DERECHO ON 25TH OF JUNE 2008

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I. INTRODUCTION

Derechos are known as “widespread, convectively induced windstorms” and have been known as prolific wind damage producers. The criteria for derechos can be found in (Johns and Hirt, 1987). Most of these phenomena are linked to the organised storm systems attaining the characteristic of “bow echoes”, their structure and flow is described for example in (Weisman, 2000). Bow echoes and supercells arise in similar conditions, often with strong deep layer shear and high instability (Evans, J. S., and C. A. Doswell III, 2001:), but some differences have been found, such as in (Doswell, C. A. III, and J. S. Evans, 2003). On 25th of June 2008, a widespread, convectively induced windstorm travelled across most of the Czech republic and affected several other countries as well. The windstorm was mostly the result of the formation of two bow echo systems. Apart from the straight-line wind damage, an F2 tornado also occurred. Several supercells have been observed on this day as well.

The main three goals of this case study is to

1/ Evaluate the environmental conditions in relation to the supercell and bow echo development.

2/ Compare the remote sensing, visual observations and measurements of weather stations.

3/ Make a detailed damage analysis and make an inspection of its relation to the mesoscale structures within the bow echo.

II. SYNOPTIC-SCALE AND MESOSCALE ENVIRONMENTAL CONDITIONS

On 25th of June 2008 a prevailing zonal flow was present with several disturbances, notably a short-wave trough over the Eastern Atlantic and a ridge passing over Central Europe. A strong westerly-northwesterly upper-level jet stream crossed the northern part of a warm sector with high theta-e values across central Europe. At the surface, a shallow trough emerged from a surface low centered over Great Britain. A significant frontal system developed, its warm front slowly progressing to the northeast across Germany and Poland with warm and moist air mass (dew points locally over 20°C) being advected behind it. Significant destabilization occurred during the daytime hours in this air mass as shown by 12 UTC soundings from Germany and the Czech Republic.

Strong, mostly unidirectional wind shear was present, with values over 20 m/s in the 0 – 6 km layer. Above the level of approximately 500 hPa winds did not increase at all, or even weakened, implying rather weak storm relative winds in the upper troposphere. Backing low level winds and enhanced SREH along the frontal boundary were simulated by several numerical models. SREH values increased ahead of the amplifying trough towards the evening and models simulated over 300 J/kg across the 0-3 km layer in eastern Bohemia. At the same time, low level shear increased with values up to 20 m/s across the 0-3 km layer and over 10 m/s across the 0-1 km layer, implying a risk of tornadoes and severe wind gusts.

III. REMOTE SENSING, VISUAL OBSERVATIONS AND MEASUREMENTS OF WEATHER STATIONS

A line of isolated cells, including supercells, formed over Germany and western Bohemia and progressed eastwards around 14:00 UTC. Storm coverage grew quickly with the merging of the cold pools of individual storms. The storm system attained a linear shape and developed into a squall line shortly before 16:00 UTC. In the mean time, moist air, with dew points exceeding 20°C, was spreading northward from Austria into Eastern Bohemia. Ahead of the storm system, two isolated supercells were observed and extensively documented by local storm spotters.

FIG. 1: Supercell above north eastern Bohemia, 15:25 UTC

Radar signatures such as hook echoes were observed with these storms. At the same time a mesolow formed in this area at 17:00 UTC with enhanced convergence of very moist air ahead of the progressing system. In this region, the squall line gained characteristics of a bow echo.

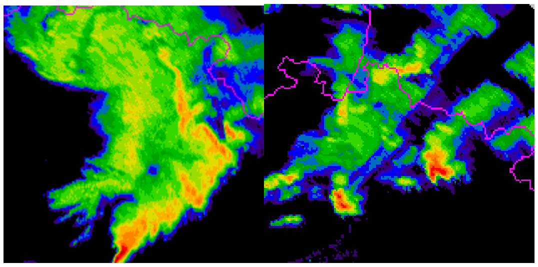

FIG. 2: Radar PPI 0.9° captions of the storm development. Left: bow echo stage. Right: Isolated supercell with hook echo (a photo of it can be found in Figure 1)

A clear bow apex and rear inflow notch were observed. The bow echo attained considerable forward speed, approaching 100 km/h, soon engulfing two isolated supercells. The wind damage was most prolific during the “bowing stage” with several stations reporting gusts above 32 m/s. A northern book-end vortex became dominant during this process.

