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IMPACT STUDY OF MAP IOP2B OBSERVATIONS ON THE MESOSACLE NUMERICAL SIMULATION

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1. INTRODUCTION

During Mesoscale Alpine Programme (MAP, Binder et al. 1996, Bougeault et al. 2001) Special Observing Period (SOP) a large number of additional upper-air soundings, instrument flights and high-resolution surface observations have been collected. To study the impact of the observations on numerical simulation is important to help make effective use of the resources for observations from the MAP field experiment. In this study mesoscale numerical simulation have been conducted by using the ALADIN model and the ECMWF 4D-Var assimilation experiments for investigating the impact of the additional MAP observations.

2. THE LAM ALADIN

ALADIN is a limited area model with high-resolution, which has been used operationally in Meteo-France, ZAMG and 11 other European national weather services. The model can be used in hydrostatic mode (8-12 km horizontal resolution) and non-hydrostatic mode (2-7 km horizontal resolution) for scientific research. The main characteristics of the model are as follows:

• Hybrid vertical co-ordinates; spectral method with bi-periodic extension of the domain using elliptical truncation of double-Fourier series; two-time level semi-Lagrangian advection scheme; semi-implicit time-stepping; fourth order horizontal diffusion; Davies-Kalberg type relaxation and digital filter initialisation (DFI).

• Kessler-type scheme for large scale precipitation; Geleyn's scheme of shallow convection and simple radiation; Bougeault-type scheme of deep convection; Boer-type scheme of gravity wave drag; force-restore method for soil temperature and water; vertical exchange calculation taking into account a planetary boundary layer and a surface layer based on the Louis scheme.

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The LAM system ALADIN-AUSTRIA in ZAMG has been used for carrying on the simulation, which is with 9.6 km horizontal resolution, 41 levels in vertical, hydrostatic.

3. ASSIMILATION SYSTEM AND EXPERIMENTS

The assimilation of the MAP additional observations was the ECMWF 4D-Var assimilation system T511/159L60 Cycle24R3 (Keil and Cardinali 2003), 4 assimilation experiments have been used for providing the initial conditions and lateral boundary conditions of the ALADIN-AUSTRIA simulations:

Control: without any MAP additional observations and European windprofilers.

Alldata: with all MAP additional observations and 16 European windprofilers.

Noprof: no windprofiler, but with all MAP additional observations.

MAPre: MAP-reanalysis, same as **Alldata**, but only 12 European windprofilers after quality control QC.

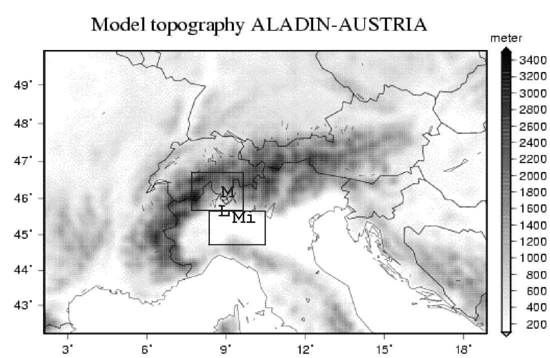


Figure 1: Domain of interest of ALADIN-AUSTRIA simulation. **M:** Lago Maggiore area; **Mi:** Central Po Valley area.

4. DOMAIN AND METEOROLOGICAL SITUATION

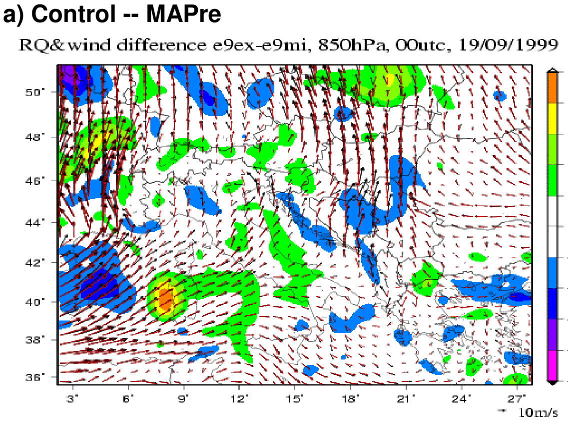
The domain for the numerical simulations used in this study is an area of 2770km x 2480km over Europe. The central part of the domain is shown in Fig. 1. MAP IOP2B (19/20 September 1999), one of the most intense rainfall case during the MAP SOP was chosen for studying the impact, all the simulations started at 00UTC 19 September 1999, and integrated to 54 hours.

