SENSITIVITY TO THE INITIAL CONDITIONS – NUMERICAL SIMULATIONS OF THE MAP IOP5 AND MAP IOP15

Stjepan Ivatek–Šahdan and Branka Ivančan-Picek

Meteorological and Hydrological Service, Zagreb, Croatia
E-mail: *ivateks@cirus.dhz.hr*

Abstract: Numerical simulations of the precipitation system during the MAP IOP5 and the extreme *Bura* wind case during the MAP IOP15 have been performed with ALADIN/HR (hydrostatic) limited area model. Three experiments were performed. For the reference experiment (ARPE) ARPEGE operational analysis from 1999 were used. The other two experiments (ECAR and ECMW) have the same upper-air fields, from the 4D-Var ECMWF MAP reanalysis. In the experiment ECAR the surface fields were taken from ARPEGE operational surface analysis from 1999. In the ECMW experiment, initial surface fields are taken partly from ECMWF MAP reanalysis and partly from the ARPEGE climatology file for appropriate months. Results of the numerical experiments show the higher sensitivity to the initial conditions for the MAP IOP5 heavy precipitation case. The different initial and boundary conditions for the extreme *Bura* wind case during the MAP IOP15 have not given significantly different wind field in the corresponding numerical experiments.

Keywords *– ALADIN/HR, MAP, IOP5, heavy precipitation, IOP15, Bura, sensitivity to initial conditions*

1. INTRODUCTION

Although the performance of the numerical weather forecasts has greatly improved over the recent decades, predicting the fine-scale processes in mountain region continues to be a major challenge. The availability of the MAP data allows us to perform simulations of the most relevant MAP IOP's, in order to assess the impact of the different parameterisation, initial and boundary conditions on limited area model results. For some specific cases, precipitation fields were found extremely sensitive to the initial conditions (Lascaux et al., 2004; Buzzi et al., 2004).

Here, the numerical simulations of the precipitation system during the MAP IOP5 and the extreme Bura wind case during the MAP IOP15 have been performed with ALADIN/HR (hydrostatic) limited area model. The sensitivity of the results to the initial conditions is reported.

2. NUMERICAL SETUP

The simulations were carried out with the hydrostatic ALADIN/HR model. Three experiments were performed. Different analyses were used to produce initial and boundary conditions with operational version of global model ARPEGE in 2004. Afterwards, the output files were dynamically adapted first to the ALADIN/LACE domain with 12.2 km resolution and afterward to the ALADIN/HR domain with 8 km resolution using the 54-hour integration with the operational ALADIN/HR model setup. For the reference experiment (**ARPE**) operational analysis from 1999 of the ARPEGE global model were used, 3D-Var for the upper-air fields and CANARI (OI-analysis) for the surface fields were used. The other two experiments (**ECAR** and **ECMW**) have the same upper-air fields, from the 4D-Var ECMWF MAP reanalysis. In the experiment ECAR the surface fields were taken from operational surface analysis from 1999 (it as for ARPE). In the ECMW experiment, initial surface fields are taken partly from the ECMWF MAP reanalysis (soil temperature, soil wetness and snow depth) and partly from climatology files for appropriate months.

3. RESULTS FOR THE MAP IOP 5 CASE

During the MAP IOP5 heavy precipitation occurred in the early morning of 4 October 1999 along the border between Slovenia and western Croatia (Ivančan-Picek et al., 2003). Orographic influence on convectively unstable air advected by the warm and humid current from the Mediterranean caused a large amount of rain. The existing frontal zone was modified by the convergence between the southerly winds associated with the Alpine lee cyclogenesis, and the northerly flow around the eastern flank of the Alps after a splitting process in the north Alpine orographic blocking. Intensive precipitation (100 – 200 mm/12 hours) is associated with a narrow band of strong convective activity along the frontal zone in the Slovenia/Croatia border area. Squall line following the front passage formed over the western Slovenia resulting with precipitation maximum of 241 mm measured at the *Soča* station. Fig. 1 presents the time evolution of the precipitation system as it has been observed with the Alpine radar composite (MAP Data Centre).