At 18:00 UTC, approximately one hour after the passage of the gust front, a sounding from Prague-Libus showed a very strong Rear Inflow Jet (RIJ) at an altitude of about 3 km ASL with a maximum speed over 35 m/s. Rear Inflow Jets are characteristic of bow echoes and play a major role in the wind potential of these systems (Wakimoto, 2001). The Front to rear and the Rear Inflow Jet have also been derived from the VAD radar analysis with the radar at Brdy. A significant meso-high developed in the wake of the gust front, with pressure differences of 7 hPa across a very small distance, which likely contributed to the severe wind gusts. On PPI scans of low elevations, LEWP structures were evident, suggesting that embedded circulations might have been present. Later on, after 19:00 UTC the bow echo had turned into a shape of “comma echo”, described in e.g. (Fujita, 1979).

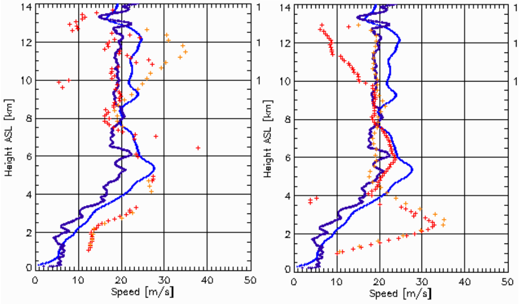

FIG. 3: VAD profile of the Radar at Brdy before and after the passage of the gust front (red crosses stand for 13,4° elevation and orange for 34,3°) at 16:14 and 16:54 overlaid with 12 UTC sounding measurements from Prague and Prostejov (light and dark blue lines respectively).

IV. DAMAGE ANALYSIS

The first reports from the media and public showed extensive wind damage, mainly in the eastern part of Bohemia. An in-situ survey showed even more than we could have imagined. The first presumption was the F-3 tornado, 100 – 300 m wide. Eyewitnesses described a tornado, and we also found typical damages which could not have been caused by anything else than a tornado.

FIG. 4: The arrow shows the area with the largest damage.

Thanks to our collaborators among amateur storm chasers we obtained air photos, which helped the most to decide what had happened there. On these photos it can be seen that most trees fell eastwards, the same direction as the whole system. If it had been a tornado, trees would have fallen in various directions, suggestive of tornado rotation. That is the reason why we finally agreed that most damage was caused by numerous strong F2-F3 microbursts. But thanks to the eyewitnesses and some local tornadic damage, we are sure there was one or more tornadoes of F2 intensity as well. Some very local damage also seemed to be caused by suction vortices. It seems that the most severe damage and a tornado had occurred on the northern half of the bow visible in Figure 2, with possible enhancement due to the merger of the supercell and bow echo, embedding the circulation of the supercell in the system.

FIG. 5: Most trees fell down eastwards, the same direction as the whole system moved.

V. REFERENCES

Doswell, C. A. III, and J. S. Evans, 2003: Proximity sounding analysis for derechos and supercells: An assessment of similarities and differences. *Atmos. Research*, **67-68**, 117-133.

Evans, J. S., and C. A. Doswell III, 2001: Examination of derecho environments using proximity soundings. *Wea. Forecasting*, **16**, 329-342.

Fujita, T. T., 1978: Manual of downburst identification for project Nimrod. Satellite and Mesometeorology Research Paper 156, Dept. of Geophysical Sciences, University of Chicago, 104 pp.

Gatzen, C., 2004: A derecho in Europe: Berlin, 10 July 2002. *Wea. Forecasting*, **19**, 639-645.

Johns, R. H., and W. D. Hirt, 1987: Derechos: widespread convectively induced windstorms. *Wea. Forecasting*, **2**, 32-49.

Punkka, A-J., and J. Teittinen, 2004: The severe thunderstorm outbreak in Finland on 5 July 2002. Preprints, *22nd Conf. on Severe Local Storms*, Hyannis, MA, Amer. Meteor. Soc, Paper P4.9, 7 pp.

Wakimoto, R. M. 2001: Convectively driven high wind events. *Severe Convective Storms, Meteor. Monogr.*, No. 50, Amer. Meteor. Soc., 255-298.

Weisman, M. L., 1993: The genesis of severe, long-lived bow echoes. *J. Atmos.Sci.*, **50**, 646-670

Weisman, M. L., 2001: Bow echoes: A tribute of T. T. Fujita. *Bull. Amer. Meteor. Soc.*, **82**, 97-116.