalman filter for operation on variables which do not change constantly, like wind or precipitation.
The result of the application of the Multimodel to the wind velocity forecast is highly satisfactory. At all the venues there was a significant reduction in errors, particularly evident at high mountain altitudes.
The mean error value was virtually nil on the plain and at high mountain altitudes and below 0.5 m/s at middle mountain altitudes.
The RMSE was below 0.5 m/s on the plain and between 1 m/s and 1.5 m/s at the mountain venues, with the exception of SSF where it settled at 2 m/s.
The same considerations can be made for the Olympic period and for the Paralympic period.

Pressure

The suggestion of predicted pressure was only included in the database at the last moment, and this is why the proposal for forecasters was restricted to forecasts supplied by the ECMWF model and the Kalman filter applied to it.
The ECMWF forecasts, suitably interpolated at the station altitude, were usually adequate for all venues, despite sometimes being characterised by mean errors of about 2-3 hPa. Post-processing with the Kalman filter significantly improved the average forecast error, substantially eliminated by the use of the filter.
The RMSE of the direct output of the model and the Kalman filter was highly satisfactory, being around 1 hPa at all the venues. However the Kalman filter presented a sudden worsening of the RMSE in the last expiries (from +60 h to +72 h).
The same considerations can be made for the Olympic period and for the Paralympic period.

Conclusions

The forecasts introduced into the database as suggestions for the forecasters at the venues were producer with exceptional reliability. The Multimodel SuperEnsemble in particular, not being linked to the acquisition of a single model, was an extremely strong and reliable method.
From the viewpoint of the quality of the data entered, the direct outputs of the models had contrasting results, depending on the variable considered and the venues. In the middle mountain venues in particular, the forecasts were usually unsatisfactory.
The post-processing methods enabled a considerable improvement in the forecasts of all variables and all venues and therefore represented an extremely important aid in the automatic suggestion of the forecasts to the forecasters at each venue.
The performances of the Kalman filter and the Multimodel SuperEnsemble were usually comparable and the availability of several sources of good quality input data provided a broad selection of choices for each venue forecaster.

2.5.2 CHECK ON THE CORRECT NATURE OF THE FORECASTS

2.5.2.1 Numeric forecasts

During the Olympic and Paralympic periods the C49 report (see ref. Chapter 2) containing both a textual part of weather information and a numeric part of the forecast for the 3 days following the day of issue, was issued every day. In particular, the numeric forecast was formulated with an hourly expiry starting at 6.00 a.m. local time until 9.00 p.m. for the first day, with three-hourly expiries for the second and third days starting at 00.00 until 9.00 p.m.
The variables forecast were the following: sky condition, air temperature, relative humidity, wind direction and intensity, quantity of precipitation, snow surface temperature, velocity of the strongest gust of wind, type of precipitation and atmospheric pressure.

Refining a forecast in the space and time requested is undoubtedly one of the hardest and most delicate jobs. The post-processing systems, analysed in the previous paragraph, contributed considerably to improving the forecasting accuracy, being highly reliable instruments, tested and checked for over a year in the Olympic Area: every forecaster was therefore able to perfect and gauge his experience localising it throughout an extremely specific, restricted and complex territory, studying the behaviour of the meteorology models and the trend of the post-processing systems applied.

2.5.2.2 Analysis of results

Overall, the forecasts were correct and precise, during both the Olympic and Paralympic events: the various criticalities at the single venue were satisfactorily predicted, with the right times and no false alarms or absence of warning.

There was however some imprecision, particularly linked to the overestimate or underestimate of the amounts of precipitation or an incorrect forecast of the snow depth limit. The latter, in particular, determined an incorrect forecast for the city of Torino on the 19th of February, when a deep depression from the Atlantic approached the North-West Alps, causing unsettled weather conditions from the morning onwards at all the mountain venues with widespread snow, and snowy precipitation even on the plain, meeting a layer of cold air in the lower strata of the atmosphere.

The trend of the main variables is analysed below: temperature, humidity, wind, gust intensity and precipitation. The most objective instrument for verifying the forecasts issued is the C49 numeric report: for every expiry and every venue the mean error (ME) of the forecasts formulated, the root mean square error (RMSE), the mean absolute error (MAE) and a comparison between the mean value forecast and mean value observed for the variables. In short, the figures below show explanatory graphs of the comparison between forecasts issued and observations in two venues, Sestriere and Torino, one being representative of an Olympic mountain venue and the other of a plain venue.

Let's start to analyse the temperature forecasts formulated.

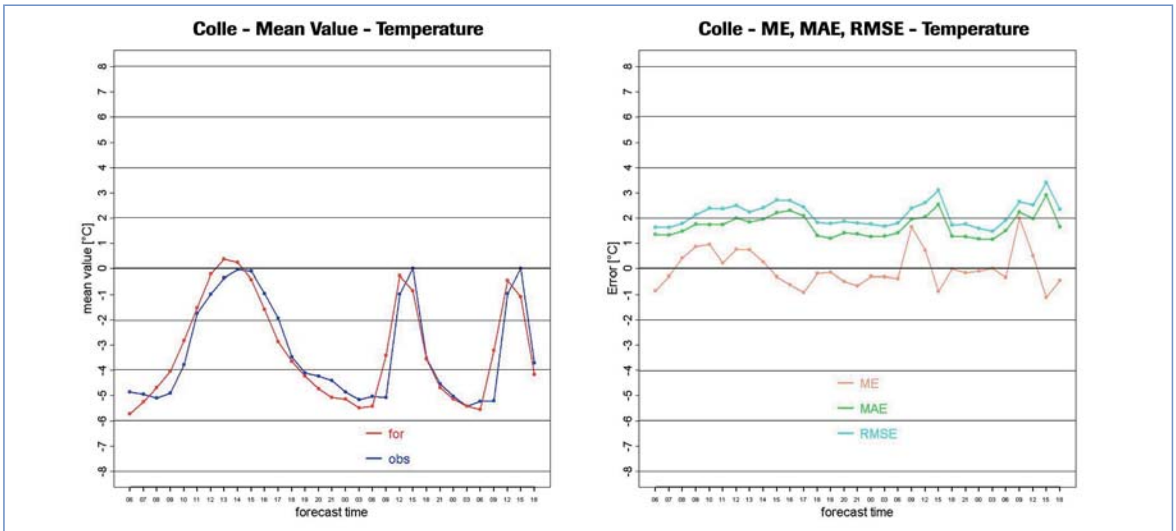


Figure 2.199 - Analysis of the results of the temperature forecast for the Sestriere Colle venue for the Olympic period

The left side of the figure shows the average temperature values forecast and observed in relation to the forecast time, i.e. the expiry for which the forecast was formulated. The right side shows the ME, MAE and RMSE of the forecast formulated.

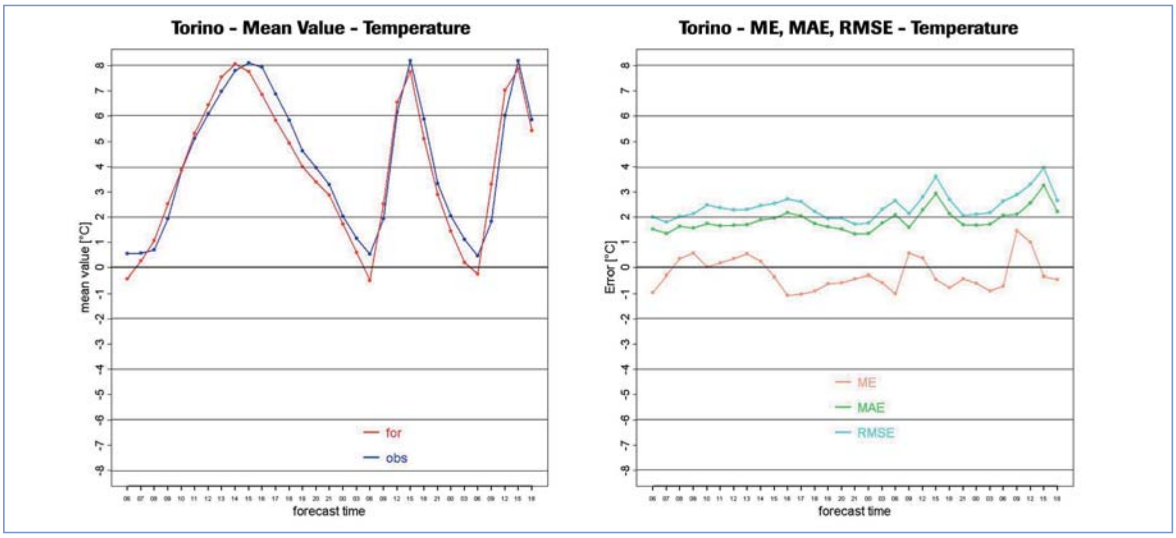


Figure 2.200 - Analysis of the results of the temperature forecast for the Torino venue for the Olympic period
The left side of the figure shows the average temperature values forecast and observed in relation to the forecast time, i.e. the expiry for which the forecast was formulated. The right side shows the ME, MAE and RMSE of the forecast formulated.

A common observation which can be drawn from the analysis of the results is that the maximum and minimum temperature values were forecast effectively, despite detecting an increase in error with the increase in expiry. A slight anticipation (also generalised for all the other venues) can however be noticed in the temperature trend forecast compared with that observed, meaning that the minimum and maximum values were both forecast slightly early.
As far as the systemic errors in forecasting are concerned, good overall results were achieved: the main error peaks occurred during the morning (9, 10, 11 a.m.), this allows us to assume that the hours when there is more change in temperature during the day (i.e.: the temperature rises suddenly due to the sun) are the expiries for which it is harder to make an accurate forecast.
Now let's quickly analyse the humidity forecast.

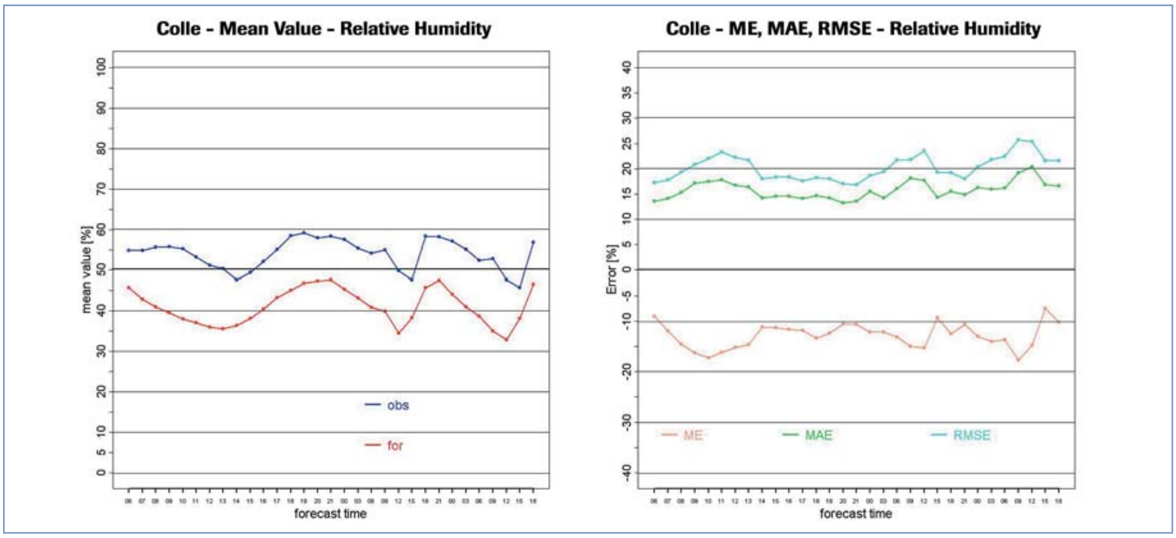


Figure 2.201 - Analysis of the results of the humidity forecast for the Sestriere Colle venue for the Olympic period
The left side of the figure shows the comparison of the relative humidity values forecast and observed, arranged in accordance with the forecast time, i.e. the expiry for which the forecast was formulated. The right side shows the ME, MAE and RMSE of the forecast formulated.

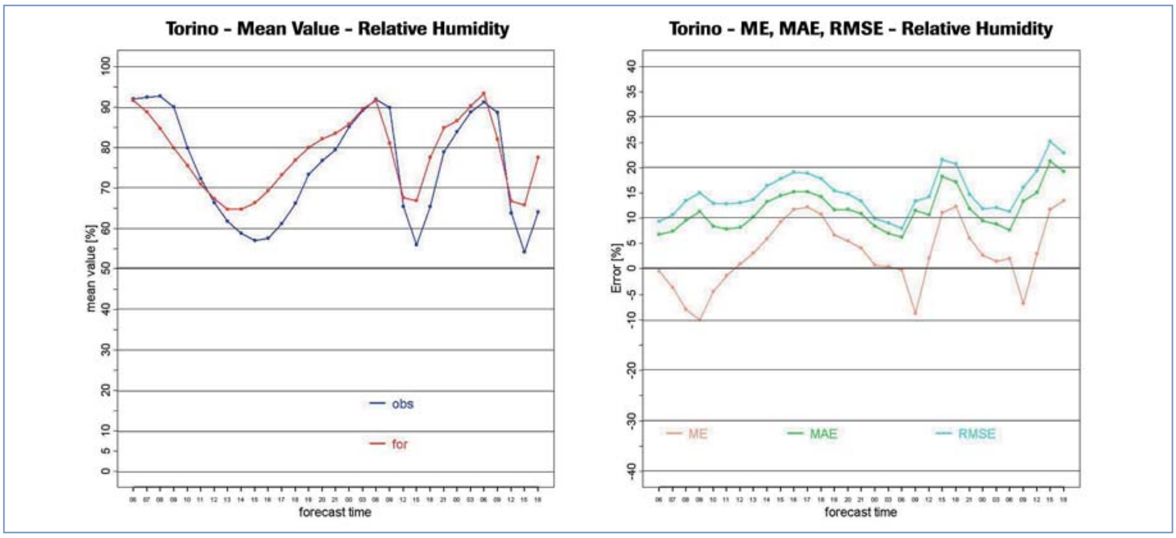


Figure 2.202 - Analysis of the results of the humidity forecast for the Torino venue for the Olympic period
The left side of the figure shows the comparison of the relative humidity values forecast and observed, arranged in accordance with the forecast time, i.e. the expiry for which the forecast was formulated. The right side shows the ME, MAE and RMSE of the forecast formulated.

Analysing the previous figures, we find very different scenarios and behaviours for the two venues taken into consideration. As far as Sestriere Colle is concerned, we can see a systematic underestimate of the humidity trend during the day, which for Torino there is a good overall result, despite a systematic overestimate in humidity in the afternoon.

As every venue had its own individual characteristics in terms of the daily humidity trend, if we analyse the results of all the venues, we find different types of error, linked closely to the location of the venue, exposure, sun, position in relation to altitude or the valley, or the slope…

Moving on to consider the wind velocity fields, the results of the accuracy of forecasting in Sestriere Colle, Torino and Sauze d'Oulx are shown below.

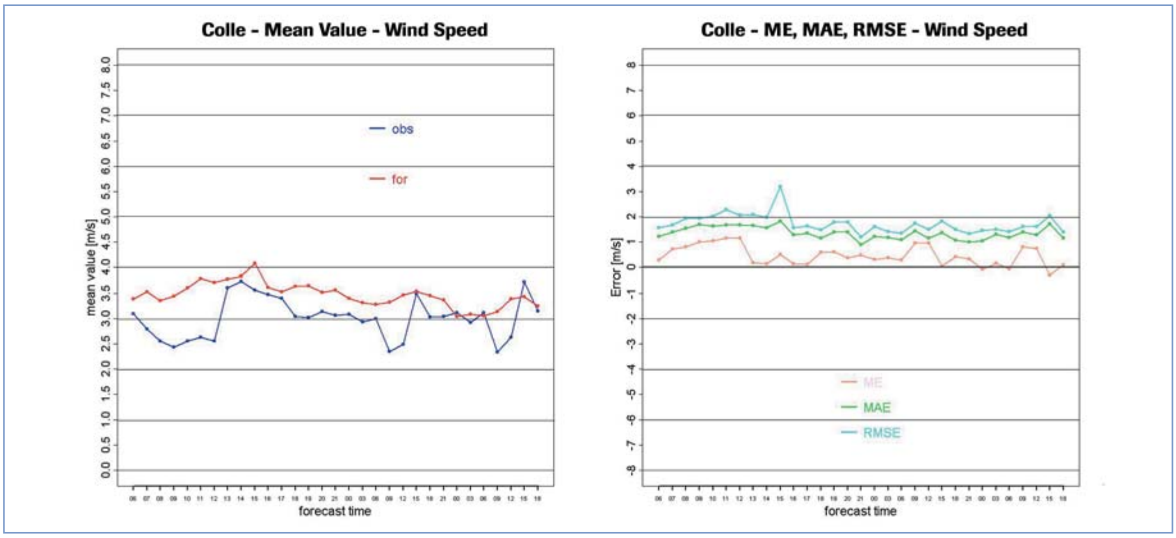


Figure 2.203 - Analysis of the results of the wind velocity forecast for the Sestriere Colle venue for the Olympic period
The left side of the figure shows the comparison of the wind values forecast and observed, arranged in accordance with the forecast time, i.e. the expiry for which the forecast was formulated. The right side shows the ME, MAE and RMSE of the forecast formulated.

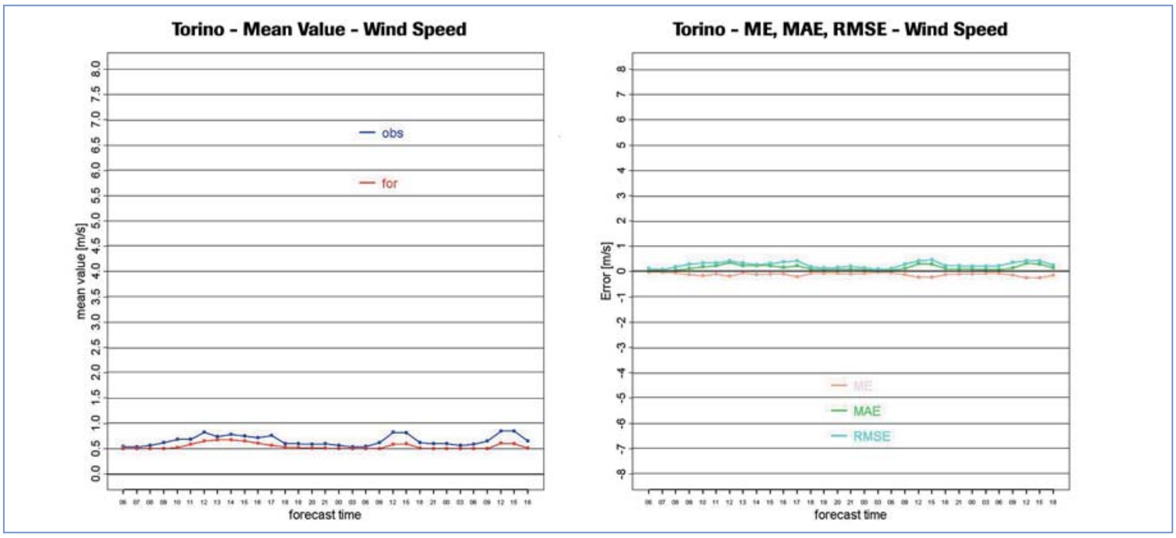


Figure 2.204 - Analysis of the results of the wind velocity forecast for the Torino venue for the Olympic period

The left side of the figure shows the comparison of the wind values forecast and observed, arranged in accordance with the forecast time, i.e. the expiry for which the forecast was formulated. The right side shows the ME, MAE and RMSE of the forecast formulated.

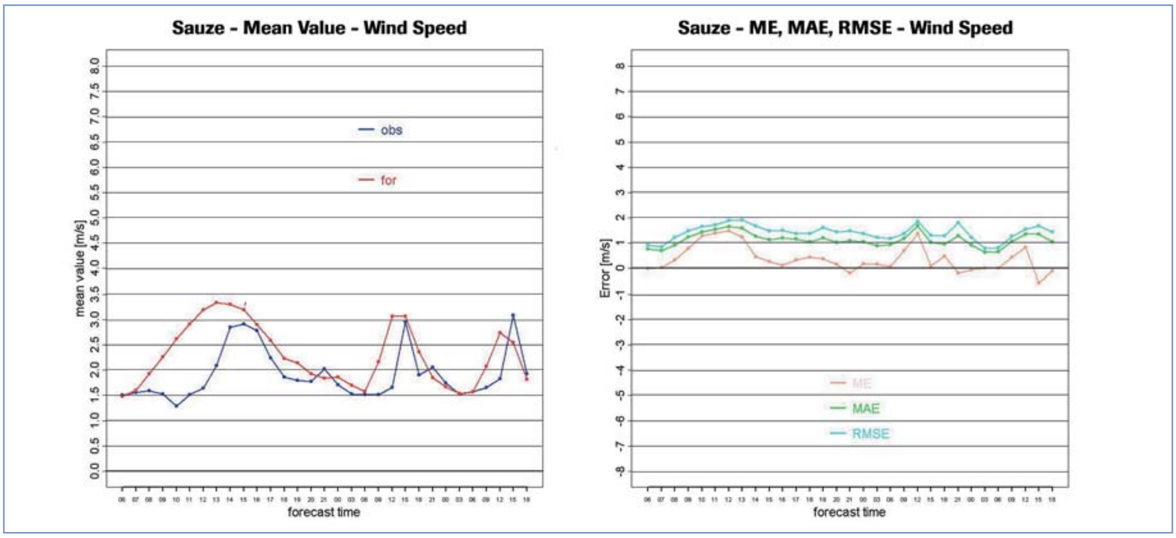


Figure 2.205 - Analysis of the results of the wind velocity forecast for the Sauze d'Oulx venue for the Olympic period

The left side of the figure shows the comparison of the wind values forecast and observed, arranged in accordance with the forecast time, i.e. the expiry for which the forecast was formulated. The right side shows the ME, MAE and RMSE of the forecast formulated.

In this case, the decision was made to show the results for the three venues, being representative of a venue on the plain, a high mountain venue and a middle valley venue, to highlight the diversity of the wind velocity forecast depending on the altitude and position of the location: the venue of Sauze d'Oulx was not chosen casually, but because it is situated at an altitude of about 1400 m on the mountainside and highly subject to breezes.

Let's start to compare the values forecast and observed at Sestriere Colle: as you can see, the maximum forecast errors occurred in the middle of the day (about 12.00 local time).

This phenomenon was mostly significant in the analysis of error at Sauze d'Oulx (figure 2.205), where the forecasting of intensification of the wind in the middle of the day, due to the arrival of breezes, is more difficult and more

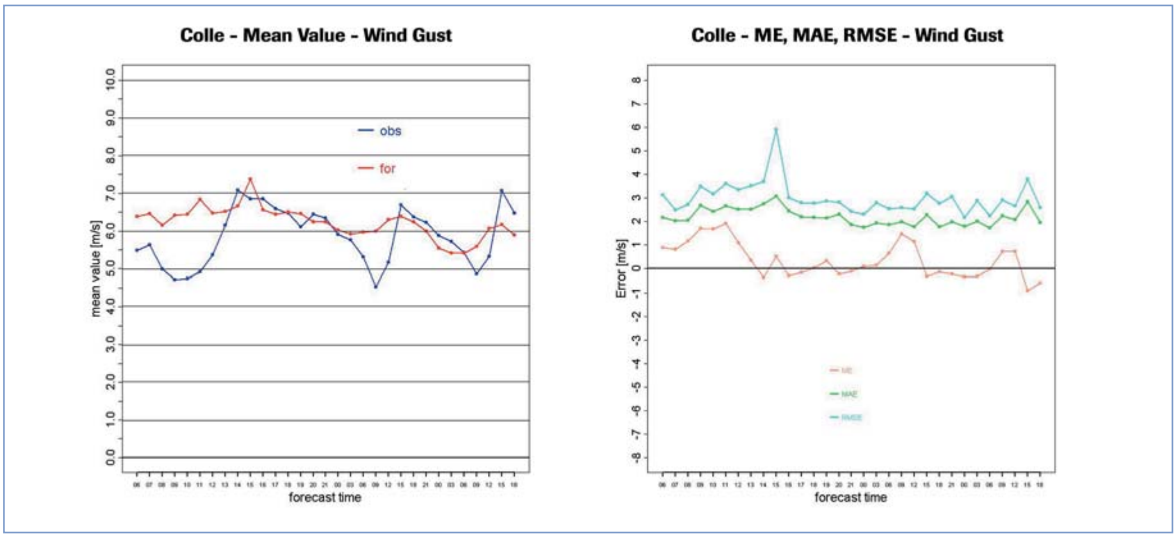


Figure 2.206 - Analysis of the results of the maximum wind velocity (gust) forecast for the Sestriere Colle venue for the Olympic period

The left side of the figure shows the comparison of the wind values forecast and observed, arranged in accordance with the forecast time, i.e. the expiry for which the forecast was formulated. The right side shows the ME, MAE and RMSE of the forecast formulated.

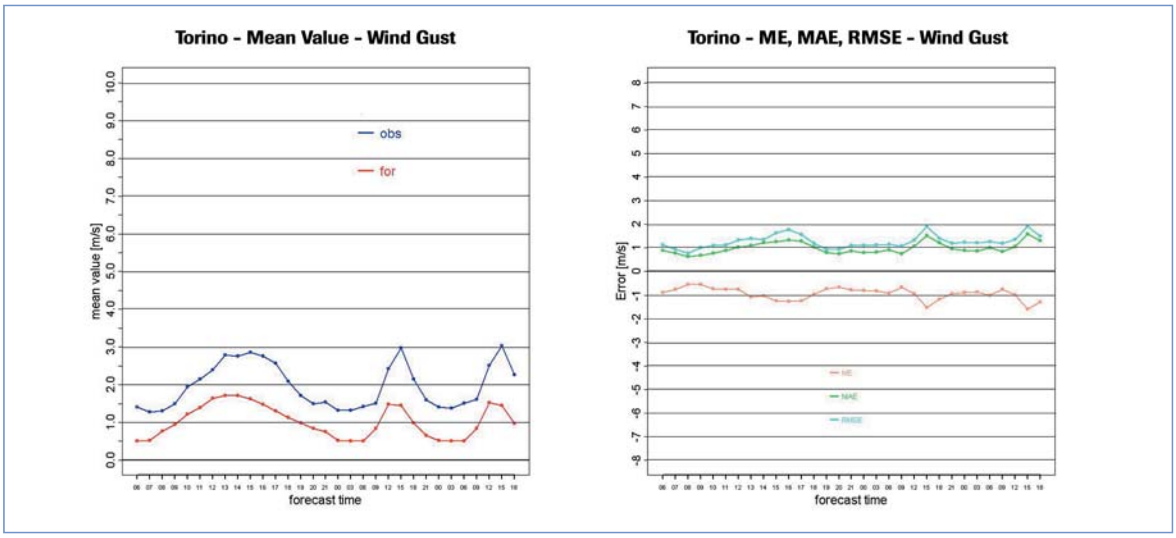


Figure 2.207 - Analysis of the results of the average wind velocity forecast for the Torino venue for the Olympic period

The left side of the figure shows the comparison of the wind values forecast and observed, arranged in accordance with the forecast time, i.e. the expiry for which the forecast was formulated. The right side shows the ME, MAE and RMSE of the forecast formulated.

subject to estimation errors.

As regards Torino, the mean wind was almost always calm or weak, so the forecast error was always minimal or nil, despite there being a slight systematic underestimate.

Examining the wind forecast in further detail, we can examine gust values. On average, we can say that the forecasting of maximum wind values was very good, especially when we consider that it is an area which is hard to forecast, partly due to its uncertain component, thanks to the fundamental and predominant role played by the forecaster's experience.

Figure 2.206 shows a slight overestimate, in gust values, especially in the morning, although the maximum values during the day appear to have been effectively forecast. As regards the results of the check for the other venues, the

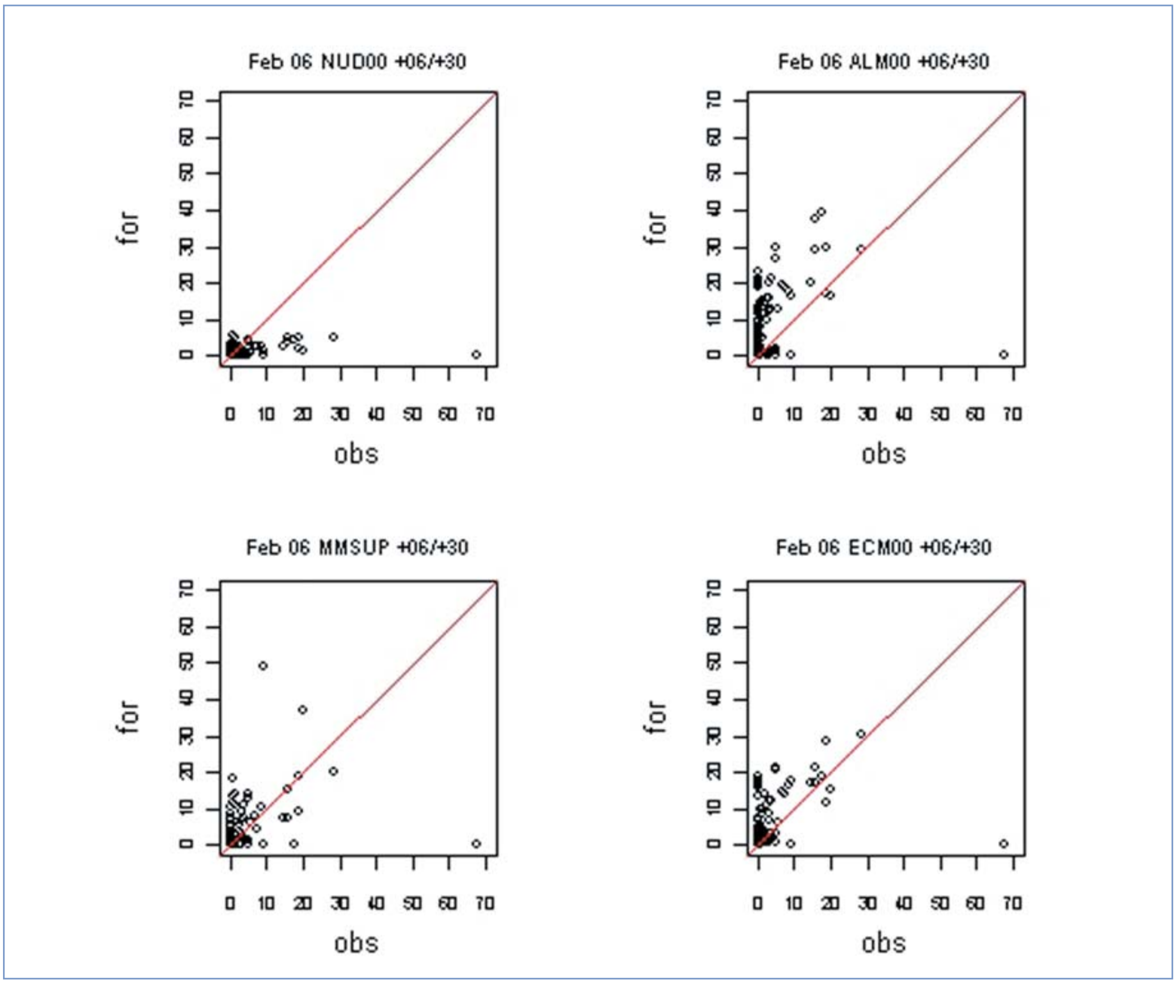


Figure 2.208 - Comparison of the values forecast and observed accumulated over 24 hours on the virtual stations of the Olympic network: from top left moving clockwise, LAMI run 00UTC (NUD00), aLMo run 00UTC, ECMWF run 00UTC and MultiModel (MMSUP)

behaviours observed were different, although there was often a tendency to overestimate.
In Torino, on the other hand, as seen in figure 2.207, the maximum gusts, despite continuing to be weak, were slightly but systematically underestimated, despite their daily cycle having been correctly forecast.

