Mediterranean Storms
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APPLICATION OF THE NON-HYDROSTATIC ARPS MODEL TO THE 21 ST -23 RD DECEMBER 2000 EXTREME WEATHER EVENT

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ABSTRACT

The non-hydrostatic meteorological model ARPS (Atmospheric Regional Prediction System) (Xue et al, 2000, 2001) is being used operatively in Galicia (Northwest of Spain) since January 2000 showing skill in predicting heavy rains (Souto et al., 2002). The extreme events occurring from 21 to 23 December 2000 gave rise to heavy rains and floods in the Southwest and the Northeast of the Iberian peninsula. While rains occurring in Portugal were due to the interaction of synoptic fronts with the local topography, in Catalonia, convective precipitation plays a major role for the observed precipitation. ARPS model is used to investigate both events. The effects of convective cumulus schemes and model resolution have been investigated. Verification of spatial rainfall distribution and quantitative precipitation forecasts were made against surface observations. Such study will help to identify operative model deficiencies and point out specific needs for improvement in the predictive skill of the ARPS model under different weather events.

1 MODEL

The non-hydrostatic ARPS (Atmospheric Regional Prediction System) model (*Xue et al.*, 2000), developed at the Centre of Analysis and Prediction of Storms (CAPS) in Oklahoma University, is used to simulate heavy rainfall events in the Mediterranean area for the extreme weather event, occurred between 21st and 23rd December 2000. In this area, convection plays an important role so different convective parameterization schemes (CPS) were analysed. Model resolution is also analysed in terms of quantitative precipitation forecasting. ARPS model was used because its nonhydrostatic dynamics, generalized terrain-following coordinate, and its nesting capabilities well suited for the complex orography of the two regions under consideration in this study. ARPS has been tested operationally for at least two years in Galicia (Spain) (*Souto et al., 2002*).

The governing equations of the ARPS include conservation equations for momentum, heat, mass, water substance (water vapor, liquid and ice), subgrid-scale turbulent kinetic energy (TKE), and the equation of state of moist air. Two convective parameterizatioin schemes have been used: the Kuo scheme (*Kuo*, 1965, 1974), which is based in a moisture convergence closure assumption, and the Kain-Fritch scheme (*Kain-Fritch*, 1990, 1993) for which the closure assumption consists of the removal of the convective available potential energy. The modified three-category ice scheme of Lin et al. (1983) is used for microphysics parameterization

To test the effect of model resolution a one-way nesting with two different sets of grids were used (outer domain: 50 km/25 km and inner domain: 10 km/5 km). As inner domains, we considered two different areas: South Portugal and the Catalonia area (Northeast of Spain). The ARPS model starts from an enhanced 12-h forecast of the NCEP AVN model, and used the boundary conditions also obtained from the NCEP AVN model at 3-h interval on the coarse grid. There are 43 sigma-z levels in the vertical extending to 21 km. Simulations were initialised on December 21, and run for three days, thus obtaining the results for Catalonia area after 72 hours the model was initialised.

2 BRIEF SYNOPTIC DESCRIPTION

From 21st to 23rd December 2000, Southwest and Northeast of the Iberian Peninsula were affected by important precipitation events whose physical description was different. The South Portugal event corresponds to a much more strong upper levels dynamic forcing with different frontal passages and maximum rainfall the 21st December 2000. While, in the Catalonia event, the synoptic situation was dominated by strong low-level wind which advected moisture towards the coast, with heavy rainfall amounts the 23rd December 2000.

3 RESULTS

A comparison between the total and the subgrid convective precipitation simulated in the coarse domain with the Kain-Fritch and the Kuo schemes (fig 1), shows how the first one produces significant more subgrid convective precipitation than the Kuo scheme. Precipitation was associated with post-frontal rainshowers and rainshowers produced by a low over Algeria.

