WEATHER SERVICE FOR THE XX OLYMPIC WINTER GAMES: FORECAST EVALUATION

Oberto E[1]., Cane D.[1], Turco M.[1], Bertolotto P.[1]

1 Regional Agency for Environmental Protection – Arpa Piemonte, Torino, Italy
E-mail : *elena.oberto@arpa.piemonte.it*

Abstract: The XX Olympic Winter Games of Torino 2006 were a challenge not only for the athletes participating to the competitions, but also for Arpa Piemonte, provider for the weather service: the Olympic Area was characterized by two narrow valleys surrounded by mountains higher than 3000 m and Torino town just at the mountain feet, with complex interaction of the weather systems with the alpine chain. The behaviour of the meteorological models (even in the case of the high resolution limited-area models) in this area was not satisfying for the very precise forecasts required by the competition managers and the organisation, due to the bad description of the orography and to poor representation in the physical parametrization. A very-dense weather station network, with standard ground stations, a dedicated radiosounding and two radar devices, was installed; a distributed weather office network, with long-trained skilled forecasters, was established; new techniques were studied and tested in the years before the event, like the Multimodel SuperEnsemble post-processing method applied on limited-area models.
In this work we present a rigorous evaluation of the weather forecast service, with an outlook over the model results, the post-processing improvement and the human contribution to the forecasts. The last Winter Olympics were a very remarkable opportunity to look at the behaviour of a complex weather service "on the field" in the alpine area and to evaluate the contributions of its components. The procedures and new techniques developed for the Olympics are a significant inheritance of knowledge for the alpine weather forecast and for the post-olympic weather service.

Keywords: *Olympic Winter Games, post-processing, Multimodel SuperEnsemble*

1. INTRODUCTION

In June 1999, the International Olympic Committee (IOC) chose Torino as the city that would host the XX Olympic Winter Games in February 10-26, 2006 and the IX Paralympic Winter Games in March 10-19, 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 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 ARPA Piemonte Weather Service makes use of the global IFS model of ECMWF and of the COSMO- LAMI (Local Area Model Italy) operationally. This limited area model is non-hydrostatic and it is developed in the framework of the COSMO Consortium among Germany, Switzerland, Italy, Greece. Poland and Romania (COnsortium for Small-scale MOdelling, www.cosmo-model.cscs.ch), and it is maintained and developed by UGM, ARPA-SMR and ARPA Piemonte.

Weather forecasts in the Olympic Area were quite a challenge due to the complex orography of the two narrow Olympic valleys surrounded by mountains higher than 3000 m. The Olympic venues spread in a narrow area and were characterized by huge differences in station elevations (fig. 1). For each venue hourly forecasts of several parameters were requested for a 72h time range, together with long-term forecasts up to 7 days.

ARPA Piemonte developed a complex distributed weather office network with long-trained experienced forecasters in the years before the event. A long study was carried out in order to obtain the best estimations of the weather parameters at each venue location, and the following model outputs and post-processing techniques proved to be the best for our purposes:

- ECMWF, COSMO- LAMI: IFS global model of the European Centre for Medium range Weather Forecasts (ECMWF) and COSMO –Model (Limited Area Model) 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 Kalman 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 COMSO- LAMI models, the outputs of the COSMO- aLMo (COSMO-Model in the Swiss weather service version, MeteoSwiss) and COSMO-LME (COSMO-Model 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 (Cane & Milelli, 2006).

2. DATA ANALYSIS

In this work we propose an analysis of the forecasts of the meteorology models and post- processing methods. The different forecasts proposed as first guess are summarised in the table (tab. 1) below:

Table 1: Different forecast first guess.

Parameter	Direct output of models	Post-processing procedure outputs
Temperature	ECMWF COSMO-LAMI	Kalman filter on ECMWF Multimodel SuperEnsemble
Relative Humidity	ECMWF COSMO-LAMI	Kalman filter on ECMWF Multimodel SuperEnsemble
Wind velocity	ECMWF COSMO-LAMI	Multimodel SuperEnsemble
Wind direction	ECMWF COSMO-LAMI	
Pressure	ECMWF COSMO-LAMI	Kalman filter on ECMWF
Precipitation	ECMWF COSMO-LAMI	Multimodel SuperEnsemble

Each forecast was elaborated on all the parameters for each station of the Olympic Area during both the period starting from the 1st to the 28th of February (Olympic period) and starting from 6th to the 16th of March (Paralympic period). Here we report temperature and wind results, considering the Olympic period, for two significant venues, Torino (240 m asl) and Sestriere (2020 m asl).