We ought to open a separate chapter for precipitation: the most subjective check was hat carried out in real time at the venue itself, where the observation and visual estimate of the precipitation was the most reliable and effective measuring instrument. Consequently, each forecaster in his own venue checked the amounts of precipitation forecast from day to day, along with the relative times. With the collection of this information by each forecaster, it was possible to obtain a general picture of the situation: up to the 15th of February there was no precipitation due to the constant presence of a flow of dry north-westerly currents over the North-West Alps. The atmospheric conditions changed drastically from the evening of the 15th onwards, with precipitation almost every day. The times and amounts of precipitation were precisely quite accurately forecast. It was harder to forecast the snow altitude, as mentioned earlier, but a good level of accuracy was obtained, apart from in a few isolated cases.
A comparison is made below with the amounts of precipitation proposed by the various models: the outputs of

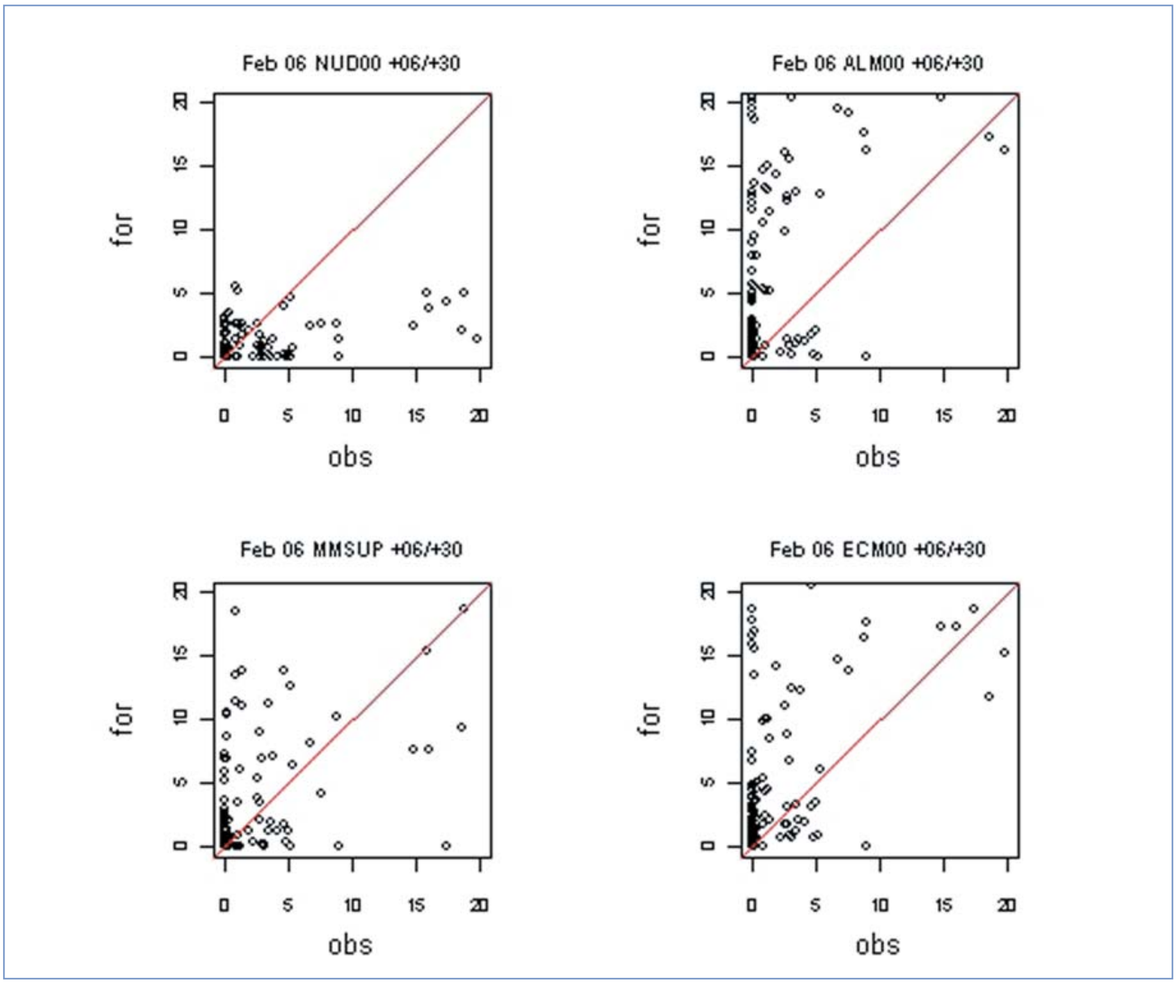


Figure 2.209 - Detail of figure 2.208 with precipitation values up to 20 mm

the runs of the 00 UTC of LAMI, aLMo, ECMWF and the MultiModel interpolated at each reference station of the Olympic Area, were considered.

The forecasts and observations for the 11 "virtual stations" representing each venue were compared, considering the values of precipitation accumulated over 24 hours in a "forecast time" interval ranging from +6h to +30h. The study was carried out both for the Olympic period (considering the whole months of February) and the Paralympic period (considering the whole month of March) and the same considerations are valid for both.

In general, as shown in figures 2.208 and 2.209, the performance levels obtained were quite good, with a few isolated cases of considerable underestimate or overestimate.

ECMWF and aLMo both show an overestimate for small and large amounts of precipitation, while LAMI seems to behave differently: in fact for small amounts of precipitation, a substantial agreement between forecast and observation emerges, while for values in excess of 5 mm, there is a clear underestimate of the precipitation values. Good performance levels were also obtained by the MultiModel, where there seem to be less overestimate and underestimate errors in general.

An objective check on precipitation in the mountains usually involves a series of big problems related to measuring the effective snowfall in the time interval considered: if we use the data related to heated pluviometers (rain gauges), we often find delays due to the heater itself which falsify the measurement value. Nor does the snow gauge supply totally reliable and consistent results. Let's take the snow that fell on the 19th of February for example and the relative measurements taken by the infrared snow gauges and manual detectors.

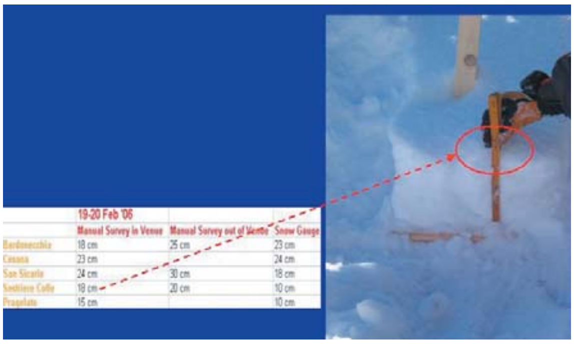


Figure 2.210 - Example of measurement of snow on the ground, performed manually inside and outside the venue and measured using the snow gauge

As shown in figure 2.210, the values measured for the depth of snow which fell over the 24-hour period, they are often very different depending on the instrument used or the place the measurements were taken. The same manual measurement taken inside the venue is different if taken in a point of the course outside the venue, at an altitude a few hundred metres higher. Them, if we consider the value registered by the automatic snow gauge too, the result is even more different. Therefore it is easy to understand how the objective estimate of the amounts of snowy precipitation is complex and hard to interpret.

2.5.2.3 Conclusions - comparison with DMO and post-processing

In general, the forecasts during the Olympic period and the Paralympic period, reached a good level of accuracy: the errors made were limited in terms of quantity and timing, with highly accurate forecasts, also reaching a high level of satisfaction at every venue.

Once again we must highlight the component deriving from the output of the meteorology models or post-processing, which were definitely an indispensable instrument for a detailed "first guess" of the fields of the variables concerned.

In conclusion of the elaborations and processes applied, the most important added value in drawing up the forecast consisted in the application of the forecaster's experience and intuition, refined by specialised and specific skill in relation to the characteristics of the venue, acquired directly on-site.

2.5.3 CHECK ON THE LONG RANGE WEATHER FORECAST

2.5.3.1 General observations

The summarising table below indicates the percentages of reliability obtained by the long range forecasts (six days) drawn up independently by the Weather Local Centres of the various venues.

The check was carried out in relation to the forecasting of the prevailing weather symbols indicated for every day in the report, comparing the forecast with the prevailing weather effectively observed that day at the venue.

The period examined is variable depending on the start of the dispatch of the long range forecast by each venue, but should be indicated from the end of January until the last week of March- end of the Paralympic Games- with an interruption (also variable depending on the venue) between the end of the Olympic Games and the week before the start of the Paralympics.

2.5.3.2 Analysis of the check results

As shown by the summarising table, the results were very good on the whole, with a high forecast accuracy. The last column on the right shows the average reliability percentage of the long range forecasts: it begins with a value of 90% for the first day of forecasting (the meteorological "tomorrow"), falling to 80% on the third and fourth days and finally to 75% on the fifth and sixth days.

If we narrow down the field of analysis to the results of the various venues, we observe that, in any case, reliability never falls below 70%, the lows being on the fifth and sixth days, and never below 85% on the first day of forecasting or

below 80% on the second day.
We can safely say that the forecasts indicated in the various long range forecasts for "tomorrow" and "the day after tomorrow" were almost always close to reality, meaning that the prevailing weather for the two days was always correctly individuated.

Several comments and details must be presented however: firstly, the results obtained by the products processes at the various WICs of the different venues were not directly comparable, as the periods of issue changed greatly from venue to venue.
Secondly, inside the sample of days used for the check, some brief sub-periods of stable and sunny weather were observed, particularly in the first ten days of February (approximately, because obviously the weather conditions changed from venue to venue), during which it was much simpler, given the stable situation, to make a short-medium range forecast rather than a long range forecast. These results, combined with the relative tests for sub-periods with more unpredictable and unsettled situations, obviously helped raise the percentages of reliability obtained on the whole.
In conclusion, we can say that, within the limits of a check carried out on prevailing weather symbols indicated within long range weather forecasts, the results obtained were very good, and the long range forecasting formula, venue by venue, was effective.

	STC-STB	SSF	CSS	CSP	PRP	PRA	TO-PIN	SDO	BDY	TOTAL
Day 1	90	90	90	90	90	85	85	90	90	90
Day 2	85	90	80	85	90	85	85	85	85	85
Day 3	80	80	80	80	80	75	80	80	85	80
Day 4	80	75	80	80	80	80	80	80	80	80
Day 5	75	75	75	80	80	70	80	80	75	75
Day 6	75	75	75	75	75	70	80	75	70	75

Figure 2.211 - Results obtained from the check on the long-term weather forecasts
Key:
STC-STB: Sestriere Colle - Sestriere Banchetta
SSF: San Sicario Fraiteve
CSS: Cesana San Sicario
CSP: Cesana Pariol
PRP: Pragelato Plan
PRA: Pragelato
TO-PIN: Torino - Pinerolo
SDO: Sauze D'Oulx
BDY: Bardonecchia
TOTAL: overall average of the results

2.6 BUDGET

The budget available fore the nivo-meteorology assistance service was € 3,705,484.00, to which the Organising Committee and Arpa Piemonte contributed, as shown in the table below, in a proportion of 70% and 30% respectively.
It should also be pointed out that the majority of investments by Arpa Piemonte regard durable assets, particularly hardware and meteorology instruments, which shall remain the Agency's property. Part of the costs sustained by the TOROC too are linked to durable assets, and must therefore be considered as an investment the effects of which will continue after the Olympic period.

The budget available was used up entirely and the expenses were distributed among the various cost items, as shown in the table below.
As we can see, the expenses for labour costs are weighted, proving the importance of "people" in the provision of the service, not only in the short period of the Games but also during the preparatory and test phases, guaranteeing the achievement of a high level of quality and experience.

Another important budget item is that related to the combination of hardware, software, connectivity and technological equipment, which accounts for a percentage of 39%.

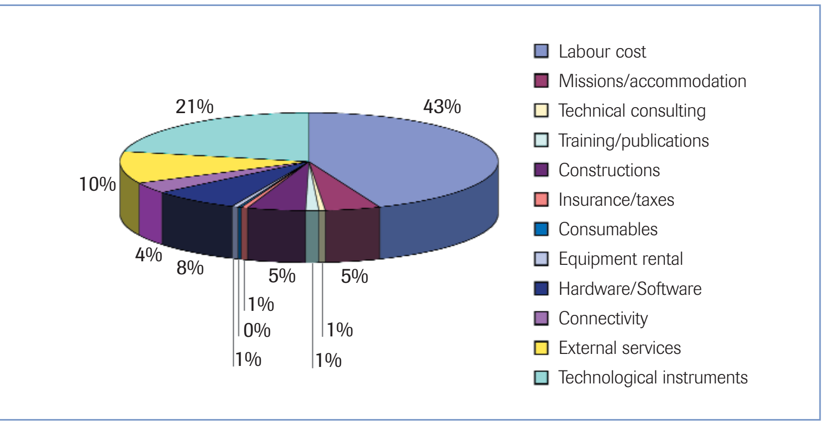


Figure 2.212 - Graphic representation in percentage of expenses sustained in the different cost categories

INCOME	
ARPA Budget	€ 1.123.200,00
TOROC Budget	€ 2.582.284,00
TOTAL	€ 3.705.484,00

EXPENSES	
Labour cost	€ 1.628.396,00
Missions/accommodation	€ 170.705,00
Technical consulting	€ 26.245,00
Training/publications	€ 35.079,00
Constructions	€ 184.635,00
Insurance/taxes	€ 21.144,00
Consumables	€ 13.148,00
Equipment rental	€ 20.711,00
Hardware/Software	€ 280.632,00
Connectivity	€ 131.000,00
External services	€ 393.789,00
Technological instruments	€ 800.000,00
Total	€ 3.705.484,00

Figure 2.213 - Table summarising the budget

2.7 CONCLUSION AND ADVICES

Adequate programming and planning of the complex system of activities related to the provision of the nivo-meteorology assistance service for the Torino 2006 Olympic Winter Games, together with a strategy of anticipation, used by the Agency from 1997, and particularly from the preparation of the candidacy of Torino as Host City before the International Olympic Committee, were the determining elements to guarantee adequate support for the best success of the Olympic event.

The considerable effort made by Arpa Piemonte, partly with the cooperation of the Organising Committee, both in terms of investments and staff involved, enabled the actuation of an extremely widespread and complex service, structured throughout the whole Olympic Area, and based on highly qualified and skilled operators in the sector.

The entire staff involved in the nivo-meteorology assistance service, at different levels of responsibility, worked with passion and commitment, playing a fundamental role in the success of the Olympic event. The Olympic slogan "Passion Lives Here" effectively represents the strong involvement, also at individual level, of the Arpa Piemonte staff.

Figura 2.214 - Passion Lives Here

"…in the ultracompetitive Olympic environment, even science is regarded with suspicion…" from these words, which appeared in Wall Street Journal during the Games, we can see a very important concept on which it is necessary to operate immediately in the proposition of a service for the support of a big event, technologically and scientifically advanced, but still a supporting service: educating the user of the service in relation to the possibilities that it offers in relation to the problems that might arise during the manifestation as opposed to the aspects of scientific rigour and innovation, which are rarely appreciated and risk erecting a sort of "barrier" between those who issue the service and those who use it.

The same article says "…-You take anything related to the Olympics, and it's overdone- concedes John Aalberg, the assistant technical delegate and member of the jury at the cross-country skiing site…", an expression which can be absolutely shared, but which is highly motivated by the unique nature of the event, by those involved in its organisation, and also a justification of merit: the very unique nature of the event, the fact that it cannot be reproduced, the lack of a "second chance" undoubtedly lead to an over-sizing in terms of organisation, but this remains within the opportunities for development, growth and innovation produced by the effort. A task that does not end with the Games is the attempt to makes the very most of everything achieved, in terms of human capital, technology, instrumentation, knowledge and experience in the enrichment of more ordinary activities.

From the experience gained throughout these years of activity, we can draw a few considerations that summarise the organisational and operational problems faced, as well as the solutions individuated to guarantee adequate forecasting support for the Olympic event.

2.7.1 KEY POINTS RELATED TO THE PLANNING OF THE SERVICE

The main key points related to the planning of the service, which have characterised the work and preparation of the Olympic event during these years are listed below. Some recommendations are given for every one, dedicated particularly to those who will be organising the nivo-meteorology service for the next editions of the Games, and will be useful every time meteorology is used in support of events of every kind, not just in the world of sport:

- the design of the meteorology service is a particularly complex activity, which requires considerable commitment, spread over a number of years, and implicates important strategic choices which often have to be made on the basis of nothing more that project indications; consequently it is advisable:
  - to develop a plan for the meteorology support in good time, including expenses estimates for investments and their management, for use as guidelines for preparation;
  - to "educate" the executives and staff of the Organising Committee in advance to make sure they know that there is a meteorology service within the context of the organisation of the Games and try to make them aware of the usefulness of this service for various functions;
  - to know the exact requirements of the user (Organising Committee, International Federations, those responsible for preparing the courses, the sports equipment, the managers of the districts, local and territorial authorities involved in the event...): this will enable the design of an assistance service geared towards satisfying requirements;
  - a distributed system, like that implemented for the XX Olympic Winter Games, with dedicated weather offices for every venue and a special, multidisciplinary team, specialised in the characteristics of the competitions, guarantees excellent contact with the directors of the competition venues;
  - to envisage an authoritative action of address and overall surveillance of the service;

- as regards the staff, preparation, motivation, willingness and the aspects linked with the owing environment are all important; consequently it is recommended:
  - that the meteorologists working in the competition venues and those at the Operation centre form a close knit team;
  - that the staff is guaranteed complete training, with realistic test sessions on the job: a long period of training on the Olympic Area is necessary for staff involved in the local weather forecast phase and particularly in the more

critical meteorology parameters for the relative sport;
- that there be a close synergy and cooperation between all the members of the staff (meteorologists, nivologists and technicians) for the best success of the service itself;

- as regards the availability of data observed at the competition venues, its spatial density, frequency of acquisition, length of historic records and the technological aspects at the base of the service, such as communications, analysis and forecasting instruments; consequently it is advisable:
  - to work in close contact with the organising committee to ensure that the weather team has suitable technological instruments and communication systems before the Games, so that they can gain familiarity with them;
  - to meticulously prepare a support and back-up system, both with regard to the IT systems and human resources in the event of unexpected technical or personal problems;
  - to guarantee the presence of a dense network of ground observations and an archive of high resolution analyses and forecasts: this makes it possible to have more realistic and reliable forecasts for the single competition venues;
  - to guarantee the reliability of the numeric models in support of the forecasting and interpretation of the phenomena and the reliability of measurements; these are the two crucial aspects of the quality of the service performed;
  - to use telecommunications lines between the venues and between the venues and central offices with adequate band amplitude, often higher than that planned on the basis of theoretic transfers: for a correct assessment of the problems related to the load of the telecommunications lines, it is advisable to run test events simultaneously at all the competition venues;
  - to dedicate activities of study and development of data post-processing methods to improve the forecast, taking into account the difficulties of the high resolution numeric models currently available to clearly describe the mountain areas;
  - to know the meteorological peculiarities of the competition venues, the geography of the location, the local effect of every synoptic situation and the climatology of the area of interest;
  - to carry out a specific investigation to highlight the sectors of the Olympic roads potentially exposed to the risk of avalanche for the planning of mobility in the Olympic period;

- in relation to the operational planning implemented during the "games time" phase, experimenting it and refining it during the test events, as well as the working and checking procedures: consequently it is advisable:
  - to guarantee the reliability of the numeric models in support of the forecasting and interpretation of the phenomena and the reliability of measurements; these are the two crucial aspects of the quality of the service performed;
  - to work with the different organisational functions to define a combination of critical thresholds related to every meteorology parameter (wind, temperature, fresh snow…) which may influence sport and other activities at the single venues. In the service for the Torino 2006 Games, these thresholds were used to establish the criticality of a given weather situation in relation to the impacts that it may cause;
  - to adapt the planning of the activities during the period of the Games to the venue policy and overall organisation, having to answer directly to the venue and the competition manager;
  - to have a clear definition of the tasks and responsibilities of the different institutional subjects involved in the context of the system for the warning and prevention of the risk of avalanche with the preventive study of the possible criticalities on the roads and the definition of specific procedures;

- lastly, remember that a lot of time has to be dedicated to the official data and information distribution system, especially to the feeding of the Games Intranet system (2.2.8.2) INFO200X, in our case INFO2006; consequently it is advisable:

- to work together with the developers for the choice of appropriate symbols for the representation of the typical mountain phenomena of the area involved in the Games (also envisage symbols for the sky conditions, for the night too);
- when defining the specifics of the xml input files, to work in close contact with the Organising Committee and the system developers;
- when defining the products related to snow, to flank the indication of the quantity of fresh snow, which must be accompanied by the accumulation time, by an indication of the depth of snow on the ground, extending the product to all the venues and not just those in the mountains;
- to envisage the possibility of supplying the data observed related to several points of the venue, with an indication of the altitudes of reference: venues which stretch through more than 100m of altitude must be represented by data observed at different altitudes.

2.7.2 KEY POINTS IN RELATION TO THE OPERATING SERVICE DURING THE GAMES

Lastly, the good practices which played a key role during the Torino 2006 Olympic and Paralympic Games are listed below in the form of recommendations and suggestions for the operating phase of the service:

- to guarantee ample flexibility of the extemporary requests of users;
- to ensure continuous communication between all the staff involved (also by phone) especially in the case of quick changes in the weather situation: this was the only instrument, together with an efficient monitoring network, which enabled the supervision of the short range evolution of the critical phenomena;
- to define procedure and working methods at venue level in order to guarantee the constant exchange of information between all the team members, especially in the case of rotation of the staff on a shift basis;
- to assign at least one expert forecaster to the main operation centre (in the case of Torino2006 the Main Operation Centre) to have a close link with the directors of the organising committee and the international organisations involved;
- to frequently check the level of user satisfaction both before and during the Games;
- to assign direct responsibility for the individual activities to all members of staff, especially to the meteorologists, who have to make decisions individually for the venues;
- to connect the weather forecast communication process to the operating process for their production;
- to implement a precise strategy and relative procedures for assistance at all the competition venues by outside companies, such as the suppliers of specialist instruments, and for relations with the media;
- to test all the procedures to be implements during games time, beforehand;
- to enable the meteorologists to work in teams to avoid excessive physical and mental stress which might affect the quality of their work;
- to create peripheral weather offices within the competition venue to guarantee sensitivity to the local weather conditions and accurate information every time it can be successfully distributed;
- to keep ahead in order to create expertise: a specific forecasting skill localised on an Alpine area;
- to work in close harmony with all the functions at the single venues, paying particular attention to communication: the members of the weather staff must be included in the organisation, in the address books and the telephone books and the indication of the weather office at the venue must be clear so that it can be easily reached by everyone and in every situation;
- to preventively agree the layout of the various products and reports so that they are officially recognised throughout the whole venue, by the various functions, the trainers and athletes;

- to acquire adequate knowledge of the territory and its criticalities from the point of view of the natural risks that form the indispensable basis for the definition of adequate procedures for the management of potential critical situations, with adequate monitoring of the relevant snow and weather parameters.

"The TOROC was always able to rely on the extremely close collaboration of the Arpa Piemonte Environmental Monitoring and Forecasting Area, both during the definition of the competition programme and the choice of the venues, and during the whole approach to the Games, but during the months of January, February and March 2006 in particular, the weather 'task force' was irreplaceable for the success not only of the sporting competitions, but also for enabling everyone, with its highly accurate forecasts, to be ready for anything, to guarantee the perfect operation of the whole organisational 'machine'. Planning and test work was fundamental in order to be ready for 2006, not only with advanced technological structures and equipment, but also, and most importantly, with close knit teams of meteorology technicians with multiple operating situations at venue level and central level.
The winning card was definitely the design of a distributed system of professional skills operating directly at the venues, capable of supporting, with their activities, operations in moments of 'weather' crisis in 'real time'".
Giorgio Viterbo - Head of Sport Services, TOROC

"I visited three different weather centers in Turin that had been set up for the Games. I was really stunned by the level of detail of the information they were collecting, the preparedness of the staff, the historical database. The one problem I saw was of communication. As I wrote, many teams seem reluctant to use the data. Many also don't realize how extensive the data is and how much information is available. If the right people on the teams knew about this beforehand the information might be used more extensively".
Gabriel Kahn - Wall Street Journal

"I visited the Italian weather service, first in Torino at the operations center where I met Renata Pelosini, and secondly at Sestriere in the mountains. I would like to add a comment that they decided not to go for more and more detailed mesoscale models, but rather, emphasized post-processing. And I was very impressed with this approach showing tendencies and correlations for various valleys and venues. The degree to which they were forecasting very specific weather phenomena was astounding to me, such as short term forecasts of the winds at the top and bottom of the ski jump. I can see that the only way to achieve success in this environment is to have forecasters who have lived and worked in the area for many years. The Sestriere office had been open for perhaps 9 years and clearly that was key to having the ability to reliably forecast very small scale phenomena over very short time scales".
Timothy C. Spangler Ph.D. - Director Cooperative Program for Operational Meteorology, Education and Training

"… we learned of the demands and requirements and how they vary from venue to venue and at the TOROC operations centre. We were impressed by the enthusiasm and energy of your staff and by their skilfull and professional interactions with Olympic Officials in some very stressful situations".
Al Wallace - Director, Meteorological Service of Canada
Chris Doyle - Chief Meteorologist for the 2010 Winter Games

Top row, left to right: *De Luigi Chiara, Machetta Renzo, Boggiatto Claudio, Belfiore Anastasio, Arbia Gabriella, Bisceglie Giovanni, Altavilla Annarita* - Second row, left to right: *Antonini Fabio, Bande Stefano, Colao Alberto, Cotti Alberto, Costa Paolo, Oberto Elena, Bertea Andrea* - Third row, left to right: *Prola Maria Cristina, Cane Daniele, Di Lernia Fabrizio, Giaccone Andrea, Muraro Massimo, Bovo Stefano, Cordola Marco* - Fourth row, left to right: *Vita Delia, Gandini Daniele, Marca Emanuele, Vargiu Antioco, Carambia Vito, Rava Mauro, Bertaccini Pancrazio* - Fifth row, left to right: *Bertolotto Paolo, Musso Silvia, Nejmi Mohamed, Solero Erika, Lagorio Marco, Cogerino Giorgio, Loglisci Nicola* - Sixth row, left to right: *Martorina Salvatore, Olivero Alberto, Orione Fiammetta, Milelli Massimo, Moro Daniele, Paesano Giovanni, Pellegrini Umberto* - Seventh row, left to right: *Palamara Francesco, Pelosini Renata, Piazza Andrea, Ronchi Christian, Olivero Enrico* - Eighth row, left to right: *Turco Marco, Poncino Serena, Picollo Mariaelena*

3 Monitoring the air quality

3. Monitoring the air quality

3.1 AIMS OF THE MONITORING CAMPAIGNS

3.1.1 PREFACE

The pre-Olympic period during the constructions of the sites and the Olympic period during the competitions were subject to an in-depth assessment of the air quality.

In particularly, prior to the opening of the XX Olympic Winter Games Torino 2006, various monitoring activities were put into practice, such as campaigns to measure the quality of the air in the various Olympic venues by request of the Bodies involved in the organisation of the Games. Arpa Piemonte, by appointment of the Provincia di Torino, also set up a specific system to process information related to the air quality for the area of Olympic interest, capable of satisfying the need for daily information and clarity, comprehensibility and accessibility provided for by the European Directives on the matter. For this purpose a methodology inspired by those previously used for the production of the Air Quality Index (AQI) in the metropolitan area of Torino (based upon the use of measurements acquired by the air quality monitoring network) and in the conurbations of Asti, Novara and Vercelli was implemented (starting with the estimates of the of concentrations of pollutants in the atmosphere).

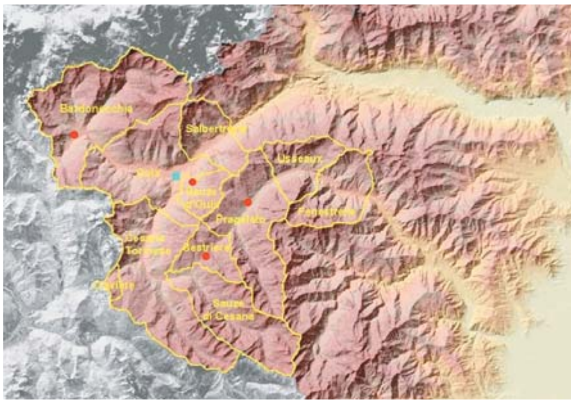


Figure 3.1 - Conurbation AQI

The identification of the conurbation in which to apply the AQI during the Games (figure 3.1) was carried out by Arpa Piemonte Environmental Monitoring and Forecasting Area in conjunction with the Provincia di Torino; 11 municipalities in the high Valle di Susa and high Val Chisone were included: Bardonecchia, Cesana, Claviere, Fenestrelle, Oulx, Pragelato, Salbertrand, Sauze di Cesana, Sauze d'Oulx, Sestriere and Usseaux.

3.1.2 PRE-OLYMPIC PHASE

During the pre-Olympic phase, activities included the campaign performed in Sestriere in 2004, carried out following a request by Sestriere Municipal Police Force, the campaigns Cesana and Pragelato in January and February 2005, carried out following a request by the TOROC.

The remaining monitoring campaigns performed during 2003 and 2005 were carried out following a request from the EIA/SEA Manager, in order to perform parallel campaigns alongside those performed by the technicians appointed by Agenzia Torino 2006.

The table below shows all the monitoring activities carried out during this ante operam phase:

REQUEST DATE	REQUEST RECORD	VENUE	MONITORING PERIOD	REPORT RECORD	REPORT DATE	
		Cesana	7-17 august 2003			2003
		San Sicario	20 aug-7 sept 2006			
		Sestriere	10-24 august 2003			
27/04/2004	53543	Sestriere	4 june-15 july 2004			2004
		TOROC - Cesana town council	21 jan–13 feb 2005	39075/06	30/03/2005	2005
		TOROC - Pragelato primary school	21 jan–13 feb 2005			

REQUEST DATE	REQUEST RECORD	VENUE	MONITORING PERIOD	REPORT RECORD	REPORT DATE	
04/04/2005	40900/02.03	Cesana, Bauvier street 23	5-14 april 2005	92332/06.02	20/07/2005	2005
		San Sicario Old Town	5-14 apr, 29 apr- 9 may			
28/04/2005	51979/02.03	Avigliana – Sacro Cuore Institute	17-27 may 2005	108083/06	30/08/2005	
		Avigliana, Bacchiasso street Ab. Bruno	31 may–15 june 2005			
25/07/2005	94436/02.03	Cesana P. Des Escartons 6	6-21 july 2006	116989/06.02	21/09/2005	
		Cesana Tourist office	22 july–6 august 2006			
		San Sicario Old Town	10-25 august 2005			
16/09/2005	114920/02.03	Cesana, Italsider street 44	6-21 september 2005	129274/06.02	18/10/2005	
		Cesana	10-25 october 2005	157594/06.02	19/12/2005	

3.1.2.1 Resources and samples collected

In 2003, two people from the Torino Department were employed.

In 2004/2005, three people from the Department were employed, along with two from the EIA/SEA Service at head office.

About 30 on-site inspections were carried out between 2003 and 2005 (7 in 2003, 3 in 2004 and 20 in 2005) to choose the venues and replace the samples.

A total of 270 samples were taken (46 in 2003, 45 in 2004 and 179 in 2005).