The MAP IOP2B is a case with typical synoptic situation for heavy precipitation over the Alps. The cold front approaches the Alps from the West, which intensifies the west-east pressure gradient and therefore the low-level jet ahead of it. Moreover, warm and moist air from Africa crosses the Mediterranean Sea and this leads to the formation of conditionally unstable airmass.

5. RESULTS

To validate the ALADIN numerical simulations especially over the complex mountainous area, the precipitation analysis (version 2.0, 25km resolution) from ETH, Zürich, (Frei and Häller 2001); radar precipitation analysis provided by the MAP Data Center, Zürich, are used. In the following we will focus on the impact study on the initial conditions and the simulation of precipitation.

a) Control -- MAPre



b) MAPre – Noprof

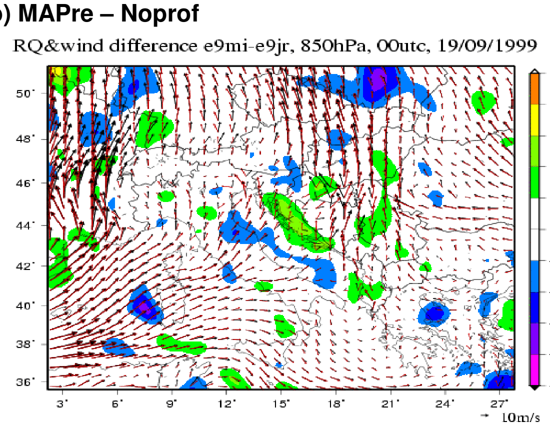


Figure 2: Analysis differences of relative humidity and horizontal wind at 850 hPa, valid for 00UTC, 19 September 1999; **a)** between the experiments **Control** (wind vector in black) and **MAPre** (wind vector in red); **b)** between **MAPre** (wind vector in black) and **Noprof** (wind vector in red).

5.1 *Imapct on the initial conditions*

As shown in Fig. 2a, assimilation of the MAP observations leads to drier conditions prevail along the Alpine mountain chain and over Italy while moister air over Po Valley; brings moister air to north (from the region Gulf of Lion to west of the Alpine), and drier air to the Alpine over Mediterranean Sea close to Sardinia. It reduces one of the two low level jet intensity toward Alpine over Mediterranean Sea. This impact is mainly coming from the MAP observation without windprofiler, (see Fig. 2b). The windprofiler seems to dry the troposphere locally over Mediterranean Sea and Adriatic Sea. The 4 denied windprofilers have a negligible influence on both humidity and wind, only very locally moistening impact on the initial condition in southern Alpine region, near Sardinia and Balkan (not shown).

5.2 *Impact on the numerical simulations*

a. Accumulated precipitation

In Fig. 3 and Fig. 4, the daily accumulated precipitation from the gauge based precipitation analysis in 25km resolution and the numerical simulations of precipitation averaged onto the 25km grid with the 4 experiments for the 19^{th} and 20^{th} September 1999 are displayed. On the 19^{th} , following the frontal system progression, the accumulated rain maxima are located on the France slopes of the Maritime Alps, Lago Maggiore and Massif Central. Differences between simulation and observation are found in all the experiments, weak rainfall maximum on the Massif Central, too more rain in Piedmont area, stronger rainfall related to Apennines, and the rain fell a little bit earlier than the observation in Maritime Alps. The simulation with using MAP additional data **Noprof** doesn't improve the overestimation over Lago Maggiore and Piedmont area, Maritime Alps, and even leads an underestimation in Rhone Valley between France Alps and the Massif Central. The impact of the windprofiler **MAPre** is more positive in the Lago Maggiore area and in Rhone Valley than the experiment **Noprof**. It seems to dry the air in the Maritime Alps and Apennines. The 4 in the assimilation system denied windprofilers (due to the QC) experiment **Alldata** have more moistening impact in Piedmont and Maritime Alps, and drying influence in Rhone Valley, those are not agreed with the observation. During the second day 20^{th}, strong rainfall belt more than 75 mm was found on the southern foothills of the Alps, with maxima over Lago Maggiore, in Dolomites and the strongest in Carnic Alps in north-eastern Italy. In all the simulations, a strong rainfall zone is recognisable on the southern slopes of Italy Alps, but the strongest rainfall maximum in the Carnic region northeastern Italy is missed, and an overestimation on south side of the Apennines is recovered by all the simulations. No investigation on that failure has been carried on due to lack of the humidity radio-soundings in those two areas. The MAP additional observations **Noprof** intensifies the rainfall over Lago Maggiore, which is close to the observation (**Noprof** vs. **Control**), makes the rainfall maximum area more west,

