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USE OF HIGH RESOLUTION REANALYSES FOR SIMULATING MAP IOP PRECIPITATION EVENTS WITH BOLAM AND MOLOCH MODELS

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ABSTRACT

The availability of the 4-D VAR ECMWF reanalysis for the MAP Special Observing Period, allows us to perform a numerical assessment of its impact on high resolution forecasts in comparison with the operational 3-D VAR ECMWF analysis. By means of the BOLAM (hydrostatic) and MOLOCH (non-hydrostatic) limited area models operating at different resolutions and using ECMWF analysis and reanalysis as initial conditions, we evaluated the quantitative precipitation forecasts in three MAP Intensive Observing Periods using statistical scores applied to the precipitation fields.

1 INTRODUCTION

Notwithstanding the relevant progresses obtained in the last decades in numerical weather prediction with the use of Limited Area Models, the short range quantitative precipitation forecasting in the mesoscale is still a challenging problem. Recent progresses in rainfall prediction are in part due to improvement of analysis techniques. The 4D VAR analysis methods have the capability of incorporate in a time window of several hours a large amount of data coming from satellites, airplanes, atmospheric soundings, as well as from ground based platforms (i.e. radars, wind profilers, surface stations).

One of the objectives of the Mesoscale Alpine Programme (MAP; see *Bougeault et al., 2001*) is to study the orographic precipitation mechanisms and improve the rainfall prediction in mountainous areas, especially in case of heavy precipitation events. Studying heavy orographic rainfall episodes that occurred in the region south of the Alps we focus on three different MAP-SOP episodes corresponding to Intensive Observing Periods (IOP) 2b, 8 and 15, respectively. The high resolution raingauge data from the MAP dataset allows us to evaluate the quality of simulated precipitation fields over the Alpine region and northern Italy using statistical scores. Moreover the recent availability of MAP reanalysis (MAP-RA), produced at ECMWF (*Keil & Cardinali, 2003*), allows us to evaluate the impact of conventional and non conventional data on the numerical forecasts. In particular we test the sensitivity of the precipitation forecasts versus analysis, considering the results of the simulations starting with MAP-RA and those starting with the operational analysis (OP99; namely the analysis produced by ECMWF 3-D VAR scheme in 1999). The numerical evaluation is made by means of two Limited Area Models developed at ISAC, BOLAM and MOLOCH, the latter nested into the BOLAM output fields.

2 EXPERIMENTAL SET-UP AND RESULTS

The numerical simulations are performed using the hydrostatic model BOLAM (*Buzzi et al., 2003a*) and the non-hydrostatic model MOLOCH (*Buzzi et al., 2003b*), the latter developed recently. The models have in common some of the physical parameterizations (radiation, soil and surface schemes). The atmospheric convection, an important process involved in the rain production, is parameterized in BOLAM, while it is explicitly resolved in MOLOCH. We use the same modeling strategy for the three case studies. Sequential self-nesting is employed. The initial and lateral boundary conditions for the low resolutions BOLAM runs (0.2° x 0.2°, 38 vertical levels) are supplied by ECMWF 6-hourly analyses (either OP99 or MAP-RA). The high resolution BOLAM simulations are nested in the lower ones with a horizontal spacing of about 6.5 km and 44 vertical levels. MOLOCH runs at 2.2 x 2.2 km with 50 vertical levels are nested into BOLAM high resolution experiments, with lateral boundary conditions updated every hour.

The case studies represent events of moderate to heavy precipitation over the Alpine chain and more in general over northern Italy. The MAP IOPs 2b and 8 are similar in several aspects: in both cases the synoptic southerly or south-westerly flow impinging the Alps caused strong orographic precipitation over the south side of the barrier. However, the IOP 2b case was characterized by a slight potential instability upstream of the Alps, while in IOP 8 the flow presented a more stable vertical profile. Mainly convective rain was observed in IOP 2b, with precipitation maxima larger than 200 mm in 24h located along the southern side of the Alps. Conversely, IOP 8 was characterized mainly by stratiform precipitation with values exceeding 100 mm in 24h in few areas. A quite different weather event is represented by IOP 15. In that case a deep lee cyclone formed south of the Alps, causing strong precipitation over the Po valley and northern Appennines.

Here we focus on the 24 hour accumulated precipitation fields predicted by BOLAM (at high resolution) and MOLOCH, initialized with OP99 and MAP-RA analyses, comparing the results with MAP raingauge data using objective statistical scores. Figure 1 shows, for IOP 2b, the precipitation field forecasted by BOLAM and MOLOCH, respectively, using MAP-RA as initial and boundary conditions in the low resolution BOLAM run. The explicit convection in MOLOCH is highlighted by the evident precipitation 'trails' starting upstream of the Ligurian coast which are not present in the BOLAM output. However, some of the rain spatial variability can be attributed also to the higher orographic resolution of MOLOCH compared to that of BOLAM. Over the Lago Maggiore area and the western Alps both models produce maxima exceeding 200 mm over 24h. Objective scores are computed for all the case studies and models in order to compare the predicted precipitation with raingauge data from MAP dataset. In Figure 2 the bias score computed cumulatively over all the cases is depicted. BOLAM shows weaker sensitivity than MOLOCH to the reanalysis, especially for thresholds smaller than 50 mm. The left and right column of Figure 3 refers to the threat score and the false alarm score, respectively, for IOP 2b (first row), IOP 8 (second raw) and IOP 15 (last raw) cases. Black (red) lines refer to BOLAM (MOLOCH) while continuous (dotted) lines indicate the OP99 (MAP-RA) runs. For IOP 2b the use of MAP-RA produces a negative impact on the BOLAM model results and, to a less extent, on MOLOCH at high thresholds. In IOP 8 case the skill at thresholds above 20 mm is improved using the reanalysis. More evident impact due to the use of MAP-RA is evident for IOP 15 for both models. In this case the separation between OP99 and MAP-RA curves is yet evident from moderate thresholds, with MOLOCH giving consistently better results at high thresholds.