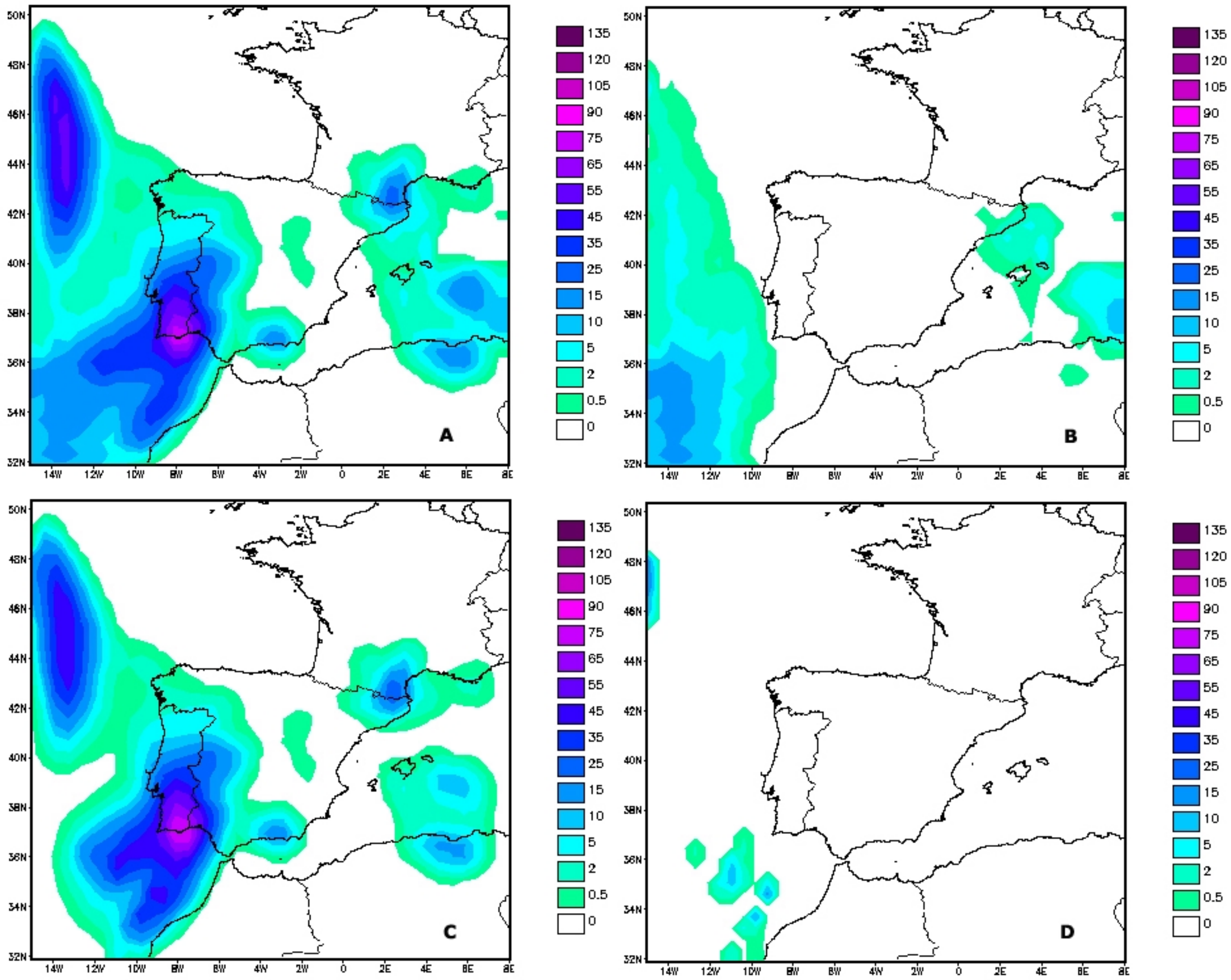

Figure 1. Comparison between the total precipitation (left figures, A & C) and the subgrid convective precipitation (right figures, B & D) simulated in the outer domain of 50 km of resolution with the Kain-Fritch scheme (top figures, A & B) and with the Kuo scheme (bottom figures, C & D) for the first day of simulation (21st December 2000).

Dealing with spatial rainfall distribution in the inner domains, a comparison between the real and the simulated precipitation for 10 km resolution in South Portugal area (with a data set of 15 weather stations located in South Portugal) for the first day of simulation shows how the model captures the pattern of rainfall distribution. Increasing resolution to 5 km, the pattern is now well defined and the maximum rainfall areas do not show more quantitative precipitation.

In Catalonia, the same analysis (with a data set of 79 weather stations spread out over Catalonia) for the third day of simulation (72 hours forecasting) shows, for the 10 km resolution simulations, maximum and minimum rainfall areas slightly displaced from the real postions, while for the 5 km resolution, the pattern is again better defined and there are new maximum rainfall areas. It is interesting to point out that these maxima show much more quantitative precipitation values than for the 10 km ones, which are in better agreement with the real data.

Results of temporal rainfall distribution in the Catalonia area reveal that there is not significant differences between the two convective parameterization schemes used in these simulations for the 10 km resolution. Only for light rainfall amounts the effect of increasing model resolution is very significant, while this benefit tends to decrease for heavy rainfall amounts. On the other hand, for the South Portugal event, the same analysis (fig. 2) shows that only the 10 km resolution simulation with the Kain-Fritch scheme is able to reproduce the post-frontal rainshowers.