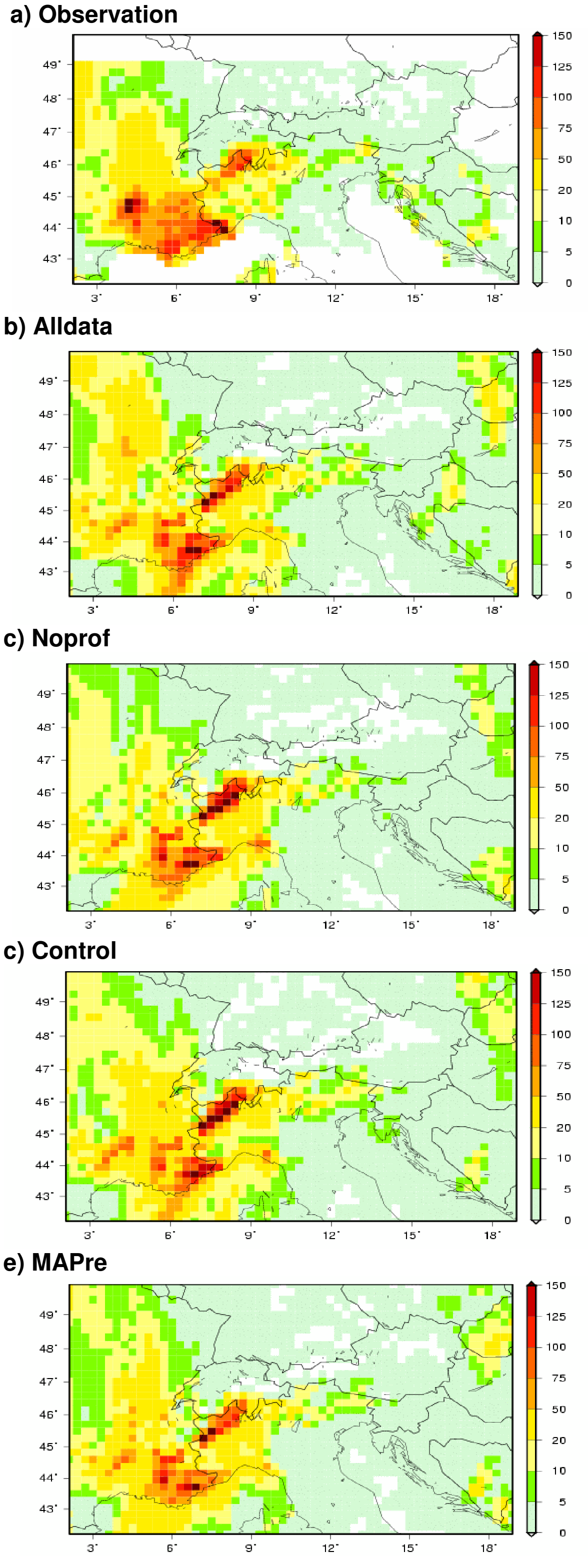


Figure 3: 24 hours accumulated rainfall from 06UTC 19 September to 06UTC 20 September 1999. All the simulations started at 00UTC September 1999, and integrated to 54 hours.

