Mediterranean Storms
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DIABATIC PROCESSES CONTRIBUTION TO THE NOVEMBER 2001 STORM

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ABSTRACT

Between the 9th-15th of November 2001 a very deep cyclogenesis event occurred in the Western Mediterranean basin. The quantious and dramatic damages both in material and human loses and the recorded values of fall in pressure, heavy rain and wind were so important that it can be qualified as the most important and violent meteorological event for the last decades. The complexity of the meteorological situation was big enough to have all of the ingredients for a very well developed baroclinic cyclone in the first stage and a hurricane-like storm at the second part of the event. In this paper the role of the latent heat release from precipitation and both the sensible and latent heat fluxes in the generation and development of the cyclone is investigated.

1 INTRODUCTION: THE EVENT, SOCIETAL IMPACT AND METEOROLOGICAL RECORDS

The event affected the North of Algeria and the East part of Spain, especially the island of Mallorca. It occurred since the 9th of November of 2001 and it actually persisted during a week, until the 16th. This paper will be focus on the 10-11th of November when the major damages and the most deepening of the cyclone were produced. For illustrating purposes it can be mentioned that during these two days more than 100,000 trees were uprooted in the island of Mallorca. Sustained wind speed and wind gusts greater than 30 m/s and 42 m/s, respectively, were recorded; a 7.5 m of significant wave height was measured and wave heights of 11 m were analysed in some points in or around the Balearics. In reference to rainfall, more than 300 mm was recorded in Mallorca in 48 h (more than 700 mm, during the whole episode).

From time to time, especially in autumn, the Mediterranean area is affected by sudden events of extreme adverse weather. Such events are either a consequence of a great storm occurred at the Atlantic (may be by direct influence or because it is reactivated when arriving to our zone) or intrinsically Mediterranean. However (with the exception of some large Genoa cyclones), the temporal and spatial scales of those phenomena are usually smaller than the case now under study.

2 SYNOPTIC ENVIRONMENT: DEVELOPMENT PHASES

Day 10 Nov. at 00 UTC the synoptic environment was determined by the presence of a high level deep through whose axis was located over Eastern of Spain mainland extending from the Gibraltar Strait to the Alps. An upper level jet streak maximum was over the South edge of the Atlas with a speed greater than 60 m/s. The mean sea level pressure chart showed a low inner Algeria with a pressure lesser than 998 hPa at its center. A secondary low in front of the coast of Algeria, in the sea, was also present. At 18 UTC Nov. 10, the main low was located over the west part of Tunisia showing a closed isobar of 998 hPa as it did the secondary low. A jet maximum of 70 m/s reached the zone between the two surface lows, leaving the first cyclone at the right part of the jet while the low over the sea stayed at the left output of the jet streak where the positive dynamical forcing was the highest.

During the next 12 hours the surface low reached its maximum development. At 00 UTC Nov. 11 the pressure at the center of the low was below 996 hPa and six hours later it decreased below 990 hPa, as figure 1 shows.

At high levels the trough evolved in a cut-off low getting over northern Africa and southern Spain at 18 UTC Nov. 10. The cut-off displaced rapidly over the surface low and it moved in anticlockwise sense around the low level cyclone, during day 11, in such a way that the tilt of the axis changed its orientation. When it occurred, at 06 UTC Nov. 11 the system began the decay. During the 12 hours of intensification the speed at the jet streak was always greater than 70-75 m/s.

The temperature analysis at 925 hPa (not shown here) presented a strong thermal gradient, both days, 10 and 11, what was indicative of the strong baroclinity of the event.

Thereafter, it can be said that the case was strongly baroclinic, with important PV advection from upper levels, with the characteristics of a rapidly deepening storm on the sea (the pressure at the center of the low decreased more than 6 hPa in 6 hours). This kind of rapidly deepening cyclones are not frequent in the Mediterranean. Moreover, the deepening occurred on the sea and the episode was an event of heavy and efficient rainfall during day 10. Thereafter, the dynamical mechanisms altogether with the sensible and latent heat fluxes from surface (especially from the sea) and the latent heat release from precipitation could be the major factors responsible for the deepening of the surface cyclone.

