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Sensitivity of precipitation forecasts to convective parameterization in the October 2007 Flash Flood in the Valencia Region (Eastern Spain)

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Abstract. The Valencia region, on the Mediterranean coast of the Iberian Peninsula, is an area prone to torrential rains, especially the north of Alicante province and the south of Valencia province. In October 2007, a torrential rain event with accumulated rainfall values exceeding 400 mm in less than 24 h affected the aforementioned areas, producing flash floods that caused extensive economic losses and human casualties. Several simulations of this rain event have been performed with the Regional Atmospheric Modeling System (RAMS) to test the influence of the different convective parameterization scheme implemented in the model on the precipitation forecast.

1 Introduction

Torrential rains and flash-floods are common in the Western Mediterranean, occurring mostly from late summer to autumn. These heavy rain events can cause high economic losses and, sometimes, human casualties. Thus, a better understanding and a proper forecasting of these events is an important issue in Mediterranean meteorology. Numerous efforts addressing this problem from different points of view have been made during recent years, ranging from the study of trends in both the number of torrential events and their precipitation (Alpert et al., 2002; Peñarrocha et al., 2002; Millán et al., 2005) to the study of the favourable atmospheric environment for heavy rains in the Mediterranean basin (Millán et al., 1995; Estrela et al., 2002, 2003; Fita et al., 2007). Numerous efforts have also been devoted to different aspects and sensitivities of the numerical modelling of such torrential rain events (Bresson et al., 2009; Federico et al., 2008, Pastor et al., 2001; Lebeaupin et al., 2006, 2009; Miglietta and Regano, 2008).

In October 2007 a torrential rain event took place in the Valencia region, mainly affecting coastal areas and nearby mountains in the center-south of the region. More than 400 mm in 24 h were recorded at some stations in this area, with less intense rainfall in the rest of the region. A detailed description of this rain event, from its meteorological scenario and recorded data to its numerical modelling using Regional Atmospheric Modeling System (RAMS) (Pielke et al., 1992; Cotton et al., 2003), is given in Pastor et al. (2010).

In the present work, the authors investigate the effects of the different convective parameterization schemes implemented in RAMS model on precipitation forecasts. This is done by means of high-resolution simulations of the October 2007 rain event.

2 Model configuration

Six different sensitivity experiments have been carried out with RAMS in its version 6.0. These simulations have been performed using two-way interactive nested grids at increasing horizontal resolution of 40.5, 13.5, 4.5 and 1.5 km, respectively. Vertical discretization consists of a 45-level stretched vertical coordinate with a 30 m spacing near the

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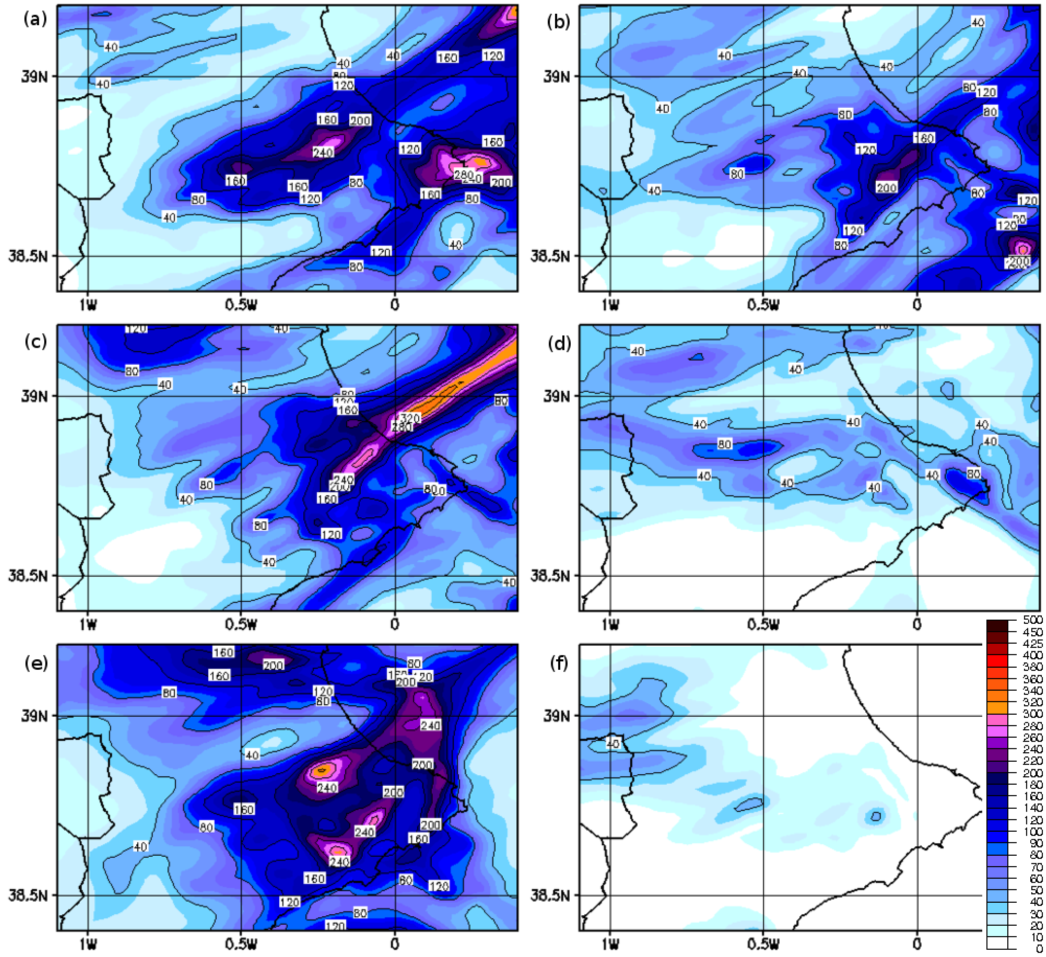