3.1.3 OLYMPIC PHASE OF THE XX GAMES

3.1.3.1 Activities performed

In relation to the Olympic phase of the Games, a monitoring campaign was carried out in five Olympic venues, aimed at measuring the air quality, following a request from the General Management of Arpa Piemonte (protocol n° 43242/05 dated 8-04-2005) which requested the performance in the areas involved in the XX Olympic Winter Games 2006 of air quality monitoring campaigns in Torino, Pragelato, Sestriere, Sauze d'Oulx and Bardonecchia, simultaneously implementing the production of the AQI for the "Olympic" towns, maintaining the main operational characteristics of those already in production in the main urban conurbations in Regione Piemonte, namely:

1. daily processing of the air quality index for the previous day, starting with the information related to the levels of nitrogen dioxide, PM_{10} particles and ozone for the day prior to the issue of the index;
2. a complete range of weather forecasting information (valid for the current and next days) related to the capacity for accumulation or dispersion of pollutants by the lower atmospheric strata.

The service was implemented with the support, as described earlier, of a specific air quality monitoring programme, activated by Arpa Piemonte for the Olympic Games at the venues with the installation of four mobile stations in Bardonecchia, Pragelato, Sauze d'Oulx e Sestriere, in areas considered to be representative of the air quality in the municipal area; information on the levels of pollution was also supplied by the permanent monitoring station installed in Oulx in November 2005.

3.1.3.2 Mobile laboratories

The monitoring campaigns to acquire air quality data were carried out with the aid of fully equipped mobile laboratories. These laboratories are usually equipped with analysing instruments for the constant measuring of chemical pollutants, such as sulphur dioxide, nitrogen oxides, carbon monoxide, ozone and benzene, and with samplers of PM_{10} atmospheric particles, the concentration of which is determined in the laboratory using a gravimeter or automatic analysing instruments depending on the fittings in the mobile laboratory.

The various mobile laboratories assigned to the Provincial Departments with the coordination of SC05 and in the context of the activities performed to supply the air quality trend, measured the air quality parameters during the XX Olympic Winter Games Torino 2006 in:

- Sestriere
- Pragelato
- Bardonecchia
- Sauze d'Oulx
- Torino.

3.2 DESCRIPTION OF THE MONITORING SITES

The most suitable site for the monitoring campaign was identified in agreement with the Municipal Authorities. Within the municipal area, the sites were selected on the basis of the technical criterion of monitoring the air quality in the areas with the highest resident population and/or involved in the competitions.

- For Sestriere, the mobile laboratory was positioned in the area parallel to the weather station, opposite the downhill ski slopes for the period from January 18th to March 5th 2006.
- For Pragelato, the mobile laboratory was positioned in Via del Rif (in the parking area of the AMBRA 80 condominium) opposite the ski jumps, from December 28th 2005 to March 10th 2006.
- For Bardonecchia, the mobile laboratory was positioned near the lake in Via Mallen, from January 16th to March 8th 2006.

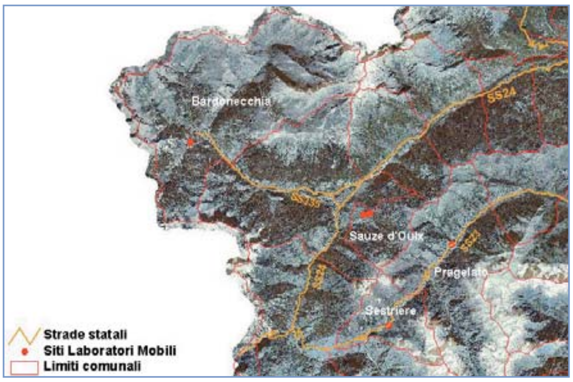


Figure 3.2 - Aerial picture of the Olympic venues

- For Sauze d'Oulx the mobile laboratory was positioned in Viale Genevris (the market square) from January 13th to March 3rd 2006.
- For Torino, the mobile laboratory was positioned in Corso IV Novembre on the corner of Corso Monte Lungo from February 9th to March 19th 2006.

The measuring stations and the TMU (Territorial Mobile Unit) coordinates of the sites are summarised in table 3.1 below and in the map of Northwest Piedmont, including the Susa and Chisone Valleys (figure 3.2).

Figures 3.3 - 3.4 - 3.5 and 3.6 show the aerial pictures of the Olympic venues (excluding Torino).

COMMUNE	ADDRESS	UTM COORDINATES	
		X	Y
Torino	At the corner of IV Novembre and Monte Lungo Street	394085	4989536
Sauze d'Oulx	Genevris street (market square)	331488	4988664
Sestriere	Pinerolo street (close to Arpa meteo office)	332915	4980556
Bardonecchia	Mallen street (Laghetto area)	318620	4993800
Pragelato	Rif street (Ambra palace Parking)	337471	4986435

Table 3.1

Figure 3.3 - Sestriere - Mobile laboratory site - TMU coordinates x 1332846 - Y 4980355

Figure 3.4 - Sauze d'Oulx - Viale Generis piazza Mercato - TMU coordinates UTMx 331405 - UTMy 4988465 Altitude 1509 m above sea level

Figure 3.5 - Bardonecchia - Via Mallen Municipal lake area - TMU coordinates UTM x 318620 UTM y 4993800

Figure 3.6 - Pragelato - Via Del Rif - TMU coordinates UTMx 337471 - UTMy 4986435

3.3 PARAMETERS ANALYSED

The parameters analysed are those for which the laws currently in force set limits: ozone (O_3), nitrogen oxides (NO, NO_x, NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), benzene and PM_{10} (particulate).

3.3.1 NITROGEN OXIDES (NO, NO_2)

Nitrogen oxide (NO) is a colourless, tasteless and odourless gas. It is produced mainly during high temperature combustion together with nitrogen dioxide and is then oxidised in the atmosphere by oxygen and, more quickly by ozone, producing nitrogen dioxide. **Nitrogen dioxide (NO_2)** is a toxic, red-yellow coloured gas with a strong, pungent smell and considerable irritant power; it is an energetic oxidant which is highly reactive and therefore extremely corrosive. Nitrogen dioxide plays a fundamental role in the formation of photochemical smog, as it forms the basic intermediary for the production of a whole series of secondary toxic pollutants such as ozone. The main anthropic source of nitrogen oxide is high temperature combustion, as occurs in motor vehicle engines: the high temperature generated during combustion causes the reaction between the nitrogen in the air and oxygen, forming nitrogen monoxide. When the fumes are mixed with air as they leave the exhaust pipe, a significant amount of nitrogen dioxide is formed as a result of oxidisation of the monoxide by the oxygen. Being an extremely irritating gas it can cause respiratory pathologies (bronchitis, allergies, etc.) and affect haemoglobin by oxidising its iron content and therefore damaging the capacity to transport oxygen, also contributing to the formation of acid rain.

3

Measuring technique: nitrogen oxides were analysed using the chemiluminescence method. The method is based on the chemical reaction between nitrogen monoxide and ozone, which produces a characteristic luminescence with intensity proportional to the concentration of NO. The reaction is specific for nitrogen monoxide. In this way the instrument alternatively measures the NO and the sum of NO + NO_2 (NO_x). The concentration of dioxide is calculated on the difference between the total oxides (NO_x) and nitrogen monoxide (NO).
Nitrogen dioxide was monitored in: Sauze d'Oulx, Pragelato, Bardonecchia, Sestriere and Torino.

3.3.2 OZONE (O_3)

Ozone is a highly concentrated, bluish coloured toxic gas with considerable oxidising power. It is contained in the stratosphere (the layer of atmosphere present between altitudes of 10 and 50 km) where it is produced by molecular oxygen due to the action of the UV solar rays and offers protection against the UV radiations generated by the sun.
When this pollutant is present in the immediate vicinity of the earth's surface (troposphere) it is responsible for the formation of photochemical smog. This happens mainly in the summer, when solar radiation is more intense and temperatures are higher.
Ozone is formed as a result of photochemical reactions involving nitrogen oxides and COV.
Low concentrations of ozone can irritate the throat, respiratory system and eyes, while higher concentrations can alter the function of the respiratory system and cause asthma attacks.
Measuring technique: the continuous operation of the analysing instrument is based upon the ozone's capacity to absorb ultraviolet rays with opportune wavelengths, generated by a lamp inside the instrument. The ultraviolet rays cross the measuring chamber containing the gas sample and, in the presence of ozone, are absorbed in proportion to the concentration of the gas.
Ozone was monitored in: Sauze d'Oulx, Pragelato, Bardonecchia, Sestriere and Torino.

3.3.3 CARBON MONOXIDE (CO)

Carbon oxide (CO) or **carbon monoxide** is a colourless, odourless, flammable and highly toxic gas. It is formed during the combustion of organic substances, when they are incomplete due to a lack of air (i.e.: oxygen). Natural and anthropic emissions have now reached the same level and this enables us to clearly see the trend in pollution that has been established over the last century. Carbon monoxide is mainly present in urban areas due to the pollution produced by vehicle exhaust fumes.
The main natural emissions are due to forest fires, volcanic eruptions, emissions from the oceans and from swamps and the oxidisation of methane and hydrocarbons in general emitted naturally into the atmosphere.
The highest concentrations in exhaust fumes occur when the engine is running at the minimum.
At higher speeds the production of CO is decidedly lower and petrol engines give off greater quantities of CO than diesel engines.
CO adheres to the haemoglobin in the blood, blocking the transportation of oxygen to the various parts of the body, affecting the central nervous system and the cardiovascular system.
Measuring technique: carbon monoxide is analysed through the absorption of infrared rays (IR). The gas sample is passed through a beam of IR rays. The presence of CO in the gas causes a drop in the intensity of the radiation in a quantity which depends on the concentration of monoxide.
Carbon monoxide was monitored in: Sauze d'Oulx, Pragelato, Bardonecchia, Sestriere and Torino.

3.3.4 PARTICULATE MATERIAL (PM_x)

Particulate material is formed from all the non-gaseous material present in the air. The particles are of varying nature:

organic material dispersed by vegetables, inorganic material produced by the wind for example and by soil erosion.
In urban areas, particulate material is generated by industrial processes carried out in foundries, cement works, building sites, etc., as well as by the use of tyres, asphalt, brakes and exhaust fumes emitted mainly by vehicles with diesel engines.
The impact on human health is determined, other than the chemical components, by the size of the particles:

- particles with a diameter of more than **10 µm**: stop in the first respiratory tract
- particles with a diameter between **5** and **10 µm**: reach the trachea and bronchi
- particles with a diameter of less than **5 µm**: can reach as far as the pulmonary alveoli

and the main consequences are respiratory pathologies such as asthma, bronchitis and emphysema.
Measuring technique: EN 12341
The measuring of PM_{10} is based upon the gravimetric reference method, indicated in Ministerial Decree 60/02, Annexe XI, point 1. Said method involves weighing the filter in which the atmospheric particulate has previously been accumulated, giving the concentration value of PM_{10} dust.
The necessary preliminary phase of conditioning the filter (taken to 20±1 °C and 50±5% humidity for 48 hours before and after taking the sample), carried out once more immediately before weighing it, involves a few days' delay in obtaining the data.
This manual method can be replaced by automatic methods with certification of equivalence, as specified by Ministerial Decree 60/02, Annexe XI, point 2.
PM_{10} was monitored at: Sauze d'Oulx, Pragelato, Bardonecchia, Sestriere and Torino.

3.3.5 BENZENE (C_6H_6)

Benzene is an colourless, flammable, liquid, aromatic hydrocarbon.
It is present throughout the air, deriving from both natural (forest fires, volcanic emissions) and artificial (mainly industrial emissions and exhaust fumes from motor vehicles with petrol engines) combustion processes, as well as from the combustion of organic matter (such as tobacco smoke).
Motor vehicle fuels also contain other aromatic hydrocarbons such as toluene and lots of meta-, ortho- and para-isomers of xylene.
Benzene is substance which causes cancer in humans. Exposure to high concentrations causes acute damage to the bone marrow and chronic exposure can cause leukaemia.
Measuring technique: Benzene is measured using the capillary gaschromatographic technique in the gaseous phase, which enables the rapid separation and identification (15 minutes) of the components of the gas sample. The use of a selective detector for aromatic composts enables the separation of any interfering subjects and the precise and accurate measurement of the quantity of benzene.
Benzene was monitored at: Sauze d'Oulx, Pragelato, Bardonecchia, Sestriere and Torino.

3.3.6 SULPHUR DIOXIDE (SO_2)

Sulphur dioxide at ambient temperature is a colourless gas with an acrid, pungent and penetrating smell, produced both by anthropic and natural sources.
Natural production is due mainly to volcanic eruptions, while the main anthropic emissions of sulphur dioxide come from combustion processes which use fossil fuels (diesel, oil, coal), in which sulphur is present as an impurity, and from metallurgical processes. A usually rather small percentage of the sulphur dioxide in the air comes from traffic, particularly from vehicles with diesel engines. Until a few years ago, sulphur dioxide was considered to be the main air pollutant. Today, the progressive improvement in the quality of fuels following the reduction of the amount of sulphur contained in refinery products, and the ever-increasing use of methane gas, have considerably reduced the

presence of SO_2 in the air.

Measuring technique: sulphur dioxide is continuously measured using an analysing instrument based upon the principle of measurement of the intensity of the radiation emitted as fluorescence by SO_2 molecules when they are activated by irradiation with ultraviolet rays.

The environmental air sample is introduced into a cell and irradiated by ultraviolet rays made monochromatic by a filter. The SO_2 molecules excited by these ultraviolet rays emit specific radiation at a higher wavelength.

Sulphur dioxide was monitored in: Sauze d'Oulx, Pragelato, Bardonecchia, Sestriere and Torino.

Table 3.2 summarises the pollutants monitored at the 5 Olympic venues.

PULLUTANTS	PRAGELATO	SESTRIERE	BARDONECCHIA	SAUZE D'OULX	TORINO
Carbon monoxide	☐	☐	☐	☐	☐
Nitrogen dioxide	☐	☐	☐	☐	☐
Sulphur dioxide	☐		☐	☐	☐
Benzene	☐	☐	☐	☐	☐
Ozone	☐	☐	☐	☐	☐
Particulate material	☐	☐	☐	☐	☐

Table 3.2

3.4 REFERENCE LAWS

- **Legislative Decree no. 351 dated 04/08/1999** (implementing framework directive 96/62/CE) establishes the fundamental principles for the reduction of atmospheric pollution, making provision for the setting of limit values and alarm thresholds for certain pollutants, as well as the target value for ozone in order to avoid, prevent or reduce the damaging effects for human health and the environment in general. The decree also makes provision for the individuation of the common assessment methods and criteria that enable the distinction, throughout the country, of areas where it is opportune to preserve air quality which is good from those where it has to be improved.

- **Ministerial Decree no. 60 dated April 2nd 2002** (acknowledgement of directive 1999/30/CE) of the Council of April 22nd 1999 concerning the environmental air quality limit values for sulphur dioxide, nitrogen dioxide, nitrogen oxides, particles and lead, and of directive 2000/69/CE in relation to the environmental air quality limit values for benzene and carbon monoxide.

- **Legislative Decree no. 183 dated May 21st 2004** (implementation of directive 2002/3/CE in relation to ozone in the air).

- **Regional Law no. 43 dated April 7th 2000** (provisions for environmental defence from atmospheric pollution. First implementation of the Regional Plan for the restoration and defence of air quality).

Tables 3.3 and 3.4 indicate the reference values provided for by the laws currently in force.

PULLUTANT	LIMIT	PARAMETER	REFERENCE VALUES	ALLOWED EXCEEDING VALUES	DATE TO OBSERVE LIMITS
Ozone (O3) Legislative Decree 21/05/04 n.1839	Information threshold	Hourly average	180 $\mu g/m^3$	-	-
	Alarm threshold	Daily average	240 $\mu g/m^3$	-	-
	Target value for human health protection	8-hour average daily maximum	120 $\mu g/m^3$ (1)	25 days a civil year as 3 years average	2010
	Target value for vegetation protection	AOT40 deduced from 1-hour values from may to july	18000 $\mu g/m^3$ *h As five years average (2)		2010
	Long term target for vegetation protection	AOT40 deduced from 1-hour values from may to july	6000 $\mu g/m^3$ *h (2)		
Benzopyrene	Quality target D.M. 25/11/94	Daily values moving average	1 ng/m^3 (4)	-	-

(1): Dragged moving average is deduced hourly from the 8 values concerning intervals h÷(h-8)
(2): ATO_{40} is the sum of differences between hourly concentrations above 80 $\mu g/m^3$ and 80 $\mu g/m^3$ value which have been surveyed in a definite period of time by using only hourly values. The hourly values have been surveyed daily between 8.00 a.m. and 22.00 p.m.
(3): Sampling frequency is 1 sample every z days, with z=3÷6; z can be more than 7 in rural areas, but z should never be equal to 7
(4): Average period is civil year (1st January - 31st December)

Table 3.3 - Limit values for ozone and benzopyrene

PULLUTANT	LIMIT	AVERAGE PERIOD	REFERENCE VALUES	ALLOWED EXCEEDING VALUES	FIXED DATE TO OBSERVE LIMITS
Sulphur dioxide (SO_2)	Hourly limit value for human health protection	1 hour	350 $\mu g/m^3$	24 times/civil year	1st jan 05
	Daily limit value for human health protection	24 hours	125 $\mu g/m^3$	3 times/civil year	1st jan 05
	Limit value for ecosystems protection	Civil year Winter (1 oct – 31 mar)	20 $\mu g/m^3$	--	19th july 01
	Alarm threshold	3 consecutive hours	500 $\mu g/m^3$	--	--
Nitrogen dioxide (NO_2) and Nitrogen oxides (NO_x)	Hourly limit value for human health protection	1 hour	200 $\mu g/m^3$ (NO2)	18 times/civil year	1st jan 01
	Daily limit value for human health protection	Civil year	40 $\mu g/m^3$ (NO2)	--	1st jan 01
	Alarm threshold	3 consecutive hours	400 $\mu g/m^3$	--	--
	Annual limit value for vegetation protection	Civil year	30 $\mu g/m^3$ (NOx)	--	19th july 01
Carbon monoxide (CO)	Limit value for human health protection	8-hours average daily Maximum	10 mg/m^3	--	1st jan 05
Lead (Pb)	Annual limit value for human health protection	Civil year	0.5 $\mu g/m^3$	--	1st jan 05
Particulate material (PM_{10}) Phase 1	Daily limit value for human health protection	24 hours	50 $\mu g/m^3$	35 times/civil year	1st jan 05
	Annual limit value for human health protection	Civil year	40 $\mu g/m^3$	--	1st jan 05
Benzene	Annual limit value for human health protection	Civil year	5 $\mu g/m^3$	--	1st jan 01

Table 3.4 - Ministerial Decree no. 60 dated 2nd April 2002

3

3.5 INSTRUMENTS USED

The analysing and sampling instruments listed in the table below were used during the monitoring campaigns on the mobile laboratories of the five Arpa Piemonte Departments:

	TORINO	ASTI (SESTRIERE)	VERCELLI (BARDONECCHIA)	CUNEO (PRAGELATO)	ALESSANDRIA (SAUZE D'OULX)
Carbon Monoxide analyzer	API 300 A	API 300 E	API 300	API 300 E	API 300 E
Nitrogen oxides analyzer	MONITOR EUROPE ML 9841B	API 200 E	API 200	API 200 E	API 200 E
Ozone analyzer	MONITOR EUROPE ML 9810B	API M400 E	API 400	API 400 E	DASIBI 1108
Benzene, toluene, xilene analyzer	SYNTECH Spectras GC 855	SYNTEC Spectras GC 855	SYNTEC Spectras GC 855	SYNTEC Spectras GC 955	SYNTEC Spectras GC 855
Sulphur oxides analyzer	API 100 E	-----------	API 100	API 100 E	DASIBI 4108
Beta-ray meter of PM_{10}	-----------	-----------	-----------	-----------	ENVIRONMENT 101 M
Beta-ray meter of PM_{10} and TEOM	-----------	-----------	-----------	1400 A	-----------
PM10 air sampler	Tecora Charlie	Tecora Charlie	Tecora Charlie	Tecora Charlie	-----------

Table 3.5 - Instruments used

3.6 ANALYSIS AND COMPARISON OF POLLUTANTS

3.6.1 CARBON MONOXIDE (CO)

Table 3.6 shows the data for carbon monoxide measured during the monitoring period at the five Olympic venues. Graph 3.7 represents, for every day of monitoring, the maximum average values over eight hours compared with the limit

MOBILE LABORATORY PARAMETER: CARBON MONOXIDE (CO) (MILLIGRAM/CUBIC METER)	PRAGELATO	SESTRIERE	SALICE D'ULZIO	BARDONECCHIA	TORINO
Average daily minimum	0.4	0.2	0.5	0.6	0.5
Average daily maximum	1.0	0.7	1.0	2.0	2.6
Average of the daily averages	0.7	0.5	0.7	1.3	1.3
Valid days	69	35	28	48	39
Percentage valid days	95%	74%	56%	92%	100%
Average hourly maximum	3.6	2.0	2.7	3.0	4.4
Valid hours	1672	867	782	1148	926
Percentage valid hours	95%	77%	65%	92%	99%
8-hours averages minimum	0.3	0.0	0.4	0.5	0.4
8-hour averages average	0.7	0.5	0.7	1.3	1.3
8-hour averages maximum	1.4	1.0	1.8	2.4	2.8
Percentage valid 8-hour averages	95%	75%	64%	91%	98%
Number of times the limit value for human health protection was exceeded over an 8-hour average (10)	0	0	0	0	0
Number of days the limit value for human health protection was exceeded at least once over an 8-hour average (10)	0	0	0	0	0

Table 3.6 - Carbon Monoxide

for the protection of human health established by the laws in force.

The reference limit value for the protection of human health over an eight-hour average (10 mg/m^3) was never exceeded in any of the Olympic venues.

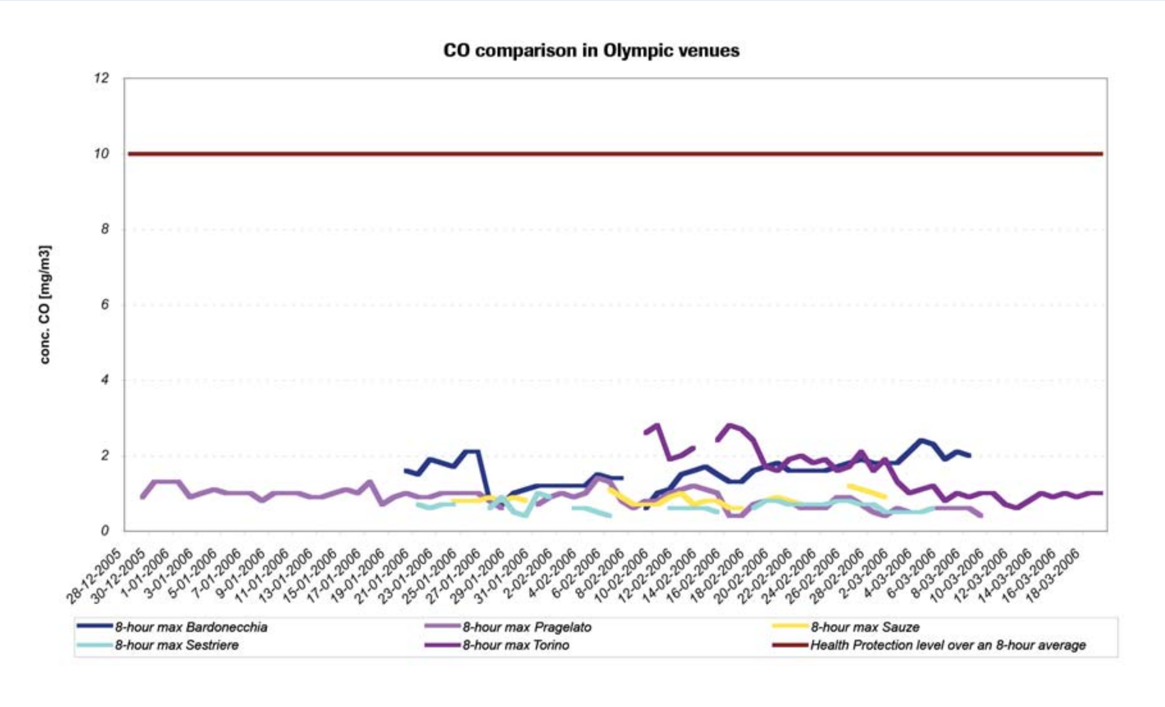


Figure 3.7 - Carbon Monoxide: maximum values of the eight-hour average

3.6.2 BENZENE

Table 3.7 shows the data for benzene measured during the monitoring period at the five Olympic venues.

MOBILE LABORATORY PARAMETER: BENZENE (MICROGRAM/CUBIC METER)	PRAGELATO	SESTRIERE	SALICE D'ULZIO	BARDONECCHIA	TORINO
Average daily minimum	0.5	0.2	0.8	0.5	1.5
Average daily maximum	2.5	1.9	5.7	2.5	6.6
Average of the daily averages	1.3	0.9	4.5	1.4	3.8
Valid days	66	36	18	46	38
Percentage valid days	90%	77%	36%	88%	97%
Average of hourly values	1.3	0.9	4.2	1.4	3.8
Average hourly maximum	9.2	5.5	8.7	7.1	13.3
Valid hours	1637	886	549	1151	914
Percentage valid hours	93%	79%	46%	92%	98%

Table 3.7

The average value of the daily averages measured during the campaigns for benzene was lower than the legal limit.

This comparison provides a rough guide only, as the limit for the protection of human health of 5 µg/m^3 established by Ministerial decree 60/2002 as of January 1st 2010 refers to a period of one year. Figure 3.8 represents the average daily trend in benzene at the five Olympic venues.

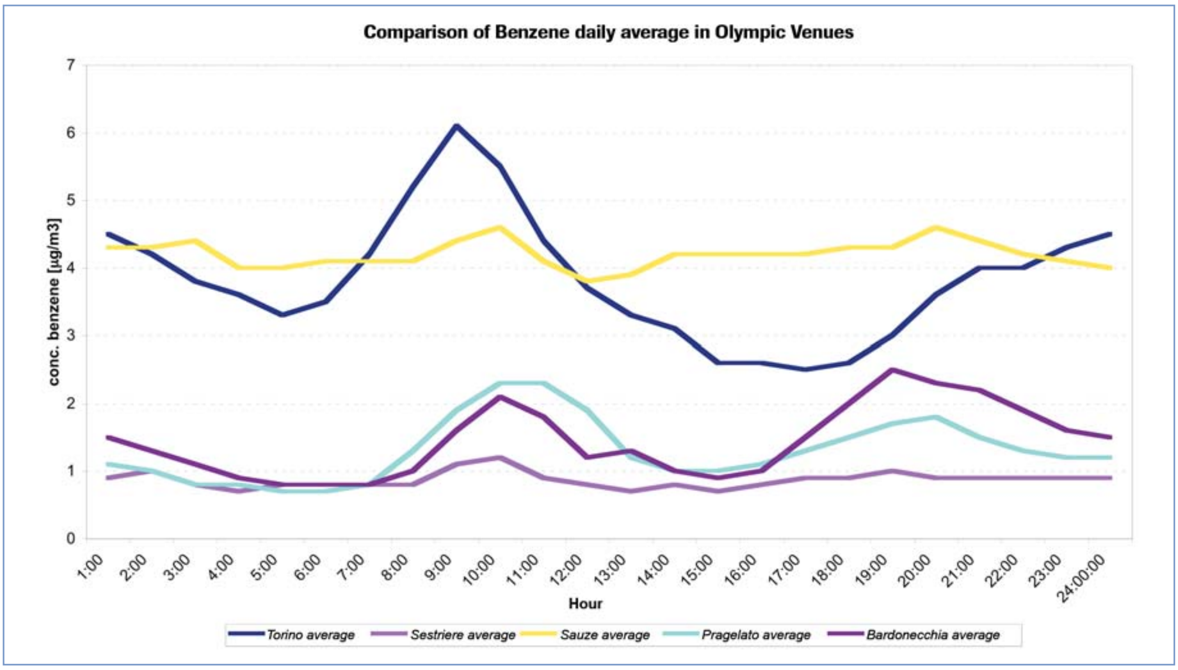


Figure 3.8 - Benzene: average daily trend

3.6.3 OZONE (O_3)

Table 3.8 shows the data for ozone measured during the monitoring period at the five Olympic venues.
Ozone is regulated by Legislative decree no. 183 dated 21/05/2004, which establishes an "information threshold" and an "alarm threshold" with an hourly average of 180 µg/m^3 for the first and 240 µg/m^3 for the second. This decree also provides for "target values" for 2010 and "long-term aims" for the protection of human health (120 µg/m^3 as the maximum daily eight-hour average) and for the protection of vegetation.
The data measured during the measuring campaigns in the five towns falls well within the threshold values established by the laws in force and reflects the winter trend where this pollutant is present in concentrations which are not high.
Figure 3.9 shows the maximum hourly concentrations and figure 3.10 shows the average daily trend.

MOBILE LABORATORY PARAMETER: OZONE (O_3) (MICROGRAM/CUBIC METER)	PRAGELATO	SESTRIERE	SALICE D'ULZIO	BARDONECCHIA	TORINO
Average daily minimum	31	23	25	17	5
Average daily maximum	101	77	91	87	57
Average of the daily averages	56	50	59	41	18
Valid days	69	37	21	50	38
Percentage valid days	95%	79%	42%	96%	97%
Average hourly maximum	124	92	149	128	80
Valid hours	1674	888	627	1211	915
Percentage valid hours	96%	79%	52%	97%	98%
8-hour average minimum	14	16	11	2	2
8-hour average average	56	50	57	41	18
8-hour average maximum	115	84	123	100	69
Percentage valid 8-hour averages	95%	77%	50%	97%	97%
Number of times the limit value for human health protection was exceeded over an 8-hour average (120)	0	0	1	0	0

MOBILE LABORATORY PARAMETER: OZONE (O_3) (MICROGRAM/CUBIC METER)	PRAGELATO	SESTRIERE	SALICE D'ULZIO	BARDONECCHIA	TORINO
Number of days the limit value for human health protection was exceeded at least once over an 8-hour average (120)	0	0	1	0	0
Information threshold exceeding (180)	0	0	0	0	0
Number of days the information threshold was exceeded at least once (180)	0	0	0	0	0
Alarm threshold exceeding (240)	0	0	0	0	0
Number of days the alarm threshold was exceeded at least once (240)	0	0	0	0	0
Tangible property threshold exceeding (40)	51	28	18	20	1

Table 3.8

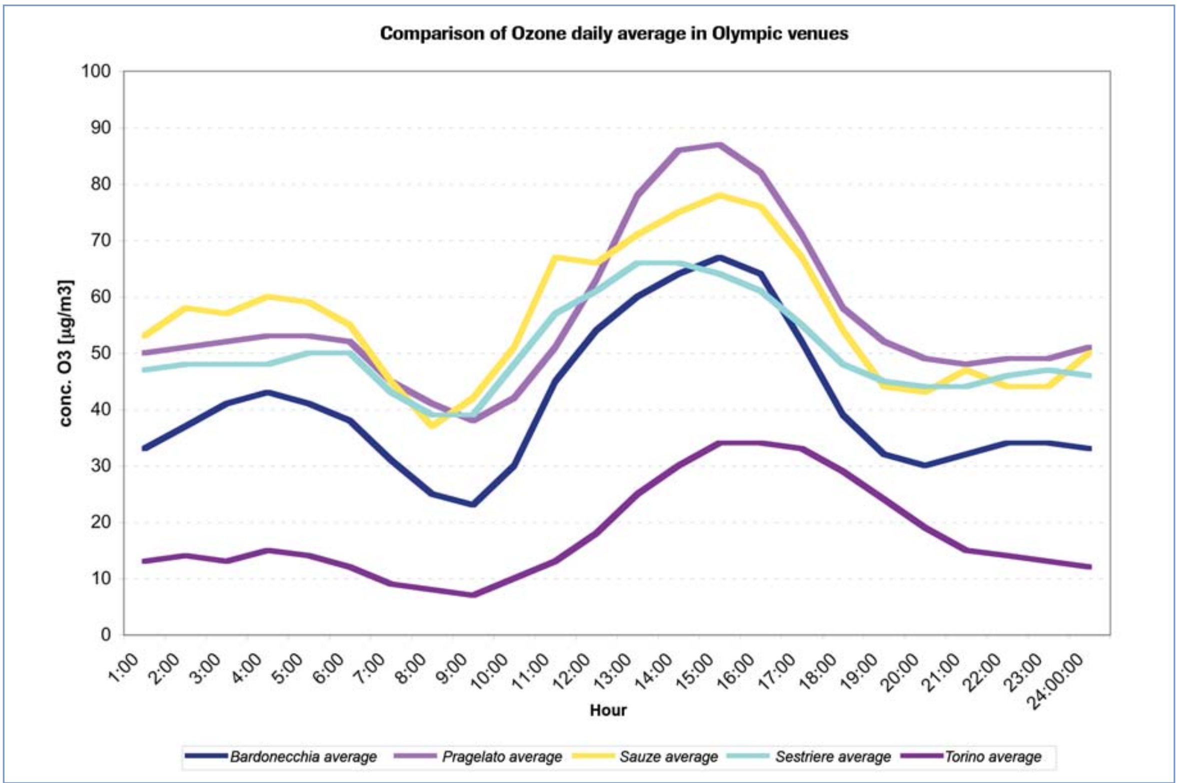


Figure 3.9 - Ozone: average daily ozone trend

3.6.4 NITROGEN DIOXIDE (NO_2)

Table 3.9 shows the data for nitrogen dioxide measured during the monitoring period at the five Olympic venues. Ministerial Decree 60/2002 provides, for the protection of human health, an average annual limit of 40 µg/m^3 and an hourly limit of 200 µg/m^3, not to be exceeded more than 18 times during the calendar year. Figure 3.10 shows how the legal limit was exceeded on days with considerable thermal inversions on several occasions at all venues apart from Bardonecchia and figure 3.11 shows the number of times the limit was exceeded and the hourly peaks for the five Olympic venues.

