CENTRAL EUROPEAN CONVECTIVE STORMS PENETRATING DEEP INTO THE LOWER STRATOSPHERE – MSG IR AND RADAR OBSERVATIONS AND RADIATIVE TRANSFER MODELING

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I. INTRODUCTION

This study addresses Meteosat Second Generation (MSG) observations of European convective storms which exhibit a feature resembling a cold ring (occasionally also referred to as a "cold doughnut shape") in IR-window bands surrounding a central warm core (CWC). While similar storms are not rare, their duration is typically much shorter and they often have a smaller magnitude and horizontal extent compared to the case from 25 June 2006 documented below.

The interpretation of similar cases seems to be closely linked to the explanation of a *close-in warm area* (CWA) and a *cold-U/V* (or *enhanced-V*) shape, which occur at the tops of severe storms (e.g. Adler and Mack, 1986; Heymsfield et al., 1991; McCann, 1983; Negri, 1982). In both cases, CWA and CWC seem to result from wake effects taking a place downwind from an area of overshooting tops or an elevated central dome, penetrating into the warmer lower stratosphere. However, validation of this mechanism lacked support from radar observations, since most of the European radar networks do not routinely process data above 10 – 14 km CAPPI.

II. PRESENTATION OF RESEARCH

The severe storms from 25 June 2006 documented in this study, exhibiting a textbook "cold doughnut shape", occurred above the Czech Republic and Austria at latitudes of 48° to 50° N (Fig. 1). The study compares MSG-1 IR window observations with data from the *Czech Radar Network* (CZRAD). For the purpose of this study, CHMI radar volume data processing software was modified, in order to enable examination of the structure of convective storms up to 20 km above the ground. These changes documented (for the first time ever in the Czech Republic) that echo tops of these storms reached heights of 18 – 20 km (Fig. 2). This would be nothing exceptional in much lower latitudes, but at this geographic region it is a rather unique case.

The paper documents the evolution of these storms, observed in parallel from MSG-1 and in the CZRAD data processed by the above mentioned modified software, documenting the onset of the CWC in the IR10.8 images and slightly earlier formation of the radar-detected "dome" lifting high above the tropopause.

In addition to satellite and radar observations, a radiative transfer model (RTM) will be used to determine the amount of ice mass in the lower stratosphere necessary to produce a CWC in the IR satellite data. The sounding shown in Fig. 3 will be used as input to the model, and a cloud composed of varying amounts of pristine ice can be inserted at different levels, including in the lower stratosphere. Output from the model includes IR brightness temperatures, so we can determine whether the observed CWC could realistically have resulted from ice at warm stratospheric temperatures.

The observations and interpretations above will also be examined from a cloud model point of view. We will analyze simulated storm top data with similar CWC features to trace the responsible mechanisms.

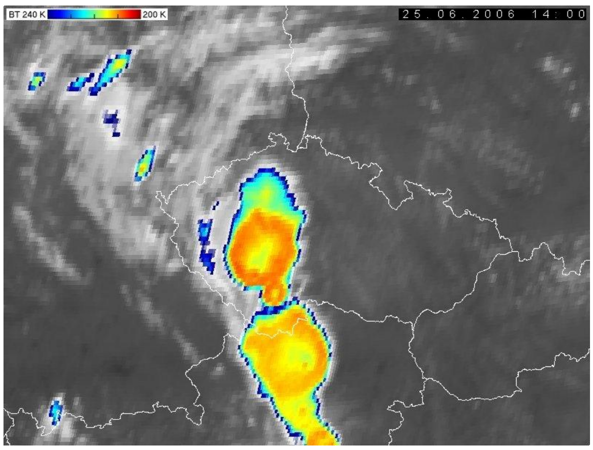

FIG. 1: "Cold doughnut shaped" storms above the Czech Republic and Austria. 25 June 2006, 14:00 UTC, MSG-1 band IR 10.8. The colour enhancement shows the temperature range from 240 K (blue) down to 200 K (dark red).