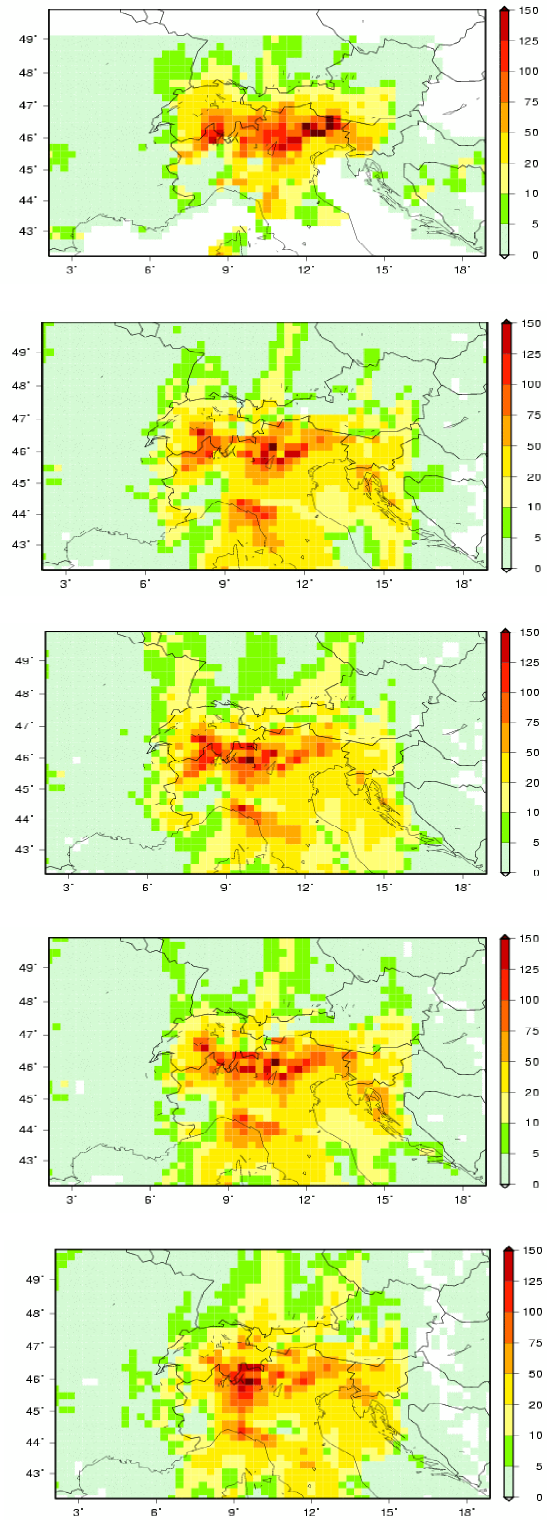


Figure 4: 24 hours accumulated rainfall from 06UTC 20 September to 06UTC 21 September 1999. All the simulations started at 00UTC September 1999, and integrated to 54 hours.

i.e. drying the atmosphere in the region Dolomites and Carnic Alps, overestimates the rain north of the Alps in Bavaria. Windprofiler seems to dry the atmosphere in most of the region except in Bergamese and Bavaria (comparison among the experiments **MAPre**, **Noprof** and **Control**); the maximum in Lago Maggiore is remarkably reduced. The impact of the 4 denied windprofilers on the precipitation simulation is in certain sense positive (**Alldata** vs. **MAPre**), better agreement in Lago Maggiore, Dolomites and in north of the Alps Bavaria with the observation.

b. Time evolution of the rainfall

To study the impact of the MAP observations on the precipitation simulation in details, we divide the Po Valley into 2 areas Lago Maggiore and Central Po Valley represented in Fig 1, which are with different orographic characteristics. The temporal evolution of the rain averaged over those areas is shown in Fig. 5. During the first day, the cold front approaches the Po Valley, in the Central Po Valley all the simulations generalize the rainfall well, the experiment **Noprof** is much closer to the observation in timing and amount of the rainfall than the **Control** one, the impact of the MAP data without windprofiler is very remarkable positive. The windprofiler improves the second maximum but makes worse for the first one and overestimates in-between much. The general impact of the windprofiler is moistening the area. The experiment **Alldata** dries the area compared with the MAP-reanalysis.

