# OBSERVATIONAL AND NUMERICAL ANALSYIS OF A HEAVY PRECIPITATION EVENT OVER SOUTHERN ITALY

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## I. INTRODUCTION

The Ionian Italian region is one of the Mediterranean areas prone to heavy precipitation (Federico et al., 2002; Miglietta and Regano, 2008). The nearly arc-shaped topography with steep mountains on the western boundary may favour the southerly unstable flow coming from the Mediterranean Sea to release instability.

In the present study, a heavy precipitation event affecting Basilicata and Apulia during 12 and 13 November 2004 is analyzed through observations and numerical simulations performed with the Weather Research and Forecasting (WRF) Model. Rain gauges recorded two distinct precipitation maxima in different phases of the event: on 12 November, a maximum of about 250 mm in less than 12 hours occurred over the northernmost coastal zone of the Gulf of Taranto; on 13 November, a maximum amount of about 200 mm was recorded over the central part of Salento peninsula. Such amounts are about one third of the mean annual precipitation of the affected zones.

The first stages of this event were analysed in Horvath et al. (2006) that focused their attention mainly on the generation of a deep cyclone in the lee of the Atlas Mountains and on severe windstorms over Croatia. Here, we focus on the precipitation features over Italy to identify the main synoptic and mesoscale factors responsible for the generation of convection, and to highlight the main features of the event.

## II. THE EVENT

The heavy precipitation event lasted more than 24 h starting in the afternoon of 12 November 2004. As two distinct rainfall maxima can be identified in the observations, the event can be roughly subdivided into two phases. During the first phase, corresponding to the second half of 12 November, the largest precipitation affected localized Ionian coastal areas of southern Basilicata and adjacent Apulia territory (Fig. 1). The two most intense rain peaks were observed at 16 UTC and 22 UTC, the latter producing the largest rain rate of the event, 103 mm in a 2-h period. Convection organized along a line that, in the following hours, shifted and persisted over a narrow area of Salento for about 12 h leading to the second phase of the event. During this phase, a maximum amount of 145 mm was recorded from 00 UTC to 16 UTC 13 November, whereas 202 mm were recorded on 13 November in the same narrow area.

The event was associated with a wide Atlantic trough that, at the surface, induced a cyclonic circulation leading to a LLJ that extended from northern Africa to southern Italy. The LLJ advected a potentially unstable airstream with high moisture content very close to the surface. At about 00 UTC 13 November, in the middle of the event, a weak short-wave trough (SWT), developed on the forward flank of a potential vorticity (PV) anomaly, approached southern Italy moving from southwest to northeast. The SWT was associated with dry air and, crossing the Apennines, contributed to deepen a weak surface low over the Adriatic Sea. The associated circulation favored the shift of the convective line towards Salento. During the afternoon of 13 November, following the whole synoptic system shift, the LLJ and the convective line moved definitively northeastward leaving southern Italy.

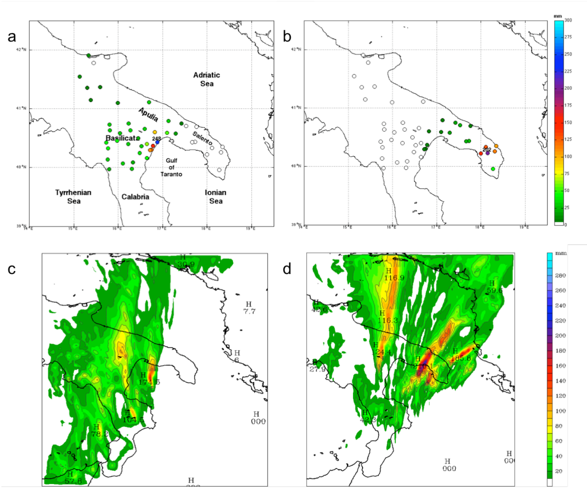


FIG. 1: Observed (top panels) and simulated (bottom panels) precipitation (mm) accumulated during the first phase of the event (a, c), from 12 UTC 12 November to 00 UTC 13 November, and the second phase (b, d), from 00 UTC to 16 UTC 13 November.

## III. NUMERICAL OUTPUTS

The WRF model has been implemented on two domains nested with a two-way technique. The outer domain covers the central and western Mediterranean basin and north-western Africa with grid spacing of 16 km. The inner domain is centred over southern Italy and Ionian Sea; it is made up of 128 × 148 grid points with grid spacing of 4 km. No convection parameterization is used on the inner domain. The simulation is initialized at 00 UTC 12 November 2004 and integrated for 72 h. Initial and boundary conditions are provided by ECMWF forecast with grid spacing of 0.5° ×

0.5°. The boundary conditions, including sea surface temperature field, are updated every 6 h.

