Low Cape and High Shear Tornadoes

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I. INTRODUCTION

Italy is characterized by a relatively high number of tornado events (Giaiotti et al., 2007) even if CAPE values are not particularly high, at least if compared with other Countries. This work is devoted to analyse a tornado outbreak (two separate tornadic events almost at the same time 10-11 UTC, 11-12 LT, distant at least 50 km) that occurred during 9th December 2006 in Friuli Venezia Giulia (Italy) into an environment characterized by low CAPE (of the order of 30 J/kg; Manzato and Morgan 2003) but high shear (15 m/s in 1000 m). These events (pictures have been taken) did not show any significant rotation aloft (no mesocyclones detected) neither significant electrical activity (no CG lightning detected by national lightning network and no thunders heard). The common element between these two events is the small distance between tornado occurrence and mountains (roughly 10 km). The dynamical role played by orography is analyzed by way of analytical computations and numerical simulations. It is shown that forced convergence exerted by orography might supply the needed upward movement to sustain the event as well as the vorticity stretching to produce a tornado. High shear, moreover, helps to avoid hydrometeor loading, that might suppress the release of CAPE.

II. PRESENTATION OF RESEARCH

The event occurred in Cassacco (UD), see FIG. 1, was photographed by a meteorologist amatoeur and reported in the ESWD database.

FIG. 1: Photography of the Cassacco tornadic event, captured by Raffaele Fantino. It occurred roughly at 09:45 UTC of 9th December 2006

The CAPE-Helicity diagram (see FIG. 2) obtained using both real data, retrieved through an atmospheric sounding carried out by Italian Air Force (WMO code 16044) almost in the middle of Friulian plain, and numerical simulations performed through the WRF numerical model initialized on the ECMWF global model show that CAPE and Helicity values were quite low, in particular when compared with typical values of different Countries (Brooks and Doswell, 2001). The fact that both real and simulated data show similar values is considered an evidence of the fact that the experimental low values of CAPE and Helicity are actually representatives of the real environmental situation of the area.

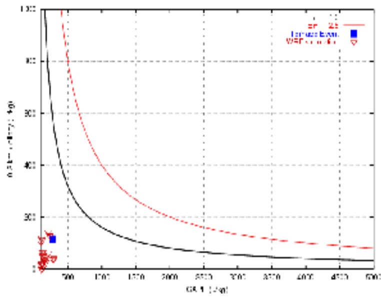

FIG. 2: CAPE-Helicity diagram with the data of the 9th December 2006. Blue square is referring to data obtained through the 1200 UTC (1300 LT) while red triangles are referring to simulated data retrieved on the event position and time.

The analyzed RADAR data can exclude the presence of mesocyclones associated to tornado events, moreover even reflectivity shows quite small values, which should exclude the presence of vigorous updraughts and of the associated high levels of condensation rate and precipitation formation.

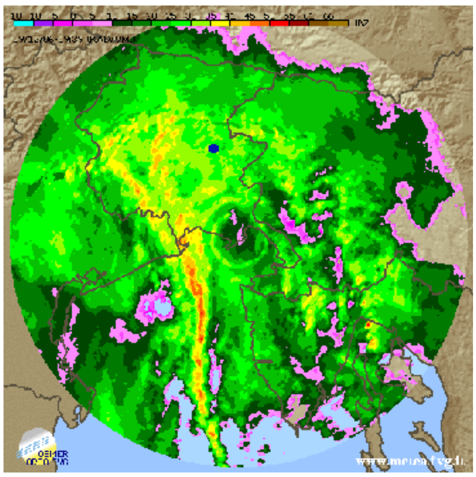

FIG. 3: VMI image of 09th December 2006, 0940 UTC. The blue dot represents the position of the Cassacco event. No particular reflectivity is shown.

The latter aspect, is consistent with the reported absence of relevant precipitations and of lightning activity, which in considered possible only in presence of high vertical velocities.

The relatively low values of helicity are consistent with the absence of mesocyclones (Brooks et al., 1994), while the reported small dimensions of hail are consistent with the small values of hail reported (Palencia et al., 2010). However, even if the observed values of CAPE are in principle sufficient to sustain hailstones with a diameter up to 0.5 cm, this can happen only if all the available potential energy is transformed in kinetic energy. This is possible is all the other ancillary effects that tend to damp vertical motions, e.g., hydrometeor loading and hydrodynamic drag are switched off or severely reduced (Markovski, 2007). The only effect found through the analysis of this event, is that related to the high shear in the lowest levels, which strongly tilts vertical motions. This tilting, in principle, should be enough large to reduce both hydrometeor loading and hydrodynamic drag. In this sense, high shear is not a source of the tornado vorticity, as happens for example in cases of high cape or helicity, but is an indirect aid to convection release and to the development of small but persistent vertical motions.

If shear and helicity are not able to explain the vorticity enhancement, another mechanism for the concentration of vorticity has to be taken into accout. Looking at the wind field during the event, as it is revealed through a mesonetwork which supply information every five minutes (figure 4), it is possible to see that, because of the orography which characterize the area, southeasterly flow inpinging the mountains tends to deviate westward in the neighbourhood of the event area. This has the double advantage to create vorticity kinematically and to enhance it locally because of the convergence which occur on the event area.

III. RESULTS AND CONCLUSIONS

The tornadic outbreak that occurred on 9th December 2006 in Friuli Venezia Giulia give useful constraints for the conceptual and numerical models of tornado occurrence.

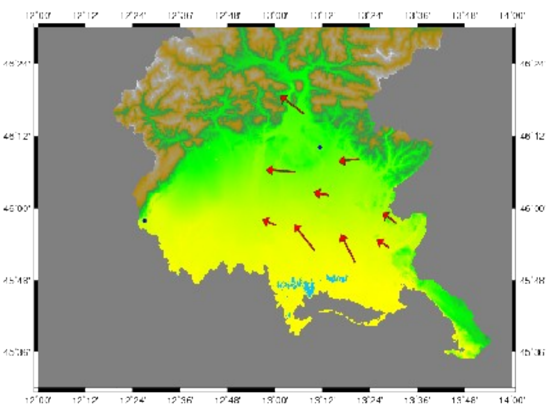

FIG. 4: Wind vectors referring to 0945 UTC retrieved through a mesonetwork. The blue point represents the position of the Cassacco event, which occurred nearly at the same time. The blue dot on the left hand of the picture represents the Caneva event.

Thanks to this event, we can say that tornadoes, in fact, might occur even in low CAPE and helicity environments. But, at least in the case of Cassacco, it seems that low level shear should play a major role in reducing the upward motion damping due to hydrometeor loading and hydrodynamic drag. In this case, a relevant role seems to be played by orography in creating vorticity through kinematic mechanisms, e.g., steering the southerly flow and causing a convergence area near to the foothills. This convergence area, is considered relevant even for the convection onset., i.e., to overcame the however low CIN, which, on the Friuli Venezia Giulia plain, during the events was of the order of 20 J/kg.

Even if the frame depicted for the occurrence of this tornado outbreak seems qualitatively coherent, a more detailed quantitative analysis is however needed to test the conceptual model. In particular, further attention would be devoted to analyze the twin event of Caneva and the role played by precipitations and downdraught in triggering convergence enhancing convection and vorticity.

IV. ACKNOWLEDGMENTS

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