A FIRST ANALYSIS OF THE LARGE-SCALE CYCLONIC ENVIRONMENTS THAT LEAD TO MEDICANE DEVELOPMENT

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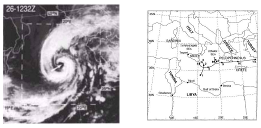
Tropical-like storms are occasionally observed over the Mediterranean Sea. These mesoscale vortices are warm-core cyclones and along their mature stage present a clear eye surrounded by an axysymmetric cloud structure. These storms are rare events, but surface winds can sometimes attain near-hurricane force, and therefore coastal regions can be severely affected. Recently, it has been agreed to call these hurricane-like storms as medicanes (Mediterranean hurricanes).
The synoptic analyses of some medicane events coincide to point out that exist certain atmospheric environments favourable to the development of medicanes. Specifically, the presence of a low-level vortex and a cold upper troposphere trough or cut-off seem to play a key role in the development and maintenance of such storms. The main goal of the present study is just to deep into these parent large-scale cyclonic environments that lead to medicane development. To do that, a Mediterranean cyclone dataset, derived from the ERA-40 reanalysis, will be used. This cyclone dataset contains a description of the vertical structure of all the surface cyclones detected in the Mediterranean basin along a large period. A few, but well-known, medicane events will be investigated by means such cyclone dataset. That includes to look for the presence of a primary low-level cyclone and the presence of an upper-level trough or cut-off. The main characteristics of such parent cyclonic structures will be obtained and compared against ordinary cyclonic environments derived from other cyclones detected in the same region and in the same season. It is intended to improve the knowledge about which meteorological conditions are necessary to develop a medicane and to discriminate between precursor and non-precursor cyclonic environments.

January 1982

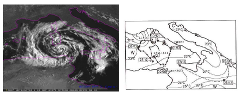
The vortex of 24-28 January formed over the Central Mediterranean, between Libya and Sicily. During its 5-day lifetime it moved towards the east, but in a rather complicated path. See Reed et al.(2001) for further details.



Left: NOAA7 IR satellite image, 1232 UTC on 26 Jan. Right: storm track (dots show low positions at 12h intervals, 1 represents 12UTC 23 Jan). Both figures from Reed et al., 2001.

September 1983

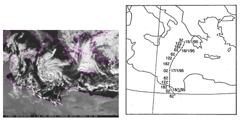
At the end of September 1983 a sybsynoptic vortex developed over the Mediterranean along several days (27 Sep - 1 Oct). The vortex formed south of Sardinia and moved in a large circle. See Rasmussen and Zick, 1987 for further details.



Left: IR Meteosat image, 0730 UTC on 28 Sept. Right: track of the inicial low pressure center (dashed line) an the vortex (solid line), with data/UTC annotations. 3-hourly position are marked with small dots (from Rasmussen and Zick, 1987).

January 1995

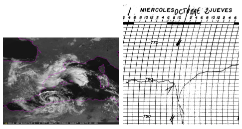
In mid-January 1995 a small hurricane-like cyclone was detected by the satellite imagery over the Central Mediterranean. The cyclone formed in the morning of 15 January and moved southwards during the next three days, until it reached land and decayed. See Lagouvardos et al. (1999) and Pytharoulis et al.(2000) for further details.



Left: VIS Meteosat image, 1300 UTC on 16 Jan. Right: track of the cyclone (from Pytharoulis et al., 2000)

October 1986

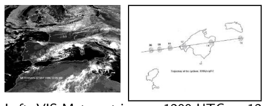
On the 1 October 1986 a small vortex was detected in the Argelian sea. It moved towards the Iberian peninsula, affecting Palma on the 2, with strong winds. See Jansà (1986) for further details.



Left: IR Meteosat image, 1030 UTC on 1 Oct. Right: pressure at Palma on 1 and 2 October.

September 1996

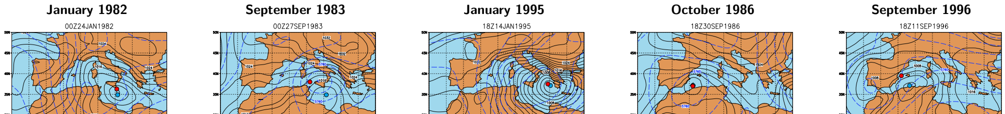
In the morning of the 12 September a small cyclone formed in the gulf of Valencia. This warm-core cyclone moved eastwards, and along its short lifetime it could be followed by satellite and radar images, and other conventional observations (as radiosoundings and mean sea level pressure and wind). See Gili et al. (1997) for further details.



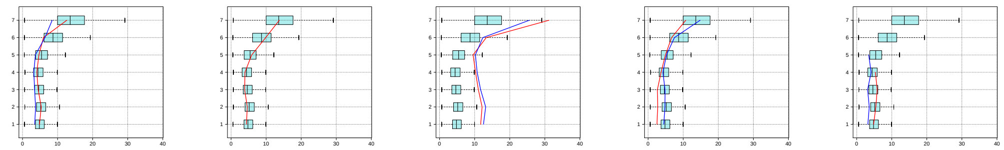
Left: VIS Meteosat image, 1200 UTC on 12 Sept. Right: track of the cyclone (from Gili et al., 1997).