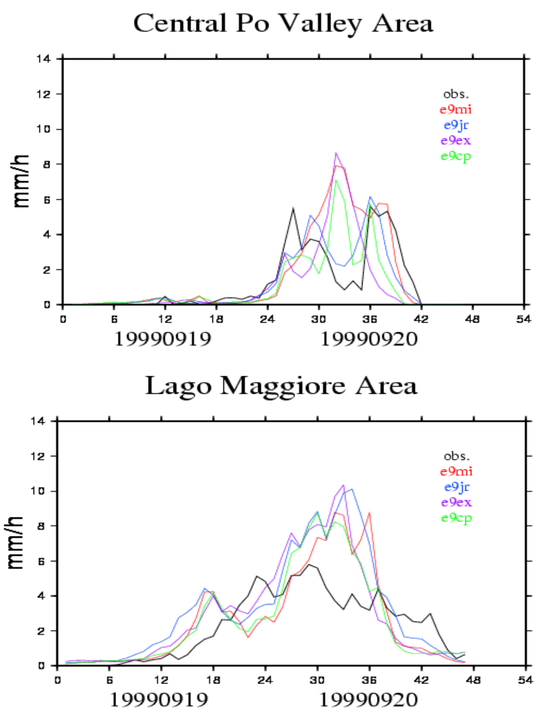
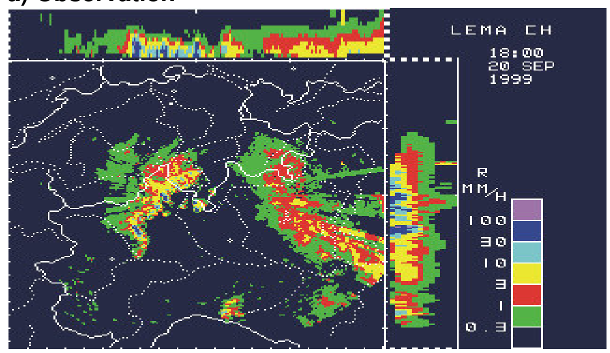


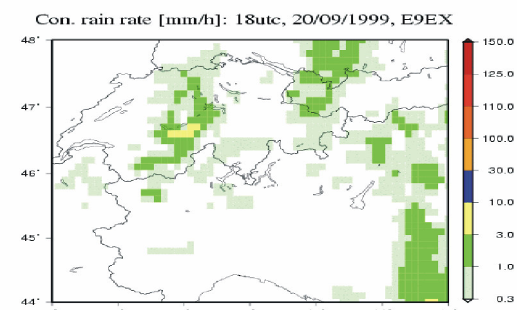
Figure 5. Time evolution of the hourly rainfall over the areas Lago Maggiore and Central Po Valley localized in Fig.1. e9mi: **MAPre,** in red; e9jr: **Noprof,** in blue; e9ex: **Control,** in violet; e9cp; **Alldata,** in green.

In the Lago Maggiore area, the simulations have similar performance, remarkable is that windprofiler dries the area which reduces the overestimation, other additional MAP data has very small impact, and the 4 denied windprofiler (experiment **Alldata**) provides a good timing for the rainfall.

a) Observation



b) Control



c) MAPre

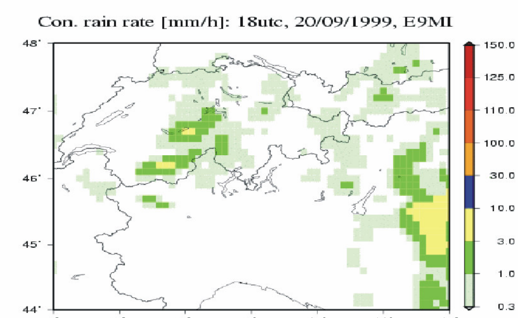


Figure 6. Radar-derived precipitation rate from the Monte Lema radar valid at 18UTC on 20 September 1999, and the simulations of convective rain rate from the experiments **Control** and **MAPre**.

c. Convection

Fig. 6 shows the radar-derived precipitation rate from the Monte Lema radar (Joss *et al.* 1998) and the corresponding simulations of the convective rain rate. Deep convection occurred late on 20th along the southeast-facing slopes of the Alps, no simulations has so strong convective activities in the region as in the observation, rather weak convection on the top of the mountain.

6. CONCLUSION

We have studied the impact of the additional MAP observation and the European windprofiler on the mesoscale numerical simulation over mountainous area. MAP IOP2B case, the most intense rainfall case during the SOP was chosen for the investigation. ALADIN-AUSTRIA and ECMWF 4D-Var assimilation experiments have been used to carry on the simulation. The emphasis has been put on the simulation of precipitation. Simulations of accumulated precipitation, time evolution of the area averaged precipitation, convective rainfall rate are compared with rain-gauge and radar observation. The main conclusions of this study are summarized in following:

- The additional MAP observations, high-resolution upper air soundings, aircraft European dropsondes, have significant influence on the simulation.
- The impact of the windprofiler is strong.
- The ECMWF MAP re-analysis doesn't always provide the best simulation.
- The after QC denied windprofilers have remarkable impact on the simulation, sometimes it is positive.

Further works on this subject are still to be done, especially on the mesoscale predictability of the quantitative precipitation forecast over complex mountainous area.

Acknowledgements

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