Fig. 1. RAMS forecast accumulated precipitation for the whole event: **(a)** Kuo1, **(b)** KF1, **(c)** Kuo2, **(d)** KF2, **(e)** Kuo3 and **(f)** KF3 (mm).

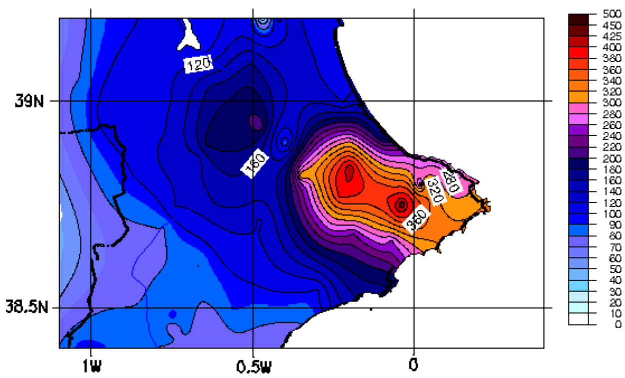

Fig. 2. Accumulated precipitation (mm) observed for the 48 h period 11–12 October 2007. Data recorded by CEAM Meteorology Department, Spanish Meteorological Agency (AEMET) and Confederación Hidrográfica del Júcar (CHJ).

surface increasing gradually up to 1000 m near the model top at 16 000 m. The atmospheric boundary and initial conditions are obtained from the National Centre for Environmental Prediction (NCEP) global Final Analyses (FNL), available every 6 h at 1×1 degree resolution. Simulations of 48 h are run for each experiment, starting at 00:00 UTC on 11 October 2007. The convective parameterization schemes supplied by RAMS are activated/deactivated in the three outer domains: Kuo (Molinari, 1985) and Kain-Fritsch (KF) (Kain and Fritsch, 1993; Castro et al., 2002) schemes (Table 1). Convection is explicitly resolved in the inner domain.

3 Results

The effect of activating or not activating a convective parameterization scheme in the three outer grids is investigated by considering the total accumulated precipitation and its hourly evolution against observations for each of the experiments. The results are analysed only for the inner model domain, which is centred on the rain area. From this analysis, it has

