Mediterranean Storms
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HIRLAM_INM AND ECMWF ANALYSES: COMPARISON OF THEIR BEHAVIOUR IN CYCLONES DETECTION

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ABSTRACT

One of the specific objectives of the MEDEX Project is the carrying out of a dynamically oriented climatology of cyclones that produce high impact weather in the Mediterranean. With this purpose, two cyclone catalogues, respectively based on HIRLAM_INM and ECMWF operational objective analyses, have been obtained for the last years in the Meteorological Centre of the Balearic Islands of the INM, the former covering the West Mediterranean basin and the latter covering all throughout the Mediterranean. When comparing both cyclone databases in the common area of study some significant differences have been observed, mainly on some areas. In this work these differences are shown and studied and some possible causes are explored.

1 INTRODUCTION

The MEDEX (MEDiterranean EXperiment) is a project of the World Meteorological Organization (WMO), and the creation of an objective dynamic climatology of surface cyclones that produce hazardous weather in the Mediterranean is one of its objectives.

For this reason, two cyclone catalogues have been obtained in the Meteorological Centre of the Balearic Islands of the INM, one based on HIRLAM_INM 0.5º operational objective analyses covering the West Mediterranean, and the other one based on ECMWF analyses covering all throughout the Mediterranean basin. The procedure for objective detection and tracking of surface cyclones (actually the cyclones at mean sea level) was developed for HIRLAM analyses (*Picornell et al*., 2001) and it was adapted and applied to ECMWF analyses of the same grid resolution (*Gil et al.,* 2003). When the procedure has been applied to the two model analyses, some differences have been observed in the common area covered by both models. In this work these differences are studied and their possible causes are shown.

In this paper, the word 'cyclone' is used in a general meaning, associated to both the 'classical' extra-tropical cyclones and the shallow depressions.

2 METHODOLOGY

The ECMWF catalogue covers, at the moment (it is planned to extend it until June 2003), a 3-year period, between June 1998 and May 2001. It is based on operational sea level pressure objective analyses at 00, 06, 12 and 18 UTC (for more details about this catalogue the reader is referred to *Gil et al.,* 2002 and 2003).

The HIRLAM catalogue covers from June 1995 and it is actualised at real time (for details about this catalogue, the reader is referred to *Picornell et al*., 2001).

As it is explained in *Gil et al*., 2003 two catalogues per each model have been extracted, one from the original mean sea level pressure (mslp hereafter) grid analyses and the other from smoothed fields (using a Cressman filter of 200Km). The comparison now presented has been elaborated from smoothed mslp fields only.

The work here presented is restricted to the common area covered by both catalogues (29ºN and 49ºN, and 12ºW and 18ºE) and to the common period of time that is between June 1998 and May 2001. Also, the area has been divided in several zones, attending geographical reasons. The results are presented in boxes of 2ºx2º lat/lon, as they have been computed.

The cyclones are detected where there is a relative minimum of pressure and they are kept if the average pressure gradient around the minima is bigger than 0.5 hPa every 100 Km at least along six of the eight main directions around the centre.

To compare the ability of detection of cyclones between the ECMWF and HIRLAM analyses we can consider (a) the number of cyclones detected and (b) the frequency of appearance of cyclones. A cyclone can be detected in successive analyses. We can identify it as the same cyclone by using a tracking algorithm (*Picornell et al*., 2001). So 'number of cyclones' is the number of different cyclones that has been detected, On the contrary, 'frequency of appearance' is the number of cyclone detections, with independence of the appearance of the same cyclone in previous analyses or not.

In order to compare the description of the cyclones by each model, some parameters like radius, mean vorticity, circulation, lifetime and covered distance have been computed and compared.

3 RESULTS

3.1 Differences on cyclone detection

The ability of detection of cyclones for each model is obtained by comparing the number of cyclones and the number of appearance of cyclonic centres. Both are higher for HIRLAM than for ECMWF. When the number of the cyclones is considered, the difference is about 18%. That difference reduces until 10% (table 1) for the frequency of appearance.

	Number of cyclones	Frequency of appearance
ECMWF	2226	4776
HIRLAM	2702	5291

Table 1: Number of cyclones and frequency of appearance for each model.

