Numerical assessment of MAP episodes of heavy precipitation using high resolution reanalyses and assimilation of surface data

A. Buzzi, M. D'Isidoro, S. Davolio and P. Malguzzi

Institute of Atmospheric Sciences and Climate, ISAC-CNR, Bologna, Italy (www.isac.cnr.it)

1. Introduction

The availability of the MAP reanalysis (MAP-RA, Keil and Cardinali, 2003) produced by ECMWF and of the consolidated MAP data set has allowed us to perform simulations of the most relevant MAP IOP's, in order to assess the impact of the new MAP-RA on limited area model (BOLAM, hydrostatic, and MOLOCH, non hydrostatic) results and to verify model output versus MAP precipitation data. Here, only results from BOLAM and from two MAP IOPs (2b and 15) are reported.

2. Results for the IOP 15 case

In Buzzi et al (2003), the MAP IOP 15 has been studied, considering in particular the orographic effects on the rapid cyclogenesis that took place south of the Alps, the intense, though rather brief, precipitation occurrences over the Po Valley and the northern Apennines, and the strong winds, as documented, for example, by the MAP wind profilers located in Lonate. In the above paper, consistent forecast errors in the standard model version (initialized from 1999 operational ECMWF analyses, as in the MAP BOLAM suite set up during the field phase, except for the replacement of the ECMWF forecasts with the analyses as boundary values) were heuristically attributed partly to model deficiencies and partly to initial analysis problems. Model deficiencies were found to be mainly related to the representation of orography, while the application of a 3-D VAR analysis method, (re)-assimilating standard observations (SYNOP and TEMP) at model resolution (about 20 km) had a positive impact on the forecast fields, namely precipitation and wind in the vicinity and south of the Alps. Therefore, a different representation of the orography (essentially an enhancement following filtering) and the assimilation (3-D VAR reanalysis, Buzzi et al, 2003) of MAP data into the operational ECMWF analysis introduced sensible amelioration in the forecast. However, although the dynamical fields in a 30 h forecast (starting Nov. 6, 00 UTC) were basically satisfactory, the detailed precipitation in the self nested run at high resolution (7 km) gave a clear precipitation deficit in a region between the Northern Adriatic and the eastern Alps (Fig. 1).

The sequence of model runs has been repeated using the MAP-RA as initial and boundary conditions. The control case of Fig. 1(a) is based on the ECMWF 1999 operational analysis, while Fig. 1(b) shows the results starting from the MAP-RA. The main errors of Fig. 1(a), identified in precipitation deficit around Milano and over the land surrounding the northern Adriatic, are at least partially corrected in Fig. 1(b), although a small region of under-predicted precipitation remains over the central Po Valley. Fig. 1(c) reports, for comparison, the accumulated precipitation in the case of the application of the 3-D VAR reanalysis described in Buzzi et al (2003). The latter represents a clear improvement only in the western Po Valley and, to a smaller extent, over the eastern Alps. For verification purposes of internal consistency, a fourth experiment has been done starting from a 3-D VAR reanalysis of the MAP-RA, assimilating surface data (temperature, humidity and wind). The only benefit of such procedure might in principle be related to the better resolution that would allow some more surface data to be assimilated; however, it cannot be justified in principle because it might well deteriorate the superior 4-D VAR based analysis. As expected, the results (not shown as precipitation map, but avaluated in Fig. 2) are very similar to those of the MAP-RA case, except for a decrease of the precipitation maximum over the northern Adriatic sea, where no observations are available for verification. The equitable threat score in Fig. 2 quantitatively confirms the above results: the introduction of the MAP-RA has a substantial positive effects (true also for the false alarm and bias scores), while the assimilation of additional surface data has little impact (in both operational and MAP-RA cases).

3. Results for the IOP 2b case

The modeling strategy for IOP 2b is similar to that of IOP 15. Self-nested runs are initiated Sept.

