Preliminary results of the MM5 real-time forecast during the MAP experiment

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1. INTRODUCTION

During the MAP/SOP the MM5 mesoscale model was used operationally over the Alpine region. One of the goal of the experiment was to improve the heavy precipitation forecast, that is one of the most difficult field to forecast over region having complex topography. In the past several heavy precipitation events occurred on both side of the Alpine region (Piedmont Brig, Vaisone-LaRomane, etc). Several studies were done to analyze these events (Massacand et al.1998, Buzzi et al.1998, Ferretti et al.,2000) suggesting several mechanisms related either to the large scale forcing or to the local forcing.

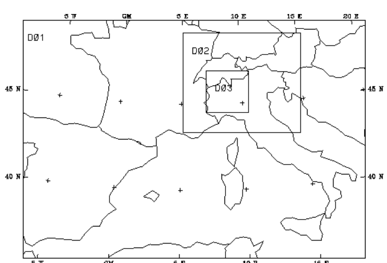

Figure 1: Model domain: D03 is the MAP Italian target area.

2. MODEL CONFIGURATION

The MM5 model configuration is the one used operationally at PSTd'A/UNIAQ (Paolucci et al., 1999): the Kain-Fritsch cumulus convection parameterization (Kain and Fritsch, 1990), associated to an explicit computation of cloud water and rain is used. The MRF (Troen and Mahrt, 1986) is used for the boundary layer. 24 vertical levels not equally spaced in the sigma coordinate are used. Three domains two-way nested (Fig. 1) were used: the coarse domain has a grid size of 27km, the inner domain has a grid size of 9km, and the inner most domain has a grid size of 3km. The model was initialized using ECMWF data analyses and the B.C. were upgraded every 6h using ECMWF forecast.

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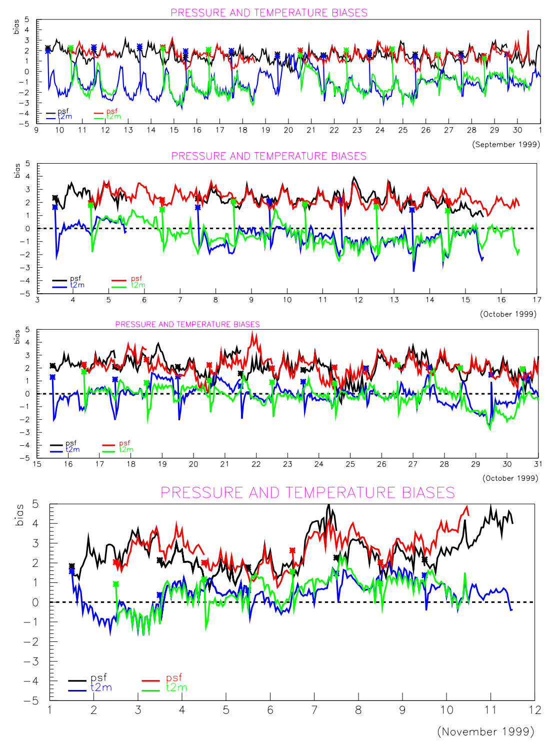

Figure 2: Pressure and temperature biases for the whole MAP/SOP period.

3. SCORE OVER THE MAP/SOP

Since one of the goal of the MAP was to improve the high resolution weather forecast, a preliminary analyses of the skill score of the MM5 is presented. The pressure bias (Fig. 2) shows an overall good agreement with the observations but a small overestimation is found.

During September the bias is bounded in the range of 2-3 mb, consistently reducing during the Intensive Observation Period (IOP) from 17 to 21 Sep, 1999 (IOP2).