LOW-LEVEL CYCLONE

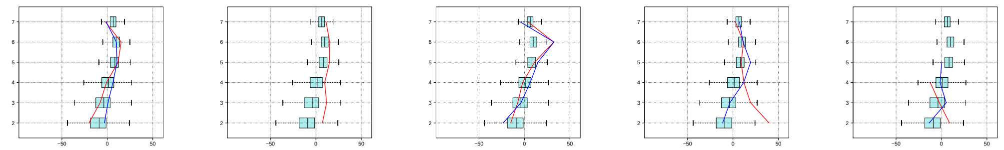
The presence of a surface cyclone is looked for at the time and before the medicane formed in 5 well-known cases from the ERA-40 surface cyclone dataset (Campins et al., 2009). In all 5 cases a surface cyclone is detected very close to the region where the medicane formed. These primary surface cyclones are present at least 24 hours before the medicane appearance (except for the case of September 1983 where the primary depression is detected only 12 hours before). General characteristics of these primary cyclones are studied by means some parameters at low and upper levels. Cyclone characteristics 24 hours (H-24, blue lines) and 12 hours (H-12, red lines) before the medicane appearance (H-0) are displayed and compared against mean characteristics of a subset of ERA-40 cyclone dataset, composed by the mobile and long-living cyclones.



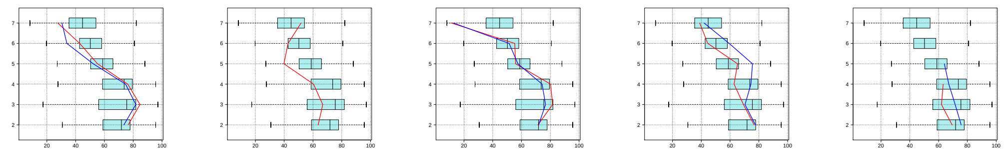
Mslp (black solid, in hPa) and geopotential at 500 hPa (blue dashed, in gpm) at H-12. Blue dot: primary cyclone (H-12), red dot: medicane appearance (H-0).



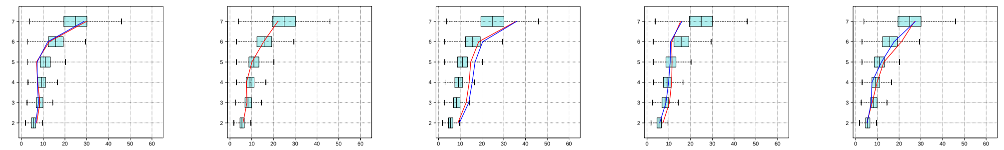
Vertical distribution -from mslp (1) to 300 hPa (7)- of geostrophic circulation (CG in $10^7 m^2 s^{-1}$) for the primary cyclone and the subset of mobile and long-living cyclones.



Same as row 2 for the laplacian of temperature (in $10^{-6} C\ km^{-2}$), but from 100 hPa (2) to 300 hPa (7).



Same as row 3 for the relative humidity (in %).



Same as row 3 for the wind speed (in ms^{-1}).

Wind shear
(Wind speed 300 hPa - wind speed 850 hPa; in ms^{-1})

	H-24	H-12	H-0	Subset average
January 1982	18.5	11.9	-3.7	15.7
September 1983		21.0	10.0	15.7
January 1995	26.0	4.5	-3.8	15.7
October 1986	8.0	7.7	3.5	15.7
September 1996	20.5	17.6	21.2	15.7

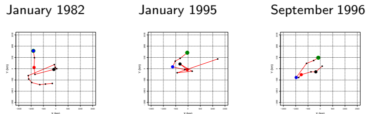
Low-level moist static stability
($\theta_e(1000hPa) - \theta_e(850hPa)$, in $10^{-7} m^4\ s^2\ kg^{-2}$).

	H-24	H-12	H-0	Subset average
January 1982	-1.9	-1.8	0.2	0.6
September 1993		-2.1	-2.0	0.6
January 1995	-0.4	-0.9	-0.4	0.6
October 1986	-2.4	-3.5	-5.1	0.6
September 1996	-3.2	-3.8	-1.0	0.6

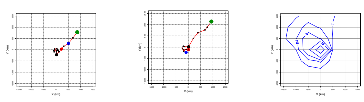
UPPER LEVEL CUT-OFF

By means the same methodology used to derive the ERA-40 surface cyclone climatology a new set of upper-level cut-offs at 500 hPa is obtained. The presence of such cold upper-level features is investigated for the 5 medicane events. Figures show the relative position (in km) between the location of the 500 hPa cut-off and the real medicane positions (0,0), derived from satellite images, for a 6h interval (green dots refer to the first detection of the 500 hPa cut-off, the blue ones refer to H-24, the red ones to H-12 and the black ones to H-0. To compare these results, the frequency distribution (in %) of the relative position of the 500 hPa cut-off and surface cyclone (derived from the ERA-40 dataset) for the mobile and long-living cyclones is calculated.

January 1982 | January 1995 | September 1996



September 1983 | October 1986 | Mobile cyclones



Results show that in all 5 cases a cut-off is present at 500 hPa. These upper-level features move towards the region where the medicane will develop, being over it at the time when vortex forms. However, mobile and long-living cyclones exhibit a similar behaviour, that is, in a large proportion of these depressions a 500 hPa cut-off is located over the surface cyclone or at its northwest.

SUMMARY

- In all 5 cases, a surface cyclone is detected before (24 hours or even more, except in September 1983 case).
- Surface cyclones are in general well-developed depressions, not particularly intense.
- In all 5 cases an upper-level cut-off is located very close to the region where the medicanes appear.
- Wind shear is intense before the medicane generation, decreasing with time.
- Low-level potential instability before the medicane generation is strong.
- The 5 primary surface cyclones are not significantly different from the mobile and long-living ERA-40 cyclone subset.
- Thus, for these 5 cases a similar typology of the vertical structure of the primary surface cyclone can not be derived by means the ERA-40 cyclone dataset. However it must be pointed out that 5 events are not enough, and a larger medicane dataset must be obtained.

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Some satellite images are obtained from http://www.uib.es/depart/dfs/meteorologia/METEOROLOGIA/MEDICANES.