Mountain Meteorology in the Middle of the Western Mediterranean Basin: Study of an Intense Rainfall Episode in Corsica, 14 September 2006

Dominique Lambert¹, Sébastien Argence¹, Evelyne Richard¹

¹ Laboratoire d’Aérologie, CNRS-UPS, Toulouse, France
E-mail: dominique.lambert@aero.obs-mip.fr

Abstract: A preliminary study of the 14 September 2006 heavy rainfall episode in Corsica is presented. Two sets of initial and coupling fields are used to run the French Meso-NH model with three nested domains (50, 10 and 2 km horizontal resolution). Whereas at large scale the situation is well captured by both simulations, at fine scale they present significant differences. The comparison with the observations does not allow to discriminate between the two simulations. Even if the main high-level dynamic ingredients usually associated with rain storms are present in both simulations, their fine scale evolution is not well reproduced. Near the surface, both simulations present significant differences. Vertical motion fields associated with convective phenomena are different in the innermost domain. A cold pool acting as a warm front off the East coast is associated to the main rainfall area over the sea in one simulation whereas in the second simulation, it seems that the Corsican mountain acts as a barrier and that results into inland rainfall. This preliminary study gives perspectives for future sensitivity tests. For example, it is planned to investigate the influence of the high level dynamics, the SST and a better description of the orography.

Keywords: Mediterranean intense rainfall, dynamics, simulations

1. Introduction

Flooding is one of the most devastating natural hazards in terms of human life loss along with windstorms. The Mediterranean climate, usually pleasant with sunshine and fine weather, can sometimes be characterized by intense rainfall events on a variety of space and time scales. The Mediterranean Basin is known to present one of the highest concentrations of cyclones in the world (Pettersen (1956)). Especially, the Gulf of Genoa is the area where the concentration of cyclones is maximal.

In the last few years, several high precipitation events have been listed all around the western Mediterranean Basin, in Spain, Italy, Algeria, France… For example, in November 2001, a storm flooding in Algiers caused 886 victims (Argence et al. (2006)).

The main synoptic ingredients leading to such heavy rainstorms are well known: in most of the cases, these two main ingredients are an upper tropospheric trough and a low level supply in warm and wet air. In spite of this knowledge and of recent improvements in operational forecasting, numerical weather predictions regularly fail to reproduce intensity and distribution of precipitation of heavy rainstorms at mesoscale.

In this work, we present preliminary results of the 14 November 2006 case study in Corsica. Section 2 provides a brief description of the meteorological situation. In section 3, two Meso-Nh simulations are analyzed to obtain a better interpretation at finest scale. Conclusions and perspectives for future work are given in the final section.

2. Description of the Case Study

Corsica is located at the middle of the occidental Mediterranean basin, 15 km north of Sardinia, 80 km west of the Italian coast and 160 km south-east of the French Riviera. It is a “mountain surrounded by the sea”. It is 2710 metres at its highest point and has twenty other mountains of over two thousand metres. The average altitude is 568 m. Corsica has the highest mountains and the most rivers of any Mediterranean island. 180 kilometres long, 80 kilometres in width, the mountain run roughly north-west to south-east.

On 14 September 2006, a heavy rainfall episode reached the eastern part of the Island with accumulated precipitations higher than 400 mm which caused impressive material damages. Figure 1 displays the 24-hour accumulated precipitation from 14 September 6 UTC to 15 September 6 UTC obtained from the Météo-France rain gauge network. This figure shows that mainly the eastern coast of the Island is affected by the
rain storm with values around 150 mm except for the extreme south. The maximum value (435 mm) is located in Solenzara.

On 14 September 00 UTC, the meteorological synoptic situation is characterised by an upper level trough extending from the North Atlantic to the south of Spain (Fig. 2). Downstream of this main trough, an elongated Potential Vorticity (PV) filament extends from south England to Algeria. At low levels, warm and wet air masses are advected from Africa to the north of the western part of the Mediterranean Basin. At synoptic scale, all the ingredients are present to produce a rainy episode. The difficulty is to predict when and where at fine scale.

3. INITIAL AND COUPLING ANALYSES SENSITIVITY ON TWO MESONH SIMULATIONS

Two sets of initial and coupling fields (ECMWF\textsuperscript{1} and ARPEGE\textsuperscript{2} analyses) are used to run the French Meso-NH model (Lafore et al. (1998)) starting from 13 September 12 UTC and integrated over 36 hours. The model is used with three two-way nested domains of 50, 10 and 2 km grid spacing (Fig. 3), respectively called model1, model2 and model3. Model3 is characterised by an explicit description of the convection. Figures 4a and 4b display results of these two simulations in terms of 6-hour accumulated rainfalls from 14 September 06 UTC to 12 UTC. Let us call E1 (resp. E2) the Meso-NH simulation coupled with ECMWF (resp. ARPEGE). Both simulations reproduce the rain episode. Nevertheless, E1 and E2 are very different in localisation and intensity in model3. During these 6 hours, the maximum value of E1 is 394 mm whereas it is 318 mm for E2. Moreover, most of the precipitations are located inland for E1 and over the sea for E2. Figure 4c displays precipitations given by the radar located in Aleria and rain gauge data. These observational data give more confidence in E1 for the localisation (inland) and in E2 for the intensity. Note that the 6-12-hour interval has been chosen because radar data are not available during the entire episode.