We computed the statistics parameter usually 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).

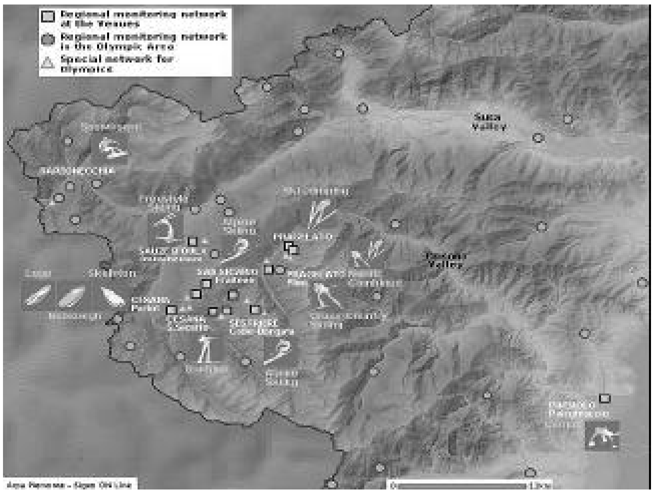

Figure 1: The Olympic valleys. The logos: the Olympic venues. Triangles and circles: the weather stations.

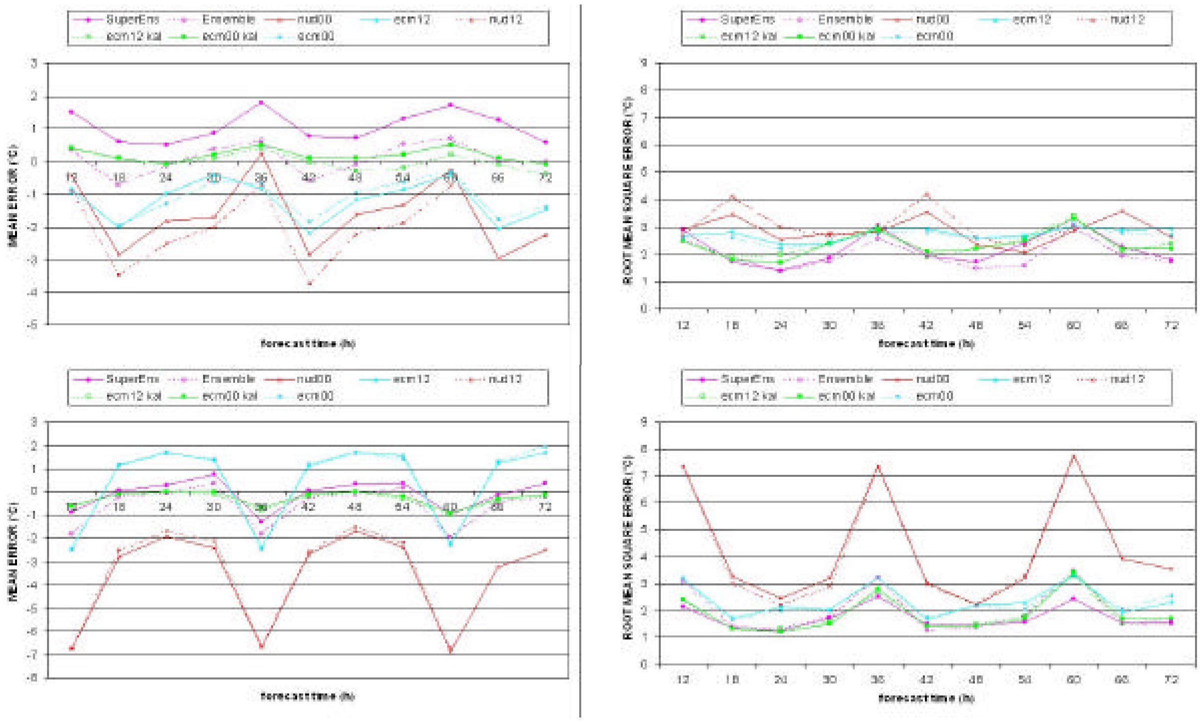

Figure 2: Temperature results for Torino venue (top) and Sestriere venue (bottom). Left column: mean error with respect to observations. Right column: root mean square error. Pink lines: Multimodel Ensemble and SuperEnsemble results; blue lines: ECMWF direct model output; green lines: Kalman filter calculated from ECMWF; red lines: COSMO- LAMI direct model output.