Fig. 1 shows the seasonal mean differences of frequency of appearance for cyclonic centres. The differences have been calculated, from seasonal mean of frequency of appearance for the presence of cyclonic centres, subtracting the ECMWF's frequency of appearance from the HIRLAM's frequency. On the coast of Morocco both models have a maximum of frequency of appearance of similar order, but the location is different. Although both maxima are on the coastline when the ECMWF catalogue is considered this maximum is located northwards and it presents a more concentrate distribution than for HIRLAM catalogue. In this zone the models detect a similar number of centres, but they do this at different grid point and at different time. The maximum difference is observed in summer and the minimum in winter, as shown in the figure. The differences on the frequency of appearance are also important in the interior of Algeria, except in winter, season in which these differences are almost non-existent. Summer is the season of highest differences between both models. And the SE of the Iberian Peninsula, Alboran Sea and around Balearics are the zones with major differences of frequency of appearance throughout the whole year.

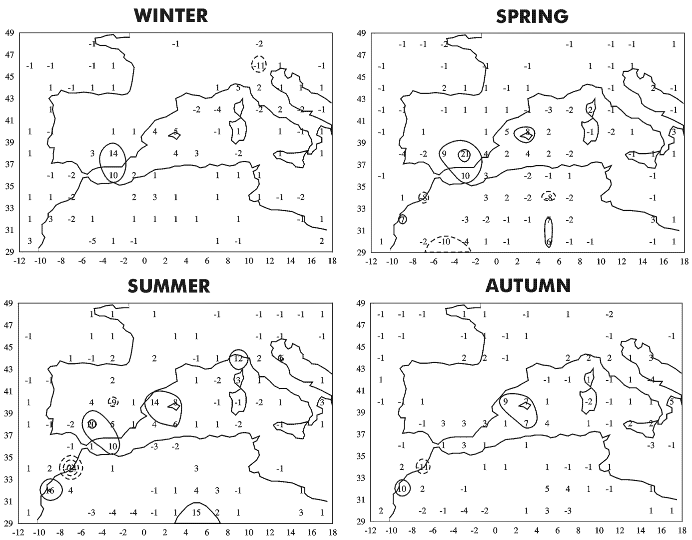

Figure 1: Seasonal mean difference of frequency of appearance between both models for cyclonic centres. The contour is from 5 or –5 every 10 units. Solid lines are the positive differences and mean a higher frequency for the HIRLAM's appearance than for the ECMWF's appearance and dashed line are the negative differences and mean a higher frequency for the ECMWF's appearance in front of the HIRLAM's appearance.

3.2 Differences on cyclones' characteristics

The main characteristics of cyclones detected by both models have been studied. The medium values of radius, area, mean vorticity, circulation, covered distance and lifetime of the cyclones are given in table 2.

The cyclones detected by the ECMWF model are slightly bigger than the ones by the HIRLAM, and they have a bit higher values of circulation and mean vorticity. Also, the centres detected by the ECMWF live more time and their covered distances are longer than the ones for centres detected from HIRLAM (but the distribution are very similar for the both models).

	Radius (Km)	Area ($x10^3$ km^2)	Mean Vorticity ($x10^{-5}s^{-1}$)	Circulation ($x10^7m^2s^{-1}$)	Lifetime (Hrs)	Covered Distance (Km)
ECMWF	408.7	551.215	67.4	3.6	12.9	281.3
HIRLAM	404.8	539.758	65.9	3.5	11.7	237.0

Table 2: Mean values of radius, area, mean vorticity, circulation, lifetime and covered distance.

4 EXAMPLES

In order to illustrate these differences, two different examples are shown.

In the first example, fig. 2, the cyclonic centre, identified with a star, is only detected by the HIRLAM model. This low pressure is a centre with circulation $2.9x10^7m^2s^{-1}$, mean vorticity $55.78x10^{-5}s^{-1}$ and a pressure of 1011.90hPa in the centre, and this is situated to the South-West of the Balearic Islands. The ECMWF model detects a minimum of pressure in the South-East of the Iberian Peninsula (represented as a closed isobar right in the figure), but this minimum is not kept as a cyclone because the average pressure gradient around the minimum does not fulfil the conditions defined for it.

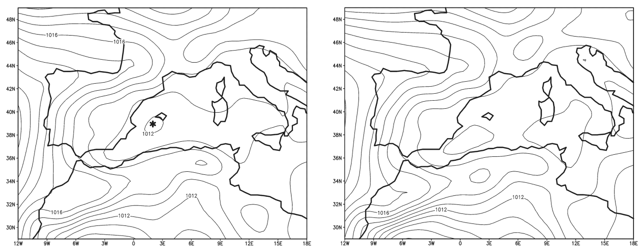

Figure 2: HIRLAM (left) and ECMWF (right) mslp analyses (lines every 1hPa) on 25 June 1998 at 06:00 UTC. Detected cyclones are marked with a star.