What are the reasons of such differences? First we investigate the high-level dynamics. Figure 5 displays the brightness temperature of the Meteosat Second Generation water vapour (MSGWV) image superimposed with the 1.5 pvu\textsuperscript{3} altitude of E1(Fig. 5a) and E2 (Fig. 5b) on model2 for the 14 September 06 UTC. The high level PV structure is different in E1 and E2. None of the simulations is in agreement with the MSGWV image for which we expect high PV values for high brightness temperatures. On model2, E1 presents a north-south elongated structure over the sea with maximum values in the southern part whereas E2 presents a small PV structure over south France. As a consequence, the high level dynamics is different in E1 and E2 (not shown).

The dynamics near the surface is now investigated. Figure 6 displays the wind at 10 m high for E1 and E2 on 14 September 09 UTC. The two simulations are in agreement for the wind direction with the surface wind blowing from south-east. However, they are different in intensity off the East coast. E1 is more intense than E2 and E2 exhibits a very low wind area off the North-East coast. This area corresponds to a cooling shown in Fig. 7b. This cooling can be associated with the extension of the cloudy structure off the East coast as already mentioned (Fig. 4b). In their study Nuiissier et al. (2007) have already mentioned this phenomenon called a low level cold pool. This cold pool acts as a warm front characterised by ascending motions off the East coast in E2 (Fig. 7b). On the contrary, this cold pool is not present in E1 and the upward vertical velocity is associated, in this case, with the mountain which acts as a barrier.

4. CONCLUSIONS AND PERSPECTIVES

A preliminary study of the 14 September 2006 heavy rainfall episode in Corsica is presented. Two initial and coupling fields set are used to run the Meso-NH model. Whereas at large scale the situation is well reproduced by both simulations, at fine scale, they present significant differences. The comparison with the observations allows discriminating between the two simulations. If the main high level dynamic ingredients usually associated with rain storms are present in both simulations, their fine scale evolution is not well reproduced. It can be hypothesised that the high level analyses accuracy is not good enough. Sensitivity tests using a PV inversion tool (Chaigne and Arborgast (2000); Lambert et al. (2004)) will be performed to bring the high level analyses closer to the atmospheric real state. This expected improvement should allow a better

\textsuperscript{1} European Center for Medium range Weather Forcasting

\textsuperscript{2} Action de Recherche Petite Echelle Grande Echelle, from Météo-France

\textsuperscript{3} 1 pvu = 10^4 m^2s^{-1}K kg$^{-1}$
understanding of the processes at the low levels. Then, it should allow to discriminate between orographic forcing suggested to explain the simulation E1 and the low level cold pool suggested for E2.

These high altitude sensitivity tests on the dynamics will only be available if they are not distorted by the surface conditions. Figure 8 displays the sea surface temperature (SST) difference between ECMWF and ARPEGE analyses for the 13 September 2006. The Gulf of Genoa is characterised by a SST difference up to 2.5 degrees. Even if Lebaupin el al. (2006) have shown that it is more the average SST than the presence of anomalies which impacts the forecast of such precipitation events, sensitivity tests on the SST will be performed.

Once high altitude and surface conditions will be refined, the influence of a better description of the mountain orography on the local wind field and on the rainfall will be tested. This study is realised in the frame of the future Hydrological cycle in the Mediterranean Experiment (HYMEX http://www.cnrm.meteo.fr/hymex).

Acknowledgements: We wish to thank Pierre Tabary and Claudine Guéguen (Météo-France, DSO/CMR) for providing the radar data and Valérie Jacq (Météo-France, DIR SE) for providing rain-gauge data.

REFERENCES


**Figure 1:** Rain-gauge accumulated precipitations (mm) from 14 Sept. 06 UTC to 15 Sept. 06 UTC. (Courtesy from DIR Sud-Est – Météo-France).

**Figure 2:** ARPEGE analysis for 14 Sept. 00 UTC: 850 hPa equivalent potential temperature (pink colours, K), 850 hPa wind arrows & altitude of the 1.5 pvu surface (blue and green isolines, m).

**Figure 3:** Simulation domains with topography.

**Figure 4:** Accumulated precipitations (mm) from 14 Sept. 06 UTC to 12 UTC for E1 (a) & E2 (b) simulations, (c) for radar (Météo France / DSO / CMR) and rain-gauge data (little squares).

**Figure 5:** Altitude of the 1.5 pvu surface (isolines) and MSG water vapour brightness temperature (colours, K) for 14 Sept. 06 UTC.

**Figure 6:** Wind (ms⁻¹) at 10 m high for 14 Sept. 09 UTC for E1 (a) & E2 (b).

**Figure 7:** 50 m high virtual potential temperature (purple colours, K) & 500 m high vertical velocity (blue, ms⁻¹) for 14 Sept. 09 UTC for E1 (a) & E2 (b).

**Figure 8:** SST difference (K) between ECMWF and ARPEGE analyses for 13 Sept.