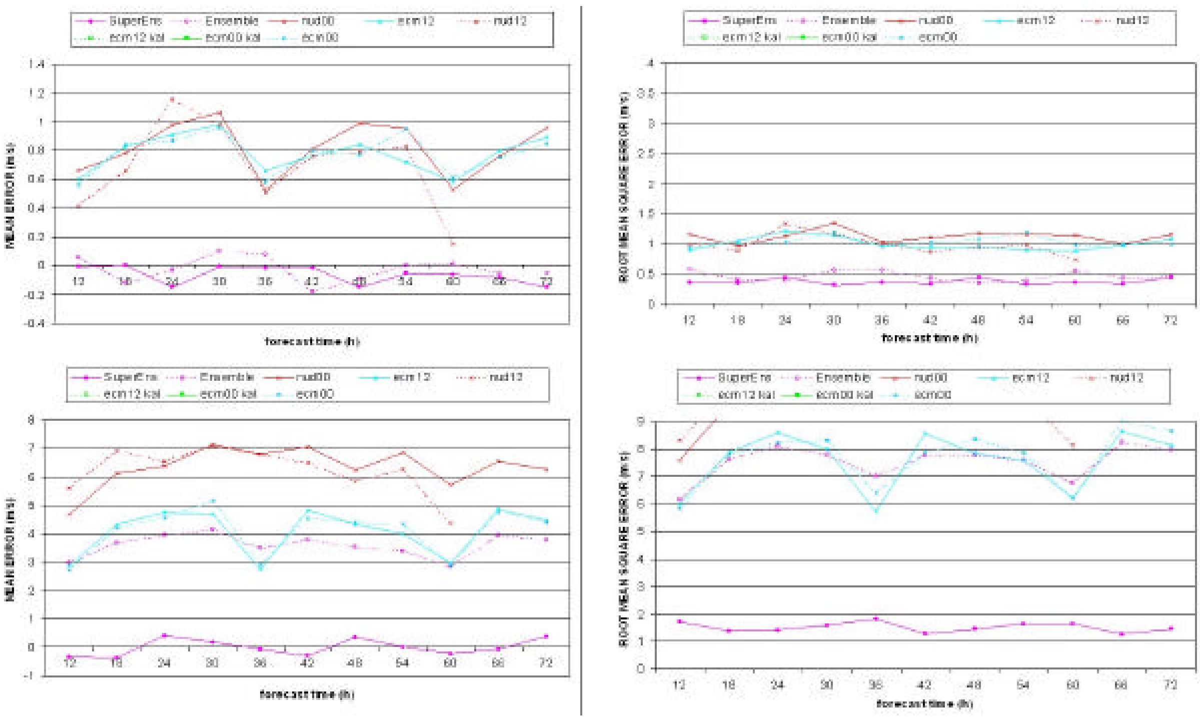

Figure 3: Wind results for Torino venue (top) and Sestriere venue (bottom). Left column: mean error with respect to observations. Right column: root mean square error. Pink lines: Multimodel Ensemble and SuperEnsemble results; blue lines: ECMWF direct model output; green lines: Kalman filter calculated from ECMWF; red lines: COSMO- LAMI direct model output.

2.1 temperatures

Figure 2 shows the results of the temperature forecast evaluation. The direct outputs of the models present errors which are often very consistent, especially those of the COSMO- LAMI 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.

2.2 winds

We report in figure 3 the results of the wind forecast evaluation. 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 COSMO- 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. 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.

3. CONCLUSIONS

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. Whereas, 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. 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.

REFERENCES

Cane D., Milelli M., "Weather forecasts obtained with a Multimodel SuperEnsemble Technique in a complex orography region", Meteorologische Zeitschrift, 2006, Vol. 15, No. 2, 207-214

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