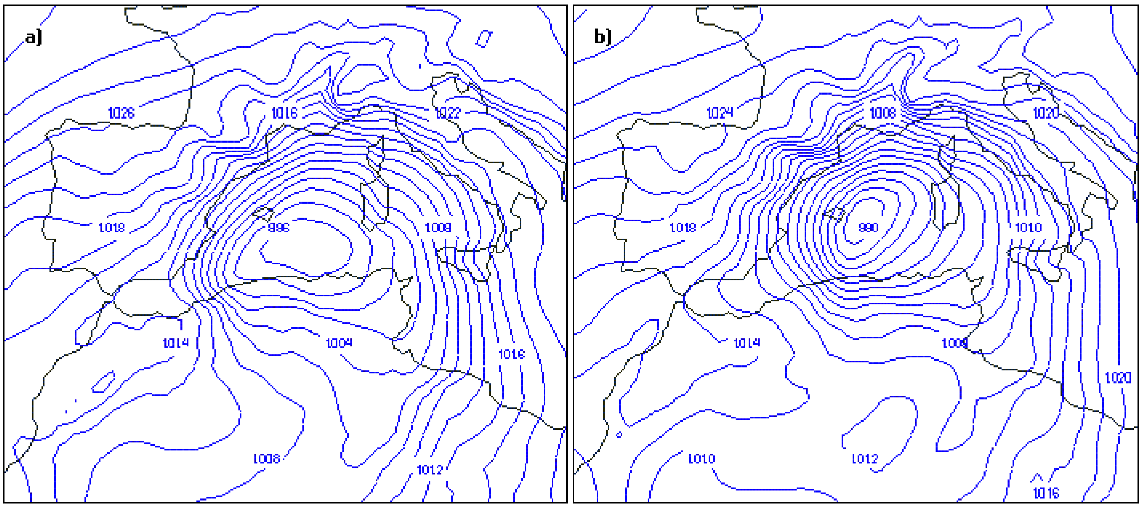

Figure 1. Mean sea level pressure charts from HIRLAM/INM operational analysis for a) 11 Nov. at 00 UTC and b) 11 Nov. at 06 UTC. Contouring interval, 2 hPa.

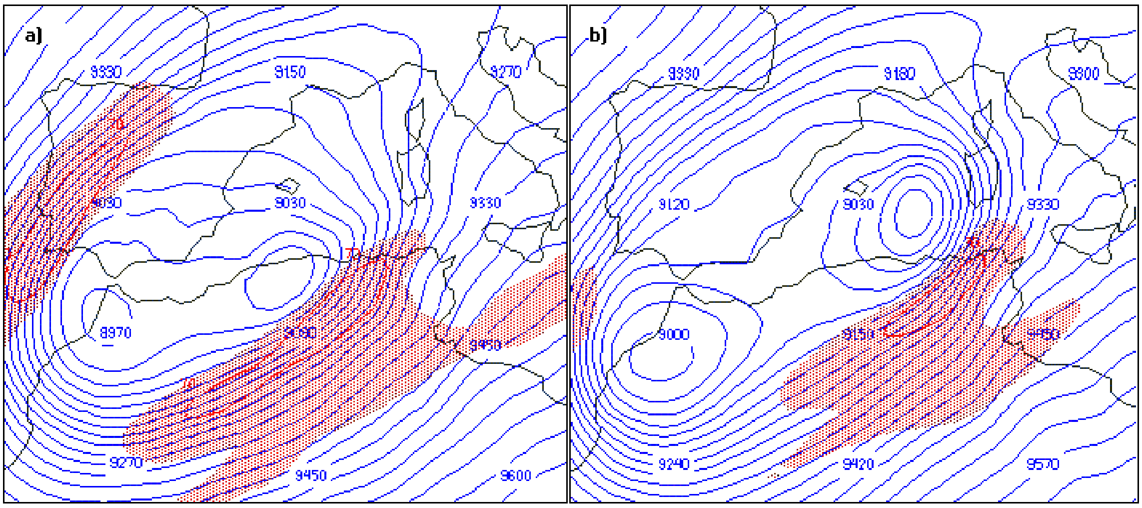

Figure 2. HIRLAM/INM analysis. Geopotential height at 300 hPa, in blue lines; contouring interval, 30 gpm. Shaded red area, points with wind speed greater than 60 m/s. Red line, 70 m/s wind isothac, for a) 11 Nov. at 00 UTC and b) 11 Nov. at 06 UTC