The maximum hourly concentration was 262 µg/m³ in Pragelato.

MOBILE LABORATORY PARAMETER: NITROGEN DIOXIDE (NO_2) (MICROGRAM/CUBIC METER)	PRAGELATO	SESTRIERE	SALICE D'ULZIO	BARDONECCHIA	TORINO
Average daily minimum	17	21	15	9	31
Average daily maximum	135	130	82	93	143
Average of the daily averages	72	69	48	49	77
Valid days	69	34	28	50	39
Percentage valid days	95%	72%	56%	96%	100%
Average of hourly values	71	69	48	49	77
Average hourly maximum	262	231	214	129	233
Valid hours	1673	816	785	1200	927
Percentage valid hours	95%	72%	65%	96%	99%
Number of times hourly limit value for human health protection was exceeded (200)	24	7	3	0	6
Number of days the hourly limit value for human health protection was exceeded at least once (200)	11	3	3	0	2
Alarm threshold exceeding (400)	0	0	0	0	0
Number of days the alarm threshold was exceeded at least once (400)	0	0	0	0	0

Table 3.9

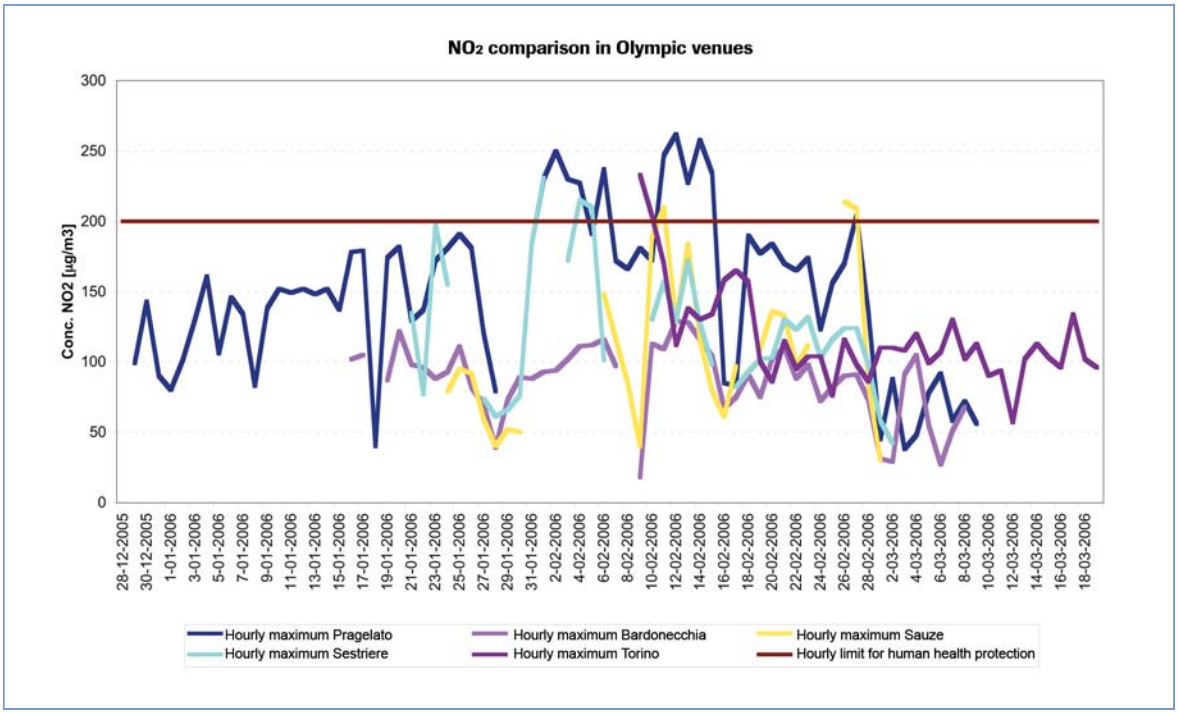


Figure 3.10 - Nitrogen dioxide: maximum hourly concentration

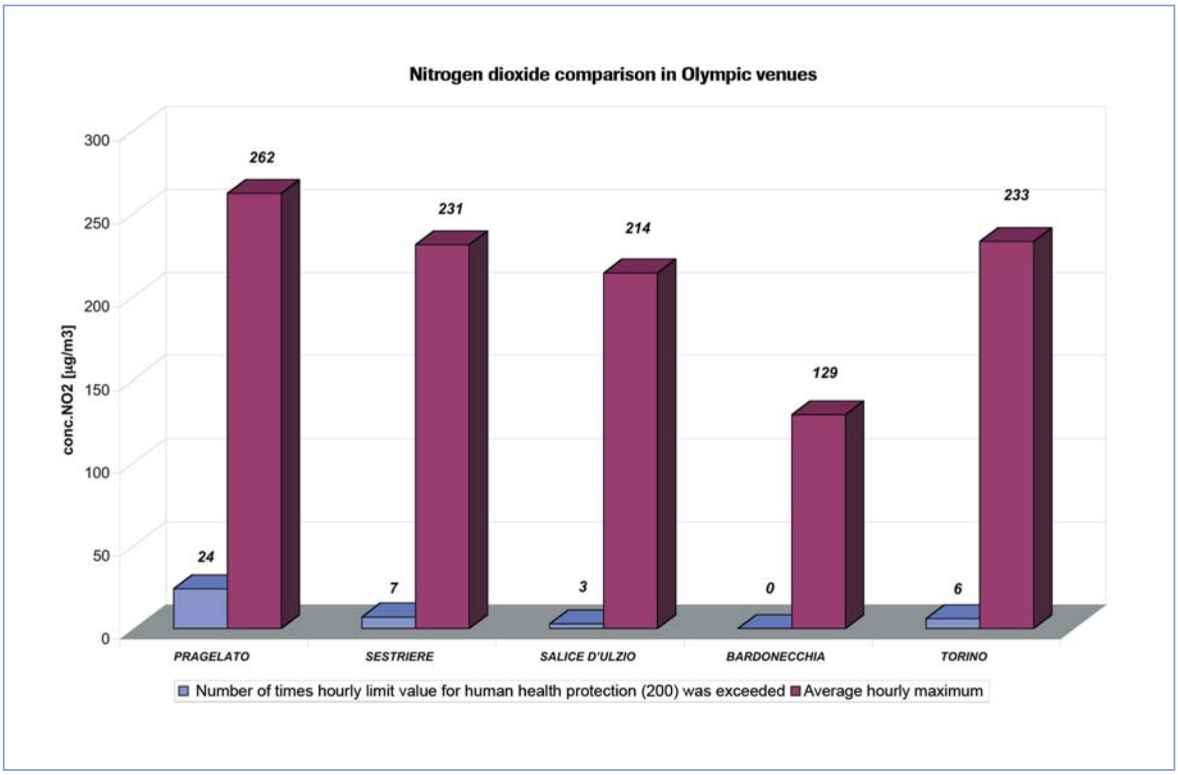


Figure 3.11 - Nitrogen dioxide: number of times NO_2 limit was exceeded and hourly maximums

3.6.5 PARTICULATE MATERIAL (PM_{10})

Table 3.10 shows the data for PM_{10} measured during the monitoring period at the five Olympic venues.
Ministerial Decree 60/2002 provides, for the protection of human health, an average concentration annual limit of 40 µg/m^3 and a daily limit of 50 µg/m^3, not to be exceeded more than 35 times during the year.
Concentrations during the monitoring period exceeded the limits on several occasions, with a maximum of 26 values above the daily limit in Torino and no values above the limit in Sauze d'Oulx, as shown in figures 3.12 and 3.13 below.
The highest values were measured during days characterised by poor diffusive capacity of the air.

MOBILE LABORATORY PARAMETER: PARTICULATE MATERIAL (PM_{10}) (MICROGRAM/CUBIC METER)	PRAGELATO	SESTRIERE	SALICE D'ULZIO	BARDONECCHIA	TORINO
Average daily minimum	7	3	2	4	14
Average daily maximum	93	93	50	128	240
Average of the daily averages	36	34	24	36	85
Valid days	63	22	30	52	34
Percentage valid days	86%	47%	60%	100%	87%
Average of hourly values	36				
Average hourly maximum	310				
Valid hours	1553				
Percentage valid hours	89%				
Number of times daily limit value for human health protection was exceeded (50)	16	6	0	14	26

Table 3.10 - PM_{10} Particulate Material

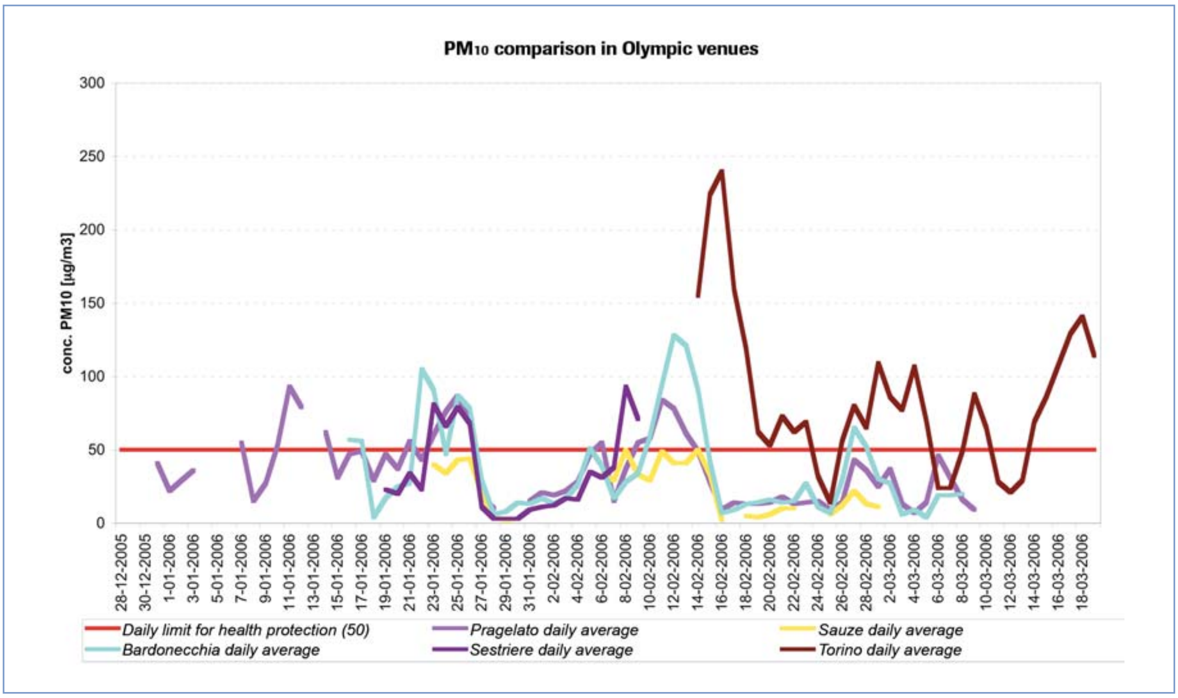


Figure 3.12 - PM10: average daily concentrations

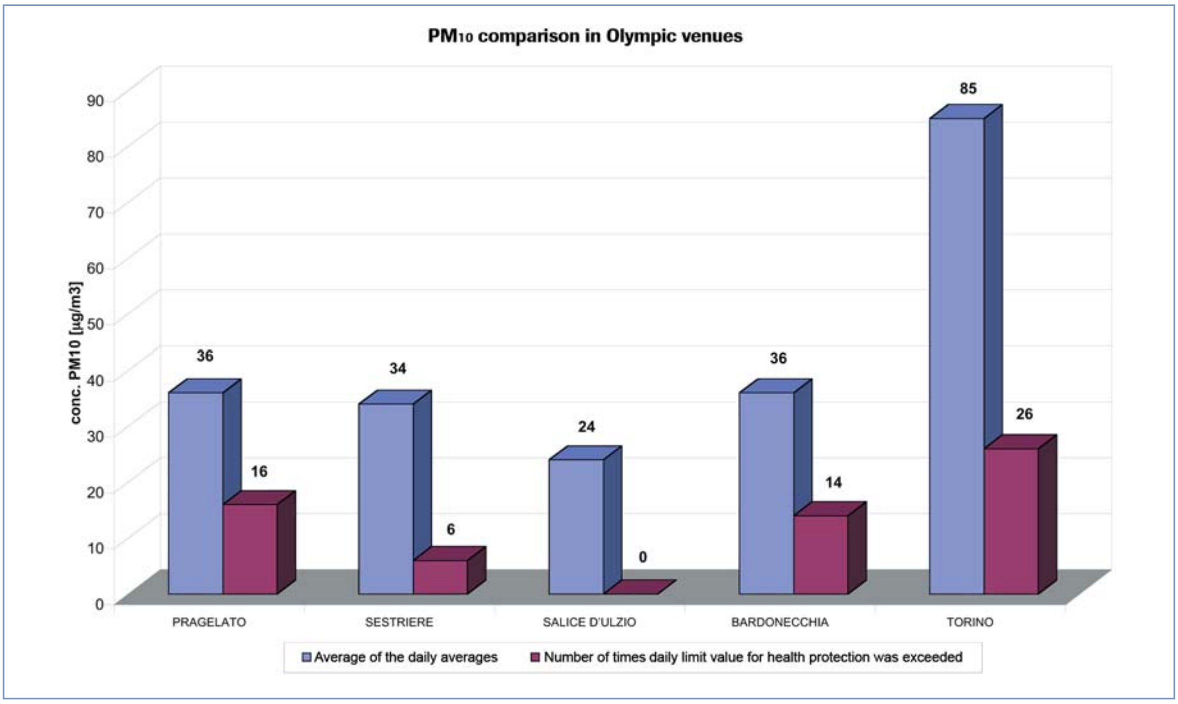


Figure 3.13 - PM10: average daily number of times PM10 limit was exceeded and average of the daily averages

3.6.6 SULPHUR DIOXIDE (SO_2)

Table 3.11 below groups together the data for sulphur dioxide (SO_2) measured at the five Olympic venues during the monitoring period.

The graph in figure 3.14 illustrates the average day for each measuring site and the values measured were well below the limits for the protection of human health established by Ministerial Decree 60/2002, these being a daily average of 125 µg/m³ not to be exceeded more than three times in the calendar year, and an hourly average of 350 µg/m³ not to be exceeded more than 24 times in the calendar year.

MOBILE LABORATORY PARAMETER: SULPHUR DIOXIDE (SO_2) (MICROGRAM/CUBIC METER)	PRAGELATO	SESTRIERE	SALICE D'ULZIO	BARDONECCHIA	TORINO
Average daily minimum	5	-	3	0	5
Average daily maximum	11	-	32	17	12
Average of the daily averages	8	-	15	6	9
Valid days	69	-	28	48	27
Percentage valid days	95%	-	56%	92%	69%
Average of hourly values	8	-	15	6	9
Average hourly maximum	25	-	87	60	25
Valid hours	1672	-	775	1159	646
Percentage valid hours	95%	-	65%	93%	69%
Number of times hourly limit value for health protection was exceeded (350)	0	-	0	0	0
Number of days hourly limit value for health protection was exceeded at least once (350)	0	-	0	0	0
Number of times daily limit value for health protection was exceeded (125)	0	-	0	0	0
Alarm threshold exceeding (500)	0	-	0	0	0
Number of days the alarm threshold was exceeded at least once (500)	0	-	0	0	0

Table 3.11

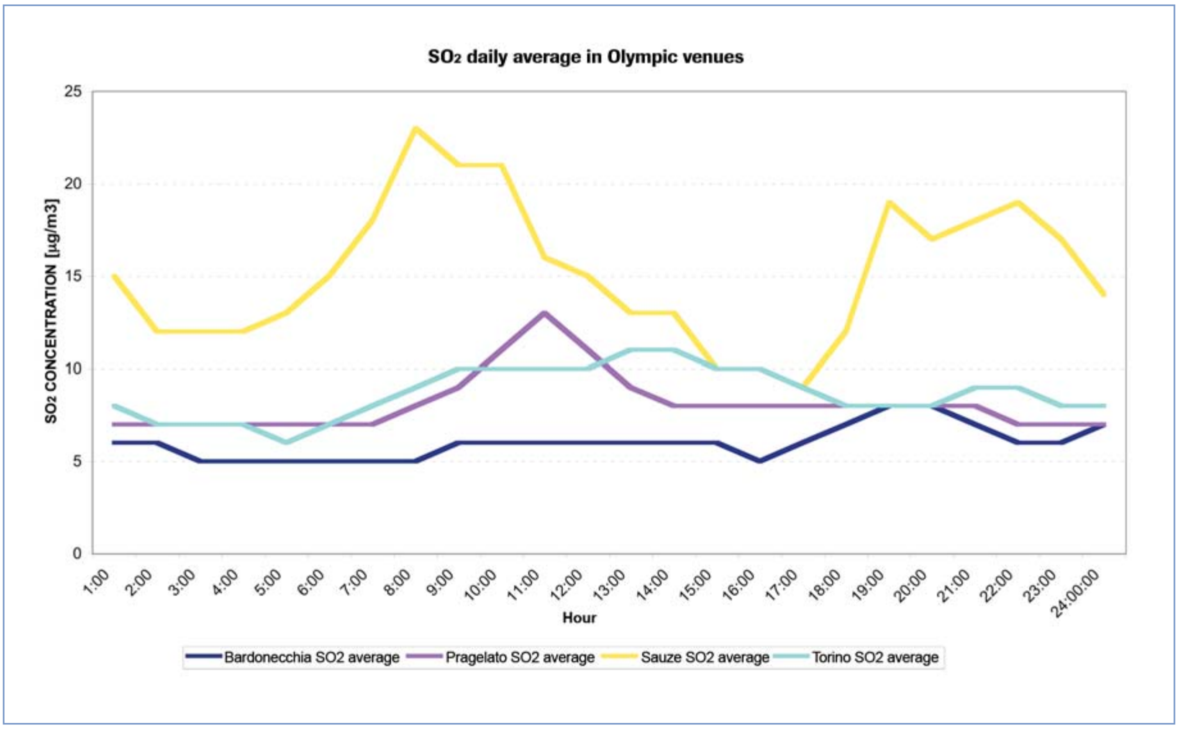


Figure 3.14 - SO_2: average daily trend

3.7 CONCLUSION

3.7.1 JUDGEMENT OF AIR QUALITY

The measuring campaign between the period of the Torino 2006 Olympic Winter Games, with the use of mobile laboratories, enabled the measurement of the parameters of interest for air quality.

As far as ozone is concerned, the values measured were characteristic of the winter season, when concentrations are lower than in the hotter months, although the values at the mountain venues were higher than those measured in the capital.

The limit set by Ministerial decree 60/2002 for carbon monoxide was fully respected, as was that for benzene, for which the average value of the monitoring period was contained, although on certain days and at certain venues (Torino), high hourly average concentrations were measured.

3.7.2 CRITICAL SITUATIONS FOUND

Nitrogen dioxide and particulate material were the two most critical pollutants, among those monitored.

The level of nitrogen dioxide during the monitoring period exceeded the hourly limit of 200 mg/m^3 24 times (Pragelato) compared with the 18 times/year allowed by Ministerial Decree no. 60 dated April 2^{nd} 2002, also exceeding the limit at the other venues, apart from Bardonecchia.

PM_{10} exceeded the daily limit of 50 $\mu g/m^3$ 26 times in Torino and 16-14-6 times in Pragelato, Bardonecchia and Sestriere, while the limit was never exceeded in Sauze d'Oulx.

In short, the major criticalities discovered during the campaigns concerned PM_{10} and nitrogen dioxide, as well as the weather conditions which, on some days, prevented the dispersion of the pollutants produced by the traffic and local sources represented particularly by domestic heating (liquid or solid fuels).

Furthermore, some data was lost during the monitoring campaigns due to electricity blackouts which had nothing to do with Arpa Piemonte and there was also a lack of consistency in the processing of the weather reports during the monitoring period as not all the mobile laboratories of the Provincial Departments were equipped with meteorology instruments.

Consequently the climatic information for the monitoring period was not collected for all the venues.

3.7.3 POSITIVE ASPECTS

The Air Quality Index production and distribution service for the area involved in the Games – implemented by Arpa Piemonte with the IT support of the C.S.I. Piemonte Environmental Monitoring Area – was made available to the public, in Italian and English, from January 31^{st} 2006 until March 19^{th} 2006, on the website of the Provincia di Torino and on the Arpa Piemonte Olympic Weather Service website (Meteogiochi), which will be described in greater detail in the chapter on communication.

The extension of the information service and the quality of the air in the Piedmont valleys that hosted the XX Olympic Winter Games attained positive results in terms of compliance with the needs for clarity and accessibility to daily information on the air quality provided for by the laws in force, and for the considera-

NUMERIC INDEX	AIR QUALITY
1	*Excellent*
2	*Good*
3	*Fair*
4	*Mediocre*
5	*Not very healthy*
6	*Unhealthy*
7	*Very unhealthy*

Figure 3.15 - Values of the Air Quality Index and corresponding summaries of the air quality

ble interest aroused by the distribution of a specific AQI for the Piedmont valleys, not only to those actually involved in the works but also to the public, as visible in the statistics of the web server of the Arpa Piemonte Meteogiochi website.
The analysis of the values taken from the AQI (figure 3.15) in the Olympic valleys shows a clear tendency towards low values (figure 3.16), with a majority of 2 (good) and 3 (fair), while during the same period in Torino values of 6 (unhealthy) and 7 (very unhealthy) were often reached. The highest Air Quality Index values among those registered in the Olympic valleys (AQI of 4) were reached on three days in February (the 11th, 13th and 14th) and one day in March (the 15th) during the Olympic and Paralympic Games respectively; all the cases were associated with significant concentrations of PM_{10} registered at the venues of Oulx and Pragelato and with stable weather conditions, unfavourable to the dispersion of pollutants, with a consequent deterioration of the air quality.
The comparison of the trends in the daily value of the Air Quality Index for the city of Torino and for the Olympic valleys (figure 3.17) during the period of the Games shows a substantial independence of the two areas from the point of view of atmospheric pollution, linked mainly to the local dispersive weather conditions rather than to sources of emission, definitely present at both venues due to the Olympic event.

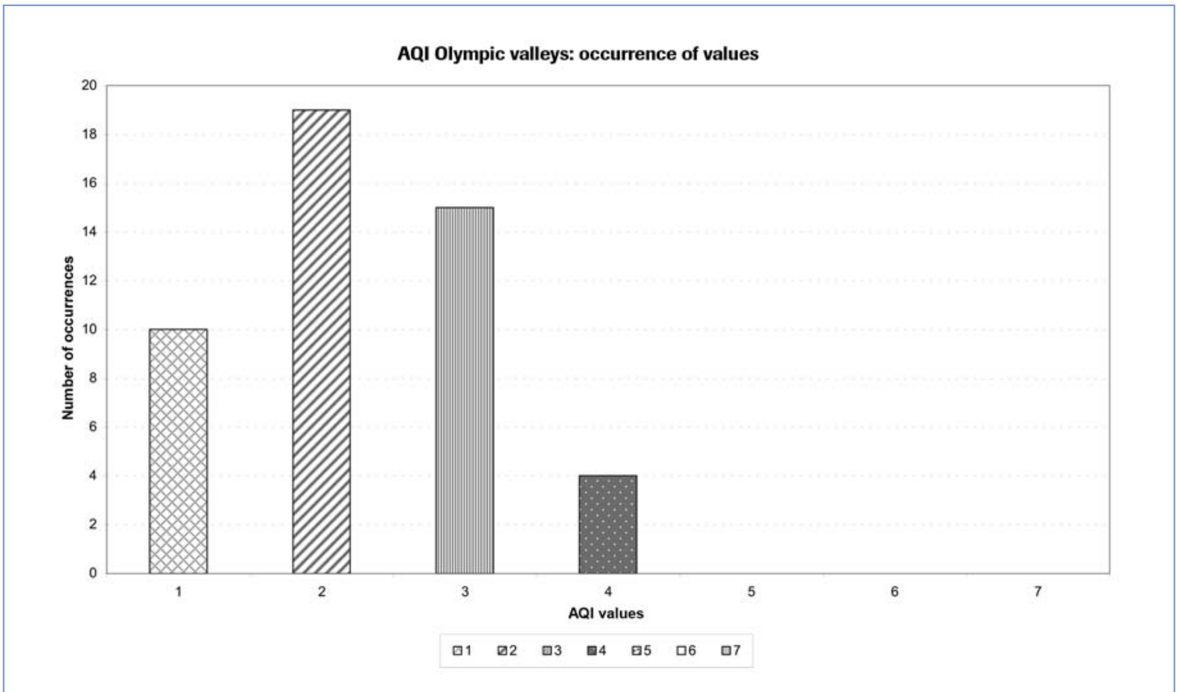


Figure 3.16 - Occurrence of the values of the AQI in the Olympic valleys

3.7.4 RESOURCES AND EQUIPMENT USED

During the Games, about 20 technicians from the Provincial departments and the Environmental Monitoring and Forecasting Area for the elaboration of the AQI were involved in about 70 on-site inspections of the mobile laboratories located at the Olympic venues, both to maintain the instruments and sampling devices and to replace the filters of the particulate material collected every day.
Following these inspection, about 177 air quality samples were taken and subject to gravimetric testing for PM_{10} and the calculation of the concentrations of fine dust in the air, as well as 48 daily elaborations of the air quality index.

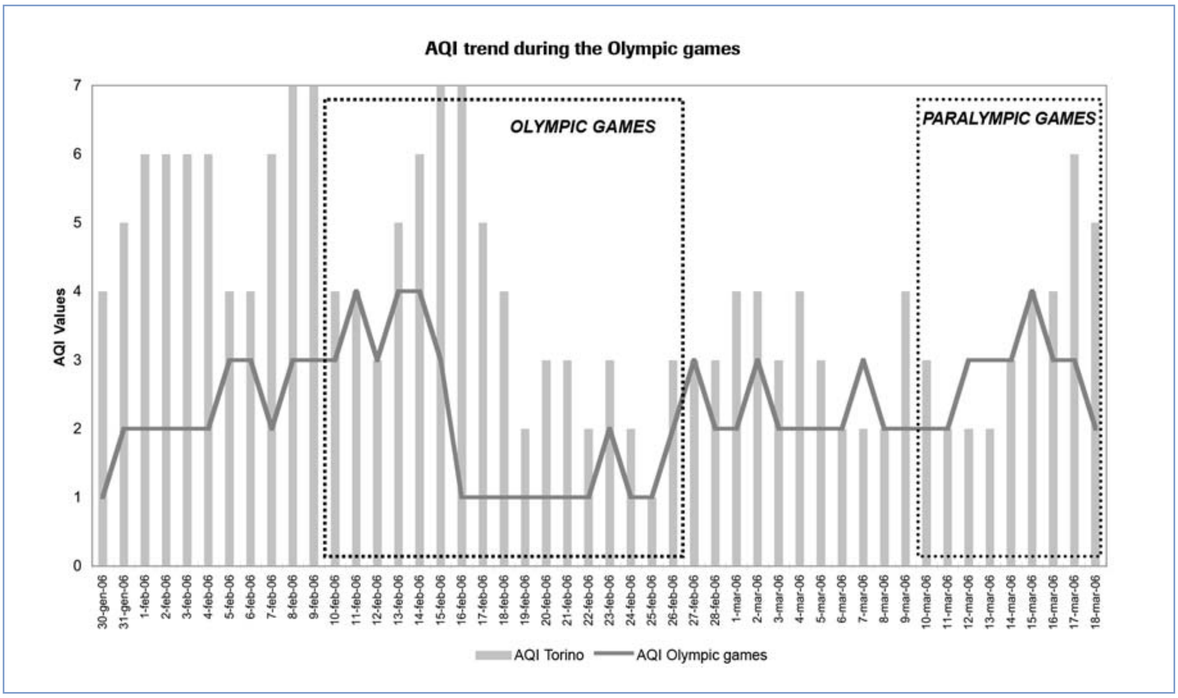


Figure 3.17 - Comparison between AQI trends (in the Torino area and the mountain area) during the Games

The Torino 2006 Water Plan 4

4. The Torino 2006 Water Plan

4.1 INTRODUCTION

The cooperation between the Provincia di Torino and Arpa Piemonte for the Water Plan Project began in 2001, with the stipulation of the first agreement. The aim was to assess the environmental quality of the drainage basins of the Dora Riparia and Chisone stream in the high Susa and Chisone Valleys, involved in the recently terminated Olympic events. Upon completion of the first joint project (February 2003), Arpa Piemonte (Torino Department) and the Provincia di Torino (Water Resources) stipulated three new agreements for the continued collaboration on the Water Plan Project in 2004, 2005 and 2006.

The commitment of Arpa Piemonte was constant and the monitoring activity carried out by the Torino Department has continued non-stop from February 2002 until today and, on the basis of the last agreement stipulated, will continue for the whole of 2006. The first report by Arpa Piemonte, delivered in February 2003, presented the results of the cognitive phase to describe the territorial features of the area examined and highlight any criticalities encountered in the first year of monitoring. The monitoring programme was then updated and corrected with regard to the choice of the measuring stations and relative sampling frequency.

With the second report (June 2004) it was possible to obtain a sufficiently wide range of data to process the first results achieved. The environmental quality indexes of the measuring stations of provincial interest were calculated and the loads of pollutants affecting the fluvial mobility strips were assessed. Operations also continued for the calibration and gauging of the simplified mathematical model, the structure of which was upgraded and lightened.

With the third report, changes to the monitoring programme, agreed between Arpa Piemonte and the Provincia di Torino, were introduced (December 2004); the results of the last two years of sampling were presented (2004 and 2005) with the elaboration of the pollutant loads and environmental indexes; assessments were made in relation to the water resource for the active duration of the project (2001-2005) and, lastly, the study of the predictive scenarios carried out using the simplified mathematical model was reported.

4.2 MONITORING

4.2.1 SAMPLING PROGRAMME UPDATE

The monitoring activity for the Torino 2006 Water Plan began in 2002 and the programme has been subject to certain changes over the years. After the first two years of investigation (2002-2003) and in the light of the results achieved, it was agreed with the Provincia di Torino to review the monitoring programme in order to optimise the times and resources used.

With the stipulation of the agreement for 2005, the proposal by Arpa Piemonte to formally classify the points of the monitoring activity in different categories depending on the sampling frequency and relative position on the territory was accepted. The points were divided into four categories (table 4.1), each of which was associated, for ease, with a different colour.