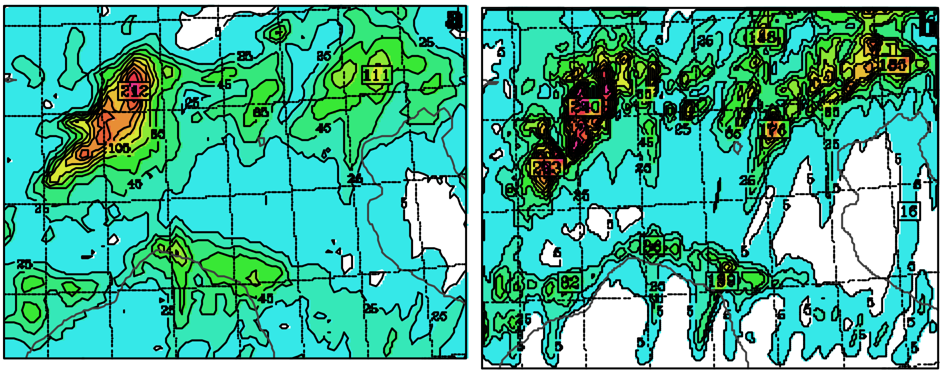

Figure 1. IOP 2b 24-hour accumulated precipitation from 00 UTC, 20 September 1999 for BOLAM (a) and MOLOCH (b) simulations nested in the MAP-RA run. Contour interval 20 mm.

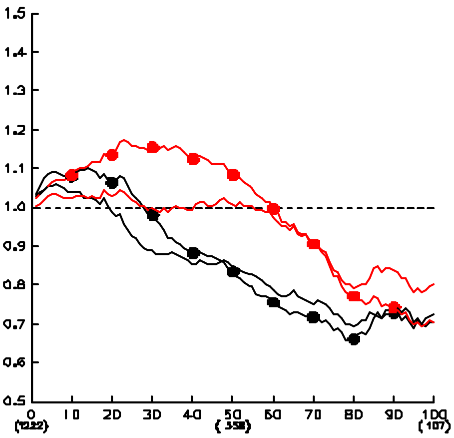

Figure 2. Bias score computed over all the case studies. Rainfall thresholds on x-axis are in mm in 24h. Numbers in brackets indicate number of observations exceeding the threshold specified above it. Black (red) lines refer to BOLAM (MOLOCH) model. The continuous (dotted) lines indicate OP99 (MAP-RA) simulations.

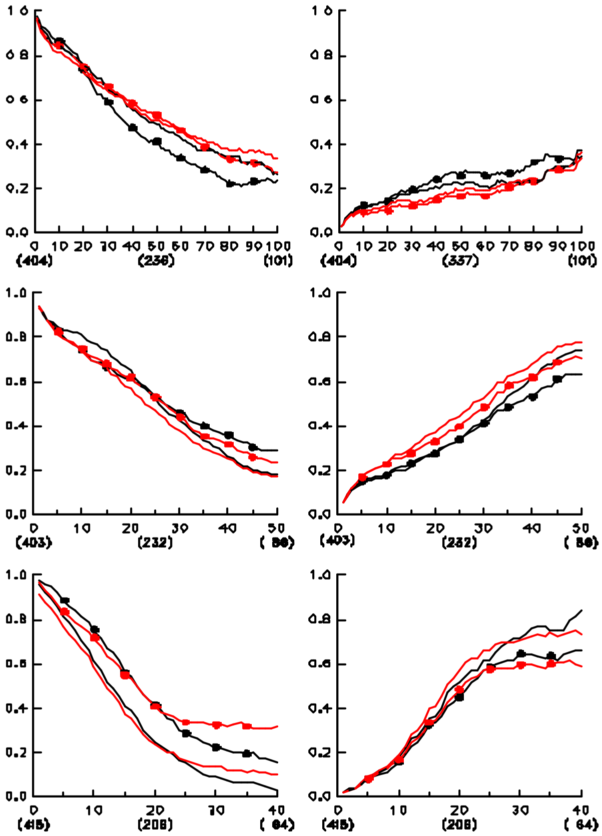

Figure 3.Threat score (left column) and False Alarm (right column) for IOP 2b, IOP 8 and IOP 15 (first, second and last raw, respectively). See Figure 2 for colours and lines explanation.

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