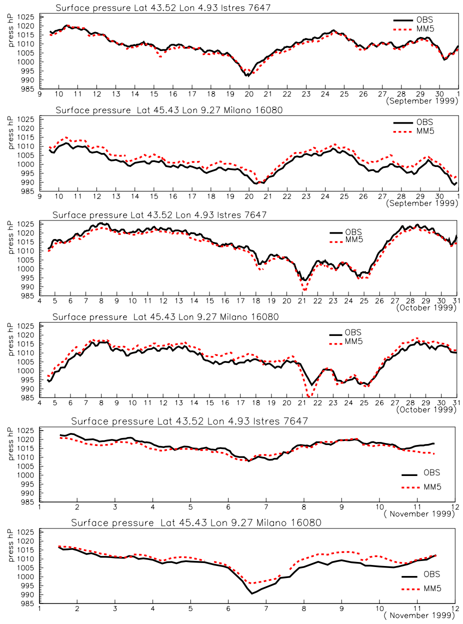

Figure 3: Observed and forecasted pressure surface at Istres (FR) and Milano-Lina te (IT) for the MAP period.

Similarly during IOP8 (19-21 Oct, 1999). On the other hand a large increase of the pressure bias is found during the ending of IOP15 (4-7 Nov, 1999), that was characterized by a deep trough sweeping over the Mediterranean area from north-west, producing a tropopause folding and a cut-off low over the Tyrrhenian Sea. A reduction of the observations may explain the bias increase, but the tendency to underestimate the frontal system moving southeastward over this area is detected. A comparison between the simulations performed using different I.C. (shifted by 24hr black/red lines) infers a good performance of the model during the whole forecast. The 2m temperature show a good agreement between the forecast and the observations. However, a diurnal oscillation is found enhancing expecially during September. Furthermore a large bias at the starting time of every forecast, followed by a quick reduction is found. This would suggests a rapid model adjustment correcting a possible error in the I.C.. October also shows a small bias except for a significative increase during IOP12 (29-30 Oct, 1999), similarly for November, except for IOP15.

A comparison of the pressure forecast and the observations is shown (Fig. 3) for two selected stations, one on the France side of the Alps (Istres) and the other in the Italian side (Milano). A good agreement is generally found, but an underestimation of the minima on both side of the Alps increasing in the east one is shown. Finally the threat scores for the precipitation, for the IOP2, using different thresholds (Fig. 4) show higher values for the high resolution than for the coarse one, suggesting that the inner domain produces a more accurate forecast than the one on the coarse domain. A tendency to overestimate the rainfall during heavy precipitation events is found.

The different response of the model to the two phases of

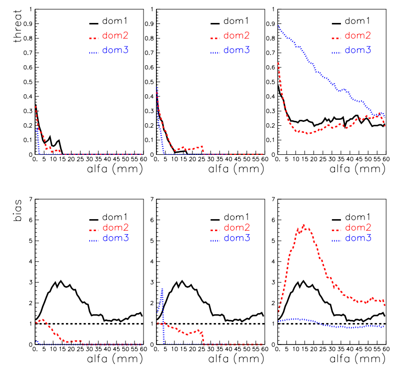

Figure 4: Threat scores and biases of the precipitation for the two IOP2 stages.

the IOP2 are clearly shown by the scores, an increase of the threat score from the first to the second phase, expecially at high resolution, is found. An exceptionally high threat score and a perfect bias on the innermost domain are associated to a large overestimation on the coarse domains, that is quite unusual. Despite of the very good skill of the MM5, during this event, the model failed to reproduce a major precipitation event on the Po Valley (Fig. 9); therefore a deeper analysis of this case is necessary.

4. CASE STUDY IOP2

During the IOP2 two upper level troughs affected the MAP areas. A squall line, associated to the first one, developed in the afternoon of 17 September (IOP2a) over the mountains northwest of the Lago Maggiore, producing heavy precipitation (Fig. 5a). This system was weaker than the one observed during IOP2b. A large amount of stations recording the rainfall over the Alpine area, during the experiment, allows for a good analysis of the model forecast over the Italian target area. An underestimation of the precipitation forecast is found (Fig. 6a) during IOP2a over the Italian target area; the poor forecast of the model may related to a difficulty of the MM5 to reproduce weak features. During the second stage (IOP2b) a frontal cloud system, with embedded convective cells, associated to a second more intense trough, swept across northern Italy, causing a large amount of precipitation, from 18 to 21 September (Fig. 5b). The forecasted areal distribution of the precipitation is better reproduced in this phase than during the previous one. The observed data (Fig. 5b) show heavy precipitation on the border between Switzerland and France, which is well forecasted by the MM5 (Fig. 6b), although an underestimation of the maxima is found.

