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HIGH RESOLUTION TERRAIN AS A TRIGGERING MECHANISM FOR THE KAIN-FRITCH SCHEME FOR THE 8-10th SEPTEMBER 2002 MEDEX CASE

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ABSTRACT

Mesoscale numerical precipitation simulations are well known to be highly sensitive to terrain characteristics and the convective parameterization scheme (CPS) selected. In addition, these factors seem to be strongly interrelated and highly dependent on the model resolution. To determine the role of each of these factors, we have performed a set of numerical calculations by using the factor separation technique (Stein and Alpert, 1993).
Topography is a very strong forcing mechanism, and the numerical results show the behaviour of the topography acting as a triggering mechanism of the convection for the Kain-Fritch scheme. In this paper, we study the relative influence of these factors to forecast heavy rainfall events, compared in increasing model resolution.
The non-hydrostatic meteorological model ARPS (Atmospheric Regional Prediction System) (Xue et al, 2001; Souto et al, 2003) is used to investigate all these issues for an extreme weather event (one of MEDEX cases) occurring September 2002 in South France. Then, heavy rainfalls occurred from 8 to 10th September, several civil damages were reported and at least 20 people died in the floods.

1 INTRODUCTION

Mesoscale numerical precipitation simulations are highly sensitive to terrain characteristics and the convective parameterization scheme (CPS) selected, but what about their synergism?

It is well known that convection serves not only to produce precipitation, but also to transport heat upward, redistribute moisture, and thereby stabilize the atmosphere. At the scale at which convective processes occur, current operational models take into account their effects via parameterization (with convective parameterization schemes). At the same time, the role of topography is basic in determining distribution and amount of precipitation. One of the most powerful ways in which topography influences the weather is through its strong local control of precipitation, which is crucial in case of extreme weather events.

In this work, we have focused not only on the isolated role played by these factors in a numerical precipitation simulation but we have tried to understand the complex nonlinear interactions between topography, model resolution and CPS. We want to understand in detail the CPS selected, the Kain-Fritch (*Kain-Fritch*, 1990, 1993) scheme. In particular, our main objective is to know in which way could the topography trigger convection in a grid column through the search of the synergism between the CPS and the topography.

The factor separation technique (Stein & Alpert, 1993), often employed (Homar et al, 1999; Alpert et al, 1996) and still in development, was the most suitable tool for this work. In this particular study we take into account two factors, so four experiments made switching on/off these factors could be algebraically combined following the factor separation technique to yield us the results.

Run	Topography	CPS (Kain-Fritch)
F_0	No	No
F_1	Yes	No
F_2	No	Yes
F_{12}	Yes	Yes

Effect of the topography: $E_1=F_1-F_0$.
Effect of the CPS (Kain-Fritch): $E_2=F_2-F_0$.
Effect of the interaction between topography and CPS: $E_{12}=F_{12}-(F_1+F_2)+F_0$

2 THE EVENT: BRIEF SYNOPTIC DESCRIPTION

From 8th to 10th September 2002, but specially Sunday 8 and Monday 9, the areas of “l'Hérault”, “le Vaucluse” and “le Gard”, in southern France, were hit by floods and severe storms. This heavy rainfall event (more than 190 mm fell in 3 hours over different areas (MeteoFrance)) produced at least 20 fatal victims (taken from CNN, 2002, September 10).

The synoptic situation was dominated by strong low-level wind which advected moisture towards the coast, with cold air at upper levels, or more specifically the active area of a westerly wave.

3 RESULTS

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 this extreme weather event. This model, which has been tested operationally for at least four years in Galicia (Spain) (*Souto et al., 2003*) and it has been used in other similar framework to study extreme weather events within the MEDEX project (*Hervella et al, 2002*), includes 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. The Kain-Fritch scheme (*Kain-Fritch*, 1990, 1993) for which the closure assumption consists of the removal of the convective available potential energy, has been used. 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 three different sets of grids were used (outer domains: 60 km/50 km/40 km and corresponding inner domains: 12km/10 km/5 km). The topography is obtained from the high-resolution GTOPO30 data set, which covers the entire globe with a resolution of 30-arc second.

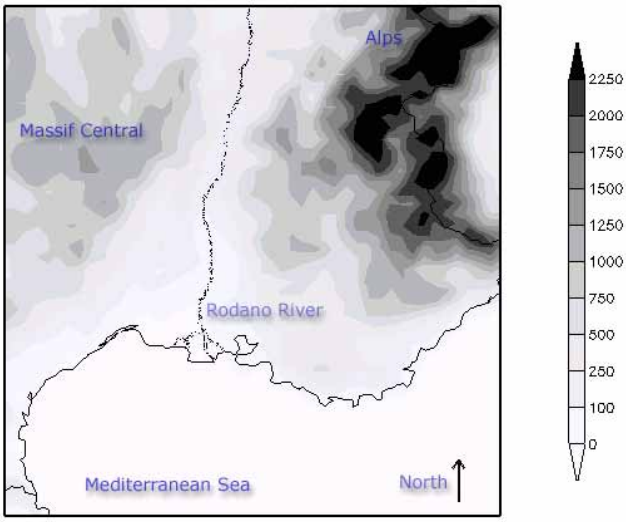

Figure 1. Area of study (southern France), numbers shown in meters.

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. Simulations are initiated on September 8, and run for three days.

Our area of study was restricted to the inner domains (the outer domain was the same for all the simulations, with topography and Kain-Fritch CPS) and we paid attention to the precipitation produced by the model, taking into account that the F_{12} (Topography + Kain-Fritch CPS) simulation was considered our control run. A comparison between the precipitation generated by the isolated topographic effect, the isolated Kain-Fritch effect, their synergism and the control run for a set of three different horizontal model resolutions is shown in fig.2.

