IMPACT OF MESOSCALE DATA ASSIMILATION ON THE FINE SCALE NUMERICAL SIMULATIONS OF THE MAP IOP2A

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1. INTRODUCTION

The intensive observing period number 2a (IOP2a) of the Mesoscale Alpine Programme (MAP - Bougeault et al., 2001) took place on 17 September 1999 over the Lago Maggiore Area in northern Italy. Between 12 UTC and 00 UTC a convective line developed over the first slopes of the Lago Maggiore mountains and propagated south-eastwards. During the early night, the system intensified and produced 70 mm of precipitation in about 6 hours.

Previous studies highlighted the strong sensitivity of the mesoscale numerical simulations of IOP2a to the initial conditions (Richard et al., 2003; Lascaux et al., 2004), stressing out the low predictability of this event (also confirmed by Hohenegger, personal communication). In particular, a simulation initialized with the ECMWF operational analysis of 17 September, 12 UTC succeeded in reproducing the development and propagation of the convective system, whereas the same simulation based upon the MAP reanalysis data completely failed. Different reasons may explain such a negative impact of the reanalysis. First, Keil and Cardinali (2004), showed that the assimilation of the Lonate wind profiler in the ECMWF system caused an excessive drying of the low-level moisture field. Second, the low-level convergence located over the Po valley, well-marked in the analysis, is no longer present in the reanalysis.

From these past experiments, it seems that any further improvement of the IOP2a simulation could not be achieved without refining the model initial state. In this study we try to explore the potential benefit of using as initial conditions of the mesoscale simulation, a high-resolution analysis as an alternative to the ECMWF analysis or reanalysis. For this purpose we made use of the 3D Var ALADIN assimilation system of Météo-France, which has been recently interfaced with the Meso-NH model. Different Meso-NH experiments, based upon an ALADIN analysis, carried out with and without additional MAP observations, have been conducted and are analyzed.

2. OBSERVATIONS

The IOP2a convective system was well observed with a ground-based network of three Doppler radars. A grided composite reflectivity field was obtained by taking for each grid cell the maximum value of the three radars. The time evolution of the observed composite reflectivity fields at 6000 m is plotted on the first row of Fig. 1.

During the first hours of the event (between 12 UTC and 18 UTC, not shown here), a few cells developed above the slopes, with a short lifetime. These cells then merged to form a south-west/north-east oriented convective line. Later, the system intensified, propagated south-eastward, and became more complex with a horseshoe structure (Fig. 1 at 00 UTC). Fig. 2a shows the observed accumulated precipitation field obtained from the hourly raingauge measurements and derived from the radar observations.

3. GENERATION OF A 3D-VAR ALADIN ANALYSIS

ALADIN (Bubnova et al., 1993) is a limited-area model operationally used at Météo-France. Its spectral truncation allows a horizontal resolution of about 9 km. Though it is not used in