CATEGORY	DESCRIPTION	COLOUR
White	Measuring stations located in the higher part of the drainage basins, where anthropic impact is limited	WHITE
Support	Measuring stations providing a support for data processing	YELLOW
Provincial	Measuring stations belonging to the next monitoring net of Provincia di Torino	PURPLE
Regional	Measuring stations shared both by the Water Plan and the Regional Bodies of Water Census	BLUE

Table 4.1 - Categories of monitoring points proposed in 2004

The decision was made to reduce, as of 2005, the sampling frequency in the measuring stations with fewer criticalities, mainly in the points known as "White" at the entrance to the drainage basins. The decision was also made to make the measuring of the capacity for the "support" points seasonal, while maintaining the monthly frequency of the biological-chemical sampling.

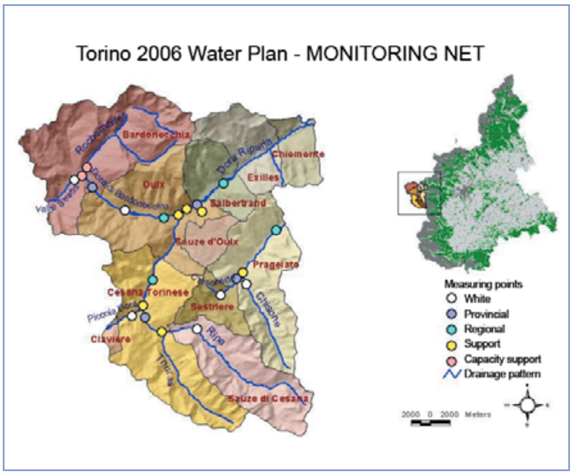


Figure 4.1 - Torino 2006 Water Plan - Monitoring network

For the measuring points of Plan, immediately downstream from the confluence between the Chisone stream and Chisonetto creek, and Blanchet, downstream from the confluence between the Torrente Ripa and the Piccola Dora, it was thought better not to directly measure the capacity, but to obtain it from the sum of the values measured on the two branches upstream from each confluence.

Following further reconnaissance of the categories fixed in this way together with the Provincia di Torino, it was decided, with this report, to reassign certain measuring stations to the relative categories. Particularly, the proposal was made to include the

BODIES OF WATER	MEASURING POINT	POINT CODE	TIPOLOGY ANALYSIS		
			Chemical - biol.	Capacity	IBE
	"white" points				
Dora di Bardonecchia	Bardonecchia "Campo Smith"	007_PA_TO_06	every 3 months	monthly (1)	-
Ripa Stream	Sauze di Cesana - Argentera Valley	001_PA_TO_06	every 3 months	every 3 months	-
Piccola Dora	Cesana - SS 24	004_PA_TO_06	every 3 months	every 3 months	-
Chisonetto Creek	Sestriere - Borgata	014_PA_TO_06	every 3 months	every 3 months	-
Chisone Stream	Pragelato - Pattemouche Chisone	017_PA_TO_06	every 3 months	every 3 months	-
	"support" points				
Dora di Bardonecchia	Oulx - Beaulard	002_PA_TO_06	every 3 months	every 3 months	-
Dora Riparia	Cesana - Bousson	002_PA_TO_06	every 3 months	every 3 months	-
	Cesana - Blanchet	005_PA_TO_06	monthly	(2)	-
	Oulx - San Lorenzo	006_PA_TO_06	monthly	every 3 months	-
	Oulx - Pont Ventoux mountain	011_PA_TO_06	monthly	(3)	-
Gran Comba	Gran Comba	013_PA_TO_06	every 6 months	-	-
Chisone Stream	Pragelato - Plan	015_PA_TO_06	monthly	(2)	-
	"capacity support" points				
	Bardonecchia Rochemolles Creek	018_PA_TO_07	-	monthly (1)	-
	Bardonecchia Frejus Valley	008_PA_TO_08	-	monthly (1)	-
	"provincial net" points				
Dora di Bardonecchia	Bardonecchia Bramafam	009_PA_TO_06	monthly	monthly (1)	every 3 months
Ripa Stream	Cesana - Sagnalonga	003_PA_TO_06	monthly	monthly	every 3 months
	Oulx - Pont Ventoux Valley	012_PA_TO_06	monthly	monthly	every 3 months
Chisonetto Creek	Pragelato - Pattemouche Chisonetto	016_PA_TO_06	monthly	monthly	every 3 months
	"regional net" points				
Dora di Bardonecchia	Oulx - Beaume	236020	monthly	-	every 3 months
Ripa Stream	Cesana - Fenils	038001	monthly	-	every 3 months
	Salbertrand	038330	monthly	-	every 3 months
Chisone Stream	Pragelato - Soucheres Basses	029002	monthly	monthly	every 3 months

Table 4.2 - Monitoring programme from January 2005

(1) The three capacities of Rio Rochemolles, Rio Frejus and Campo Smith are representative of that of Bramafam;
(2) The capacity value is obtained by adding together those measured upstream from the confluence;
(3) for technical reasons it is not possible to calculate the capacity.

monitoring stations of Bousson and Beaulard, which had been regularly sampled at quarterly intervals until January 2006 without being specifically included in any of the four categories established, in the group of support points. It was also decided to attribute the half-yearly sampling point at Gran Comba to the support category, as the quality of its water, badly affected by the anthropic impact, made its presence in the group of "white" points hard to justify. Lastly, the name "capacity support points" was given to those points where capacity only was monitored (Rochemolles and Valle Frejus).

Table 4.2 shows the new monitoring programme in force since 2005.

4.2.2 OLYMPIC MONITORING

As envisaged, the XX Olympic Winter Games took place in the Susa and Chisone Valleys from the 10th to the 26th of February 2006. In agreement with the Provincia di Torino, the decision was made to carry out a special monitoring activity during the Olympic period, not expressly provided for in the programme agreed for 2006, but considered indispensable to know the quality of the water resources in a condition of possible criticality. It was decided to run two monitoring campaigns in February. A reduced campaign in the first week of the competitions and the other, comprising a greater number of sampling points, in the second and last Olympic week.

The decision was also made to run the IBE campaign for the first quarter of 2006 in March. After a common assessment, the decision was made to take the IBE measurements some time after the end of the Olympic programme in order to be sure to measure any alterations caused by the Olympic event in the macrobentonic community. The complementary sampling schedule adhered to is summarised below.

OLYMPIC MONITORING	CHEMICAL		IBE
MEASURING POINTS	CAMPAIGN I	CAMPAIGN II	
VALLE SUSA	14/02/06	20/02/06	
Torrente valle Stretta - Campo Smith		X	
Dora di Bardonecchia - Bramafam	X	X	9/03/06
Dora Riparia - Pont Ventoux Valle	X	X	9/03/06
Torrente Ripa - Sagnalonga	X	X	9/03/06
Dora di Bardonecchia - Beaume	X	X	31/03/06
Dora Riparia - Fenils	X	X	31/03/06
Dora Riparia - Salbertrand	X	X	
Dora Riparia - San Lorenzo		X	
Dora Riparia - Pont Ventoux Monte		X	
VALLE CHISONE	13/02/06	21/02/06	
Chisone Pattemouche	X	X	
Chisonetto Pattemouche	X	X	(1)
Chisone Plan		X	
Chisone Soucheres Basses	X	X	14/03/06

(1) The frozen torrent prevented the IBE analysis from going ahead

Table 4.3 - Olympic monitoring

4.3 PRESENTATION OF THE RESULTS

Work continued on the Torino 2006 Water Plan, begun in 2002 and consolidated in 2003, throughout 2004 and 2005, and was renewed with an agreement for the whole of 2006.

In the previous Arpa Piemonte report (June 2004), both in rough form and using graphs, the analytic results for the

first two years of sampling were presented. This report presents the results for sampling years 2004 and 2005.
It wasn't always possible to perform all the investigations in every measuring point. An internal organisation problem associated with difficult climatic conditions made sampling operations impossible in October 2004 in every point in the Val Chisone and Valle Susa, apart from the regional monitoring stations in the Val Susa.
In the Val Chisone, sampling was possible in December 2004 exclusively in the point at the closure of the Soucheres Basses basin, due to ice or difficulties in accessing the riparian banks. In January and December 2005 it was impossible to carry out the sampling operations at the measuring points on the Chisonetto creek due to ice on the surface of the stream.
It was not always possible to measure the dissolved oxygen parameter in the months from April to June 2005, following the internal reorganisation of the laboratories.

4.3.1 ELABORATION AND ASSESSMENT OF THE POLLUTANT LOADS - CALCULATION OF THE ENVIRONMENTAL QUALITY INDICES

For the measuring points belonging to the future provincial monitoring network, it is possible, as in previous years, to calculate the environmental indices (LIM ecological status and status of environmental quality or SACA) as defined in annexe 1 of Legislative Decree 152/99 also for 2004 and 2005. Tables 3.1 and 3.2 show the summarised values of these indices for all the years in which the monitoring activity was carried out, from 2002 to 2005.
While there are slight variations in the LIM score and IBE values from year to year, the status of environmental quality for the measuring point at Pattemouche remains constantly sufficient. This does not just regard the last two years of analysis, but the entire period subject to examination. It is always the IBE that determines the class of the ecological status and therefore the SACA (Stato Ambientale dei Corsi d'Acqua – Environmental Status of Watercourses) value.

VAL CHISONE				
PATTEMOUCHE CHISONETTO	2002* (Feb - Dec)	2003	2004	2005
L.I.M. (macro descriptors)	270 (Class 2)	210 (Class 3)	260 (Class 2)	280 (Class 2)
I.B.E.	7.13 (Class 3)	7.00 (Class 3)	7.00 (Class 3)	7.25 (Class 3)
ECOLOGICAL STATUS	Class 3	Class 3	Class 3	Class 3
ENVIRONMENTAL STATUS	Sufficient	Sufficient	Sufficient	Sufficient

Table 4.4 - Environmental indices for the Pattemouche point on Chisonetto creek at Pragelato - 2002/2005

Chisonetto creek remains within a class of sufficient quality which, in the definition of 152/99 characterises those hydro bodies the biological quality of which shows signs of alteration deriving from human activity. As already mentioned in the previous Arpa Piemonte report, it is extremely likely that the presence of the purifier at Borgata, upstream from the measuring point, strongly influences the biological quality of the watercourses. It will also be interesting to analyse the Olympic monitoring data measured in February 2006 to asses the impact of the Olympics on the territory and the purifying efficiency of the purifier in particularly difficult conditions.

The table summarises the environmental indices values for the points of the future provincial network in the Val Susa. As far as the monitoring points of the provincial network in the Val di Susa are concerned, the trend of the environmental indices has not changed during the last two years of sampling compared with the 2002-2003 period.

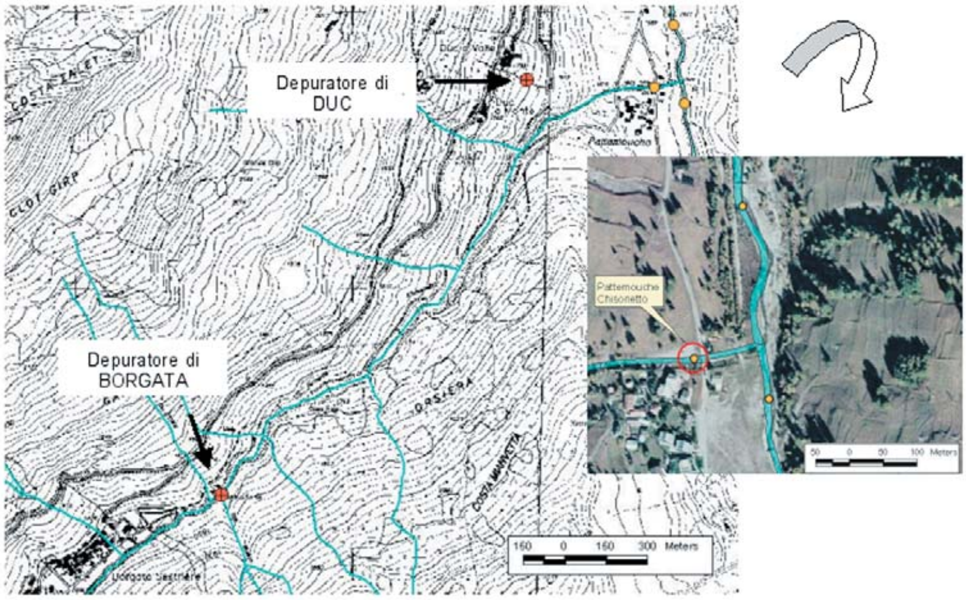


Figure 4.2 - Localisation of the discharges of Duc and Borgata and the measuring points at Pattemouche
(ctr 1:10000 and orthophoto IT2000)

For the measuring point at Bramafam, downstream from the town of Bardonecchia, in 2004 and 2005 too the main environmental index (the SACA) was **sufficient**, with a LIM score constantly in class two.

The average value of the IBE on the other hand, identified a class III score in both years, despite considerable change between the values measured in the single seasons, with a minimum in the 2005 campaign, when the IBS index reached 3, corresponding to class V.

VAL DI SUSA				
BRAMAFAM	**2002* (Feb - Dec)**	**2003**	**2004**	**2005**
L.I.M. (macro descriptors)	ND	310 (Class 2)	310 (Class 2)	345 (Class 2)
I.B.E.	ND	6.50 (Class 3)	7.00 (Class 3)	6.00 (Class 3)
ECOLOGICAL STATUS	ND	Class 3	Class 3	Class 3
ENVIRONMENTAL STATUS	ND	Sufficient	Sufficient	Sufficient

SAGNALONGA	**2002* (Feb - Dec)**	**2003**	**2004**	**2005**
L.I.M. (macro descriptors)	380 (Class 2)	360 (Class 2)	340 (Class 2)	380 (Class 2)
I.B.E.	8.00 (Class 2)	7.75 (Class 2)	8.00 (Class 2)	7.75 (Class 2)
ECOLOGICAL STATUS	Class 2	Class 2	Class 2	Class 2
ENVIRONMENTAL STATUS	Good	Good	Good	Good

PONT VENTOUX VALLE	2002* (Feb - Dec)	2003	2004	2005
L.I.M. (macro descriptors)	380 (Class 2)	330 (Class 2)	280 (Class 2)	350 (Class 2)
I.B.E.	7.50 (Class 2)	7.75 (Class 2)	7.67 (Class 2)	7.75 (Class 2)
ECOLOGICAL STATUS	Class 2	Class 2	Class 2	Class 2
ENVIRONMENTAL STATUS	Good	Good	Good	Good

Table 4.5 - Environmental indices for the provincial monitoring point in the Val di Susa - 2002/2005

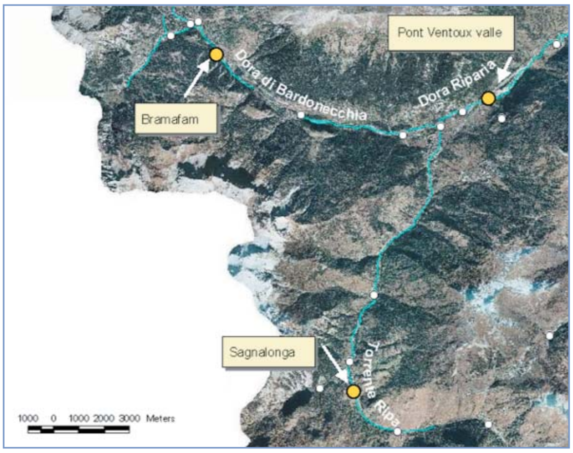


Figure 4.3 - Localisation of the measuring points of provincial interest in the Val di Susa *(from orthophoto IT2000)*

For the other two measuring points, Sagnalonga and Pont Ventoux valle, the same considerations made earlier are valid. There are no significant changes in the value of the environmental indices and particularly in the SACA, which is confirmed as **good** for both points in the two years of examination considered. In any case, the data obtained is in line with the values of the environmental indices for 2004 and 2005 in relation to the points that the Water Plan has in common with the Regional census of Hydro Bodies. In fact, the Beaume point situated on the River Dora at Bardonecchia, downstream from the Bramafam point, shows **sufficient** environmental quality, while the Fenils point, downstream from the confluence between the Torrente Ripa and the Piccola Dora and therefore downstream from the Sagnalonga point, shows, like the latter, a **good** SACA index.

4.4 MODMASE MATHEMATIC MODEL

4.4.1 GENERAL INFORMATION AND DESCRIPTION

Complexity is a characteristic common to all environmental systems traceable to the co-existence of many components, each with its own dynamics, which closely interact with each other.

The model has become an indispensable tool for the study of environmental systems. It is also used in the study of fluvial systems where, in the light of the current regulatory framework, the assessment of water quality has to consider all the possible sources of impact that influence the river. These forecasting, planning and control instruments can offer local administrations technical support in the decision-making process related to drainage and sampling, giving them an instrument with which to identify the causes of potential criticalities, thanks to which it is possible to find adequate answers to the management of the **environmental situation** and assess the effects of alternative solutions, choosing the one that seems most suitable to reach certain management or operational aims.

A mathematic model is an instrument which makes it possible to develop an answer, not only in relation to external forces, but also in relation to internal dynamics, albeit simplified. This representation can be summarised and is divided into controllable entries, such as management operations (treatment systems, water tapping, etc.) and uncontrollable entries, such as unsettled weather and widespread pollutant loads.

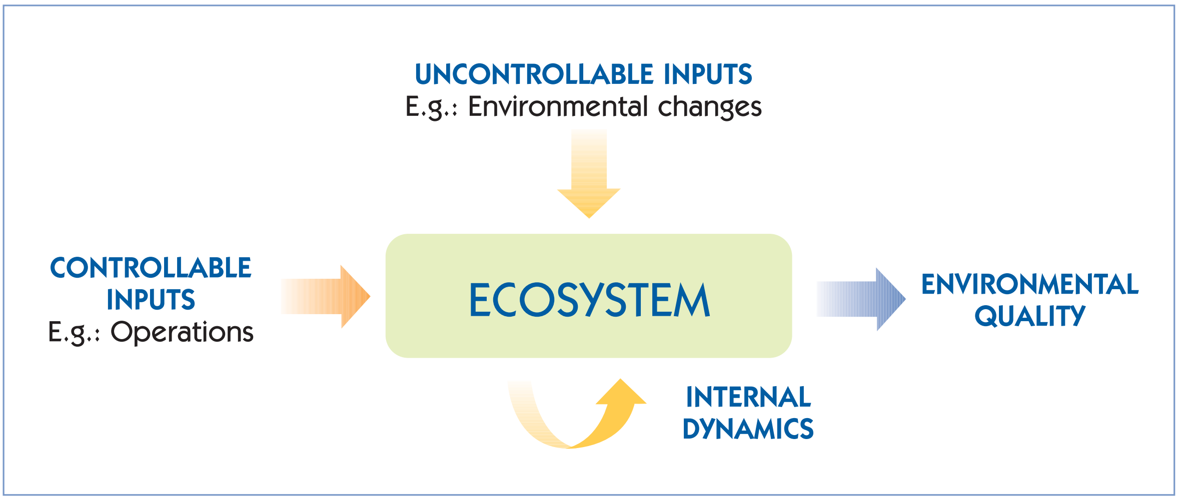


Figure 4.4 - General structure of an ecosystem seen as a dynamic system

The fluvial quality models are, from the user's point of view, calculation environments in which there is an "engine" containing the kinetics of biodegradation and bioaccumulation and other service models which take care of the solution of these dynamics, the user interface, data input and the presentation of the results in graph form. Using differential equations known as balance equations, the "engine" of the model is able to describe the accumulation of changes over a period of time in the system status variables, chosen during the planning phase.
A mathematic model is usually made up of three sub models (hydraulic, thermal and biochemical) described in brief in table 4.6.

Phase 1	**HYDRAULIC MODEL** Indispensable for the quality model Determines the movement range of the fluid (Capacity)
Phase 2	**THERMAL MODEL** Balance equations which express the conservation of thermal energy, which influence the biological dynamics and solubility of oxygen (Temperature)
Phase 3	**BIOCHEMICAL MODEL** Dynamics of biochemical reactions Interaction between Molecules and Micro-organisms (DO BOD COD, biomasses)

Table 4.6 - Mathematic model: subdivision into sub models

The thermal and hydraulic variables are independent of those of biochemical nature so, to simplify things, it is usually assumed that the first two sub models are inputs of the biochemical sub model, the only quality model to which the differential equations for the variables chosen apply.
The **MODMASE** experimental mathematic model, conceived and created for the Torino 2006 Water Plan project, has developed the methodological approach described briefly in the previous paragraph.
The particular nature of the territory subject to examination has conditioned the choice of the model instrument to use. The area is the higher part of the Chisone and Susa valleys, where the sources of impact are reduced and mainly limited to the discharges of the local municipal purifiers.
The decision was made to use a **simplified quali-quantitative model** in which the hydraulic and thermal variables were subject to simple mass balancing operations.

The biochemical sub model on the other hand uses the formulae of the Streeter and Phelps theory, which enable the description of the BOD trend and that of dissolved oxygen downstream from a concentrated discharge of biodegradable material. In fact, the degradation processes of organic substances are so complex that a status variable cannot be defined for every one of the pollutant composts and for every living species. It is necessary to define one or more aggregated variables. The most direct approach is to postulate the existence of a reaction between oxygen and an equivalent class of biodegradable substances without considering the organisms involved in the degradation process.

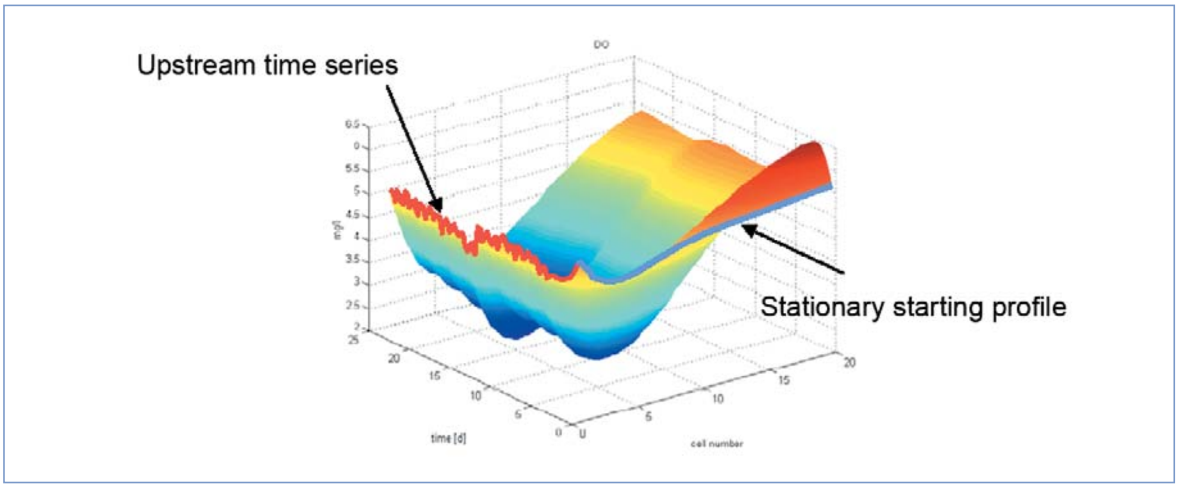


Figure 4.5 - Typical "depression" progress of dissolved oxygen downstream from a discharge
(from ANPA fluvial model RTI CTN_AIM 2/2000)

The MODMASE model therefore was built on the parameterisation of certain descriptors of the quality of the hydro body, i.e.: capacity, dissolved oxygen temperature and BOD.
All the operations envisaged for the construction of the model instrument have been carried out over the years: the nodal structure of the model for the two fluvial mobility strips was created and the gauging and calibration of MODMASE were completed using the data obtained from the monitoring activity performed.
During the last year of activity, the conclusive phase of the model processing was perfected, i.e.: the simulation of the predictive scenarios, which assume alternative conditions to the actual situation identified using on-site measurements. This simulation involves the introduction of changes in the environmental conditions and/or the anthropic pressures that influence the watercourses in order to be able to answer the question, "what would happen if…" and be able to make forecasts.

4.4.2 HYDRAULIC SPEED

The study of the hydraulic speed of the watercourse is extremely important to define the hydraulic parameters necessary to the operations of the fluvial quality model.
The measurements were taken using the current meter; this instrument measures the speed of the flow of the current along a section of the watercourse. The application of dedicated software (SOFTWARE Q) enables the calculation of the capacity of the measuring point, combining the speed values measured at a set distance from the riverbank with the length of the transect chosen for the measuring operation.

The stations in which to manually carry out the capacity measurements have been chosen on the basis of the knowledge of the territory, in conjunction with the choice of the chemical-biological monitoring points provided for by the Torino 2006 Water Plan project. The monitoring network was designed so that it would also be logical and materially possible to determine the capacity at the measuring points. Stations were chosen at the opening and closure of the basins and usually upstream and downstream from confluences with important affluents.

The graphs in figures 4.6 and 4.7 show the altimetry profiles of the fluvial mobility strips of the Chisone and Dora Riparia; the main strip is indicated in blue with the affluents in pink.
The portion of the Dora Riparia basin studied covers a difference in altitude of about 600 m, from 1600 to 1000 metres above sea level, corresponding with the closure of the basin at Salbertrand.
For the Chisone, the portion of basin studied runs from 1800 metres, upstream from the Borgata purifier on Chisonetto creek, to 1580 metres above sea level at the basin closure point at Soucheres Basses an outlying area of Pragelato.

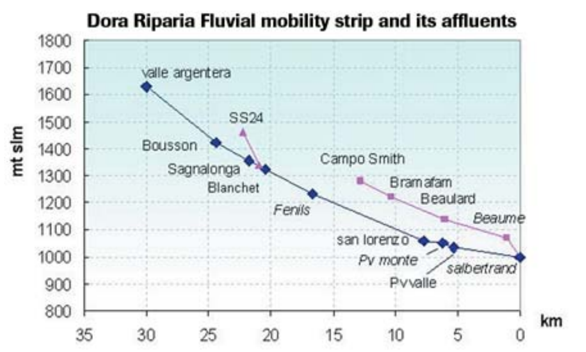


Figure 4.6 - Altimetry profile of the fluvial mobility strip of the Dora Riparia

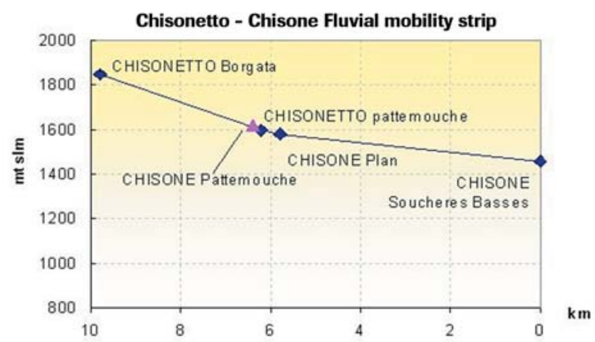


Figure 4.7 - Altimetry profile of the fluvial mobility strip of the Chisone - Chisonetto

4.4.3 WORKSHEETS

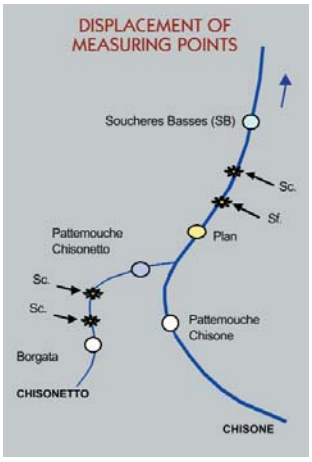


Figure 4.8

The territorial information gathered around the hydro body enabled the elaboration of the model's nodal structure, simplified in the diagram shown here. The example shows the simplified structure of the mobility strip of the Chisone, with the monitoring points (coloured dots) and impacts on the watercourse represented by the discharges of the municipal purifiers (yellow stars).
The construction of the model was long and complicated and underwent several changes and improvements during the years of activity of the project. Now the basic structure of the model comprises four sections. Remember that, during the elaboration phase, a structure was built for every month of sampling taken into consideration. The first section is that of the load input sheet. It contains all the territorial information on the discharges and analytical data of the parameters included in the model.
The load input sheet must include the number of equivalent inhabitants served by a specific purifier for the month considered or the parametric constants of the models, such as water consumption per capita and the degree of theoretic purifying efficiency of the purifiers.
The second section is dedicated to displaying the nodal structure of the model, in which it is possible to follow the trend of the four parameters chosen for the model (capacity, BOD, DO and temperature), in the nodes position along the fluvial mobility strip of the river in question. Every node, usually a discharge or a confluence between two affluents, is connected to its own calculation sheet, which enables the calculation of the changes in the BOD and DO values

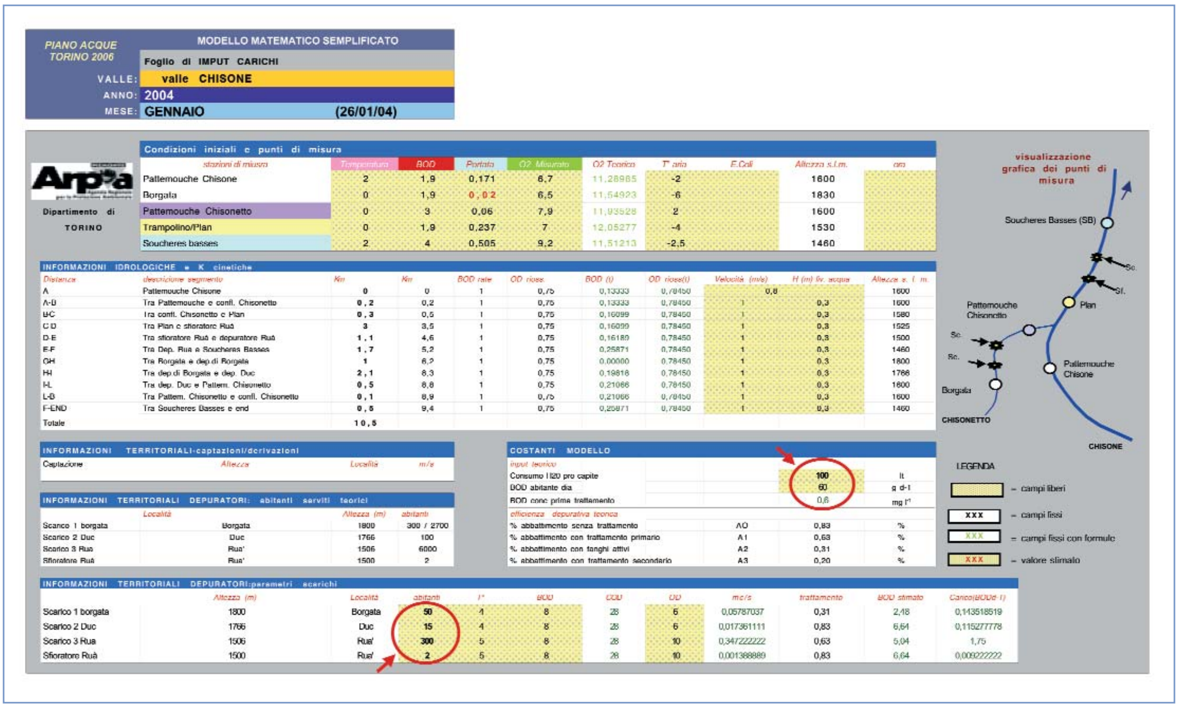


Figure 4.9 - MODMASE section 1: Territorial information

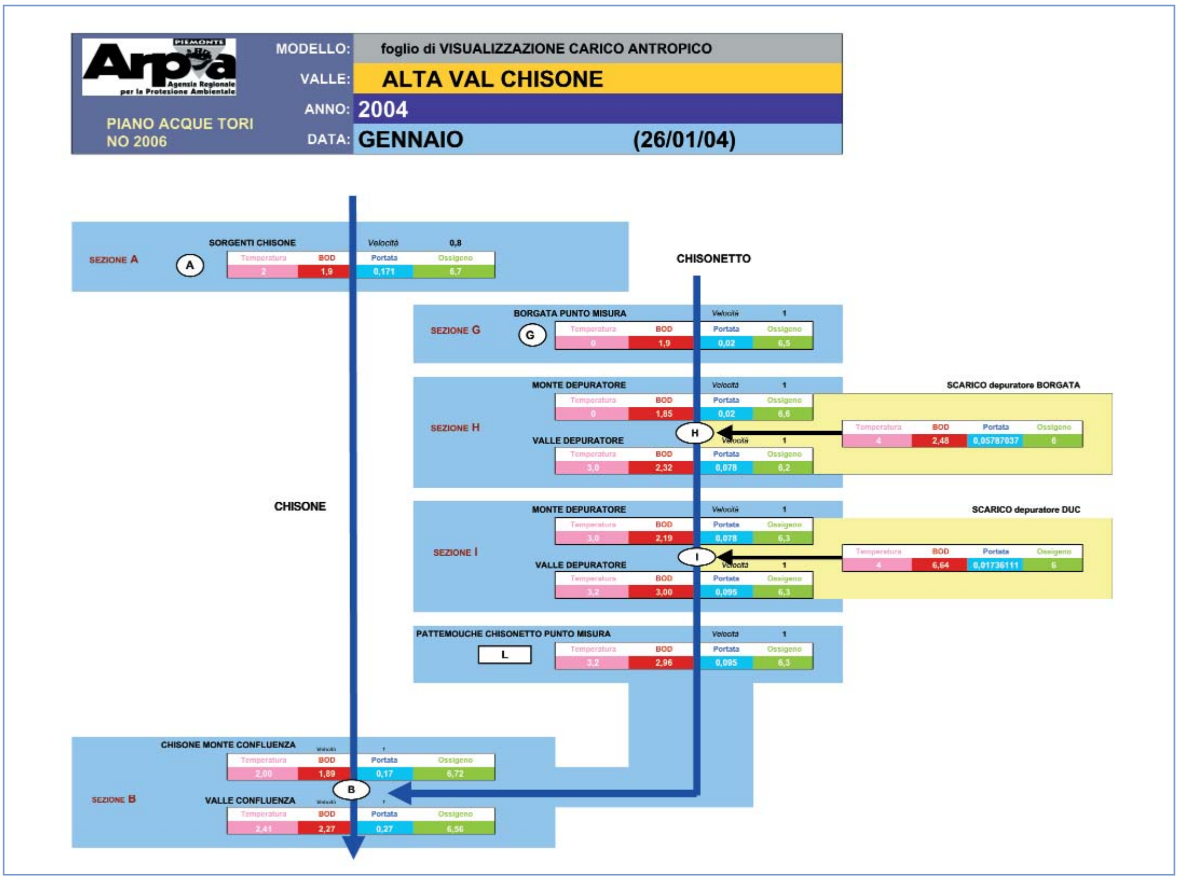


Figure 4.10 - MODMASE section 2: detail of the nodal structure of the model - Chisonetto creek