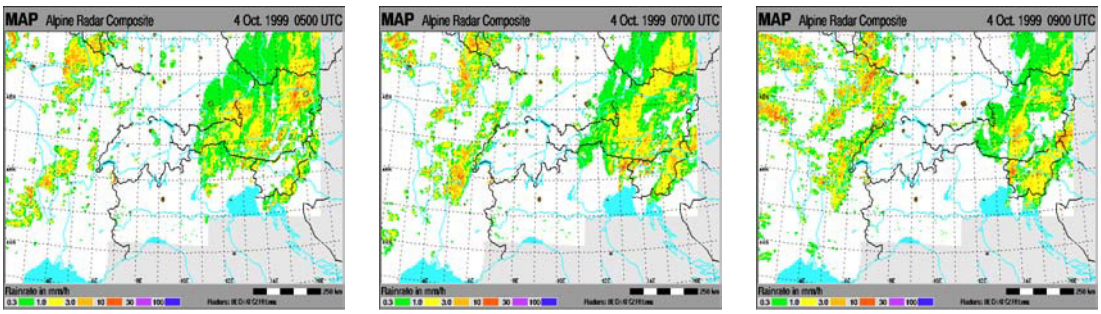

Figure 1. Alpine radar composite - time evolution of the precipitation system for 4 October 1999, 05 to 09 UTC

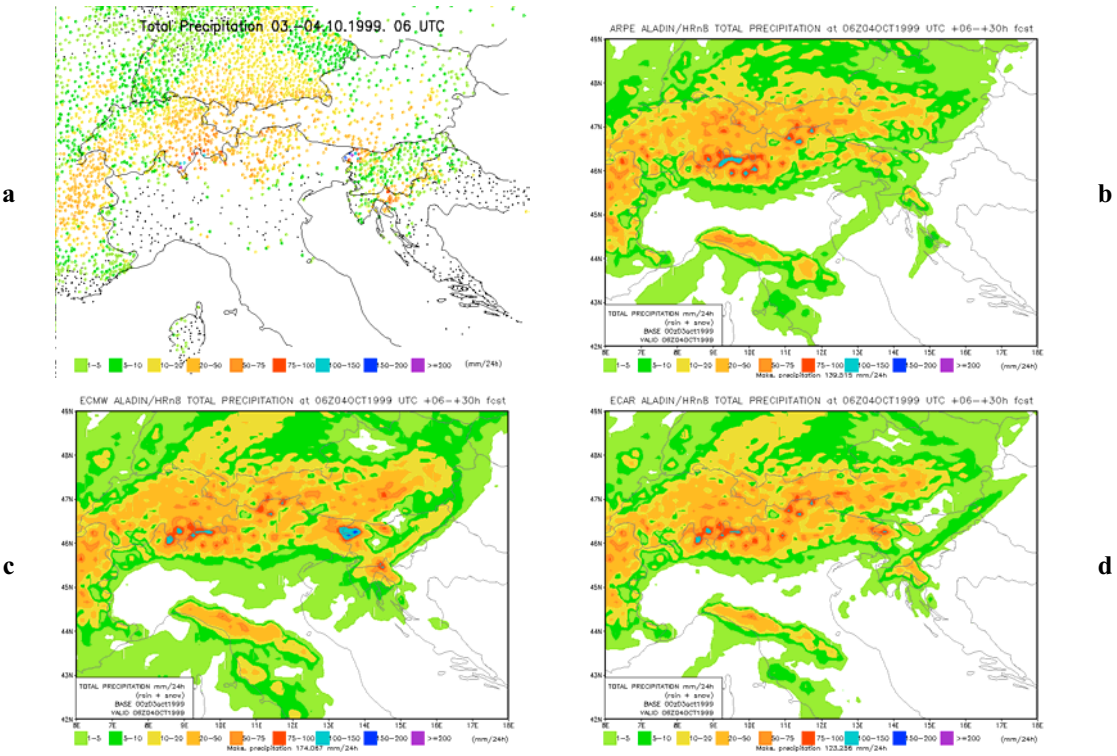

Figure 2. 24-hour accumulated precipitation (in mm) from 03 October, 06 UTC to 04 October, 06 UTC for: a) observations, b) ARPE, c) ECMW and d) ECAR run of ALADIN/HR model.

Alpine radar composite data (Fig. 1) and rain gauges measurements available over the time period from 03 October, 06 UTC to 04 October, 06 UTC (Fig. 2a) are used to asses the model results shown in Fig. 2b,c,d. Basic pattern of the precipitation distribution is in agreement with the observations. However, there are differences in location and predicted peaks.

