TORNADOES AT NOVIGRAD, ISTRIA, ON AUGUST 14, 2006

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I. INTRODUCTION

The study describes the case of two tornadoes observed on August 14, 2006, in the vicinity of Novigrad, at Istria peninsula. The event was observed by Slovak tourists on holiday and documented by photographs. The mesosynoptic analysis of this case was provided mainly by using satellite and NWP diagnostics.

II. OBSERVATION AND SYNOPTIC SITUATION

A detailed description and photographs of tornadoes were given by Mr. Kvetoslav Jansík, a Slovak tourist in Croatia, who was one of the witnesses to the event. The tornadoes were observed on August 14, 2006, from Busuja peninsula that is situated 5.5-5.6 km southerly from Novigrad city. Several showers and thunderstorms occurred over the sea at 5 – 15 km from the observation point and propagated northeastwards. Around 1040 local time (LST) a shower formed and thunders were heard. When the rain reached the coast, around 1048 LST, a dark rotating funnel started to extend from the cloud westerly to the shower (Fig. 1). Few minutes later another funnel started to extend from the cloud. This one was transparent in the middle part and it was possible to see swirling water on the sea surface. It appeared westerly to the first whirl (approximately 10 degrees to the left as viewed from the observation point). The sense of the rotation of both tornadoes was probably clockwise. The diameter of the water swirl at sea surface was probably 100-200 m and water drops could be elevated to height of several tenths of meters, probably even higher. Both funnels existed simultaneously about one minute. Later the first tornado decayed and the second tornado continued to exist for several minutes and propagated southwards. It vanished few minutes before 1100 LST. Both whirls became slanted prior to the dissipation, which was very fast (in order of seconds). During the event the wind did not substantially amplify at the observation point. Rotation of the base of the cloudiness was not observed.

The weather and the look of the sky changed very rapidly during the next ten minutes after the tornadoes have disappeared; however, showers propagating over the sea were still present (documented by a photograph, not shown). Both tornadoes propagated during their whole life time over the sea. Material damage or injuries related to the tornado occurrence are not known to the authors.

On August 14, 0600 UTC, Croatia was situated in bright area of low pressure with major centre above Denmark and secondary, shallower centre over northern Italy. At 925 hPa level a relatively warmer air was advected over the Adriatic Sea towards Istria peninsula. At 300 hPa level the direction of the flow was between southwesterly and westerly – the axis of the jet stream was crossing the central Adriatic Sea. The thunderstorms, which appeared at Istria in the morning hours, were not connected to synoptic scale fronts.

FIG 1: First tornado observed at Novigrad, approximately at 1049 LST (left) and 1050 LST (right). The view is directed towards north (at azimuth nearly 340 degrees). Novigrad is at right side of both figures (courtesy Kvetoslav Jansík).

Aerological observation at Udine station from 0000 UTC indicate that the air mass over northern Italy was instable, relatively moist, having rather weak CAPE (437 J/kg). The wind was veering with height from southeasterly to westerly, although the increase of the wind speed with height was rather moderate (the wind speed was less than 20 m/s below the tropopause). At 1200 UTC, the air became drier and the wind shear increased significantly, although the instability was weaker (133 J/kg). The wind speed was 15 m/s at 700 hPa and 25 m/s at 400 hPa level. The maximum wind speed below tropopause was 37 m/s. There was also a change of wind direction (veering) from southerly to westerly at lower and middle troposphere.

III. MESOSCALE CONDITIONS

Mesosynoptic conditions on the 14 August over Istria can be inferred from the MSG and NOAA satellite imagery. At 0700 UTC a line of convective clouds started to form at southwestern flank of earlier thunderstorm system situated at northern part of Istria peninsula. This line was elongated in southwest-northeast direction and was slowly propagating northeastwards. It had a wavy shape and new clouds were developing at its tail as could be seen on the High Resolution Visible (HRV) channel of the METEOSAT 8 (MSG) satellite around 0845 UTC (Fig. 2). The cloud top temperature was higher than 230 K (according to NOAA imagery, not shown). On the other hand, the 6 channel composition of the MSG imagery (differences of channels: 6.2 -7.3μ, 3.9-10.8μ and 1.6 – 0.6μ) after 0900 UTC shows presence of small ice particles at the tops of the clouds downstream from the tornado occurrence point (not shown). This might be an evidence of intense convection (Kerkmann, 2005).

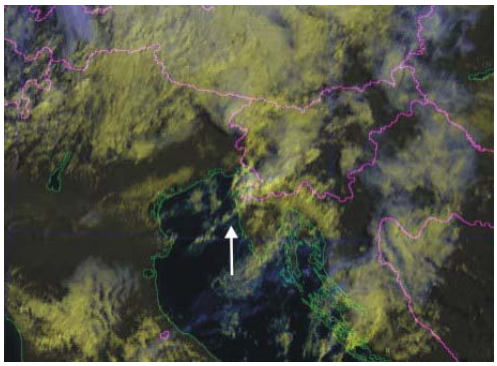

FIG. 2: Image of the High Resolution Visible Channel of Meteosat Second Generation satellite, valid for 0845 UTC. The arrow points towards the line of convective cells on which the tornadoes formed.

