Evaluation of the role of the sea-surface temperature on torrential rains on the Spanish Mediterranean coast (Valencian region) with a mesoscale numerical model (RAMS).

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ABSTRACT

Torrential rains are a frequent meteorological risk in the Mediterranean Basin. As part of a long-term research study conducted at CEAM on meteorological risks in the Western Mediterranean basin, we have studied a torrential rain event that occurred in the Valencian region in September 1989 with a mesoscale numerical model, RAMS (Regional Atmospheric Modeling System). Previous studies of torrential rains in CEAM have shown that the Sea-Surface Temperature (SST) is a key factor in the development of such events. The purpose of this work was to evaluate the role of the Sea-Surface Temperature in the development of such torrential rains and the possibility of its operational numerical forecasting. In order to do this, three different RAMS simulations were performed, progressively improving SST input data sources. These data inputs ranged from monthly climatological averages to the closer-to-real-time data available from NOAA satellite images. Significant improvement was found in the model results when using NOAA satellite images to retrieve SST data.

1. INTRODUCTION

Torrential rains are a frequent meteorological risk in the Mediterranean basin, occurring from late-summer to winter. The Valencian region, located on the east coast of the Iberian peninsula (fig. 1), is one of the most affected regions. Prior studies in CEAM on the concurrent processes in the genesis of torrential rain events in the Valencia region have shown the sea-surface temperature (SST) as a key factor in the formation of torrential rains (Millán *et al.*, 1995). The objective of this work is to quantitatively corroborate the importance of SST in the development of torrential rains. Second, we want to check the importance of accurate real-time data input into numerical models in the improvement of torrential rains operational forecasting. In this study our intention is to quantitatively confirm this improvement by progressively introducing better SST input data to the RAMS model.

2. METHODOLOGY

To accomplish this objective we have studied the torrential rain event from 4-7 September 1989 (fig. 2), one of the strongest in the last ten years. The methodology followed has consisted in running three different RAMS simulations of the event with input from three different SST data sources and looking for any improvement in the results as the SST data approach the real situation. The first two simulations were run with SST monthly averages (RAMS-distributed SST data and International Satellite Land Surface Climatology Project SST data) and the third with data derived from the available NOAA images closest to the event.

As can be seen in Fig. 3 major differences are noticed between the SST data for the Satellite simulation with respect to the other simulations. In the first two cases SST are monthly averages on a 1x1 degree global grid. For the Satellite Simulation SST data have been obtained from the close-to-the-event NOAA satellite images from August 28th with an algorithm developed at CEAM (Badenas *et al.*, 1997). The resulting data are a 0.5x0.5 degree resolution grid with an accuracy of ±0.5ºC. It was necessary to merge these data with the ISLSCP world SST data because of numerical modeling necessities. Mention should be made of the presence of a warm SST core of temperature greater than 28º C just offshore from the Valencian coast for the Satellite simulation.

The RAMS model is fundamentally a limited-area model for regional mesoscale studies (Pielke *et al.*, 1992 and Walko *et al.*, 1995). In this work the RAMS model has been initialised with a three-dimensional grid of atmospheric data provided by ECMWF and run in a non-hydrostatic mode and with its humid atmosphere options fully activated.

Figure 2 : Precipitation recorded during the event

Figure 3 : SST data for the three simulations (Control, ISLSCP and Satellite)

3. RESULTS

The model results obtained for the three simulations are shown on the following figures and their corresponding descriptions. The results are shown in order of increasing SST data-input accuracy and using the simulation run with RAMS SST distributed data as the Control Simulation.

3.1. Control Simulation

In this simulation we see (fig. 4) that the model rainfall distribution shows a fairly good agreement in spatial location with actual data from the event. A slight southerly displacement is observed in the location of the maximum rainfall area, coinciding with the *Sierra de la Safor* area, a complex orography zone where no measuring stations are located. The main disagreement between the model results and the precipitation data from the event appears in the quantity of rain. The model results disagree with the real data by at least a factor of 0.5 in most parts of the grid. The maximum precipitation from the RAMS results is 242 mm while more than 500 mm were recorded at some stations during the event.

Figure 4 : Total RAMS precipitation for the Control Simulation

3.2. ISLSCP Simulation

The total precipitation results for this simulation (fig. 5) show a small increase with respect to the Control simulation, especially in its maximum values with a plus of about 50 mm on most grid points. The maximum rain peak at a grid point is 301 mm. Regarding spatial distribution, no significant differences can be found from the CONTROL simulation. The maximum rainfall zone is located above the same location, still displaced slightly southerly displaced from the real data recorded during the event, but extending over a greater area, the 200 mm isoline being displaced North (closer to the city of Gandia).

Figure 5 : Total RAMS precipitation for the ISLSCP simulation

3.3. Satellite Simulation

RAMS results for total precipitation in this simulation are shown in Fig. 6. The most important difference from the results of the prior simulations comes from the rainfall values, almost two times greater than the ISLSCP simulation at most of the study region. Also the maximum precipitation at a grid point is 496 mm. In this case the 200 mm isoline covers a greater area than in the first two cases. This area ranges from the *Sierra de la Carrasca* on the South (at the coastal ranges as in the other cases) to some distance North the city of Gandia while in the CONTROL and ISLSCP simulations the 200 mm isoline was located to the South of Gandia. This area has also extended some distance inland to the West.

The spatial rainfall distribution does not show much difference from the prior simulations, except for the increase in the rain area. Also, the maximum amount of rain is located a short distance to the North of its position on the ISLSCP simulation, but still to the South with respect to the data recorded during the event. This maximum precipitation point coincides with the complex orography zone inside the study area where no measuring stations are located.

Figure 6 : Total RAMS precipitation for the Satellite simulation

4. CONCLUSIONS

Regarding the genesis of processes producing torrential rains, sea-surface temperature has been shown to be a key factor in the development of such events in the Western Mediterranean basin, as formulated in the Back-door Cold Front concept. The best agreement between the model results and data recorded during the event was when the SST data input to the model was closer to reality. This occurred in the SAT simulation in which the SST data had been derived from the NOAA satellite image of a day previous to the event. While the simulations run using climatological monthly averages for SST were effective in locating the spatial distribution of the rain, they did not fit the amount of rain by a factor of 0.5 at the places where maximum precipitations were recorded. Rainfall amounts calculated by the RAMS model on the SAT simulation were closer to reality but still remained lower than the actual precipitation. It has to be pointed out that, despite the fairly good model results regarding the spatial distribution of the rain, the maximum rain peaks shown by the model are displaced slightly southerly. This is due to the impact of orography on the model results; the maximums are located on a complex orography zone located to the South of the city of Gandia where no reliable measurements are available.

The second conclusion belongs to the field of numerical forecasting of meteorological hazards. It has been shown that the accurate input of real-time data can greatly improve the results of a numerical model. In this case we have chosen SST, since we expected it to have a major influence on torrential rains. The only way to obtain reliable real-time SST values was to use estimations from satellite images. Thus, the authors think that further development of numerical modeling should put more emphasis on the implementation of better real-time data input techniques. The authors think that this objective will improve operative forecasting of meteorological hazards, especially in the particular case of the Mediterranean basin.

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