MODEL FOR THE ASSESSMENT OF DISCHARGE IMPACT ARPA PIEMONTE VIA-VAS COORDINATION				
Water Quality	SECTION 1			
	CHISONE UPSTREAM CONFLUENCE		CHISONETTO	
Biological Oxygen Demand	1,89		2,96	mg/l
Dissolved Oxygen	6,72		6,28	mg/l
Capacity	0,17		0,10	m3/s
Temperature	2,00		3,16	
Hydrologic features				
Roil average stream velocity	1	m/s		
Constants, Coefficients and Initial Condition at the mixing point				
BOD Rate Constant		1,00		
Rearation Constant		0,75		
Saturation DO		11,19		
Water Temperature		2,41		
BOD initial		2,27		
DO initial		6,56		
DO Deficit at Mixing Point		4,63		

Figure 4.11 - MODMASE section 3: detail of a calculation sheet - Chisone/Chisonetto confluence

Arpa
PIANO ACQUE TORINO 2006

MODELLO:	foglio di CALIBRAZIONE
VALLE:	CHISONE
ANNO:	2004
DATA:	GENNAIO (26/01/04)

	SEZIONE		distanza tra punti	distanza in Km	TEMP. Misurata	TEMP. Modello	BOD misurato	BOD mod.	PORTATA Misurata	Portata modello	O.D. misurato	O.D. modello
CHISONE	*Sorg. Chisone*	A	0	0	2	2	1,9	1,9	0,171	0,171	6,7	6,7
	conflu.	Bm	0,25	0,25		2		1,89		0,171		6,72
		Bv	0,05	0,3		2,415		2,274		0,266		6,561
	Plan	C	0,3	0,6	0	2,415	1,9	2,256	0,237	0,266	7	6,584
	sfior. Ruà	Dm	2,9	3,5		2,415		2,099		0,266		6,790
		Dv	0,2	3,7		2,428		2,114		0,268		6,806
	dep. Ruà	Em	0,9	4,6		2,428		2,053		0,268		6,893
		Ev	0,2	4,8		3,881		3,740		0,615		8,648
	Soucheres	F	1,7	6,5	2	3,881	4	3,574	0,505	0,615	9,2	8,627
CHISONETTO	*Borgata*	G	0	0	0	0	1,9	1,9	0,02	0,02	6,5	6,5
	dep.B.	Hm	1	1		0		1,85		0,02		6,60
		Hv	0,2	1,2		2,97		2,32		0,08		6,15
	dep. Duc	Im	2,1	3,3		2,97		2,19		0,08		6,31
		Iv	0,2	3,5		3,16		3,00		0,10		6,25
	Patt. Ch.etto	L	0,5	4	0	3,16	3	2,96	0,06	0,10	7,9	6,28

Figure 4.12 - MODMASE section 4: comparison between the values measured and those elaborated by the model

TERRITORIAL INFORMATION PURIFIER: Discharges parameters							
	Altitude (m)	*Resort*	*Inhabitants*	*T°*	*BOD*	*COD*	*OD*
Discharge 1 borgata	1800	Borgata	50	4	8	28	6
Discharge 2 Duc	1766	Duc	15	4	8	28	6
Discharge 3 Rua	1506	Rua'	300	5	8	28	10
Spillway Ruà	1500	Rua'	2	5	8	28	10

Figure 4.13 - MODMASE detail of section 1 - territorial information on discharges

with the distance, on the basis of the differential equations established according to the Streeter and Phelps model. The worksheets represent the third section of the model.

The fourth and final section is represented by the calibration sheet, in which, for each of the four parameters, the values elaborated by the model are compared with the results of the monitoring campaign. The table is associated with graphs which enable visual comparison of the successful correspondence of the two series of data measured and expected.

4.4.4 GAUGING AND CALIBRATING THE MODEL

The Gauging operation consists in finding the values of the parameters (coefficients) of the model, for example the degree of purifying efficiency of a purifier, which better describe the situation in the place and on the date given (e.g.: 0.83%).

Other coefficients to gauge are the parameters of the discharges throughout the territory, e.g. the equivalent inhabitants served. They vary depending on the time of year and number of tourists (50 eq./inhab. served by the Borgata purifier were assumed for November 2004).

A model is calibrated when all its parameters have been gauged and the values of the parametric constants in correspondence with which the model better interpolates the measurements taken have been determined. The model is validated when the data calculated differs from that measured by not more than 10-20%, depending on the cases and the uncertainty of the measurements of the variables.

In our case, the calibration was carried out month by month. This phase ended with the monitoring activity of 2004. For every measuring campaign, the values of the parametric constants in correspondence with which the model better interpolated the measurements taken were determined.

Figure 4.14 shows some results of the calibrations performed in 2004 for the measuring points of Soucheres Basses and Plan on the Chisone.

In general, in most of the months in which this correspondence was searched for, a good correlation was found between the values measured and those calculated by the model, as emerges from the graphs proposed.

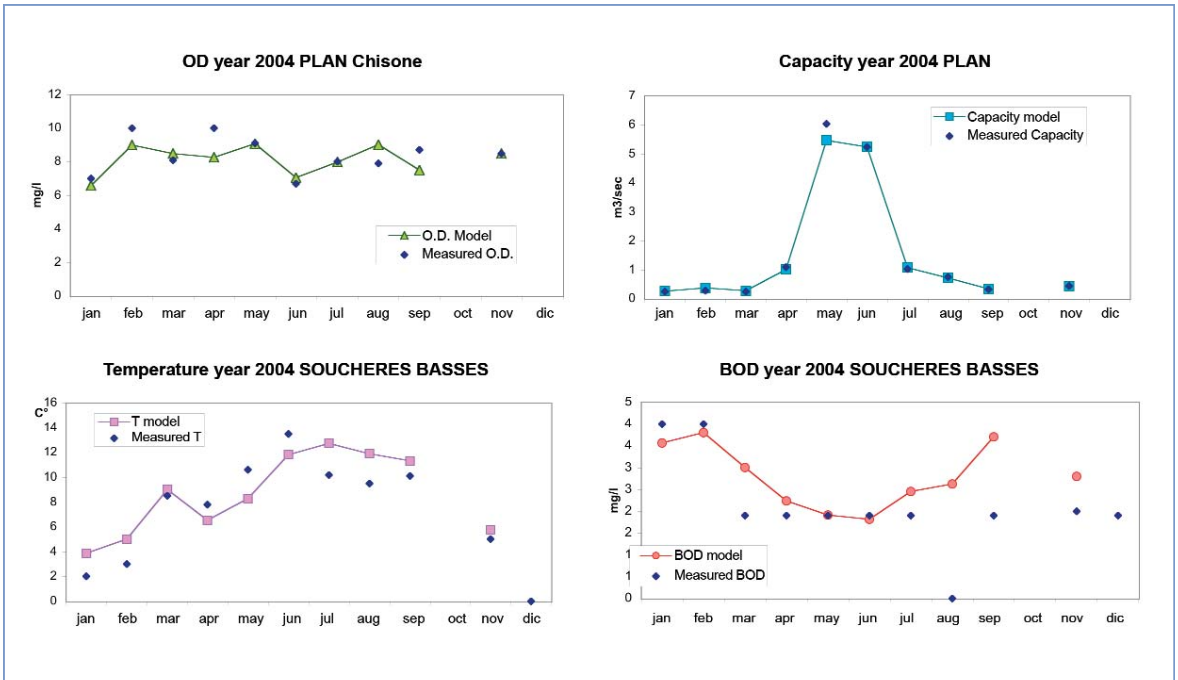


Figure 4.14 - Some results of the calibrations carried out for every month in 2004

4.5 PREDICTIVE SCENARIOS

One of the possible uses of the simplified fluvial mathematic model (MODMASE) described in the previous paragraphs, consists in the simulation of alternative scenarios compared with the real situation identified with on-site measurements. This simulation involves the introduction of changes in the environmental conditions and/or the anthropic pressures that influence the watercourses in order to be able to answer the question, "what would happen if…" and be able to make forecasts. The aim of the fluvial model is to obtain an instrument capable of supplying a description, albeit simplified, of the fluvial quality with which to assess possible alternative scenarios and supply a basis on which to build up management policies.

The paragraphs that follow describe and analyse four hypothetical scenarios.

4.5.1 SCENARIO 1

Scenario 1 assesses the consequences of an increase in the number of tourists in the basin of the Chisone stream, restricted to the municipalities of Pragelato and Sestriere Borgata. The parameters used in summer and winter seasonal simulations were those of the simplified model calibrated in August and February 2004. The Temperature, BOD and Dissolved Oxygen values in particular did not change compared with the corresponding calibration model, thus it was assumed that, in the same period but in different years, these values remain constant.

4.5.1.1 Summer simulation

Table 4.7 shows the values of the discharge parameters of the purifiers along the watercourse, measured in August 2004 and in a hypothetical summer scenario.

MODMASE – CALIBRATION AUGUST 2004							
	ALTITUDE (m)	LOCALITY	POPULATION	T°	BOD	COD	OD
Discharge 1 Borgata	1800	Borgata	60	13	6	21	8
Discharge 2 Duc	1766	Duc	20	13	6	21	8
Discharge 3 Ruà	1506	Ruà	600	13	6	21	8
Floodway Ruà	1500	Ruà	2	13	6	21	8

MODMASE - SUMMER SIMULATION							
	ALTITUDE (m)	LOCALITY	POPULATION	T°	BOD	COD	OD
Discharge 1 Borgata	1800	Borgata	800	13	6	21	8
Discharge 2 Duc	1766	Duc	100	13	6	21	8
Discharge 3 Ruà	1506	Ruà	1000	13	6	21	8
Floodway Ruà	1500	Ruà	2	13	6	21	8

Table 4.7 - Parameters of the purifier discharges in August 2004 and in the hypothetical summer scenario

The increase in the number of tourists in the municipalities of Sestriere and Pragelato involves an increase in the number of inhabitants connected to the purifiers within the territory and therefore a change in the parameters of the discharges that influence the two branches of the Chisone and Chisonetto.

The graphs in figure 4.15 show that the capacities of the Chisone and Chisonetto increase following the rise in the hydro contribution of the discharges which influence the two rivers. Due to the high number of inhabitants connected, the pollutant load also undergoes a considerable increase, as shown in the graphs indicating the BOD trend, shown above.

Table 4.8 shows the values of the discharge parameters of the purifiers along the watercourse, measured in February 2004 and in a hypothetical winter scenario.
Like the summer simulation, in the winter period there is an increase in capacities and BOD (figure 4.16).

The increase in these two parameters is much greater than in the summer simulation, inasmuch as the initial conditions are different. In February the lean capacities of the Chisone and Chisonetto are lower than those in summer, so the contribution of the purifier discharges has a greater influence on the quality of the watercourses. It would seem that the conditions with regard to the anthropic impact are more critical in the winter months.

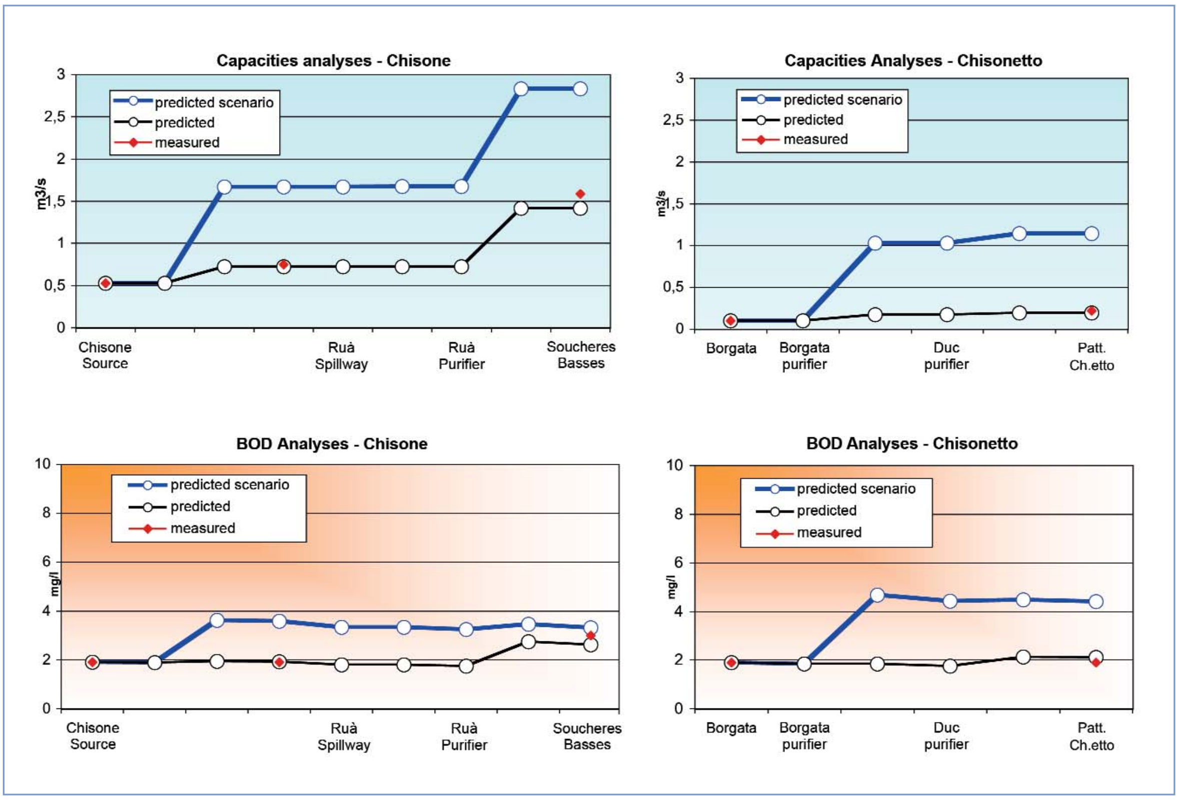


Figure 4.15 - Capacities and BOD of Chisone and Chisonetto in August 2004 and in the scenario

4.5.2 SCENARIO 2

The second scenario considers an increase in the number of tourists and a simultaneous improvement in the auto-purification capacity of the purifiers along the two branches of the Chisone stream and Chisonetto creek. The simulation was also represented in this case for the summer and for the winter, using the data from 2004 as reference. The Temperature, BOD and Dissolved Oxygen values in particular did not change compared with the corresponding calibration model, inasmuch as it was assumed that, in the same period but in different years, these values remain constant.

MODMASE - CALIBRATION FEBRUARY 2004							
	ALTITUDE (m)	LOCALITY	POPULATION	T°	BOD	COD	OD
Discharge 1 Borgata	1800	Borgata	60	5	13	45.5	8
Discharge 2 Duc	1766	Duc	20	5	13	45.5	8
Discharge 3 Ruà	1506	Ruà	600	6	8	28	8
Floodway Ruà	1500	Ruà	2	6	8	28	8

MODMASE - WINTER SIMULATION							
	ALTITUDE (m)	LOCALITY	POPULATION	T°	BOD	COD	OD
Discharge 1 Borgata	1800	Borgata	800	5	13	45.5	8
Discharge 2 Duc	1766	Duc	100	5	13	45.5	8
Discharge 3 Ruà	1506	Ruà	1000	6	8	28	8
Floodway Ruà	1500	Ruà	2	6	8	28	8

Table 4.8 - Parameters of the purifier discharges in February 2004 and in the hypothetical winter scenario

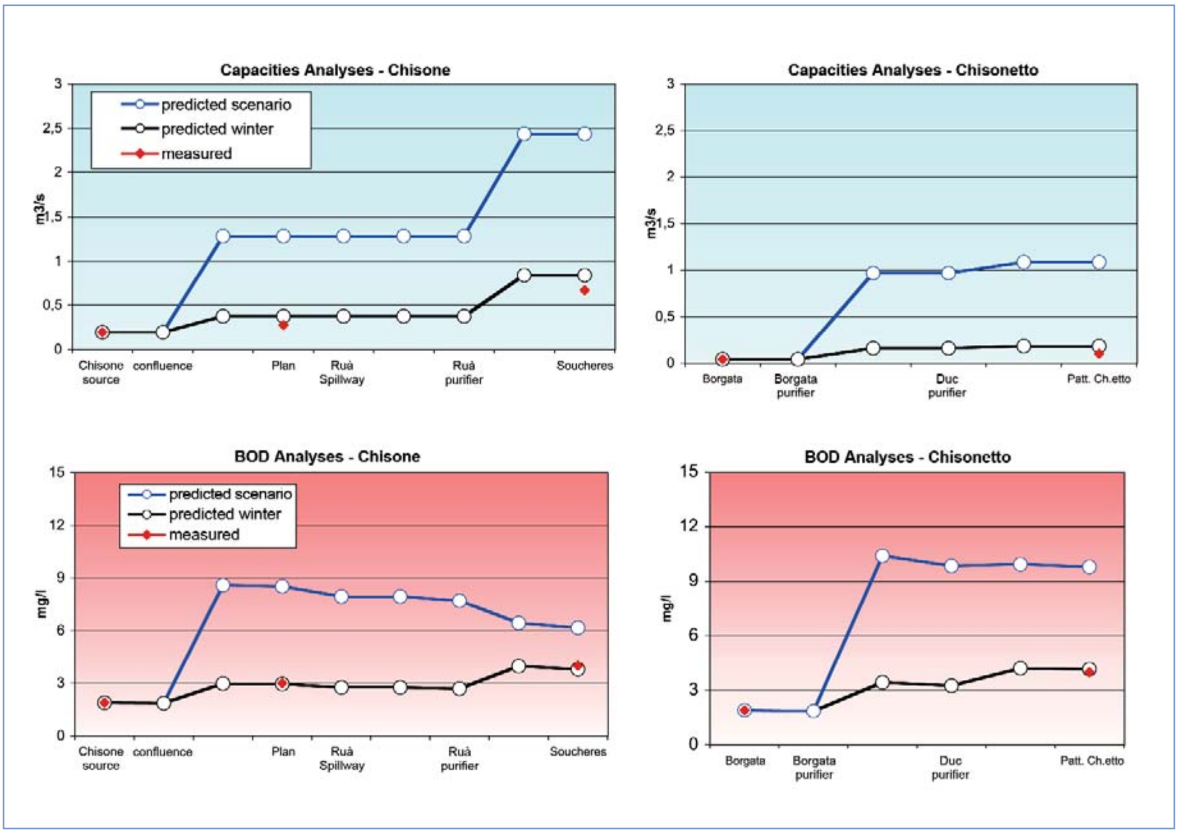


Figure 4.16 - BOD and capacities of Chisone and Chisonetto in February 2004 and in the scenario

MODMASE	TREATMENT	
DISCHARGES ALONG THE FLUVIAL MOBILITY STRIP	AUGUST 2004	SUMMER SCENARIO
Discharge 1 Borgata	0,31	0,20
Discharge 2 Duc	0,83	0,63
Discharge 3 Ruà	0,63	0,20
Floodway Ruà	0,83	0,20

Table 4.9 - Summer simulation scenario 2 - hypothetical treatment to improve discharges

MODMASE – THEORETIC PURIFYING EFFICIENCY	
% reduction without treatment	0,83
% reduction with primary treatment	0,63
% reduction with active sludge	0,31
% reduction with secondary treatment	0,20

Table 4.10 - Purifying efficiency - coefficients

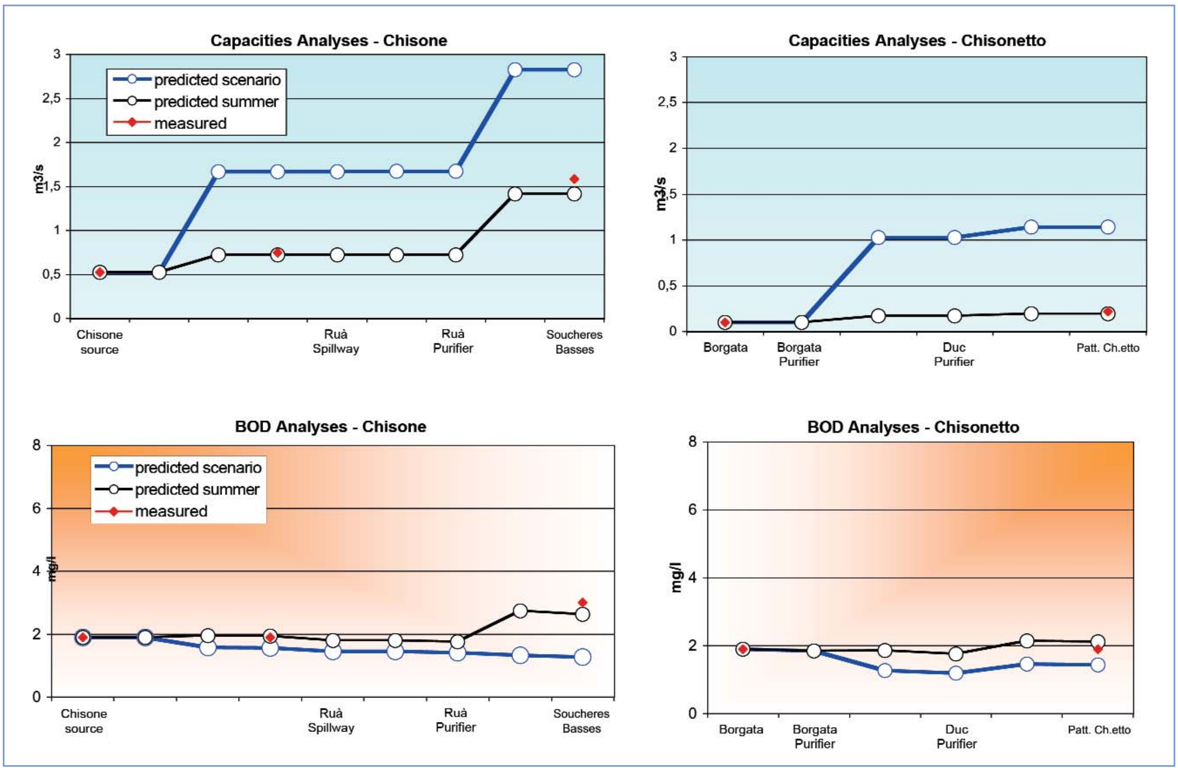


Figure 4.17 - Scenario 2 SUMMER capacities and BOD of Chisone and Chisonetto

4.5.2.1 Summer simulation

Table 4.9 shows the purifying efficiency of the systems (expressed with a coefficient representing the percentage

reduction of pollutant load) in the situation identified in August 2004 and that assumed in the improved scenario. The increase in the number of inhabitants connected was assumed to be the same as that considered for scenario 1 (table 4.7); so all the parameters related to the discharge are the same as for the previous scenario.
The values indicated correspond to the purifying efficiencies listed in table 4.10.

From a comparison between the situation identified in August 2004 and that simulated in the summer scenario, it emerges that, similarly to scenario 1, the capacities increase with regard to the contribution of discharges present but the improvement of the purifying capacity of the systems determines a considerable drop in the BOD delivered by the discharges and consequently in the watercourse (graphs in figure 4.17).

4.5.2.2 Winter simulation

The winter scenario examines the same changes considered in the summer scenario (table 4.9), but the data related to the capacities in the watercourse refer to those measured in February 2004.

As expected, like the summer scenario, the capacities increase with regard to the contribution of discharges into the watercourse but the BOD load drops considerably thanks to the improved purifying efficiency of the systems present. As observed in winter scenario 1, the capacities on the riverbed presented for February are mainly discharged waters.

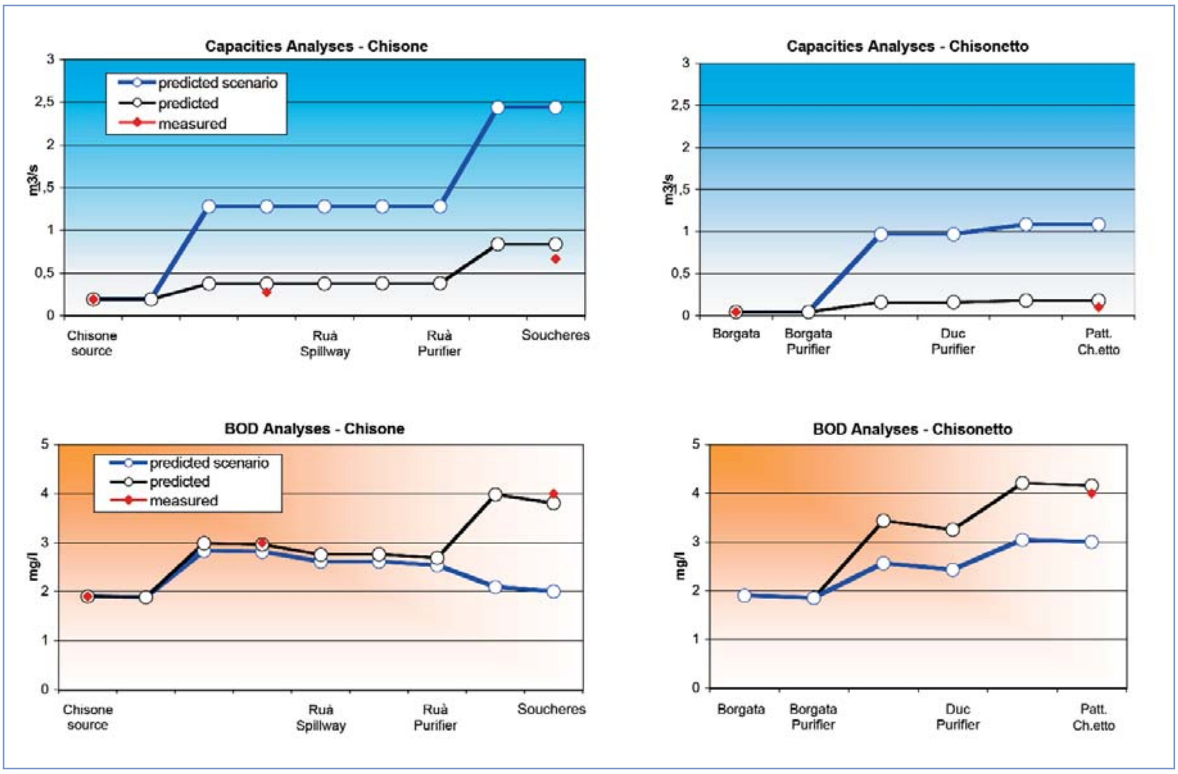


Figure 4.18 - Scenario 2 WINTER capacities and BOD of Chisone and Chisonetto

4.5.3 SCENARIO 3

The third scenario considers a reduction in the capacities on the watercourse. In this case too, two representative months were chosen: August 2004, when the drop in capacities was caused by dry summer weather, and October

2004, when it is assumed that the basin would be charged up due to programmed snow at Pattemouche (municipality of Pragelato). October was preferred over February, which was used for previous simulations, inasmuch as, in autumn, the presence of tourists is much lower than in the winter, so it does not influence the capacity of the discharges along the watercourse as would happen in February.
The data used for the summer and autumn simulations refers to 2004.

4.5.3.1 Summer simulation

For the summer scenario, a 40% drop in the natural capacities on the two stretches upstream from the discharges (Pattemouche on the Chisone and Borgata on the Chisonetto) is assumed. The variation on the branch of the Chisone consists in the passage from a capacity measured in August 2004 of 0.527 m^3/s to an assumed capacity of 0.32 m^3/s, while for the Chisonetto the passage is from 0.1 m^3/s to 0.06 m^3/s.
As regards the discharges along the watercourse, the relative parameters remain unchanged compared with the situation in August 2004, i.e.:

MODMASE – CALIBRATION AUGUST 2004							
	ALTITUDE (m)	LOCALITY	POPULATION	T°	BOD	COD	OD
Discharge 1 Borgata	1800	Borgata	60	13	6	21	8
Discharge 2 Duc	1766	Duc	20	13	6	21	8
Discharge 3 Ruà	1506	Ruà	600	13	6	21	8
Floodway Ruà	1500	Ruà	2	13	6	21	8

Table 4.11 - Values of parameters of purifier discharges in August 2004

As expected, the capacities drop considerably on the branch of the Chisone and also on that of the Chisonetto and the increase in capacity of both is determined by the contribution of discharges downstream (graphs in figure 4.19).
As regards the trend of BOD, there is just a very slight increase on both the curves of the Chisone and Chisonetto (graphs in figure 4.20).
The concentration of BOD does not in fact undergo evident changes at the monitoring points considered due to the presence of highly oxygenated water arriving from the area upstream from the discharges and such low values delivered by the discharges themselves.

