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On the vertical structure of Mediterranean explosive cyclones employing a high resolution dataset

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Explosive cyclones (or "bombs") are characterized by exceptionally and unusually large deepening in the midlatitudes, being associated with a band of strong winds and surrounded with a spiralling wall of deep cumulonimbus and strong convection. Although these events occur rarely in the Mediterranean compared to their frequency of occurrence in the oceans, they exhibit great interest due to their serious social and economic impacts on shipping and coastal regions. The main contributor to the inefficient simulation and forecasting of explosive cyclones is possibly the inadequate grid resolution concerning the analyses performed to date.

Here, we employ a high resolution reanalysis dataset, in an attempt to study the vertical structure of the explosive cyclones in the Mediterranean on a climatological basis, towards adequately understanding the behaviour of the explosive cyclogenesis in the mid and upper troposphere.

The surface explosive cyclones were detected with the aid of the University of Melbourne Cyclone Tracking Algorithm (MS algorithm), using the 1° x 1° spatial resolution of mean sea level pressure (MSLP) from ERA-40 (available through ECMWF), for the period 1962–2001. In order to describe the vertical profile of the surface explosive cyclones, the Vertical Tracing Software of the MS algorithm is employed with the aid of the ERA-40 1° x 1° geopotential height data. Cyclonic centres are detected and traced independently at five selected isobaric levels: 850, 700, 500, 300 and 200 hPa, following the corresponding surface centres. For this purpose, an increasing with height searching domain is considered, taking into account the distance and the depth of the upper level candidate in relation to the lower level cyclone. Then, cyclone radius, depth, intensity, propagation speed, and tracks are calculated at each isobaric level as well as the tilting between the surface and 500 hPa counterpart.

It is found that the surface explosive cyclones present a well organized structure, as their oceanic counterparts. About 80% of the track steps of the surface explosives extend up to 850 hPa, 57% up to 500 hPa and 30% up to 200 hPa. Regarding the tilting between the surface and 500 hPa level during the time of the explosive cyclogenesis, the vast majority (almost 96%) present westward tilting and mainly north-westward, confirming the importance of baroclinicity as one of the main mechanisms driving the explosive cyclogenesis. An analogous behaviour is also found during the time of maximum explosive deepening of the surface explosives. Moreover, a mean distance of 350 km between the surface cases and the 500 hPa counterparts during the time of explosive cyclogenesis is observed. About 45% of the surface explosive cyclones reach their maximum depth before their 500 hPa cyclone partners do, implying the importance of surface processes. Regarding the upper level cyclones depth and radius, it is found that deeper and larger scale upper level cyclones are observed in the eastern Mediterranean basin, as was found for the MSLP explosive counterparts. The examination of the track density of the upper level tracks reveals a similar behaviour with the surface explosive cases. A tendency for more intense and deeper cyclones has been detected in the area of Southern Italy, Adriatic Sea and Ionian Sea, which is statistically significant at the 700 hPa and 300 hPa, at the 95% confidence level.