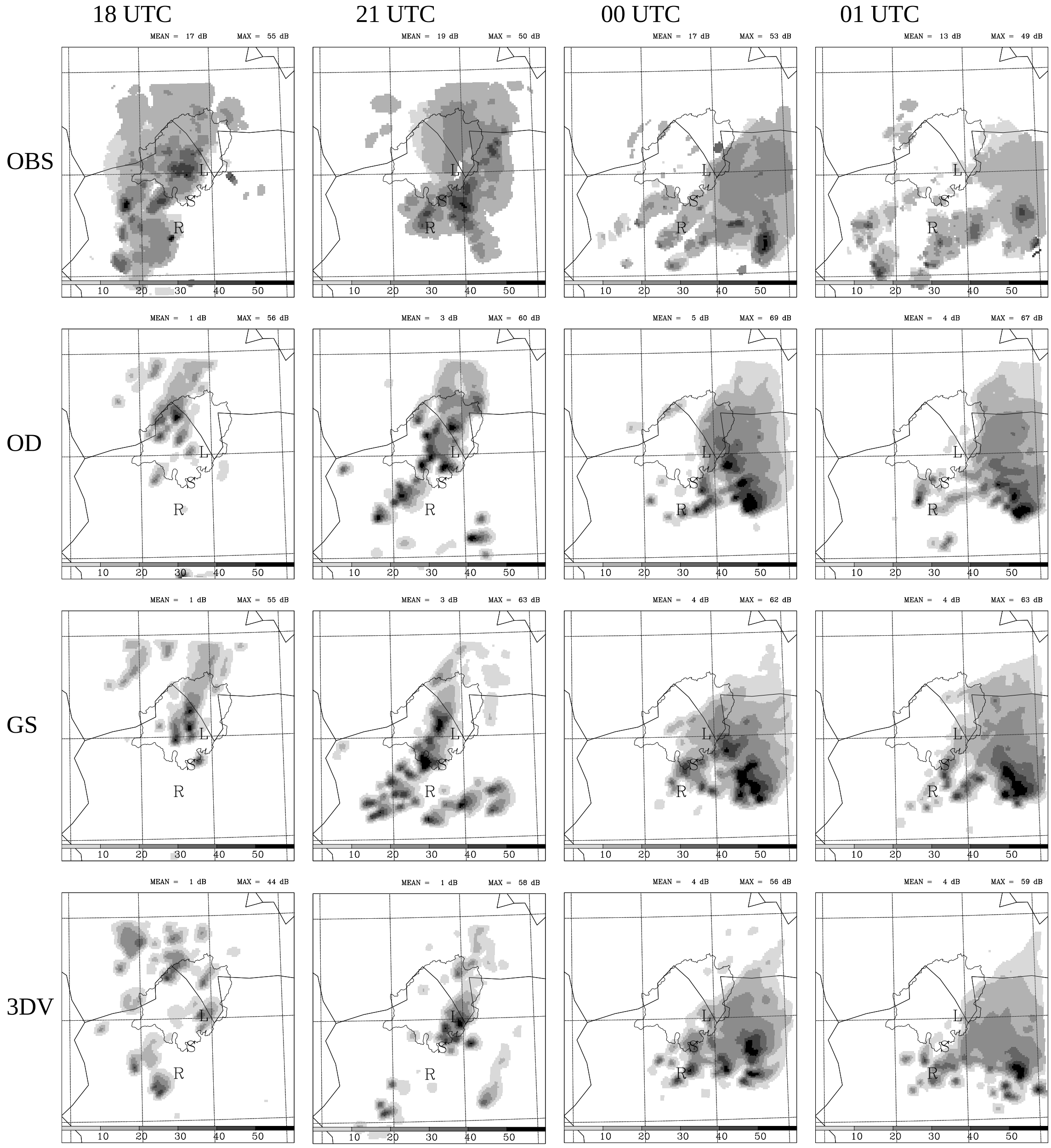

Figure 1: Reflectivity fields at 6000 m at 18 UTC, 21 UTC, 00 UTC, and 01 UTC. From top to bottom: observed radar reflectivities, equivalent radar reflectivities computed in the ECM-OD, ECM-GS and ECM-3DV experiments (units in dBZ). The letters R, S and L designate the locations of the Doppler radars (respectively, Ronsard, S-Pol and Monte-Lema). The thin black contour corresponds to the Toce-Ticino watershed.

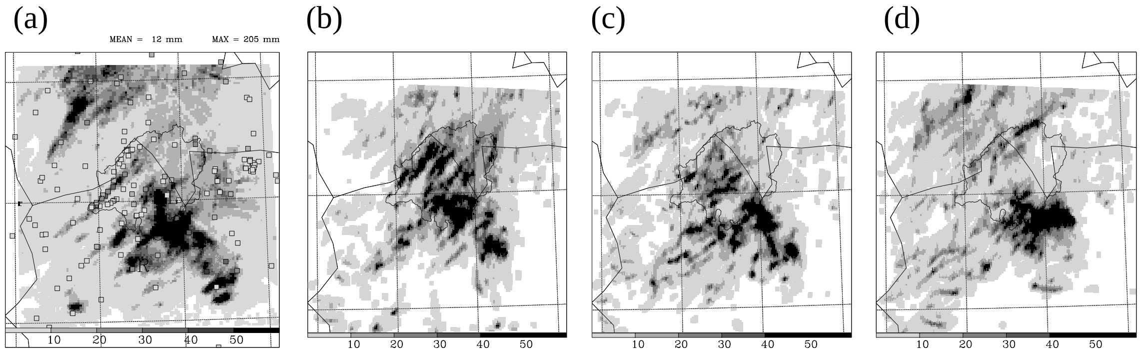

Figure 2: 12h accumulated precipitation field (in mm) from 17 September 12 UTC to 18 September 00 UTC (a) observations deduced from the radar observations with raingauge data superimposed, (b), (c) and (d) results from ECM-OD, ECM-GS and ECM-3DV respectively).

the operational suite yet, ALADIN has its own assimilation system based upon a 3D variational formulation. Details regarding the estimation of covariance errors can be found in Berre (1999).

To be consistent with our past studies, we used as a first guess of the high-resolution analysis, the ECMWF operational analysis, interpolated on the ALADIN grid. The ALADIN analysis was then constructed by introducing in the assimilation system the data of 6 high-resolution soundings located in the MAP area (San Pietro, Payerne, Ajaccio, Nice, Milano, and Lyon) as well as the data of the Lonate wind profiler.

4. RESULTS OF THE NUMERICAL SIMULATIONS

Except for their initial and boundaries conditions, all the simulations were performed identically with the mesoscale model Meso-NH (Lafore et al., 1998) run over two interactively nested domains with grid-sizes of 8 km and 2 km (Fig. 3). The innermost domain is centered above the Lago Maggiore area. In this domain convection is explicitly resolved with a microphysical scheme including 4 ice categories (pristine ice, snow, graupel, and hail). All the simulations start at 12 UTC on 17 September 1999.

The first simulation (called ECM-OD hereafter) is directly initialized and forced with the ECMWF analyses. It will be used as a reference. The corresponding equivalent reflectivity fields and the accumulated precipitation fields are displayed in the second row of Fig. 1 and in Fig. 2b, respectively. As already mentioned in the introduction, this simulation succeeds reasonably well in capturing the development and the evolution of the observed system.