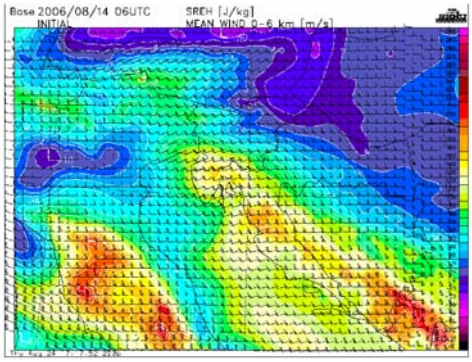

FIG. 3: Analysis of SREH (isolines plotted every 10 J/kg) and of storm motion vector (wind barbs) from ALADIN SHMÚ model, valid for August 14, 2006, 0600 UTC.

Data from radar situated on mountain Medvednica near Zagreb show between 0834 and 0946 UTC a line of convective cells (showing 45-55 Dbz radar reflectivity) crossing the northwest part of Istria in southwest-northeast direction. However, the convective cloudiness at Novigrad and to the west from Istria was very weakly detected, mainly due to big distance of the observation point from radar (nearly 200 km).

Some of the mesoscale conditions of thunderstorm development can be inferred from analysis and forecasts of hydrostatic limited area numerical model ALADIN SHMÚ (Derková, 2005). The analysis of CAPE at August 14, 0600 UTC shows moderate values up to 1400 J/kg at northern Adriatic. At the same time an area of moderate Storm to Relative Environmental Helicity (SREH, Davies-Jones et al., 1990) of 70 – 150 J/kg is present over Istria peninsula (Fig. 3). The outputs of Bulk Richardson Number (Droegemeier et al., 1993) and Energy Helicity Index (EHI, Rasmussen and Blanchard, 1998) show local maxima close to the area, where the tornadic thunderstorms occurred. However, the values of SREH and EHI are rather below of usual thresholds for supercell thunderstorms and tornado development.

III. DISCUSSION AND CONCLUSION

The observation report and the photographs give the only but very clear evidence about occurrence of two, probably non-supercellular tornadoes in the vicinity of Novigrad, on August 14, 2006. The series of thunderstorms propagating in southwest-northeast direction can be identified with narrow, wavy line of convective clouds shown by HRV MSG outputs. Convection was probably induced (supported) at outflow boundary at right-rear flank of an older system of thunderstorms.

Increase of horizontal wind shear could be reason for creation of wavy structures at the leading edge of the outflow, thus, supporting convergence and production of vertical vorticity. It can be hypothesized that the presence of streamwise vorticity diagnosed by SREH and EHI parameters was rather imporant for the mesoscale development of the whole thunderstorm line. The generation of the tornadoes was more probably induced by combination of horizontal shearing instability at lower tropospheric boundary and stretching of the air column by rapidly developing convection (such case was numerically simulated by Lee and Wilhelmson, 1997a and 1997b).

The 14 August case showed that tornadoes must not be necessary related to large thunderstorm systems with cold cloud tops, which are easy to recognize on standard visible or infrared satellite imagery. This underlines the importance of sophisticated satellite outputs showing changes in microphysical structure of convective clouds. Although operational forecasting of tornadic thunderstorms requires above all high resolution radar and satelite data, it is also important to know typical weather conditions, in which they form. This should be a motivation for collecting and providing more case studies of tornadoes along the Adria coast.

IV. REFERENCES

Davies-Jones R., Burgess D., Foster M., 1990: Test of helicity as a tornado forecast parameter. *Preprints, 16th Conf. on Severe Local Storms, Kananaskis Park, AB, Canada*, Amer. Meteor. Soc. 588-592

Derková M., 2005: Numerical weather prediction activities at the Slovak Hydrometeorological Institute. *Meteorological Journal*, 8 53-64

Droegemeier K. K., Lazarus S. M., Davies-Jones R., 1993: The Influence of Helicity on Numerically Simulated Convective Storms, *Mon. Weather Rev.*, 121 2005-2029

Kerkmann J., 2005: Applications of METEOSAT second generation (MSG): RGB images: part 04 RGB composites with channels 01-11 and their interpretation, http://oiswww.eumetsat.org/WEBOPS/msg_interpretation/

Lee B. D., Wilhelmson R. B., 1997a: The numerical simulation of non-supercell tornadogenesis: Part I: Initiation and evolution of pre-tornadic misocyclone circulations along a dry outflow boundary. *J. Atmos. Sci.,* 54 32-60

Lee B. D., Wilhelmson R. B., 1997b: The numerical simulation of non-supercell tornadogenesis: Part II: Tornado evolution along a weak outflow boundary. *J. Atmos. Sci.,* 54 2387-2415

Rasmussen E. N., Blanchard D. O., 1998: A Baseline Climatology of Sounding-Derived Supercell and Tornado Forecast Parameters. *Wea. Forecasting*, 13 1148-1164