3 NUMERICAL EXPERIMENTS

In order to determine the contribution of each one of the factors and their synergetic effects to the deepening of the cyclone by means of numerical experimentation, the technique of factor separation (*Stein & Alpert*, 1993) has been applied by using HIRLAM/INM NWP model (*Gustafsson*, 1991).

Only the contribution of surface heat fluxes and latent heat release from precipitation are investigated in this paper. The dynamical contribution from PV advection is left for another work, to be done in the future.

Following *Stein & Alpert*, for studying the contribution of two factors, four simulations must be done: a control run (CON), a simulation with latent heat release switch off (NOL), an experiment with surface heat fluxes switch off (NOF) and another one with no latent heat relase and no surface heat fluxes (NLF). From the results of experiments it will be possible to determine the ‘pure’ contribution of latent heat release (as the difference between NOF and NLF), the ‘pure’ contribution of surface heat fluxes (as the difference between NOL and NLF) and the synergetic effects between those two heat sources.

The 10 Nov. at 00 UTC run has been considered as the control simulation. At that time the cyclone is only a secondary low in front of the coast. The model maintains the low during the next hours when the maximum rain falls over Algiers. Moreover, the control run is able to develop the cyclone after 12-18 hours of integration. However the control run underestimates the observed deepening, as it can be seen when it is compared to the operational HIRLAM analysis (figure 3a). In spite of this, the evolution of the low is correct enough in the previous hours to the maximum deepening, at the moment this study is focused on.

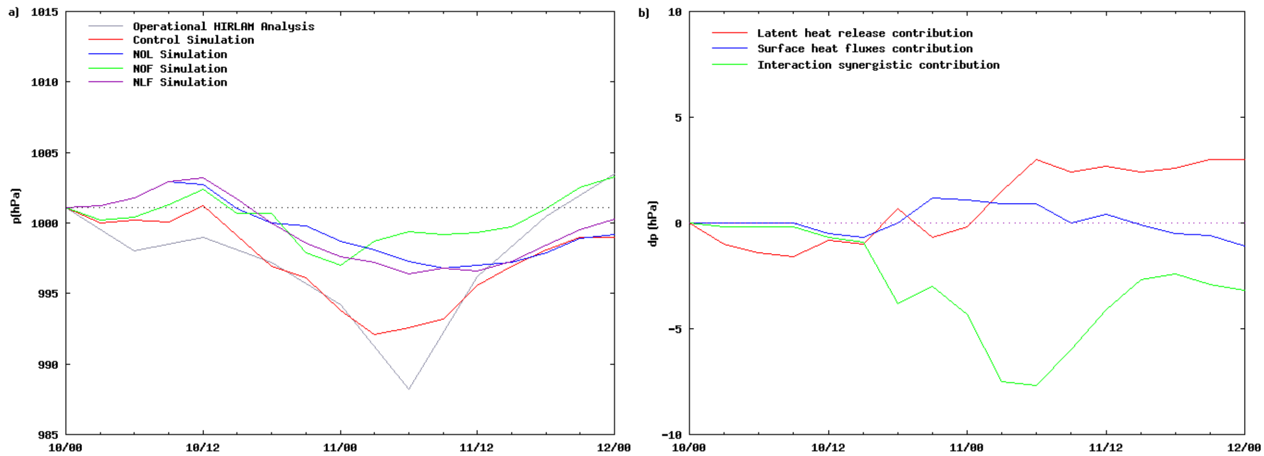

Figure 3. 48-h time evolution: a) for the pressure at the center of the cyclone for all runs and analysis, b) for the 3 contributions to the cyclone deepening