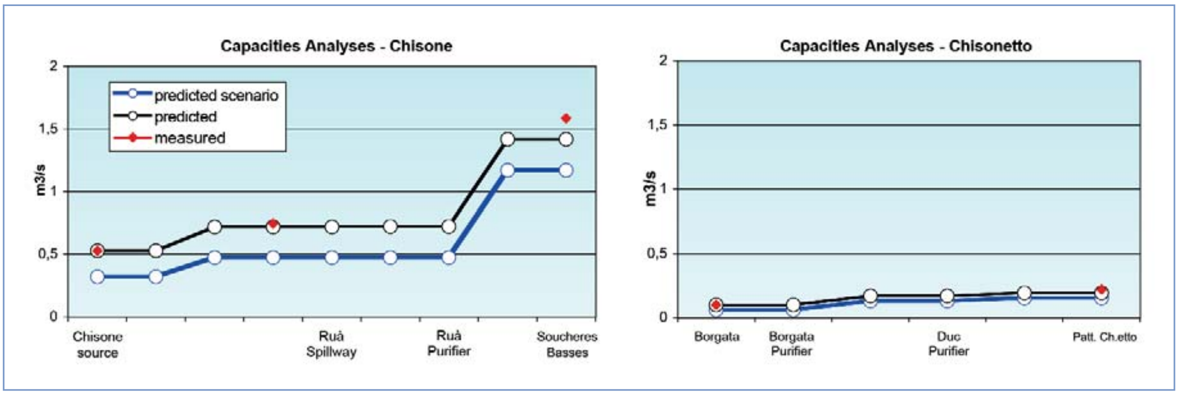


Figure 4.19 - Summer - Trend in capacities in the reference month for the scenario

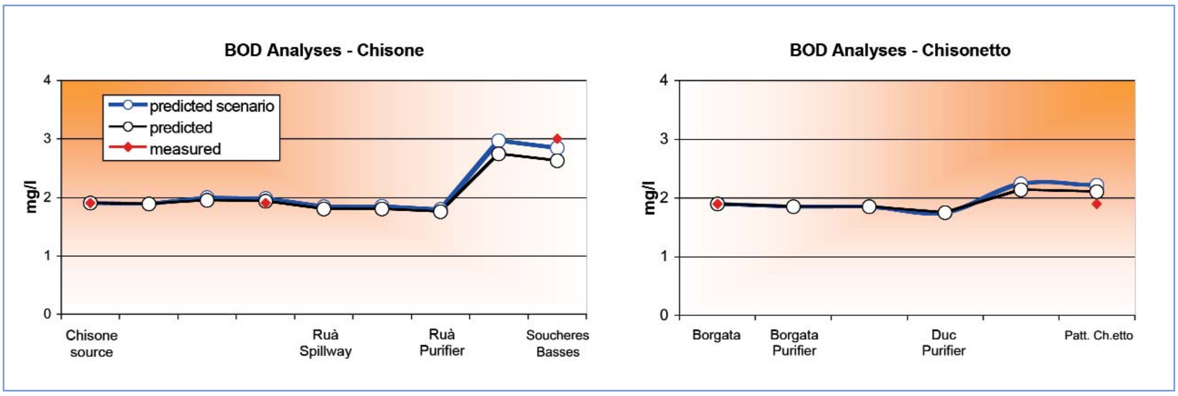


Figure 4.20 - Summer - Trend in BOD in the reference month for the scenario

4.5.3.2 Autumn simulation

The autumn scenario examines a drop in the capacities of the watercourse only on the branch of the Chisone at Pattemouche (In the municipality of Pragelato), inasmuch as it intends to simulate the effects determined by the removal of water used to fill the programmed snow basin built for the Torino 2006 Olympics.

The database on which this scenario was built refers to October 2003, a particular period in meteorological terms inasmuch as it snowed and, after this snow, the capacities measured on the stretch of the watercourse under examination were lower than the seasonal average, as shown by a comparison with the previous year shown in table 4.12:

MODMASE - SCENARIO 3 AUTUMN SIMULATION		
MEASURING STATIONS	**CAPACITY OCTOBER 2002 (m^3/s)**	**CAPACITY OCTOBER 2003 (m^3/s)**
Pattemouche Chisone	0,607	0,246
Borgata	0,078	0,039
Pattemouche Chisonetto	0,177	0,061
Trampolino/Plan	0,953	0,32
Soucheres basses	1,54	0,613

Table 4.12 - Capacities assumed in the autumn simulation

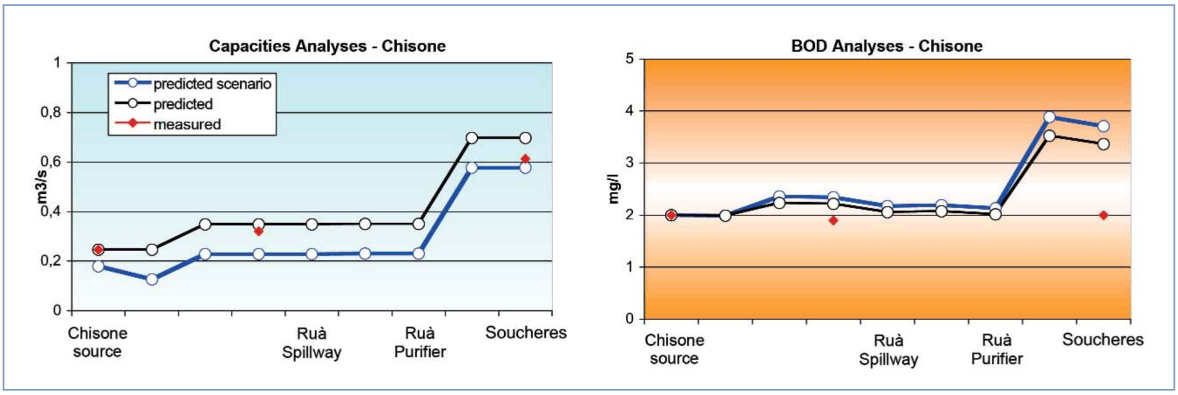


Figure 4.21 - Scenario 3 AUTUMN - Trend in capacities and BOD for the Chisone

The drop in capacity assumed on the branch of the Chisone is 30%, so upstream from the discharges the speed is about 0.18 m^3/s. Consequently there is a drop in the capacities along the stretch considered, as shown in the graph in the figure (in the winter scenario the Chisonetto branch is not considered, as no changes in capacity were assumed) and, like the summer situation, there is a slight increase in the concentration of BOD which, despite being slight, is higher than that in the summer, due to worse initial conditions.

4.5.4 SCENARIO 4

The fourth scenario intends to simulate a winter period with lean capacities lower than those in the summer period, in which, besides an increase in the number of tourists compared with the real situation of reference (February 2004), the absence of a purifying system is assumed along the stretch of the watercourse considered, leading to the assumption of a percentage of reduction in sewage of 0.83, just under one unit, due to a slight auto-purification of the watercourse.

It is possible to compare the reduction percentages of the purification system assumed in this study and listed in table 4.9 a of the summer simulation in scenario 2.

The following tables compare the anthropic value influencing the watercourse in February 2004 and the scenario assumed in a winter period with a very low lean capacity.

MODMASE – CALIBRATION FEBRUARY 2004							
	LOCALITY	POPULATION	T°	BOD	COD	OD	TREATMENT
Discharge 1 Borgata	Borgata	100	13	6	21	8	0,31
Discharge 2 Duc	Duc	20	13	6	21	8	0,83
Discharge 3 Ruà	Ruà	400	13	6	21	8	0,63
Floodway Ruà	Ruà	2	13	6	21	8	0,83

Table 4.13 - Territorial information for discharges in February 2004

MODMASE - CALIBRATION SCENARIO							
	LOCALITY	POPULATION	T°	BOD	COD	OD	TREATMENT
Discharge 1 Borgata	Borgata	3000	13	6	21	8	0,83
Discharge 2 Duc	Duc	500	13	6	21	8	0,83
Discharge 3 Ruà	Ruà	5000	13	6	21	8	0,83
Floodway Ruà	Ruà	2	13	6	21	8	0,83

Table 4.14 - Territorial information for discharges in the hypothetical summer scenario

As shown by the results presented in the graphs in figure 4.22, the situation simulated in scenario 4 is extremely critical, inasmuch as the considerable increase in capacities is determined exclusively by the contribution of the discharges which, without treatment, contribute to increasing the pollutant load on the riverbed (see BOD curve).

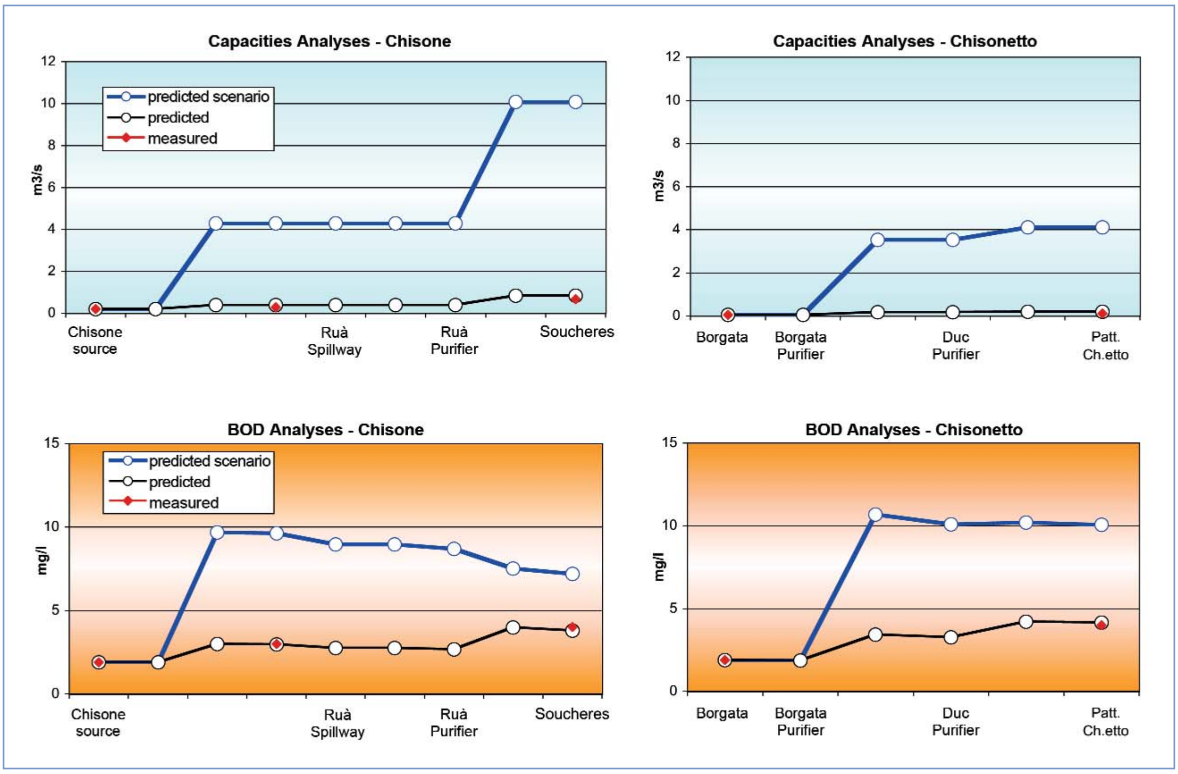


Figure 4.22 - Scenario 4 Trend in capacity and BOD

4.5 CONCLUSION

The results achieved during the monitoring activity enabled the constant assessment, by the Provincia di Torino and other Bodies concerned, of the effects induced by the anthropic activities connected both to the preparation and accomplishment of the Olympic events and to other activities, also providing useful instruments for the correct environmental planning of water resources in the mountain area of the drainage basins of the Dora Riparia and the Chisone stream.

The experience gained during the study may also be valuable to the planning of the provincial surface water monitoring network, of which the activity performed forms a significant pilot nucleus.

5 Prevention and control of the chemical risk

5. Prevention and control of the chemical risk

5.1 FOREWORD

In February 2005, the Torino Police Department activated a technical table for the planning of the organised response to collective emergencies generated during the XX Olympic Winter Games Torino 2006 by attacks, defined with the acronym NBCR (Nuclear, Biologic, Chemical, Radiological).

The specific aim of this planning was to guarantee the safety of the Olympic family, the Authorities, the press and spectators in the events of NBCR attacks, preparing, on the one hand, devices for prevention and detection and, on the other hand, devices for operational intervention aimed at mitigating the consequences and reducing the damage on the basis of pre-set scenarios and procedures.

The Civil Defence Plan, regulating the responsibilities of the various bodies and promoting actions of coordination between the operation of the police force, the structures appointed to provide technical aid and the health aid structures, was aimed at individuating specific models of response in relation to different types of threat:

- the nuclear threat (N), consisting in the deliberate dissemination into the environment of nuclear materials capable of causing damage to man (through external bodily irradiation, inhalation or ingestion of radioactive substances) or things;
- the biological threat (B), consisting in the dissemination into the environment of biological agents of varying nature (virus, bacteria, fungi, toxins, etc.) capable of causing lethal effects on men, animals or plants;
- the chemical threat (C), consisting in the deliberate dissemination into the environment of chemical composts or mixtures capable of producing the loss of human lives, either through inhalation of substances in the gaseous state or absorption through the skin and even ingestion;
- the radiological threat (R), consisting in the deliberate dissemination into the environment of radioactive materials capable of causing damage to man (through external bodily irradiation caused by sources of gamma radiation).

The planning activity was split up into targets classed as sensitive, being characterised by the local presence of dangerous subjects and/or particularly high numbers of people.

5.2 THE ROLE OF ARPA PIEMONTE

Arpa Piemonte was called upon to take part in the Police Department table, being a technical subject in possession of the specialised skills matured over the years during practical operation in emergency situations and organisational/management contexts in the planning phase. The same law used to set up the Agency (Regional Law 60/1995 amended by Regional Law 28/2002) attributes to Arpa Piemonte the activities inherent in scientific technical assistance at institutional levels, competent also for the elaboration of regulations, plans, programmes, reports, opinions, administrative provisions and operations, also of urgent nature.

Since 1997, the Agency has had a round the clock emergency assistance service operating throughout the whole regional territory to tackle environmental emergencies of anthropic nature.

Furthermore, with the institution, as of 2000, of the Technological Risk Coordination Unit, now known as Industrial Risk and Emergency Assistance, Arpa Piemonte took on an increasingly important role, alongside the other subjects involved, also within the context of activities to support the Police Departments in the preparation of external emergency plans for high risk plants.

The events that took place on September 11th 2001 renewed the institutional commitment to the issue of civil defence, as a component of the national defence, which includes military defence through the planning and organisation activity regarding the nation's material, economic, moral and financial resources necessary to the conduction of defensive operations.

In this specific context, the Agency took part on several occasions, with the other institutional subjects involved, in work groups coordinated by certain Police Departments in Piedmont for the preparation of provincial plans for civil defence against unconventional terrorist attacks, concentrating in particular on the aspects and problems of chemical risk. The

central role of Arpa Piemonte for the performance of critical analyses of the possible risk scenarios and analytical activities aimed at their characterisation, had emerged previously in this context.
On the basis and in force of previous experiences, Arpa Piemonte, in observance of its institutional tasks, had worked with the Torino Police Department on the preparation of the Civil Defence Plan for the XX Olympic Winter Games 2006 with a series of activities which fall within an overall action of specialised technical support to guarantee the safety of the population and the environment.
In particular, the prevention and control activities provided for by the Civil Defence Plan of the Police Department actively involved the Agency with regard to the chemical threat, within the context of the planning and implementation of monitoring actions to check for the presence of chemical contaminants in indoor venues, considered to be sensitive targets in relation to the plan:

- Hockey 1 (Palaisozaki)
- Hockey 2 (Torino Esposizioni)
- Palazzo a Vela
- Oval Lingotto
- Pinerolo Palazzo del Ghiaccio.

Figure 5.1 - Indoor Olympic venues Palazzo a Vela, Oval Lingotto and Pinerolo Palazzo del Ghiaccio

5.3 TECHNICAL DETAILS OF THE RISK ANALYSES

Within the context of the technical table coordinated by Torino Police Department, in support of the planning activities aimed at the prevention and control of unconventional events during the XX Olympic Winter Games Torino 2006, Arpa Piemonte carried out several specialised in-depth analyses in relation to the possible risk scenarios deriving from deliberate acts targeting the venues for the bob, luge and skeleton competitions in Cesana Torinese. The need to carry out certain specific assessments on the possible risk scenarios for the Cesana Pariol venue was dictated by the presence of anhydride ammonia as the thermal exchange fluid used to create the ice track.
The assessments carried out by the proponent when drawing up the construction plans were considered to be of little importance for the purposes of orienting the planning of civil defence activities, considering that they referred substantially to anomalies during transfer operations and the "normal" running of the venue – leaks of anhydride ammonia from the transfer hose, flanges, valves and fixed pipes as a result of breakage during the transferral of the substance to the cooling circuit of the competition track.

The in-depth analysis carried out by Arpa Piemonte considered certain possibilities of leakage due to deliberate damage of the anhydride ammonia pipes near the track and the storage tanks. The assessments were carried out according to the criteria and risk analysis methods usually used to study accident scenarios in an industrial context and the risk of relevant accident, enabling the tracing of useful decision-making elements to support the preparation of safety and emergency measures in the event of leakage due to deliberate acts.

Figure 5.2 - Cesana Pariol venue for bob, luge and skeleton competitions
In the context of the in-depth analyses carried out during the preparation of the Civil Defence Plan, attention was placed upon the Cesana Pariol venue for the chemical risk aspects connected to the presence of anhydride ammonia in the track cooling circuit.

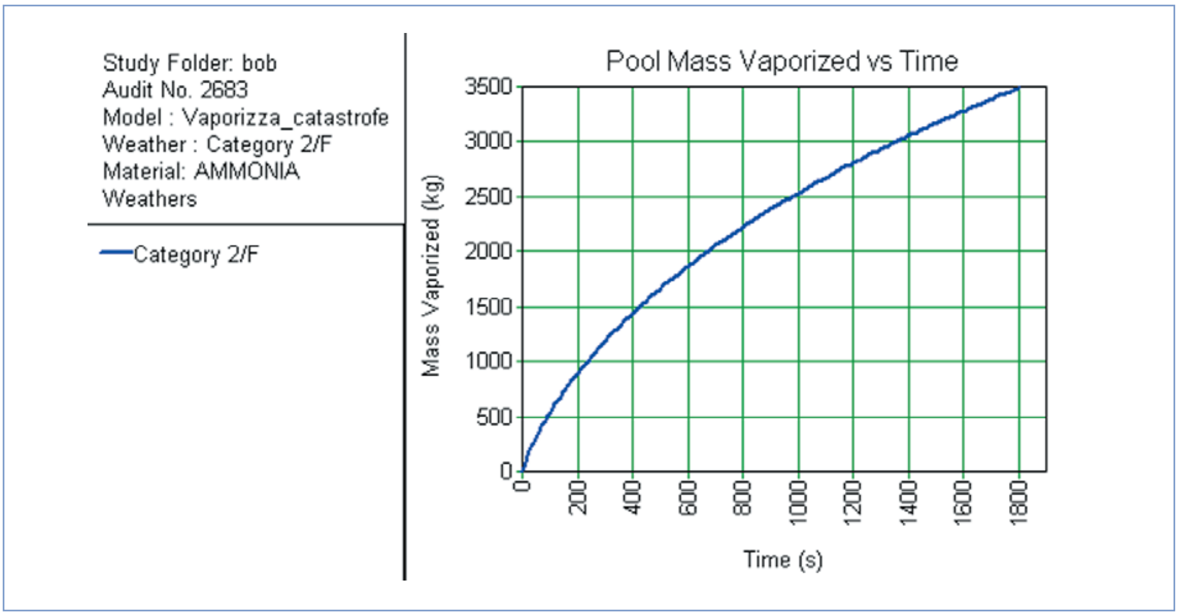


Figure 5.3 - Application of simulation model to evaporation of anhydride ammonia from a well
The assessments of the possible consequences of leakage scenarios following deliberate damage to tanks and pipes near the track were carried out by Arpa Piemonte with the application of simulation models commonly used to carry out risk analyses in the industrial context and the analysis of relevant incidents.

5.4 PLANNING AND ORGANISATION OF OPERATIONAL ACTIVITIES

5.4.1 ON-SITE INSPECTIONS AND PRELIMINARY IN-DEPTH TECHNICAL ANALYSES

Arpa Piemonte took part with the other bodies and institutions appointed to carry out the technical and health emergency activities in the joint on-site inspections organised by Torino Police Department in the period from May to September 2005 in the five indoor Olympic venues listed earlier, in order to view the locations and gain in-depth details with the representatives of Agenzia Torino 2006 and TOROC on certain technical aspects, paying particular attention to the ventilation systems.

This activity, which also involved the examination of technical documentation (plans and system diagrams), was aimed at a first individuation of the critical points of the system in relation to the possible introduction of contaminants and was functional to the organisation of the monitoring plan in terms of preliminary individuation of the investigative methods and techniques applicable.

Figure 5.4 - Air-conditioning/heating systems details in indoor Olympic venues

Before elaborating its technical-laboratoristic proposal, Arpa Piemonte carried out on-site inspections and in-depht analyses on air-conditioning/heating systems. Particular attention was paid both to the technical and working features of air-treatment units, of flues and of spouts for air injection and extraction, in order to check the applicability of sampling techniques with regards to systems working condition.

5.4.2 GENERAL CRITERIA AT THE BASIS OF THE ARPA PIEMONTE OPERATIONAL PROPOSAL

Parallel to the in-depth analyses carried out and in the light of the first results and assessments, the Agency's operational proposal was elaborated and developed, taking into consideration the **chemical risk**, and was arranged on the double front of the **analytical investigation on-site** and the **laboratory analysis**, valorising the specialist skills of the Arpa Piemonte staff and the instrumental equipment in line with the latest progress in the field of analytical techniques, to operate both in the preventive monitoring phase (prior to decontamination) and in the emergency phase.
The planning criteria at the basis of the activities planned and carried out by the Agency were oriented towards describing the evolution of an unknown risk scenario according to the time-space dimension. In particular, the analytical investigations were oriented towards the characterisation of an unknown scenario such as the dissemination of a chemical agent in a crowded indoor area, for example, through the air-conditioning/heating systems. In this context, the only possible approach for on-site measurements was that aimed at creating a panoramic view of the measuring techniques available, to investigate the chemical subject in qualitative terms for families of pollutants considered to be significant.
As regards sampling activities and laboratory analyses, it was necessary to partially overlook their largely specialist nature in favour of a time value which combined the effectiveness of the analytical determinations with a certain speed of response for the indication of the presence of undesirable substances. The laboratory investigation was not therefore aimed at the quantitative search for a single compost, but more towards highlighting situations of anomalous contamination by families of airborne organic chemical substances compared with the normal environmental air conditions observed previously.

5.4.3 ORGANISATIONAL STRUCTURES AND STAFF INVOLVED

The methodological and organisational system of the Arpa Piemonte operational proposal was prepared under the responsibility and coordination of the Area Structure of regional activities for the address and coordination of activities for industrial risk and compatible economic development, with the cooperation and support of the Area of regional activities for environmental coordination and the Department of Torino, for the specific aspects of laboratory and on-site operation respectively.
During the detailed planning phase, in the context of the same structures, small groups of technical staff were indivi-

duated which, thanks to the technical skills developed within the context of planning and managing anthropic environmental emergencies, could be successfully appointed to carry out the activities.
With a formal act by the Agency, certain services were started up (particularly those of pre-decontamination, Olympic laboratory and Olympic emergency) described further on and specifically dedicated to the performance of the activities provided for by the Civil Defence Plan, with the individuation of the staff involved and relative contexts and time of operation.
During the competitions, the coordination of the daily activities was carried out from the department assigned to Arpa Piemonte in the Olympic Operating Centre set up by Torino Police Department at TOROC Headquarters.

DAILY OPERATIONS				
PERIOD	**ACTIVE ORGANISATIONAL STRUCTURE**	**STAFF**	**TIMETABLES**	**ACTIVITY**
From the 10th to the 26th of February 2006	Pre-restoration service	A team of 4 to 8 technicians	In relation to the executive plan	Gaseous samples (canisters) and on-site measuring
	Olympic Laboratory Service	1 technician and 1 director	For 8.00 a.m. to 8.00 p.m.	Analysis of gaseous samples in GC-MS (canisters)
	Analytical technical support service	1 technician and 1 director	For 8.00 a.m. to 8.00 p.m.	Analytical technical support in the case of failures or unexpected events
	Olympic Emergency Service	2 technicians	From 4.00 p.m. to the end of the competition	Operational and specialist support in the case of emergency
	Nocturnal availability of the laboratory	1 technician and 1 director	From 8.00 p.m. to 8.00 a.m. the next day	Analytical support in the case of emergency
	Station at Olympic Head Office	1 director or official	From 7.00 a.m. to the end of the competition	Coordination of daily activities and communications to the Police Department

Figure 5.5 - Organisational and operational structures of Arpa Piemonte in the context of the Civil Defence Plan
In the period from the 10th to the 26th of February 2006, Arpa Piemonte activated specific organisational structures appointed to carry out activities provided for by the Civil Defence Plan of Torino Police Department to prevent and face collective emergencies generated by terrorist attacks in indoor Olympic venues. The daily operation of the structures was defined and agreed with the Police Department on the basis of the specific needs and with reference to the executive plan prepared on the basis of the competition calendar.

5.4.4 EXECUTIVE PLAN OF ACTIVITIES

As mentioned earlier, the executive plan of activities for the prevention and control of chemical risk was elaborated with reference to two separate but interrelated operational environments: preventive monitoring (pre-decontamination) and emergency. The macro and detailed planning activity was developed over a fairly long space of time due to the need to check the feasibility of the operating theories in the light of the system configurations of the venues, the instrumental and staff resources available and, last but not least, the needs of Torino Police Department.

Following the definition of the general operating lines, in December 2005 and January 2006 numerous on-site technical inspections were carried out at the venues subject to investigation, specifically aimed at on-site checks on the functionality of the instrumental equipment and procedures available, as well as the individuation of the sampling points and routes for constant instrumental measurements. During the on-site inspections, the measurements needed for the final perfection of the technical sampling and analysis procedures in the fixed stations were acquired, through on-site measurements, sampling and analysis activities (known as "white tests") to reach a definition of the basic levels of the systems.

5.4.4.1 Preventive Monitoring (pre-decontamination)

Preventive monitoring was aimed at checking the absence of anomalous chemical components in the indoor environments before opening the gates, to protect the public and athletes.
Considering the extreme uncertainty that characterises an unconventional risk scenario, in the pre-decontamination

SATURDAY FEBRUARY 11TH 2006	ACTIVITY	EXECUTION OF ACTIVITY		DURATION	START	END
Torino Esposizioni	Sampling with canisters	Arpa	Pre-restoration service	45 minutes	5.45 a.m.	6.30 a.m.
	Transport canisters o Arpa GRU laboratory	Municipality of Torino	Civil Protection	30 minutes	6.30 a.m.	7.00 a.m.
	Prepare samples and GC-MS analysis	Arpa	Olympic laboratory service	2 hours	7.00 a.m.	9.00 a.m.
	Validate results, print results and transmit results	Arpa	Head chemist at Olympic laboratory	30 minutes	9.00 a.m.	9.30 a.m.
	On-site monitoring with portable instrumentation	Arpa	Pre-restoration service	1 hour	8.00 a.m.	9.00 a.m.
	Validate results, print results and transmit results	Arpa	Pre-restoration coordination manager	30 minutes	9.00 a.m.	9.30 a.m.
	Inform Police Department	Arpa	Station at Olympic Head Office	30 minutes	9.30 a.m.	10.00 a.m.
	Decide and communicate accessibility of site	Police Department	--	1 hour	10.00 a.m.	11.00 a.m.
	Open gates	TOROC	--	2 hours	11.00 a.m.	1.00 p.m.
	Competition start	TOROC	--		1.00 p.m.	-

Figure 5.6 - Detailed programming of the preventive monitoring activities (pre-decontamination)

For each indoor venue a detailed daily programme of the pre-decontamination activities was drawn up which, with reference to the start of the competitions, planned, in sequence, the duration and start/end times of the single phases, with the aim of informing the Police Department of the results of the checks at least two hours before the time set for the opening of the gates.

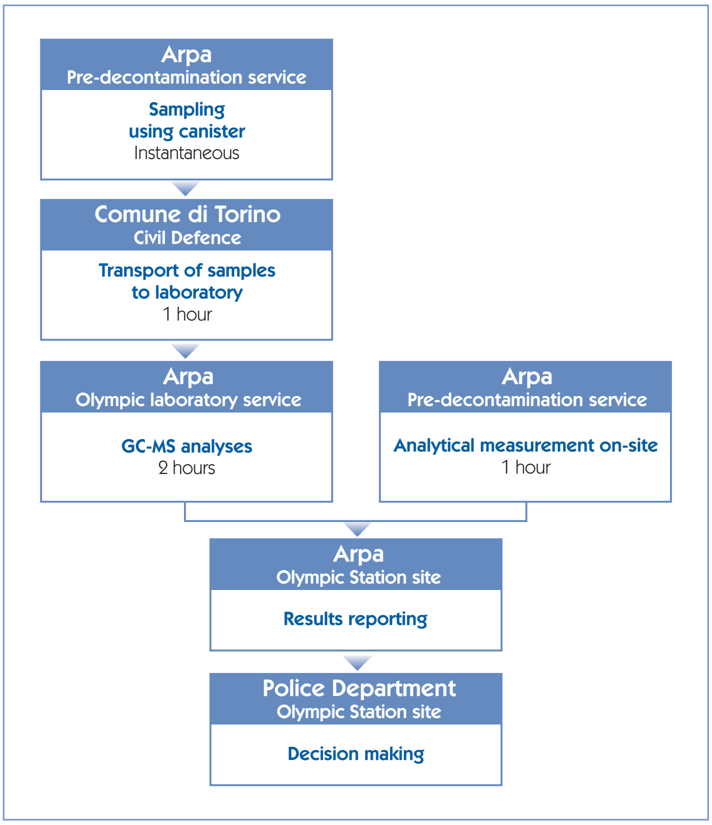


Figure 5.7 - Flow chart for operation in the preventive monitoring phase (pre-decontamination)

phase the choice was made to flank the two investigation methods, creating for each site a monitoring programme aimed at the individuation of chemical components extraneous to the environmental air quality and arranged into two phases:

- sampling of gaseous components using fixed volume samplers (canisters) and subsequent study using the fixed station GC-M technique;
- analytical measurement on-site using portable instruments.

The executive plan of the activities, detailed from day to day for each venue in the time schedule (Gantt diagram), was elaborated on the basis of the calendar of competitions and the duration of the various phases (sampling-transport-fixed station GC-M analysis and on-site monitoring) with the aim of making the results of the two investigative methods individuated available in joint times and with a consistent margin of time (one or two

hours) before the times scheduled for the opening of the gates, to enable the Police Department to make any decisions regarding access by the public.
This time restriction determined the decision to use on-site monitoring as the only investigative method for the Pinerolo venue, where the competition start times in the early hours of the morning made it impossible to use the GC-MS study technique on the samples taken with the canisters before it was time to open the gates.

5.4.4.2 Emergency phase

The Arpa Piemonte response in terms of the specialist-technical support during the emergency phase was planned on the basis of the experience acquired in the "ordinary" environmental emergency context, assessing and providing for the strengthening of human and instrumental resources in order to improve the effectiveness of the service in the case of an "extraordinary" event of unconventional nature during the Olympic events.
Allowing for the fact that the Agency staff would not enter the "hot" or "red" danger zone A and the "warm" or "orange" danger zone B during the emergency, but would stand in an "external – white" zone, during the planning phase, the possible analytical-technical approaches aimed at acquiring the support of the other emergency bodies to better characterise and circumstantiate the event were outlined in terms of instrumental equipment, staff resources and operating instructions:

- constant measurement of volatile organic substances using portable GC-FID instruments,
- absorption vials for carbon active organic components or other supports (Tenax, Amberlite, silica gel),
- colorimetric vials for gaseous contaminants and organic and inorganic fumes.