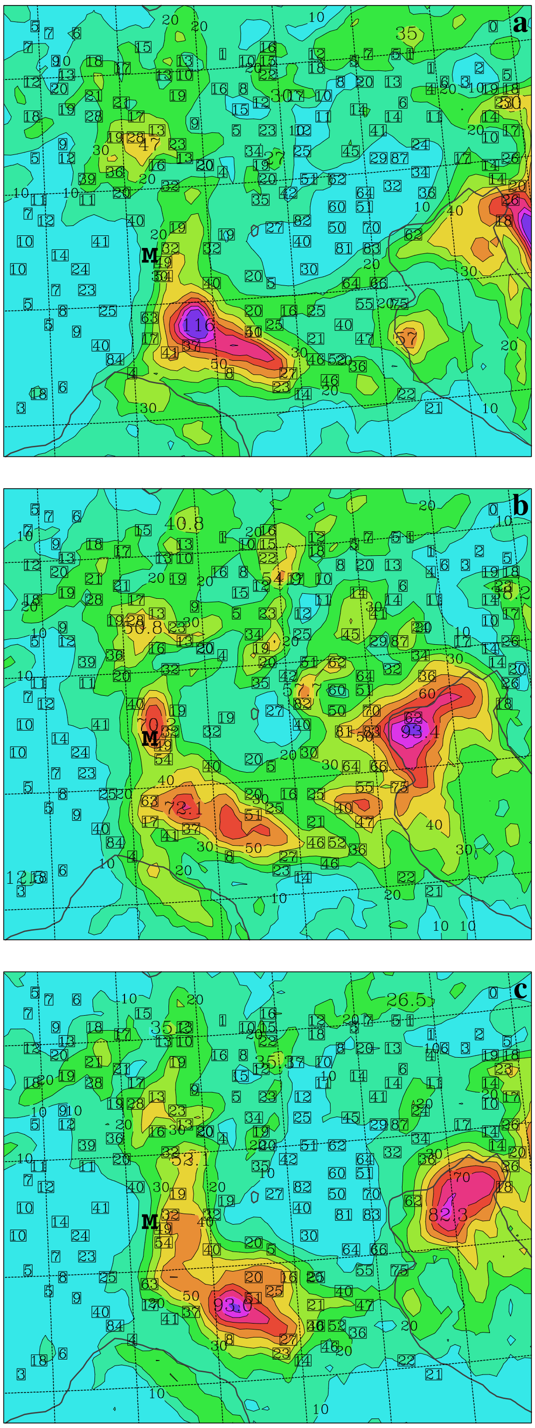

Figure 1: 24-hour accumulated precipitation from 06 UTC, 06 Nov 1999 for the run nested (a) in the ECMWF 1999 operational analyses run, (b) in the MAP-RA run and (c) in the 3-D Var reanalyses. Shading and contour interval is 10 mm. Selected observed rainfall values are plotted.

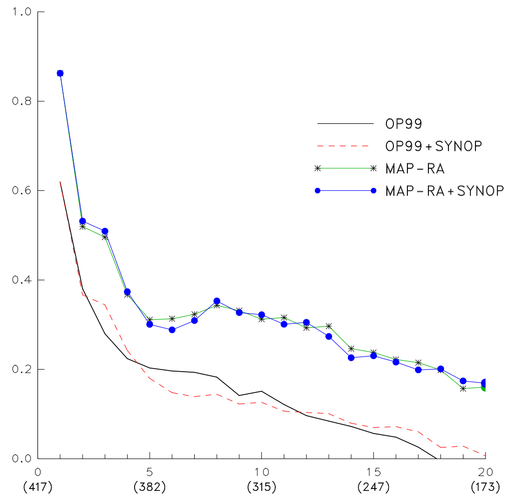

Figure 2: Equitable Threat Score for IOP 15 runs. Rainfall thresholds on x-axis are in mm/24h. Number in brackets indicates number of observations exceeding the threshold value specified above it.

19, 12 UTC. Precipitation evaluation refers to the 24-hour period starting 20 Sept., 00 UTC. Figure 3 shows the accumulated precipitation for the case initialized from MAP-RA. Observed peaks are 222 mm northwest of Lago Maggiore and 260 mm in eastern Alpine area. Predicted peaks are located almost exactly over the observed maxima, amounting to 183 mm and 120 mm, respectively. Differences from the control run (not shown), starting from the operational 1999 analyses, are not as large as in IOP 15. However, the maximum rainfall area over Piedmont is shifted to the south and that in the eastern Alps is even weaker and split. The equitable threat score in Fig. 4 clearly shows the general improvement from the control to the MAP-RA case. The same figure includes the score for the case of the 3-D VAR reanalysis of surface observations applied to the operational ECMWF analysis. The impact in this case is positive but minor. The Lonate wind profiler data allows us to document the impact of the different initial fields on local dynamics, in a time consistent way. Figure 5 shows a generally good representation of the southerly flow, peaking to 25 m/s in the morning of 20 Sept. In this case, however, the 3-D