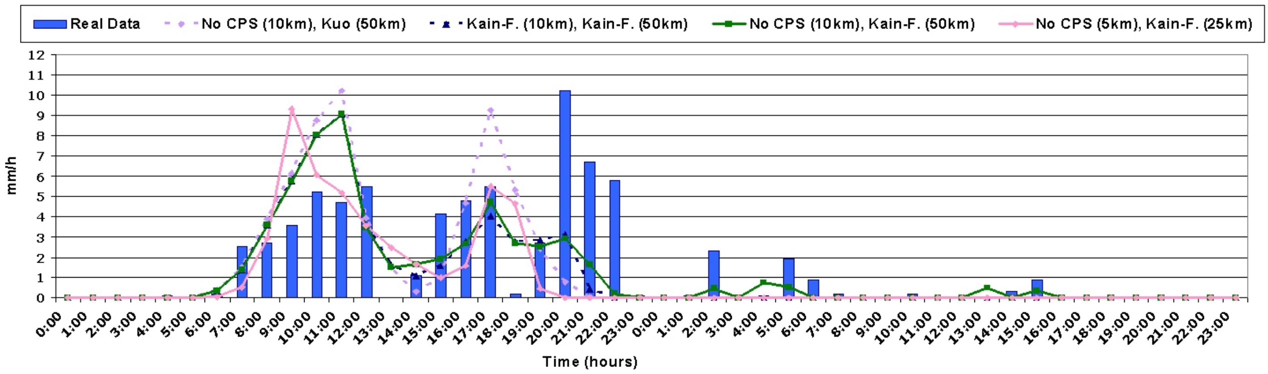

Figure 2. Time evolution of the real and simulated precipitation in the Faro Airport (Portugal). Blue, green and violet lines represent the 10 km resolution simulations with the different schemes and the pink line shows the 5 km model resolution simulation without convective parameterization scheme.

Finally, focusing our attention in the Catalonia area, we evaluate the precipitation with a time evolution tendency of the bias and the threat score for the third day of simulation (72 hours forecasting) as a function of different threshold values. For the 10 km resolution simulations, the results are very similar and they show a global tendency to underestimate heavy rainfall amounts. Going down to 5 km resolution, the results are better in all ranges showing a light tendency to overestimate heavy rainfall amounts.

The scatterplot (fig 3) confirms these results, showing the overestimation of light rainfall amounts and the underestimation of heavy precipitations amounts of the 10 km resolutions in comparison with the 5 km ones.

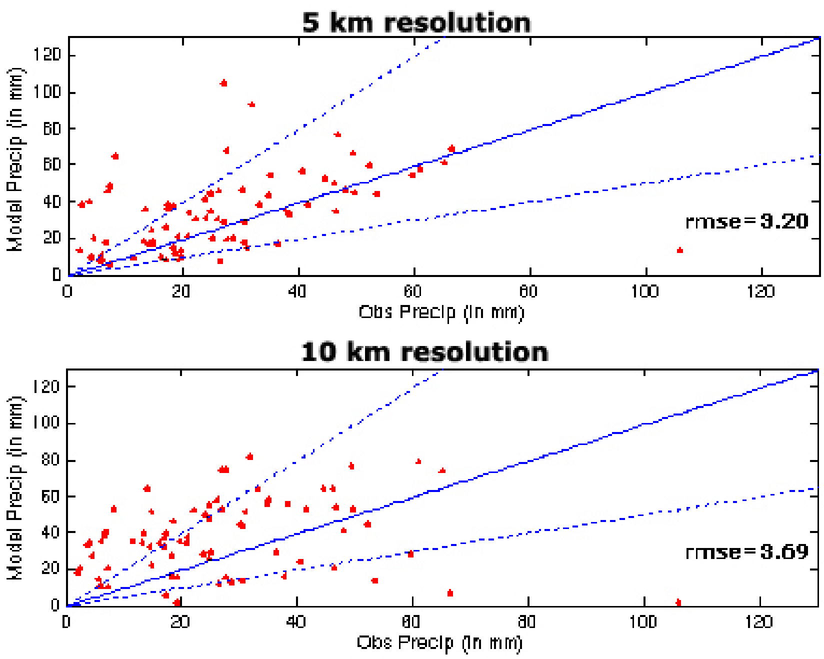

Figure 3. Scatterplot for the third day of simulation (23rd December 2000) in the Catalonia area. The top figure shows the results for the 5 km model resolution simulation and the bottom figure presents the results of the 10 km model resolution simulations, both performed without convective parameterization scheme.

4 CONCLUSIONS

In regions of heavy convective rain, there was a significant improvement in the precipitation forecast increasing the resolution of the inner domain. However in areas of frontal rain, the numerical results reveal the benefit of using Kain-Fritch convective parameterization scheme for 10 km resolution, while increasing the model resolution does not show important advances. The Kuo scheme generates less convective precipitation than the Kain-Fritch scheme, which seems to be more appropriate for this study, capturing post-frontal rainshowers.

Finally, it is interesting to remark the need of assimilation techniques to improve these results which will be presented elsewhere, and the need of more data from surface stations and rawisondes, both to be assimilated into the model and for verification purposes.

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