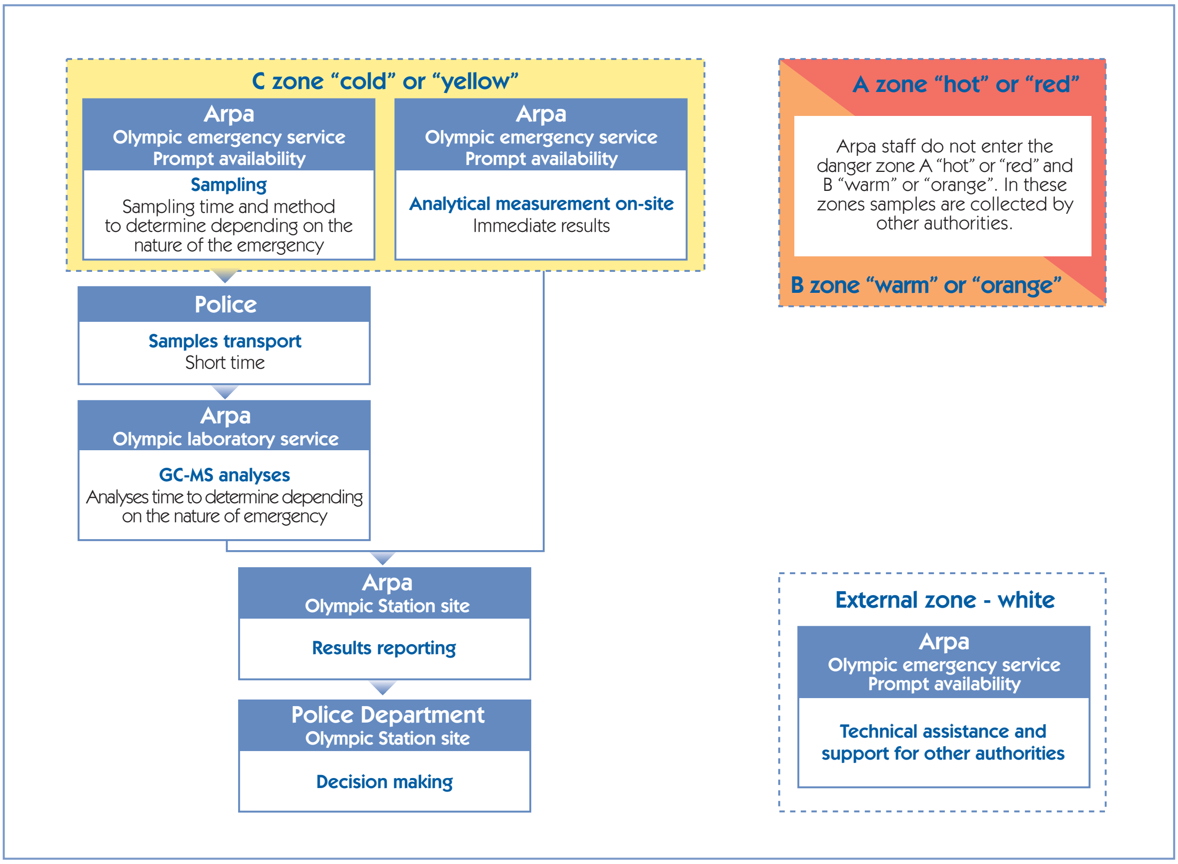


Figure 5.8 - Flow chart for operation in an emergency

5.5 PRE-DECONTAMINATION SERVICE

For the preventive monitoring of the five indoor Olympic venues, the **pre-decontamination** service was set up, manned by teams, each comprising two Arpa Piemonte technicians. The service, operatively active every day from the 10th to the 26th of February at variable times depending on the competition calendar and the time schedules of the activities, was manned on a shift basis by about twenty technical staff teams of the Area of regional activities for the address and coordination of the activities for the industrial risk and compatible economic development and the Department of Torino, equipped with specific passes to access the venues. The direct coordination of the activities and the validation of the measures taken on-site were performed by the management executives of the Micro-pollutants Pole Structure, the Territorial Service for Defence and Security and the Institutional Production Activities Structure linked to the Department of Torino under the supervision of the management executive of the industrial risk and compatible economic development.

5.5.1 SAMPLE COLLECTION AND TRANSPORT OF THE CANISTERS

Every day, in each Olympic venue in Torino gaseous samples were collected using fixed volume sampling devices (canisters). The sample, taken in a set point of the venue by a team of two Arpa Piemonte technicians, was then taken by the Civil Defence Department of the Municipality of Torino to the Arpa Piemonte laboratory in the North-West Quadrant based in Grugliasco (TO), for the analytical quality assessment of the airborne substances held by the system.
For each venue, the delivery of the canisters to the laboratory always took place within the time stipulated by the time schedule of the activities, enabling the performance of the analyses in useful time compared with the start of the competition. Altogether 50 gaseous samples were taken using canisters, and then subject to fixed station analysis to find components extraneous to the environmental air.

5.5.2 ON-SITE ANALYTICAL MEASUREMENT

The gaseous substances were also examined with instant measurement using portable analysers, capable of highlighting the presence of classes of organic and inorganic components in gaseous or vaporous form extraneous to the envi-

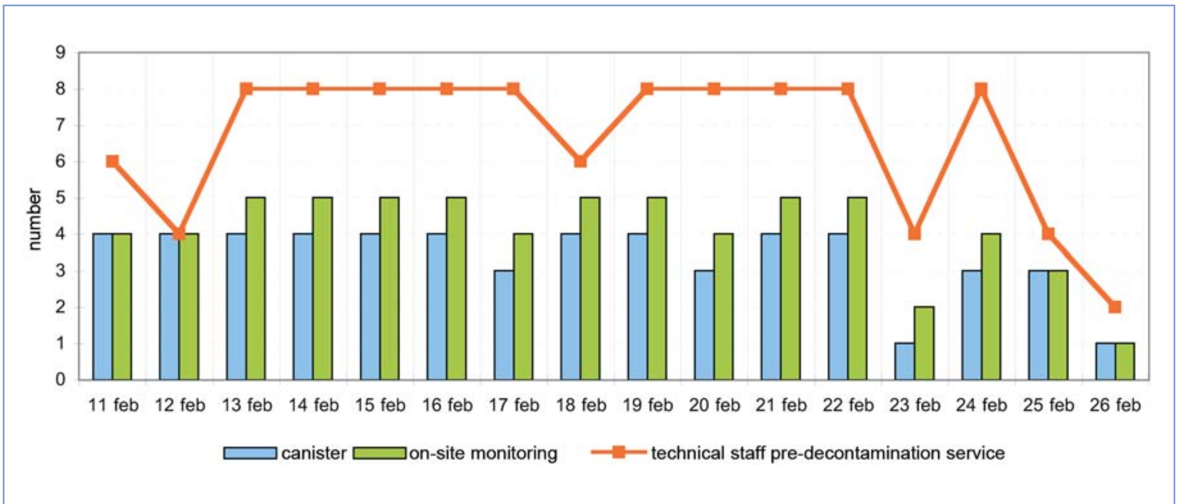


Figure 5.9 - Preventive monitoring at the indoor Olympic venues. Activities carried out and technical staff involved in the pre-decontamination service

During the XX Olympic Winter Games Torino 2006, Arpa Piemonte carried out 54 sampling operations of gaseous substances with canisters and 66 hours of on-site monitoring at the indoor Olympic venues, in accordance with a detailed programme drawn up on the basis of the competition calendar. For the collection of the samples and measurement s using portable instruments, an average of 4 to 8 technicians were involved every day, organised into teams of two units.

ronmental air quality.
Every day from the 10th to the 26th of February, an instrumental measurement operation was carried out at each Olympic competition venue using photo ionising detectors (PID) and multigas detectors equipped with infrared sensors (IR) and electrochemical cells (EC). In particular, the PID Instruments were used as the basic screening technique for measuring functional groups to which families of volatile organic substances common to particularly dangerous chemical agents could be traced; the portable multigas detectors were used for simultaneous and continuous measurement of oxygen and gas and combustible and inorganic fumes (CO_2, HC, HCN, Cl_2).
Instrumental measurements were taken by teams of two Arpa Piemonte technicians continuously for about an hour, during an inspection of the venue according to a pre-set route; the readings of the instant concentrations measured by the instruments were recorded on a special registration card in correspondence with 10 pre-set individual points on the plan of the venue and the results of the investigative activity were reported in detail in the reports and on the measurement cards.
The time spent perfecting the instrumentation and for on-site measuring, assessment and reporting of the results was compatible with that estimated in the time schedule of the activities. The results of the on-site measuring operations were communicated by the teams of technicians to the management executive for the coordination of the activities for their validation.
Altogether, over 65 hours of on-site monitoring took place. All the results of the tests carried out were transmitted to the Arpa Piemonte department set up in the Olympic Operating Centre at TOROC Headquarters and then transmitted to the Police Department by the deadlines set. In all cases, the concentration of the volatile organic substances detectable by the PID and the specific search for chemical composts in the gaseous substances showed up no anomalous situations of contamination.

5.6 OLYMPIC LABORATORY SERVICE

For the fixed station execution of the analysis during the pre-decontamination phase and in the event of an emergency, the **Olympic laboratory service**, manned by an executive and a technician, was set up at the Arpa Piemonte laboratory of the North-West Quadrant based in Grugliasco (TO). The service, operatively active every day from the 10th to the 26th of February, from 8.00 a.m. until 8.00 p.m., was manned on a shift basis by about ten staff teams of the Instrumental Activities Structure of the North-West Quadrant laboratory.

Every weekday, from Monday to Friday, at the same time, the Arpa Piemonte South-East Quadrant laboratory based in Alessandria was assigned the task of guaranteeing analytical technical support in the case of unexpected events due to failures of the instruments and/or problems with the sample collection and transport activities.

In order to guarantee the same support on Saturday and Sunday, on the 11th, 12th, 18th and 19th of February 2006, additional standby shifts were activated from 8.00 a.m. until 8.00 p.m., manned by an executive and a technician from the laboratory of the South-East Quadrant based in Alessandria.

5.6.1 FIXED STATION ANALYSIS OF CANISTERS

All the fixed station analytical activities of the canisters collected from the indoor Olympic venues were carried out in the laboratory of the North-West Quadrant in Grugliasco by qualified Agency staff, experts in the GC-MS technique, under the responsibility of an executive chemist appointed to validate the results.
The time required for the preparation of the sample, analysis and reporting of the results was congruent with that estimated in the time schedule of the activities.

The results of the fixed station analyses carried out were communicated by the executive chemist to the Arpa Piemonte department in the Olympic Operating Centre.

On the basis of the analytical determinations carried out using the GC-MS technique in the operating conditions defined, the composition of all the gaseous samples collected did not present chemical contaminations by airborne substances which showed anomalous conditions compared with the "base" obtained from the previous analyses carried out.

5.7 OLYMPIC EMERGENCY SERVICE

As mentioned earlier, to cope with anthropic emergency situations affecting the population and the environment, since 1997 Arpa Piemonte has had an emergency assistance service operational 24/7, organised into operational departments decentralised throughout the regional territory. As regards fixed station analytical activities, in emergency situations Arpa Piemonte usually supplies technical assistance and specialist and interpretative support for the analyses, with an emergency laboratory service active on Saturdays, Sundays and holidays only during the day, from 8.00 a.m. until 8.00 p.m. At night there is no emergency laboratory service.
Considering the importance and the exceptional nature of the Olympic event, from the 10th to the 26th of February 2006 (every day, including Saturday and Sunday), the Agency, in conjunction with the Police Department, decided to strengthen the usual emergency assistance service, also activating a nucleus of technical and laboratory staff appointed specially to supply operating and specialised support at night in the event of indication of collective emergency situations resulting from NBCR attacks.
For the performance of additional monitoring activity during the competitions, the **Olympic emergency service** was set up, for activation if necessary and as provided for by the coordinator of the activities in accordance with the needs of the executive of the General Service Coordination of the Torino Police Department at the Olympic Operating Centre.
The service, manned on a shift basis by the staff of the Area of industrial risk and compatible economic development and the Department of Torino individuated to carry out the pre-decontamination activities, provided for daily operation by a team of two staff units supplied with a vehicle equipped with the following:

- 1 portable GC – FID detector
- 1 portable electricity generator
- 1 photo ionisation detector (PID)
- 1 multigas detector with infrared ray IR sensors and electrochemical cells
- 2 pumps for sampling gaseous substances
- colorimetric and absorption sampling vials.

To guarantee analytical support in the event of nocturnal emergency during the Olympic events, the Olympic laboratory service was on night standby from 8.00 p.m. until 8.00 a.m. the following day; in particular, from the 10th to the 19th of February 2006, the **laboratory night standby service**, manned by an executive chemist and a technician, was provided by the North-West Quadrant laboratory in Grugliasco, while in the week from the 20th to the 26th of February 2006, it was provided by the South-East Quadrant laboratory in Alessandria.

5.8 OLYMPIC OPERATING CENTRE

For the whole period of the Olympic events, Arpa Piemonte guaranteed the presence of at least one representative at the Olympic Operating Centre set up by Torino Police Department at the TOROC Headquarters. The service was pro-

vided every day, from the 10th to the 26th of February, from 7.00 a.m. until the end of the competitions in the indoor Olympic venues subject to monitoring, involving, on a shift basis, about ten staff units, including executives and officials of the Area of industrial risk and compatible economic development and the Department of Torino, under the coordination of the executive manager of the Area of industrial risk and compatible economic development.
The Agency department at the Olympic Operating centre was the nodal point for the coordination of the daily activities and for all internal and external communications regarding their performance.
Every day, a fax was sent to the Executive of the General Service Coordination Area of the Torino Police Department containing the programme of the pre-decontamination activities planned for the next day, stating, for each venue, the start time, the names of the staff teams appointed and the number plates of the vehicles used. This communication, which from the 13th of February 2006 was promptly sent by the Police Department to all those responsible for the safety of the venues concerned using the software for the management of the events, made it possible, as of the 14th of February 2006, to create a link between the Agency technicians and the TOROC staff appointed to manage access to the venues, favouring the performance of the activities without delay in relation to the times scheduled. The only problems occurred in the days before (11th, 12th and 13th of February) when the Arpa Piemonte technicians appointed to take the samples using the canisters tried to enter the venues; these delays in the access procedures did not however significantly influence the progress of the transport activities and the laboratory analyses. Only on the 13th of February was it impossible to enter the Pinerolo venue to collect the samples required.
Another fax was sent at the end of the laboratory analyses and on-site measurements to give Torino Police Department the results of the monitoring of the vaporous substances for each venue, always respecting the margins of time expected before the opening of the gates.

5.9 CONCLUSION

The experience gained during the XX Olympic Winter Games Torino 2006, while being fortunately limited to the performance of monitoring activities as opposed to emergencies, strengthened the role and authority of the Agency as a body for the technical support of institutional subjects involved in the extremely delicate field of civil defence, for the critical analysis and characterisation of possible risk scenarios, as well as the development of certain operating procedures.
The commitment and professionalism shown by everyone in the planning, programming and prompt, precise performance of the monitoring activities and actions, valorised the knowledge and skills of Arpa Piemonte and increased the capacity for coordination and link-up both internally and also with the other subjects involved in this unique and internationally important event.
The planning and performance of the activities provided for by the Civil Defence Plan also provided an opportunity to begin the reconfiguration of the instrumental-laboratory instruments and to promote new synergies between the various structures of the Agency – for the respective organisational, technical and operational skills – actually representing a positive signal in relation to the actions underway to reorganise the emergency assistance system of Arpa Piemonte, in the pursuit of aims to improve the effectiveness and efficiency of the services rendered.

Communication activities 6

6. Communication activities

As shown throughout the previous pages, the activities carried out by Arpa Piemonte during the Torino 2006 Winter Olympics were an extenuating but stimulating commitment for the Agencies many technicians and experts.
Another important aspect which we have not yet looked at is that of the dissemination of information on the activities performed by the Agency, particularly its nivo-meteorological forecasts, carried out by the institutional Communication Structure.
The coordination of the dissemination of the nivo-meteorological forecasts must be carried out properly to ensure that not too much data is issued when the weather is stable and there is little demand for information, and that the data issued is prompt and precise when the weather conditions change. The observance of this rule is especially important during a leading sporting event of the calibre of the XX Olympic Winter Games.

6.1 BEFORE THE START OF THE GAMES

6.1.1 "THE WEATHER SERVICE FOR TORINO 2006" BROCHURE

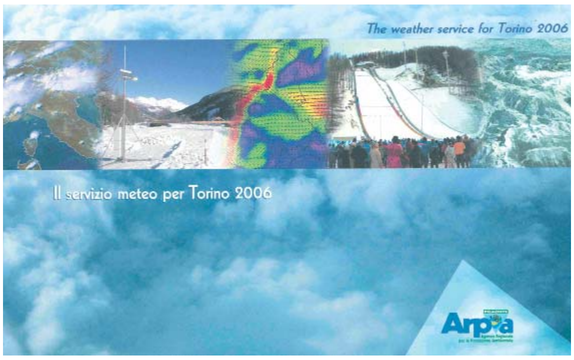


Figure 6.1

The brochure entitled *The weather service for Torino 2006* was published in December 2005, containing a summary of all the figures related to the Games: from the network of meteorology offices to the products processed during the Olympic period, from the staff involved in nivo-meteorological assistance to the overall action to defend the environment and the territory (figure 6.1). The informative booklet was published in Italian and English, with the aim of informing the general public of the Agency's role before and during the Games.

6.1.2 THE WEBSITE HTTP://METEOGIOCHI.ARPA.PIEMONTE.IT

To reach every kind of user, from the mass media to the public, Arpa Piemonte set up a special bilingual website dedicated to the weather forecasts of the Olympic Winter Games.

Before the site went on line, the institutional Communication Structure had to establish the division into periods of the two versions: the static version for the pre-Olympic period and the dynamic version for the Olympic period, also indicating anomalies in the contents and layout.

The static part of the website, published on December 15th 2005, was made up of the homepage, with the index of the pages available and the texts of the aforementioned weather brochure.
During the first six weeks that the website appeared on the Internet, it received about 16,000 visits.

6.1.3 THE PRESS CONFERENCE

On February 7th, three days before the Olympic opening ceremony, Arpa Piemonte organised a press conference to present the meteorological service.

The press release, also written in Italian and English, described the nivo-meteorological service, the structure of the meteorology offices, the instruments used, the products and the website http://meteogiochi.arpa.piemonte.it.

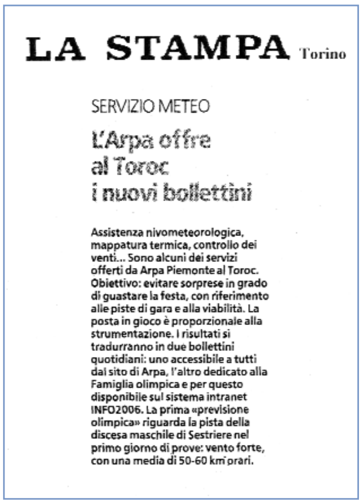
la Repubblica Torino

le previsioni

Arpa in campo con 65 stazioni

STAZIONI meteo mobili, termometri a infrarossi, anemometri sonici per misurare ogni variazione dell'intensità e della direzione del vento e 75 persone in campo, a scrutare le carte meteorologiche e ad analizzare i dati raccolti in 65 stazioni: è la task force delle previsioni del tempo di Torino 2006. Il meteo dei Giochi, settore nevralgico per gli sport invernali all'aperto, è stato affidato dal Toroc all'Arpa del Piemonte, l'agenzia regionale di protezione ambientale. Verranno emessi 370 bollettini meteo e preparati 9.146 messaggi per Info2006.

Figure 6.2



LA STAMPA Torino

SERVIZIO METEO

L'Arpa offre al Toroc i nuovi bollettini

Assistenza nivometeorologica, mappatura termica, controllo dei venti... Sono alcuni dei servizi offerti da Arpa Piemonte al Toroc. Obiettivo: evitare sorprese in grado di guastare la festa, con riferimento alle piste di gara e alla viabilità. La posta in gioco è proporzionale alla strumentazione. I risultati si tradurranno in due bollettini quotidiani: uno accessibile a tutti dal sito di Arpa, l'altro dedicato alla Famiglia olimpica e per questo disponibile sul sistema intranet INFO2006. La prima «previsione olimpica» riguarda la pista della discesa maschile di Sestriere nel primo giorno di prove: vento forte, con una media di 50-60 km orari.

Figure 6.3

TORINOCRONACA

L'Arpa ha messo in campo una task force di uomini e mezzi

Anche la tecnologia al servizio del tempo

TORINO - Nulla è lasciato al caso per i Giochi olimpici invernali, neppure "il tempo". Con la messa al bando dei metodi tradizionali l'Arpa - l'agenzia regionale di protezione ambientale - trasforma le previsioni meteo in una scienza esatta, o quasi.

Le anticipazioni nivometeorologiche sono infatti affidate a 65 stazioni meteo, tra cui 10 mobili, a termometri a infrarossi e ad anemometri sonici per misurare ogni variazione dell'intensità e della direzione del vento. Spetta poi alle 75 persone in campo e alle 8 squadre meteo attive sui siti di gara il compito di scrutare i dati e divulgarli attraverso 370 bollettini meteo e 9.146 messaggi per Info2006. Le previsioni sono consultabili on line (www.meteogiochi.arpa.piemonte.it) e saranno distribuite ogni giorno alle squadre che partecipano alle competizioni.

Per conoscere le condizioni termiche della pista viene addirittura effettuato dall'Arpa il servizio di mappatura termica delle piste di Pragelato e San Sicario. Ad esempio, al trampolino del salto di Pragelato sono stati installati due anemometri sonici triassali, apparecchi in grado di effettuare misure tridimensionali del vento in continuo e di comunicarle in tempo reale alla giuria e alle squadre. Sulle piste dello sci nordico e del biathlon, invece, è entrato in azione un termometro mobile a raggi infrarossi montato su un carrello trainato da una motoslitta che viaggia a 10 km all'ora ed è in grado di misura la temperatura superficiale della neve lungo tutto il percorso di gara. Inoltre, con il Wind Chill, l'indice di raffreddamento, è possibile conoscere la temperatura percepita dalle parti scoperte del corpo in caso di vento. Un servizio che sarà testato proprio giovedì, durante le prove di discesa libera, quando sulla pista del Sestriere «è previsto vento forte - spiega Renata Pelosini dell'Arpa - tra i 50 e i 60 chilometri orari con raffiche di 80 alla partenza».

Simona Savoldi

Figure 6.4

il Giornale del Piemonte

Svelati tutti i segreti meteo grazie all'esercito dell'Arpa

L'Agenzia è scesa in campo con grandi mezzi per tenere sotto controllo le condizioni della neve durante le gare. Sono impegnati 75 tecnici e verranno redatti oltre 370 bollettini. Prevista una spesa di 2,5 milioni di euro

Figure 6.5

The conference was attended by the leading Italian press agencies, the main Italian daily newspapers, the local newspapers directly involved in the Winter Olympics, some on-line news sites and three foreign news agencies (NHK – Japanese national television, DPA – Deutsche Press Agency and NBC – US television station). A total of 24 journalists attended.

After a brief introduction by the Arpa Piemonte weathermen, the journalists asked for more details on the new and innovative technologies used to forecast the weather and snow temperature and, last but by no means least, the weather forecast for the imminent Opening Ceremony.

The technologies used were the main subject of the articles published the following day (February 8th) some of examples which we have included (figures 6.2, 6.3, 6.4 and 6.5).

6.2 THE PRODUCTS PROCESSED DURING THE GAMES

6.2.1 THE WEBSITE HTTP://METEOGIOCHI.ARPA.PIEMONTE.IT

On February 6th, the static version of the website was replaced with the dynamic version. The pages included: the homepage with an index of the pages available, the services envisaged for all the Olympic venues and the texts of the aforementioned brochure (figures 6.6, 6.7 and 6.8).

As regards the **Olympic system**, the following information was supplied:

- the **general data conserved in the individual competition venues**, with the summary of the immediate situation, the temperature, the percentage of humidity, wind direction and intensity, the height of precipitations, the snow depth and, for certain venues only, the possibility to see the venue through a webcam;
- the **meteorological report of the Olympic system** containing the general weather forecast for the whole Olympic district;
- the **nivological report**, associated with the **avalanche report**, described the snow conditions, the state of the snowpack and the assessment of the avalanche risk;

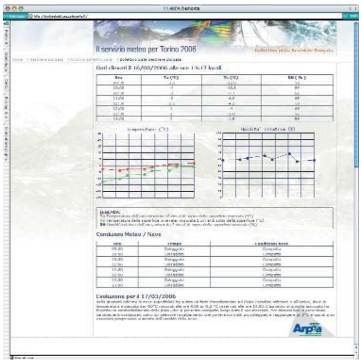


Figure 6.6

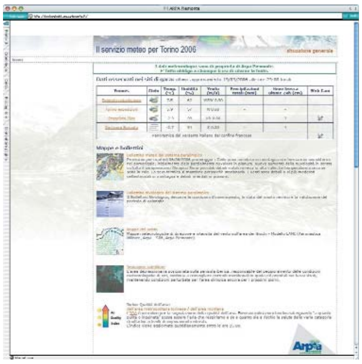


Figure 6.7

Figure 6.8

- the **wind charts**;
- the **satellite picture**;
- the **air quality index for the metropolitan area and the mountain area**.

It was also possible to obtain specific details for every Olympic **venue**, examining:

- the latest **weather forecast**, providing details for the day in question;
- the **detailed weather forecast** for the next two days;
- the **long-term weather forecast**, for the following five days;
- the **presentation** of the venue;
- the **climatologic sheet**.

The table below lists the competition venues and all the information supplied for each one.

VENUE	FORECAST FOR NEXT 2 DAYS	LONG RANGE FORECAST	CLIMA-TOLOGY DATASHEET	VENUE PRESEN-TATION	THERMAL MAPPING	COURSES REPORT	WEBCAM
Pinerolo Palaghiaccio	X	X	X	X			
Cesana San Sicario	X	X	X	X	X		
Sauze d'Oulx-Jovenceaux	X	X	X	X			
Pragelato	X	X	X	X			X
Sestriere Borgata	X	X	X	X		X	
Sestriere Colle	X	X	X	X		X	X
Cesana Pariol	X	X	X	X			X
Torino Esposizioni	X	X	X	X			
Bardonecchia	X	X	X	X		X	X
Pragelato Plan	X	X	X	X	X		X
San Sicario Fraiteve	X	X	X	X		X	X
Situation for Italian-French border							X

The same service was also offered during the Paralympics, which were held from March 10th to 19th, restricted to the competition venues, which were lower in number due to the exclusion of certain disciplines.

During the Olympic and Paralympic period, the site was visited by 170,000 people, mostly from Italy, France, Germany and the United States, with more than 5,000 average daily accesses; the peak was reached during the week from February 13th to 19th, when the number of virtual guests arrived at no less than 67,249.

6.2.2 THE RELATIONSHIP WITH THE MASS MEDIA

On the Torino 2006 official website (http://www.torino2006.org) the following figures were published regarding the credited mass media: 2688 press-agencies-photographers, 6720 radio and TV, 7 Media villages. Obviously numerous newspapers, magazines and radio and TV stations were interested in the event.

The 1998 Nagano Olympics were characterised by persistent unsettled weather and the newspapers were filled with as many articles on the weather as there were articles on the athletes. This is because, when the weather conditions are stable and favourable, the press more or less ignores them, while when the weather is bad and may affect the training sessions and competitions, it becomes of fundamental importance.

LA STAMPA

Rinviata a oggi per il forte vento

La gara di combinata nordica a squadre si disputa stamane. Alle 9 si parte con la prova di salto, alle 15 si proseguirà con il fondo. La competizione era in programma ieri mattina, ma è stata annullata dopo la prima serie di salti dal trampolino K125 a causa del forte vento che metteva a rischio l'incolumita dei saltatori. Era in testa la Germania davanti ad Austria e Russia; decimo il quartetto azzurro composto da Davide Bresadola, Jochen Stroebl, Daniele Munari e Giuseppe Michielli.

Figure 6.9

As far as the Torino 2006 Olympics are concerned, the weather favoured both the opening and closing ceremonies, with fair conditions, no precipitation and with wind and temperatures which, as correctly forecast, posed no problems with regard to the operation of the more exposed technological equipment. Even some of the downhill skiing events programmed for the early days of the event went ahead in excellent weather conditions.

As of the evening of Wednesday 15th, the weather deteriorated and the media began contacting the Agency for forecasts and details on the state of the weather (figure 6.9).

For the whole Olympic period, from February 10th to 26th 2006, the five components of the institutional Communication Structure were decentralised throughout the province in order to answer the journalists promptly and according to demand.

On a shift basis, there was always someone at the **Weather Operation Centre (WOC)** in Torino, someone at the **Local Weather Centre (LWC)** in Sestriere, and the rest of the staff were based at headquarters in via della Rocca in Torino, acting as go-betweens between the journalists and the various structures.

During the 15 days of the Olympics, 46 newspapers and programmes - 23 of which foreign - contacted Arpa Piemonte.

There were numerous requests: from the weather forecasts for the days ahead, to the specific characteristics of the technologies used for the slope temperatures, from the radar pictures to the humidity of the indoor competition structures, devoting considerable space to newspaper articles on the forecasting activity.

The radio and television services were occupied mainly with the short-term forecasts, with live and recorded interviews with the weathermen at the outdoor competition venues. In-depth television broadcasts about the technologies used during the Games were run exclusively by the national news programmes.

After the 15 Olympic days, about 80 articles on the weather forecasts has appeared in the Italian press (dailies, weeklies, press agencies, local newspapers, on line newspapers, specialist press), while twenty or so televisions articles had been broadcast.

6.3 CONCLUSION

The institutional Communication Structure operated at full capacity to offer the public – through the website and the PRU (Public Relations Office) – and the media – through pres conferences, releases and telephone or personal conversations with journalists – precise and scrupulous information on all the specific activities carried out by Arpa Piemonte.

The feedback to the website was more than satisfactory. The information was always visible and punctual. The webcams installed at the competition venues were visited and taken as reference not only by the public, but also by local authorities and foreign publications on-line.
The mass media allocated visibility to the weather forecast, especially in the days leading up to the downhill skiing official training sessions and competition, when the weather was particularly unsettled.
Arpa Piemonte was acknowledged in the articles and radio-television broadcasts as an official and authoritative provider of weather forecasting service.

After the end of the Games, the communication activities outlined below continued to be performed.

6.3.1 THE WEBSITE HTTP://METEOGIOCHI.ARPA.PIEMONTE.IT

After the end of the Paralympics, the website went back to the static version used prior to the Olympics, registering an average 2,400 monthly visits from April to August 2006.

6.3.2 THE PRESS CONFERENCE

At the end of the Winter Olympics, on March 8th 2006, a press conference entitled "Joint Activities of Arpa Piemonte and the Organising Committee of the XX Olympic Winter Games" was organised in conjunction with the TOROC.
This was an opportunity to provide an overview of all the activities performed by the Agency as part of an overall action to defend mankind and the environment, as scientific technical support in the processing of information related to the state of the environment and the eco-compatibility study in the area involved in the Olympic Plan (Valle di Susa, Val Chisone and the metropolitan area) as well as highly qualified specialised support to guarantee the safety of the entire district from the anthropic risk, i.e.: all the tasks described in chapters 1, 3, 4 and 5.
Journalists from several press agencies, on line newspapers and daily newspapers from Turin took part in the press conference.

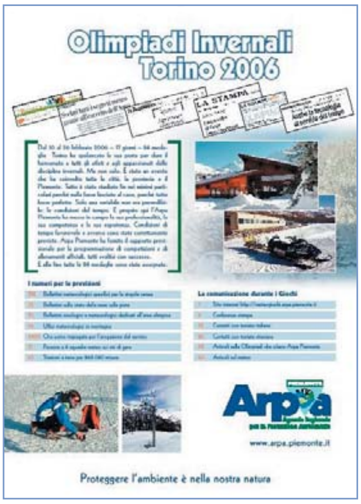


Figure 6.10

6.3.3 THE POSTER

At the Forum of the Public Administration held in Rome from May 8th to 12th 2006, the institutional Communication Structure designed a poster presenting the figures reached by the forecasting services and the numbers of contacts made by the press office (figure 6.10).