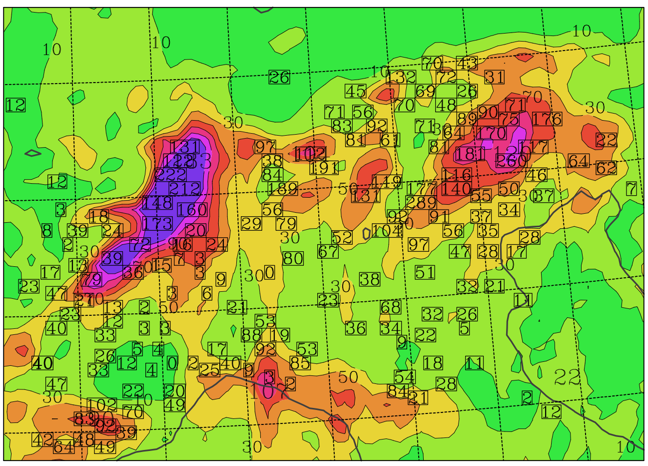

Figure 3: 24-hour accumulated precipitation from 00 UTC, 20 Sept. for the run nested in the MAP-RA run. Shading and contour interval is 20 mm. Selected observed rainfall values are plotted.

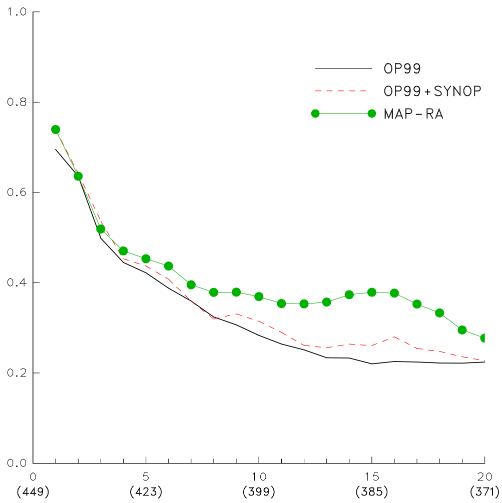

Figure 4: As Fig. 2 but for IOP 2b

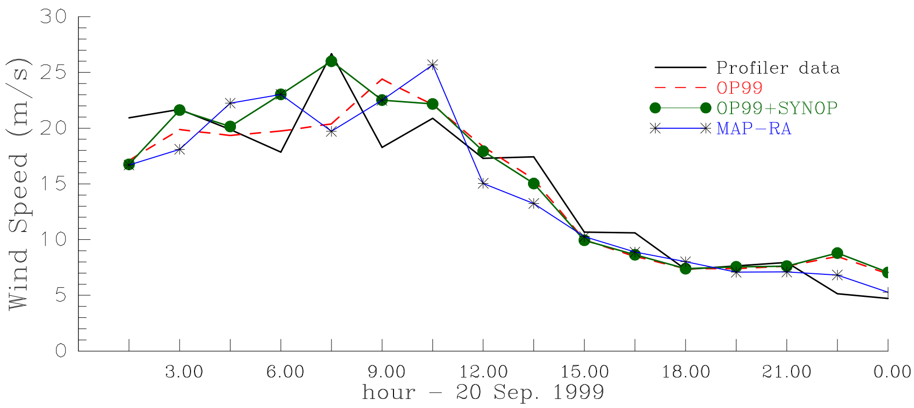

Figure 5: Wind speed measured at 2520 m a.s.l. by the wind profiler located in Lonate Pozzolo and forecasted by the model in the same location at 750 hPa for different nested runs, for IOP 2b

VAR reanalysis gives better results than the MAP-ERA case, especially for what concerns timing of the wind maximum.

4. Conclusions

The impact of the 4-D VAR MAP-RA analysis on the quantitaive precipitation forecast at relatively high resolution in the two MAP episodes considered here is clearly positive. In these cases convection was not the dominant precipitation mechanism. The effect of simpler but high resolution 3-D VAR reanalysis shows also positive effects, but cannot compete, as expected, with the more sophisticated 4-D VAR analysis.

LITERATURE

Buzzi, A., M. D'Isidoro, S. Davolio, 2003: A case study of an orographic cyclone formation south of the Alps during the MAP-SOP. *Quart. J. Roy. Meteor. Soc.*, **In print**.

Keil, C., and C. Cardinali, 2003: The ECMWF re-analysis of the Mesoscale Alpine Programme Special Observing Period. *ECMWF Technical Memorandum*, **401**.