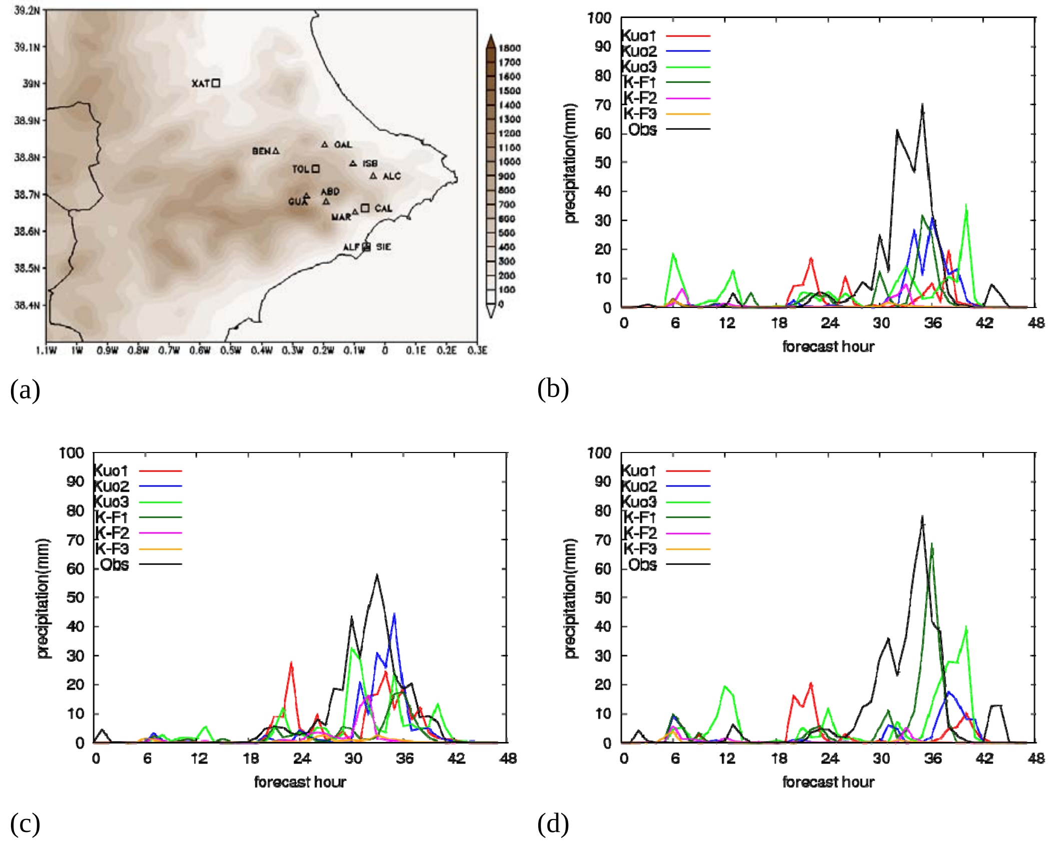

Fig. 3. (a) Grid 4 topography with stations in the area of maximum rainfall. Time evolution of observed and forecast precipitation (whole simulation time) at **(b)** Isbert (ISB) **(c)** Tollos (TOL) and **(d)** Alcalalí (ALC).

Table 1. Sensitivity experiments. Cumulus scheme settings (no cumulus parameterization on Grid 4).

Experiment	Grid 1	Grid 2	Grid 3
Kuo1	Kuo	N/A	N/A
Kuo2	Kuo	Kuo	N/A
Kuo3	Kuo	Kuo	Kuo
KF1	KF	N/A	N/A
KF2	KF	KF	N/A
KF3	KF	KF	KF

become clear that convective parameterization has a significant impact on the precipitation forecast in RAMS model.

3.1 Accumulated precipitation and spatial location

Forecast accumulated precipitation for the six different simulations are shown in Fig. 1. It can be seen that Kuo1 produces two precipitation maxima in the target area, capturing the location and underestimating the amount of rainfall observed (Fig. 2). Kuo2 displays only a narrow area of precipitation. Although in both cases, precipitation values exceed 250 mm, in terms of “integrated rainfall” over the target area, Kuo1 is remarkable better than Kuo2. The best results for the Kuo scheme experiments are obtained when the Kuo convective parameterization is activated in the three outer grids of the simulation. Then, the spatial distribution of the precipitation correctly fits the actual recorded precipitation in both extension and location. But, again, precipitation values are underpredicted although Kuo3 yields maximum accumulated values above 270 mm, and a broad area over 100 mm. In all three experiments the rain area extends from south-west to north-east and out over the sea.

In the case of the Kain-Fritsch convective parameterization scheme experiments, only KF1 gives good results while KF2 and KF3 show very low accumulated precipitation values. In KF1 the high precipitation area is less extensive than the real one, but it is well located. As in the Kuo experiments, the KF1 maximum precipitation value of 180 mm is underestimated with respect to the observed values. The other two experiments, KF2 and KF3, show very low values, below 90 and 50 mm respectively, and the location is moved to the north and inland.

3.2 Time evolution

Three stations representative of the general evolution of the forecast precipitation in the area of maximum rainfall for the whole event are analysed in this section. The comparison of the hourly evolution of the observed and forecast precipitation at these stations is shown in Fig. 3. During the first 20 hours of the simulation, very little or no precipitation was recorded. At most stations, the Kain-Fritsch, Kuo1 and Kuo2 experiments produce almost no precipitation while the Kuo3 experiment shows some precipitation peaks that are not observed. The heavy rainfall started between 20 and 24 h from the beginning of the simulation. Within this 4-h period, Kuo1 produces a rainfall that was not actually observed. The hourly evolution of the precipitation is not well reproduced for the Kuo3 experiment and for the whole simulation period. Moreover, precipitation is strongly under-predicted for the Kuo2 experiment. In contrast, KF1 produces better results than the other KF experiments. In fact, KF1 results are in general similar to those using the Kuo scheme, especially Kuo2 and Kuo3, with the maximum precipitation peaks captured even better for some stations, as for example, Alcalalí (Fig. 3d).

4 Conclusions

Several numerical simulations of an extraordinary rain event have been run. In each simulation, the implementation of convective parameterization schemes has been modified in order to investigate the effect on the precipitation forecasts. The two convective parameterization schemes in the RAMS model (Kuo and Kain-Fritsch) have been used on different domains with different spatial resolution. The methodology followed consisted of running different high-resolution simulations with four nested grids, activating or deactivating the parameterization schemes in different combinations of the three outer grids for each simulation.

To summarize the results: KF1 seems to better capture the precipitation maximum intensity peaks despite its poor achievement in accumulated totals. Although Kuo3 shows the best performance in both the location and the total accumulation of the precipitation, its hourly distribution performance is worse than KF1 and Kuo2. In general, the Kuo scheme experiments reproduce the precipitation event well, although with a remarkable underestimation (about 50% lower than observation). For most stations, the best results in event duration and peaks are produced by Kuo2 and Kuo3 experiments, while in Kuo1 the precipitation starts too soon and does not reproduce enough precipitation intensities during the rainfall.

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