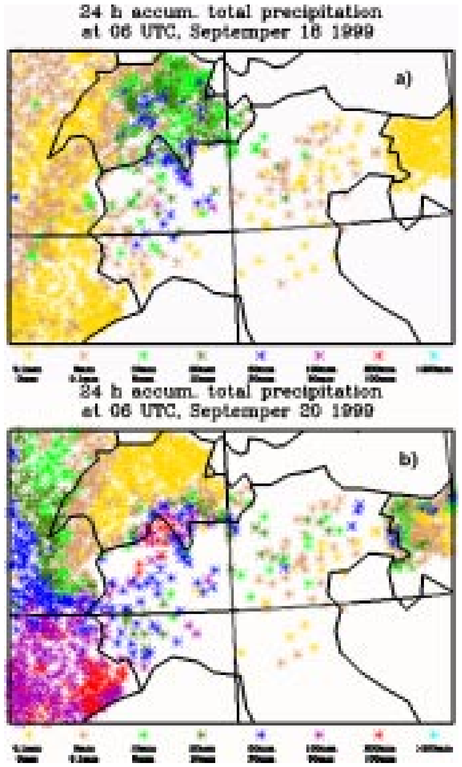

Figure 5: 24 hr accumulated observed precipitation over the Italian target area.

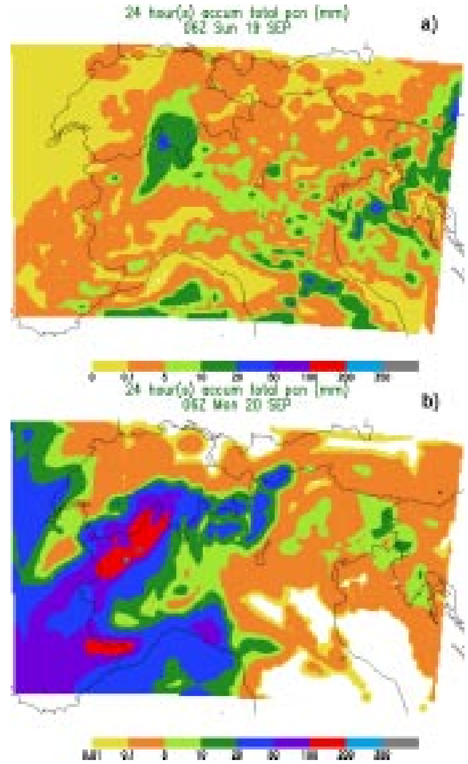

Figure 6: 24 hr accumulated precipitation forecasted by MM5 over the same area as Fig. 5.

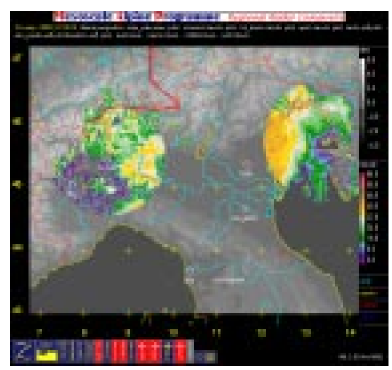

Figure 7: Radar echoes at 1000 UTC Sep 20,1999.