As the figure 3a shows, for the first 9 h of simulation, the NOL and NLF runs are equal and very different to control simulation, that is very similar to the NOF run. This fact is a first indication of the little effect that 'pure' surface heat fluxes has on the pressure at the center of the cyclone at the beginning of the event. On the contrary, it is intensely raining over Algiers around 06 UTC Nov. 10, what directly influences the maintenance of this cyclonic center through the release of the latent heat. At the model the rain is not as intense as in reality (not shown here), although it is heavy enough for making the latent heat release as the most responsible of the decreasing of the pressure during these hours, as figure 3b shows.

After that time, when the cyclone begins its true development the major contribution to the decreasing of the pressure comes from the interaction between the surface heat fluxes and the latent heat release from precipitation: the surface fluxes provide the moisture to release the latent heat from precipitation. In figure 4, the major contribution from that interaction between the surface heat fluxes and latent heat is shown.

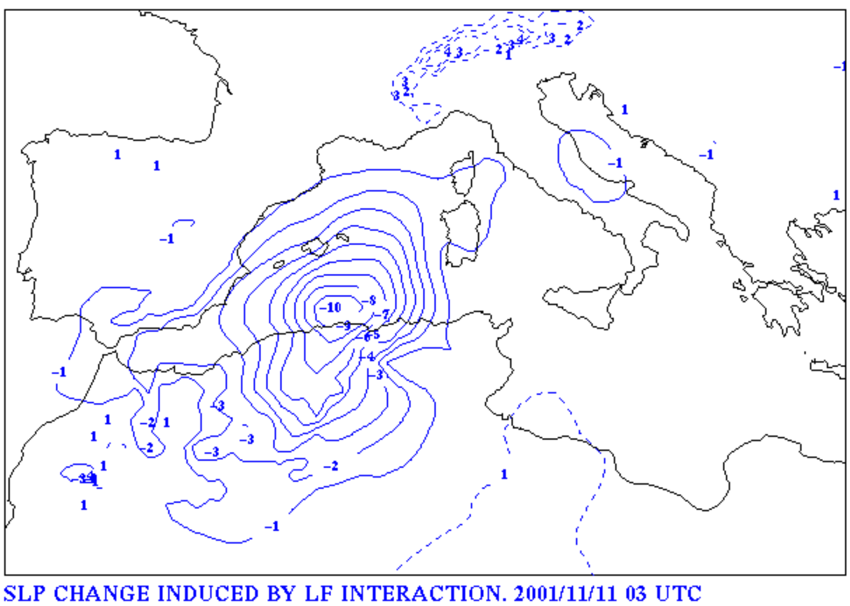

Figure 4. H+27 Sea level pressure change contribution from synergetic effects between latent heat release and heat surface fluxes.

4 CONCLUSIONS

A case of deep cyclogenesis that occurred at Western Mediterranean in Nov. 2001 has been studied by using HIRLAM/INM NWP model in order to investigate the role of both the latent heat release and the surface heat fluxes in the deepening of the cyclone. The results of the experiments indicate that the latent heat release can contribute to the first stage of the cyclone lifetime. After 12 h of integration the major contribution to the decreasing of the pressure at the center of the cyclone is due to the two factors synergetic effects.

The role of the heat transfer process between the sea surface and the atmosphere seems to be crucial at the moment of maximum development of the cyclone.

The complexity of the meteorological event as a part of a well developed baroclinic cyclone indicates that more attention must be put in the role of dynamical aspects of PV advection in order to obtain a complete knowledge of the cyclone development.

REFERENCES

Gustafsson, N. The HIRLAM model, *Seminar Proc. on Numerical Methods in Atmospheric Models, Vol. II,* ECMWF, 1991, 115-146.

Stein, U. and Alpert, P. Factor separation in Numerical Simulations. *J. Atmos. Sci.*, 1993, 50, 2107-2115.