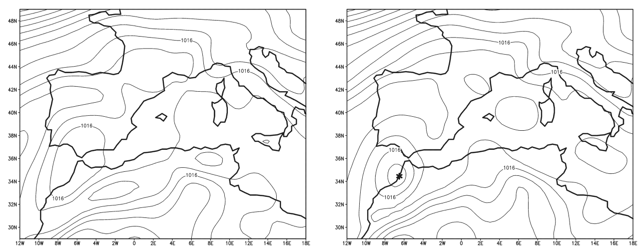

Figure 3: HIRLAM (left) and ECMWF (right) mslp analyses (lines every 1hPa) on 12 May 1999 at 00:00 UTC. Detected cyclones are marked with a star.

In the second example, fig. 3, the cyclonic centre is only detected by the ECMWF model and it is situated on the Morocco coast, with circulation $1.99x10^{7}m^{2}s^{-1}$, mean vorticity $50.74x10^{-5}s^{-1}$ and pressure in the centre of 1014.50hPa. The minimum detected by HIRLAM model does not fulfil the conditions for a minimum to be considered as a cyclone.

5 POTENTIAL CAUSES

Although statistically we have found significant differences in the capability between both models to identify the cyclones, after viewing the examples we realize that these are only differences of nuances, that is to say, the differences are small discrepancies to consider a detected minimum as a cyclone or not, depending on the threshold conditions that we have fixed.

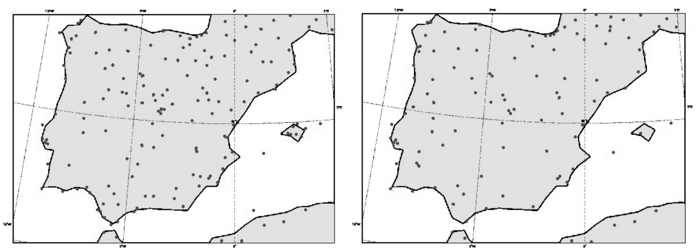

Figure 4: Network of surface weather stations assimilated by the models HIRLAM (left) and ECMWF (right).

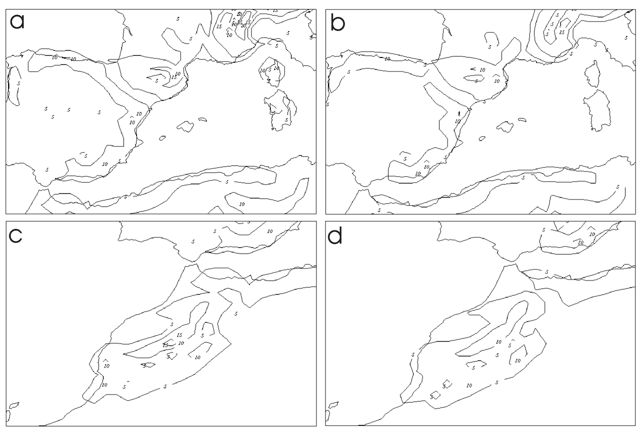

Figure 5: Module of the gradient (in m/km) for (a) and (c) HIRLAM orography; (b) and (d) ECMWF orography. Contouring interval, 5 m/km.

These discrepancies, even being minor, can have their principal origin in the different system of assimilation of data between one and the other model. While the ECMWF model has a 4DVAR assimilation system, that includes a lot of information from satellite, the HIRLAM model uses optimum interpolation.

Furthermore we have to take into account that there are differences in the number of weather stations that are assimilated by both models. HIRLAM assimilates the information of more terrestrial stations that the ECMWF model in the Iberian Peninsula, Alborán-Palos and the Balearics Islands (automatic stations) fig. 4.

Other less important reason of the differences in the detection of cyclones could come from the orographic representation. The orography used by HIRLAM is a bit different than the orography used by the ECMWF model (see fig. 5). But the differences between the orography of both models are very small.

6 CONCLUSIONS

Although the results are preliminary, we can emphasize some leading facts:

- The frequency of appearance and the total number of detected cyclones of the HIRLAM model are higher than the ones of the ECMWF model.
- The zones where the differences of frequency of appearance of cyclones are higher are the South and East of the Iberian Peninsula, the coast of Morocco, the Balearic Islands and the interior of Algeria.
- The characteristics of cyclones detected by both models (have no important differences), but the ECMWF detected cyclones are bigger, live more time and the vorticity and circulation are greater than the HIRLAM ones.
- Though statistically we have important differences between the models, when we study concrete cases we realize that they are differences of nuances.
- The main reason of these differences of nuances could be different system of assimilation of data of one and another model. Also it is necessary to take into account the differences in the number of weather stations used and the differences in the orography in the models.

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