The control case ARPE in Fig. 2b is based on the ARPEGE 1999 operational analysis (3D-Var), while the other two experiments ECMW and ECAR in Fig. 2c and d show the results starting from ECMWF MAP-RA (4D-Var) for upper-level fields with different surface fields (Paragraph 2). Intensive precipitation (100 – 200 mm/12 hours) associated with a narrow band of strong convective activity along the frontal zone in the Slovenia/Croatia border area. Predicted peaks with ARPE and ECMW experiment are located almost exactly over the observed maximums. Squall line following the front passage formed over the western Slovenia resulting with precipitation maximum of 241 mm measured at the *Soča* station.

In the ECMW experiment forecasted 24 hours precipitation is more than double as it was for ARPE simulation. In the ECMW and ECAR experiments forecasted precipitation amount in the western Slovenia and in the Slovenia/Croatia border area are better. Some remarkable differences between ECAR and ECMW simulations prove the importance of surface initial fields in correctly prediction of convection precipitation. For ECMW simulation, area with heavy precipitation (more than 100 mm/24 hours) is much bigger than it is for ECAR simulation, and maximum amount is much higher. The initial low-level moisture has a huge importance for the convection dominant precipitation, but some differences in the low-level wind should not be neglect too (not shown here).

4. RESULTS FOR THE MAP IOP 15 CASE

Sensitivity of the surface flow to the initial condition during the IOP 15, extreme *Bura* case, was study. In particular sensitivity of the surface flow to the initial conditions is reported.

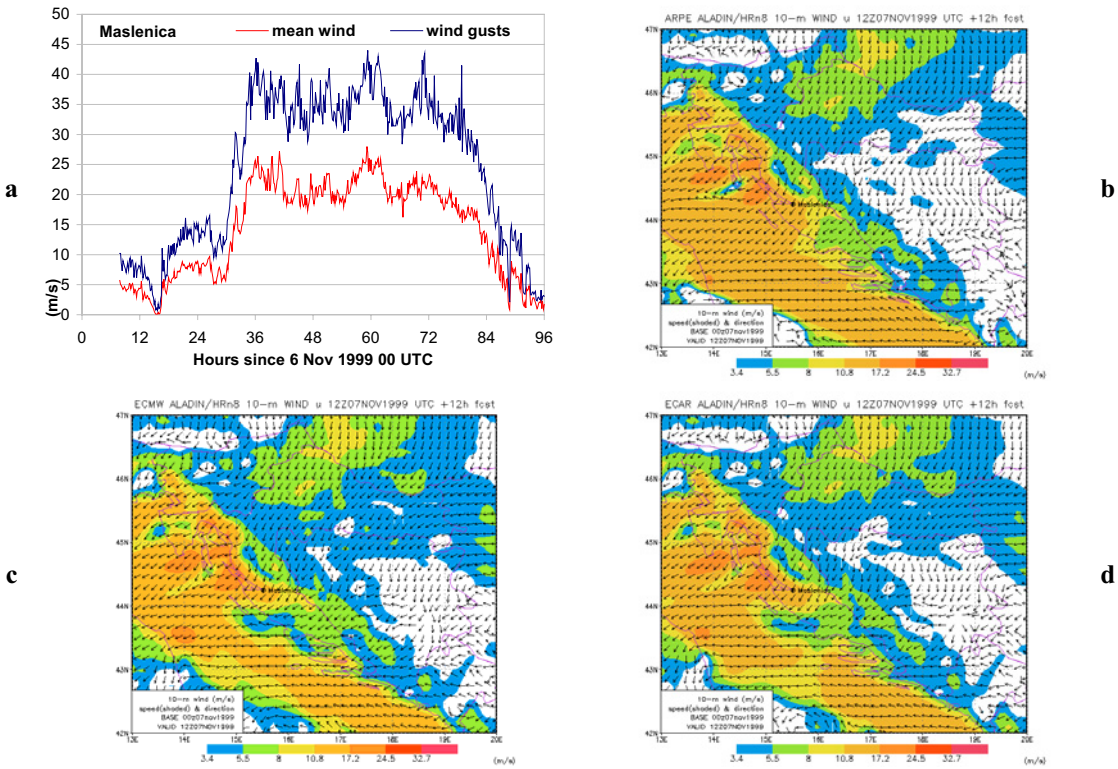

Figure 3. a) Time traces of mean wind speed and wind gusts for meteorological station Maslenica Bridge during the period 6 to 9 November 1999, 00UTC. Surface wind field (m/s) and MSL Pressure (hPa) of ALADIN/HR forecast at 12 UTC, 7 November 1999 for b) ARPE, c) ECMW and d) ECAR experiment.