The second experiment (ECM-GS) is identical except that the ECMWF analysis was first interpolated on the ALADIN grid before being interpolated on the Meso-NH grids. This double interpolation, necessary in the ALADIN/Meso-NH interface, is certainly not ideal, and owing to the sensitivity of this case, it was important to check its impact before modifying the initial state with new observations. Results are shown in third row of Fig. 1 and in Fig. 2c respectively. They are not strictly identical to the results of the control run but are pretty similar. The system propagates at the same speed and produces more or less the same precipitation pattern.

The third experiment (ECM-3DV) was initialized from the ALADIN analysis. The reflectivity fields are displayed in the fourth row of Fig. 1. Differences from the past two experiments are not very spectacular, and despite the assimilation of the Lonate wind profiler, the simulation is still able to reproduce the development of the convective system. It can be noticed, however, that in the new simulation the system tends to be weaker and to propagate slightly faster. This is especially true from 18 UTC to 21 UTC.

The corresponding accumulated precipitation is shown in Fig. 2d. On this field, differences are more apparent. Precipitation is more concentrated in the south-eastern section of the domain. In particular, and more consistently with the observations, the Toce-Ticino watershed is now almost free of precipitation. The generation of a narrow precipitation band in the north west of the domain, absent in the other two simulations, is another feature that makes this last simulation more realistic than the other two. This improvement was objectively confirmed by a statistical analysis of the results. For instance, the correlation coefficient between observed and computed precipitation increases from 0.2 to 0.5 between ECM-OD and ECM-3DV.

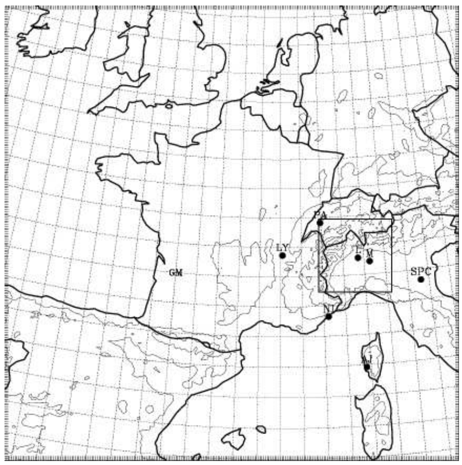

Figure 3: Topography of the first computational domain (every 1000 m, starting at 500 m). The inner black rectangle shows the horizontal limits of the second domain. The letters SPC, PA, NI, AJ, LY, M and L represent the location of the data assimilated in experiment ECM-3DV (respectively, San Pietro Capofiume, Payerne, Nice, Ajaccio, Lyon, Milan/Linate and Lonate.)

5. CONCLUSION

Three Meso-NH numerical simulations of the MAP-IOP2a convective system, starting from different model initial states have been compared. The simulation initialized from an ALADIN analysis which uses as a first guess the ECMWF analysis and which assimilates the data of six radio-soundings and one wind profiler was found to outperform the simulations initialized from the ECMWF analysis.

Further experiments are being conducted to better understand the impact of the guess on the one hand, and the impact of each observation on the analysis on the other hand. So far none of the experiments carried out with the MAP reanalysis as a first guess was successful in reproducing the IOP2a convective system.

REFERENCES

Berre, L., 1999: Estimation of synoptic and mesoscale forecast error covariances in a limited-area model. *Monthly Weather Review*, **128**, No 3, 644-667.

Bougeault, P., P. Binder, A. Buzzi, R. Dirks, R. Houze, J. Kuettner, R. B. Smith, R. Steinacker, and H. Volkert, 2001: The MAP special observing period. *Bull. Am. Meteor. Soc.*, **82**, 433-462.

Bubnova, R., A. Horanyi, S. Malardel , 1993: International Project ARPEGE/ALADIN. *LAM Newsletter no 22*, 117-130.

Keil, C. and C. Cardinali, 2004: The ECMWF reanalysis of the MAP Special Observing Period. *Q. J. R. Meteorol. Soc.*, **130**, 2837-2850

Lafore, J.P., J. Stein, N. Asencio, P. Bougeault, V. Ducrocq, J. Duron, C. Fisher, P. Hereil, P. Mascart, V. Masson, J.-P. Pinty, J.-L. Redelsperger, E. Richard et J.V. Arellano , 1998: The MESO-NH atmospheric simulation system. Part I: adiabatic formulation and control simulations. *Annales Geophysicae*, **16**, 90-109.

Lascaux, F. et E. Richard, 2004: Impact of the MAP reanalysis on the numerical simulation of the MAP-IOP2a convective system. *Meteorol. Z.*, **13**, 49-54.

Richard, E., S. Cosma, M. Hagen, and P. Tabary, 2003: High-resolution numerical simulations of the convective system observed in the Lago Maggiore area on the 17 September 1999 (MAP IOP2a). *Q. J. R. Meteorol. Soc.*, **129**, 543-564.