Introduction

Southern France is prone to devastating flash-floods during the fall season. The warming and moistening of the boundary layer through sensible and latent heat fluxes from the warm sea is known as an efficient mechanism for convective destabilization and the occurrence of intense precipitation episodes (e.g. Bassi et al., 2005). The increase of humidity in the air often leads to the role of the warm advection at low levels, induced by a broad synoptic-scale flow over the western Mediterranean sea, as well as the presence of a cold cut-off low at mid and high levels, highlighted as the main synoptic-scale ingredients for the development of severe convection. This demonstration of such a relationship can be given by sensitivity studies of HPE forecast in the presence of some upper-level Potential Vorticity (PV) features. These studies usually consist in modifying PV features from the control situation and observing the impact on the precipitation field. Then, PV surgery consists in adding PV anomaly with a full control of shape, location and amplitude to the idealized initial state.

Case 1) In a humid atmosphere, the system is located over the coast or over the sea. Topography has no more a dominant influence and a weak sensitivity to the mesoscale surface cyclone properties is found over the sea (and coastal areas) where the topographical influence is weak or absent: the trigger of convective system is due to the cyclone itself.

Case 2) The trough of case 1) had a relatively large wavelength and evolved very rapidly towards the eastern coast of Spain such that its meridionally oriented initial axis became negatively tilted by the time. Given the baroclinicity of the flow a mesoscale size cyclone developed over the eastern coast of Spain. The combined action of two distinct synoptic patterns associated with high rainfall: a) a surface Rossby wave and the southerly flow associated and b) the progression of a second low sea-level pressure from Atlantic to East France and the southerly flow associated. No precipitation observed in case b).

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Case 3) In a drier atmosphere, the system is located over the coast or over the sea. Topography has no more a dominant influence and a weak sensitivity to the mesoscale surface cyclone properties is found over the sea (and coastal areas) where the topographical influence is weak or absent: the trigger of convective system is due to the cyclone itself.

Sensitivity of convective systems to Potential Vorticity anomalies

Analytical potential vorticity anomalies are added on the different low-frequency initial conditions. The anomalies are defined by analytic functions of Gaussian shape. Anomalies of different aspect ratios, orientations and positioning were generated. The anomalies positions were chosen to generate southward flows over the western Mediterranean basin. Different locations between the Gulf of Biscay and the south-western Spain have been explored, according to the climatology of potential vorticity associated with heavy rainfall: performed using PV coherent structures associated with Mediterranean episodes between 1986 and 2007.

- Model runs with anomalies more or less elongated with four directions and different aspect ratios were performed.

- Same PV anomalies were added to low-frequency situations 1, 2 and 3. The convective situation at the initial time exhibits an intense trough and the corresponding positive PV anomaly northwest of the Balearic Peninsula at mid-tosurfaceic levels.

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- The synoptic setting of case 3) is also characterized by large-scale trough at mid-upper tropospheric levels but unlike case 1 and 2 but the trough maintained a more open wave pattern. The nature of the surface circulation is different. The low-level humidity distribution and flow are significant on the location of convective systems (with a stronger flow 1 and 2), the system is located over the topography. With a weaker flow (case 3), the system is located over the coast or the sea.

Simulations with a mesoscale model (AROME-2.5km)

Case 1) (High humidity, weak low-level flow): A high humidity is sufficient to trigger convective cells by orographic forcing.

Case 2) (High humidity, strong low-level flow): the action of the Alpine range in enhancing the LLJ along its western flank and the role of local topography are dominant in this kind of events.

Case 3) (weak humidity): much higher sensitivity to the mesoscale surface-cyclone properties are found over the sea (and coastal areas) where the topographical influence is weak or absent: the trigger of convective system is due to the cyclone itself.

Conclusion

The goal is to build an initial state quite smooth and very weak in terms of potential vorticity, characteristic of a low frequency situation. The filtering of fast waves will not happen here through a temporal filter, but by a truncation of the scales.

To study the impact of initial atmospheric environment on the genesis and maintenance of convective system, several low-frequency situations were constructed from two different situations a) and b) which are respectively associated to a convective episode over southern France and to a non precipitation episode (Figure 1).

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