Dealing with topography, inhibition areas are placed just behind unrealistic local strong rain discharge areas. As it was expected, the topographic effect is highly dependant on model horizontal resolution: increasing resolution the pattern is better defined and the model shows new inhibition areas over the Ródano river basin (fig.2).

We turn now to the examination of the isolated Kain-Fritch contribution, which points out instability areas, due to cold air at upper levels, placed in the “Massif Central”. The most surprising feature is that the isolated K-F effect is highly sensitive on model resolution: increasing resolution shows a more contrasted pattern, with more intense and located precipitation followed by precipitation inhibition areas.

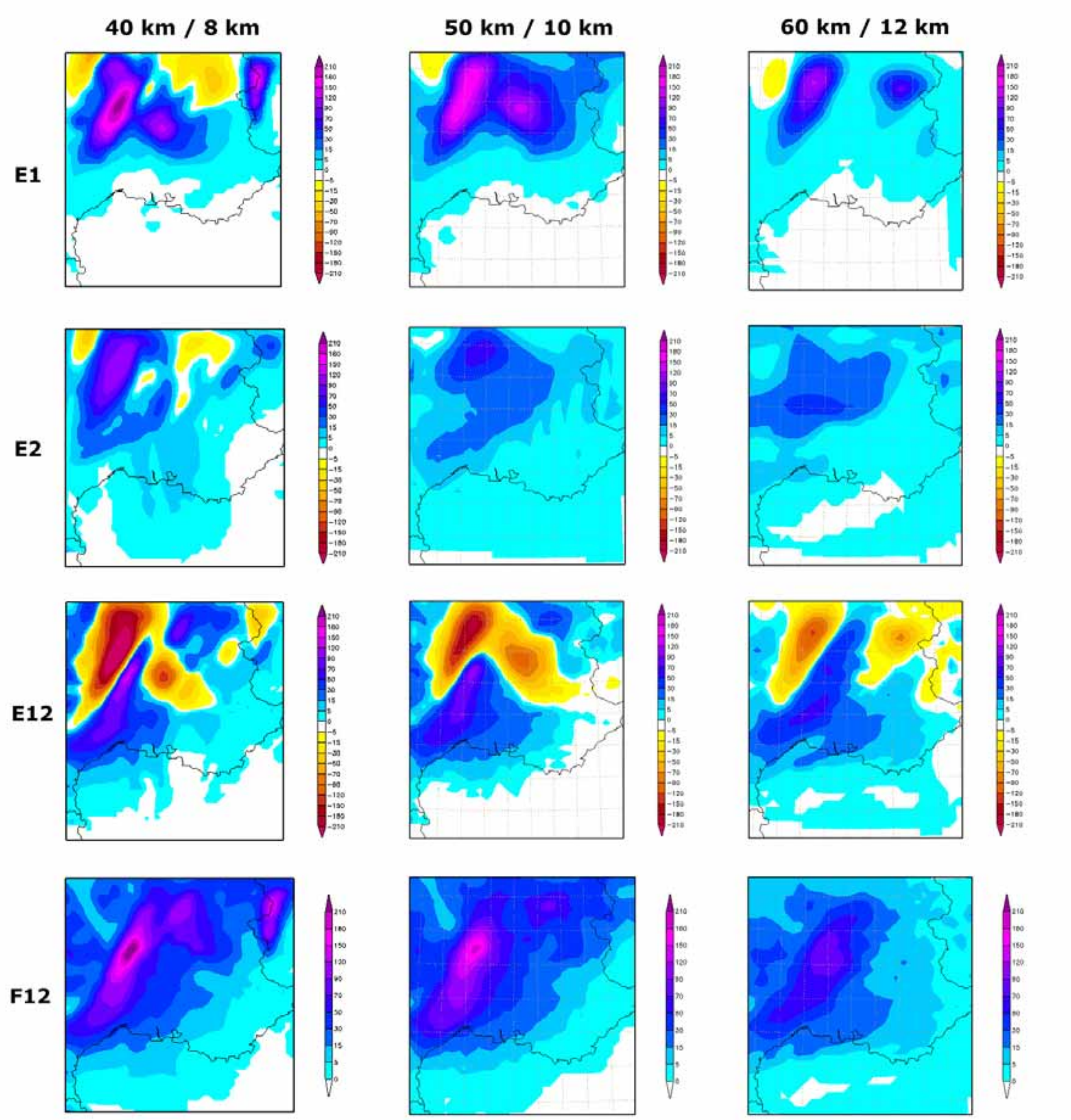

Figure 2. Comparison between the precipitation generated in 48 hours (8 and 9 September 2002) by the isolated topographic effect (first row), the isolated Kain-Fritch effect (second row), their synergy (third row) and the control run (fourth row) in the inner domain, for a set of three different horizontal model resolution: 8 km (first column), 10 km (second column) and 12 km (third column).

Finally, another important fact is the role played by the synergism of both factors in the generation of precipitation. It is this nonlinear interaction between these two factors which causes the increment of precipitation on the off side of the “Massif Central” and reduces rain over and specially on the lee side of this mountain range. It is important to notice that the interaction between topography and K-F gives rise to the major precipitation inhibition over the “Massif Central”, inhibition that increase with higher resolution. As it is expected, the synergism depends on the model resolution.

4 CONCLUSION

In this letter, we have shown that using “only” the Kain-Fritch scheme (without topography), this is able to trigger rainfall patterns with areas of inhibited and pronounced amounts of rain after some model resolution. We also conclude that the rain pattern is strongly controlled by the synergism between the topography and the Kain-Fritch scheme; it represents the major rain inhibition contribution factor.

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