The model realistically predicts the observed precipitation, although a delay of some hours affects the synoptic evolution and the shift of the linear convective system from the first to the second maximum area (FIG. 1).

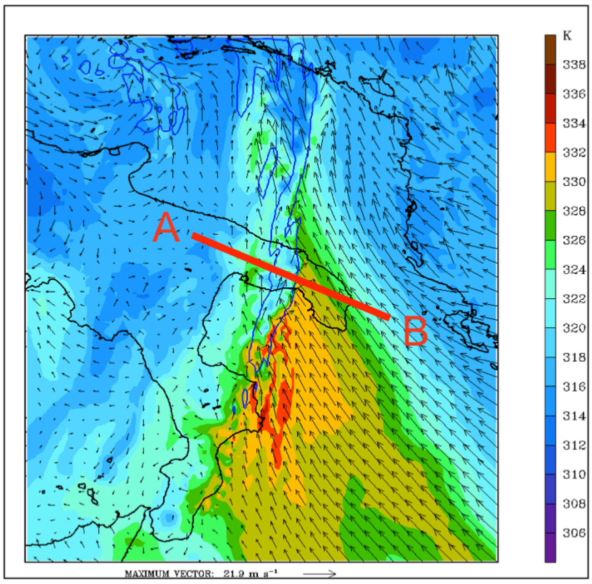


FIG. 2: 925-hPa equivalent potential temperature (shaded, every 2 K) and wind vectors, and precipitation > 5 mm (blue contour) simulated at 07 UTC 13 November 2004. The red line indicates the location of the vertical cross section shown in FIG. 3.

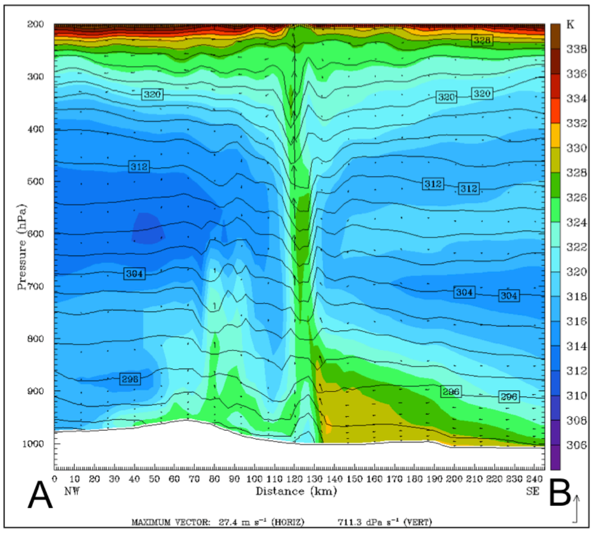


FIG. 3: Vertical cross section of equivalent potential temperature (shaded, every 2 K), potential temperature (contoured, every 2 K), and circulation vectors along the line marked in FIG. 2, at 07 UTC 13 November 2004.

The analysis of numerical outputs of the inner domain reveals that the LLJ had a major role in the event since it supplied moisture to convection throughout the event. Moreover, a strong gradient in moisture content made the warm airstream advected by the LLJ potentially unstable and lowered the level of free convection. As a result, convection could easily develop even without a strong lifting mechanism such as the orography. However, the Apennines were directly involved in triggering convection during the first phase of the event. Indeed, as diagnosed through the nondimensional Froude number, during the afternoon of the 12 November, the southerly flow impinging over the mountain range of Calabria passed from a “flow around” to a “flow over” regime as the LLJ reached the area. Convection developed over Calabria reliefs was subsequently advected by the mid-tropospheric currents, and reached the first maximum rainfall area where the LLJ continued to feed it.

The upper-level SWT associated with the passage of a PV anomaly over southern Italy was responsible for the shift of convection from the area of the first to the second maximum. Moving over the Apennines, the PV anomaly deepened a shallow vortex previously over southern Tyrrhenian. The resulting low- and mid-tropospheric currents veered from south to southwest favouring the shift of the convective line to the east. Moreover, the dryer air associated with the SWT strongly reduced CAPE and increased the LFC over the areas not affected by the LLJ. Consequently, convection was inhibited beneath the SWT and downstream of the convective line where, the convergence between the impinging south-easterly LLJ and the convective outflow was still sufficient to lift the LLJ to the LFC and maintain convection. Beneath the convective line, a cold downdraft outflow developed at about 07 UTC 13 November (FIG. 2). Its propagation caused new convection upstream that caused the convective line to further shift to the east, reaching the area of maximum observed precipitation amount (FIG. 3).

## IV. ACKNOWLEDGMENTS

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## V. REFERENCES

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