In the morning of September 20, 1999 a large intense cell northwest of Malpensa airport was shown by the radar echoes. During the following hours, a convective cell developed over the flat land (Fig. 7), moving quickly eastward and producing heavy precipitation over Novara (65mm in 6hr) and Milano-Malpensa (101mm in 6hr). At the same time the model forecast shows precipitation over the mountain on the western side of Lago Maggiore. The 12hr accumulated precipitation forecasted by the model show a maximum reaching 150mm (Fig. 8) in good agreement with the radar echos and the observation (www.joss.ucar.edu), but missing completely the rainfall in the Po Valley. As already pointed out, the MM5 forecast for IOP2 was on the overall good, but the model failed in reproducing the localized event on the Po Valley. An improvement of the I.C. may produce a better precipitation forecast, but a contribution to the precipitation may come from the soil-moisture availability. Indeed, the second phase of IOP2 was preceeded by a wet weather period, whereas the model land use was still influenced by the dry summer season. Therefore, to improve the forecast three different experiments are performed:

1) a simulation using I.C. corrected by applying the data assimilation through Objective Analysis (OA), the observed water vapor from both surface and upper air data are used;

2) a simulation using OA and increasing by 30% the soil-moisture availability at the grid points occupied by trees (OA_LND1);

3) a simulation using OA and forcing the moisture availability to be 90% at those grid points where it was raining in the first stage of IOP2 (OA_LND2).

The results show small differences on the coarse domain becoming appreciable at high resolution. Comparing the hourly accumulated precipitation at the station nearest to the observed event (Fig. ??a) the OA produces an increase of the precipitation in the first stage of IOP2, showing a bimodal structure of the rainfall as in the observations. A further improvement is obtained

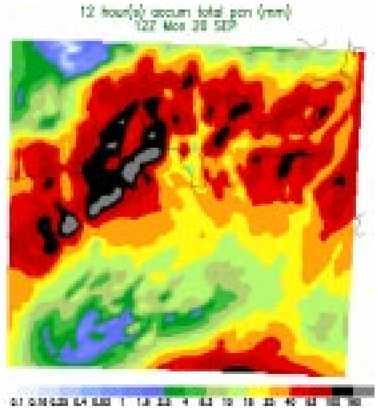

Figure 8: 12 hr accumulated precipitation forecasted by MM5.

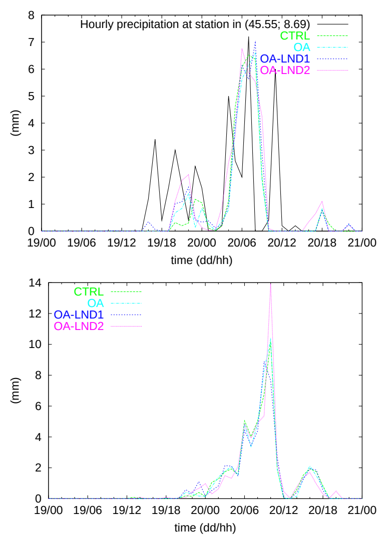

Figure 9: Observed and forecasted precipitation rate at two stations: a) Novara and b) Milano-Malpensa.

by varying the soil-moisture availability: the OA_LND1 shows the bimodal structure, but an increase of the precipitation tendency is found whereas the observations show a decrease tendency. The OA_LND2 shows a better agreement with the observations than the previous experiments suggesting that the soil-precipitation feedback is an important mechanism for the precipitation forecast. During the following hours, the differences among the experiments are smaller than for the first stage of IOP2b confirming again the tendency of the MM5 to better reproduce strong forcing than the weaker ones. Finally at Milano-Malpensa (65mm in 6hr) the three experiments (Fig. 9b) show similar trend, but the lack of the observations does not allow for a deeper analysis.

A lack of soil-precipitation mechanism feedback may be the reason for the model precipitation underestimation. It is now assessed that this is an important processes on the long term (Schar et al., 1999), but even on the short term may be a critical factor (Bernardini et al., 1999).

5. CONCLUSIONS

The skill scores of the MM5 during the MAP/SOP suggest a very good performance of the model, but this seems not to be sufficient to correctly evaluate the high resolution forecast as it is shown by a comparison at the station locations. The Objective Analysis may be a good tool to improve the precipitation forecast, but a lack of soil-precipitation mechanism feedback may be the reason for the model precipitation underestimation. The experiments show that a simple feedback process may improve the forecast.

6. REFERENCES

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Acknowledgments.
We thank NCAR for the MM5 model. The MAP archive is kindly acknowledged.