During the MAP IOP15 extreme weather situation concerning a strong flow across the Dinaric Alps is occurred (Ivatek-Šahdan and Tudor, 2004). The extreme *Bura* wind case during MAP-SOP has been performed with ALADIN/HR (hydrostatic) limited area model.

The synoptic setting, within the gusty, northeasterly downslope wind *Bura* along the eastern Adriatic developed on 7 November 1999, followed an explosive lee cyclogenesis over the western Mediterranean Sea. Locally, observed maximum wind gusts exceeded 40 m/s and mean wind exceeded 25 m/s (Fig. 3a).

Numerical model results (Fig. 3b,c,d) show the wake structure within the *Bura* flow over the Adriatic with several separate low-level jets. The *Bura* was forecast to start in the early morning on 7 November. Wind velocities were forecast to exceed 20 m/s with gust up to 33 m/s. Strong pressure gradients across the Dinaric Alps create local drag that provide intense local acceleration and strong wind generation.

The different initial and boundary conditions have not given significantly different wind field in the corresponding numerical experiments (ARPA, ECAR, ECMW). The model captured well the onset and cessation of the Bura while the agreement between simulated and observed wind speed maximums was less successful. The 8 km resolution forecasts produce too weak winds for the location of the Maslenica Bridge just downstream of the mountain pass on the Velebit Mountain. The results are improved including a new approach of the high-resolution dynamical adaptation for the mountainous parts of Croatia (not presented here). Special care was taken that the terrain height in the model is close to the actual height of the mountain peaks and passes resulted with much better prediction of the local wind speed.

5. CONCLUSION

The numerical simulations of the precipitation system during the MAP IOP5 and the extreme *Bura* wind case during the MAP IOP15 have been performed with ALADIN/HR (hydrostatic) limited area model. The sensitivity of the results to the different initial conditions is reported.

Results of the numerical experiments show the higher sensitivity to the initial conditions for the MAP IOP5, heavy precipitation case. The simulation based upon the operational ARPEGE analysis produces fairly realistic results whereas the two simulations based on the ECMWF MAP-Reanalysis prove the importance of surface initial fields in correctly prediction of convection precipitation. The low-level moisture has a huge importance for the convection dominant precipitation, but some differences in the low level wind should not neglect too.

Looking only on the wind field forecast during the MAP IOP15, the different initial conditions do not have significant influence.

Acknowledgement: *This study was partly supported by the Croatian Ministry of Science, Education and Sport through grant 0004001. We are pleased to express our appreciation to the RC LACE project and ALADIN groups of CHMI and MeteoFrance.*

REFERENCES

Buzzi, A., M.S. Davolio, M.D'Isidoro and P. Malguzzi, 2004: The impact of resolution and of MAP reanalysis on the simulations of heavy precipitation during MAP cases. *Meteor. Z.*, **13**, 91-97.

Ivančan-Picek, B., D. Glasnović and V. Jurčec, 2003: Analysis and ALADIN prediction of a heavy precipitation event on the Eastern side of the Alps during the MAP IOP5. *Meteor. Z.*, **12**, 103-112.

Ivatek-Šahdan, S. and M. Tudor, 2004: Use of high-resolution dynamical adaptation. *Meteor. Z.*, **13**, 99-108.

Keil, C. and C. Cardinali, 2003: The ECMWF Re-Analysis of the Mesoscale Alpine Programme Special Observing Period. *ECMWF TM 401.* Available from ECMWF, Shinfield Park, Reading, RG2 9AX, UK.

Lascaux, F., E. Richard, C. Keil and O. Bock, 2004: Impact of the MAP reanalysis on the numerical simulation of the MAP IOP2a convective system. *Meteor. Z.*, **13** , 49-54.