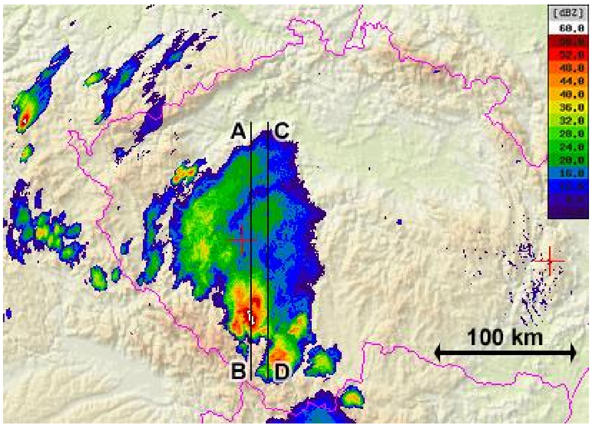

FIG. 2a: Positions of radar reflectivity vertical cross-sections A-B and C-D, shown in Fig. 2b and Fig. 2c. 25 June 2006, 14:10 UTC. The CZRAD radar locations are indicated by the red crosses.

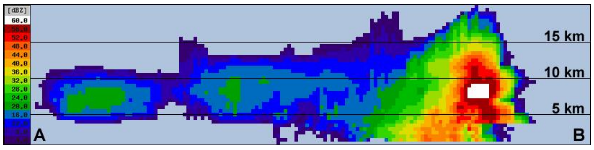

FIG. 2b: Radar reflectivity vertical cross-section A-B of the storm in Fig. 2a The cross section ranges from ground up to 20 km, lines indicate 5, 10 and 15 km CAPPI levels. Note that the high echo top is located outside the CWC.

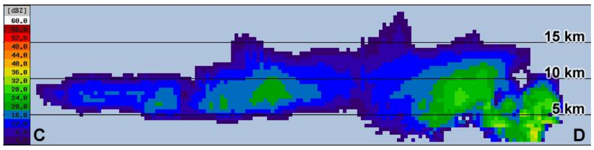

FIG. 2c: Radar reflectivity vertical cross-section C-D of the storm in Fig. 2a, sampling the storm through the central part of CWC.

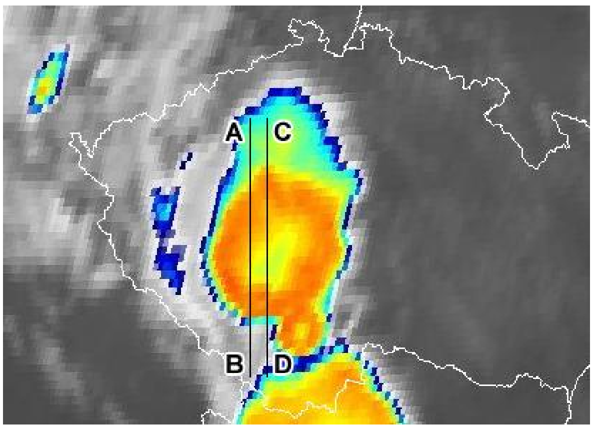

FIG. 2d: Positions of radar reflectivity vertical cross-sections A-B and C-D, shown in Fig. 2b and Fig. 2c, superimposed on the MSG IR10.8 image. Note that cross-section A-B samples the storm outside the CWC, while C-D penetrates the central part of CWC. No parallax correction to the satellite image was applied here.

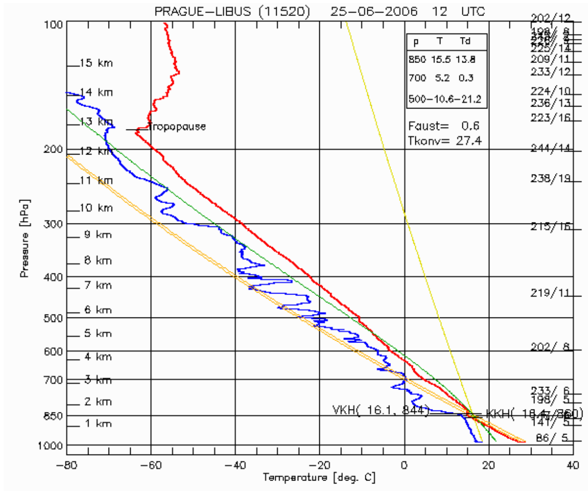

FIG. 3: Soundings at Praha–Libuš on the same day, at 12 UTC. Red shows the temperature profile; the tropopause was at 12.8 km.

III. RESULTS AND CONCLUSIONS

The study has shown a close correspondence between formation of the CWC and a presence of the radar-detected elevated dome in its proximity (within the cold ring area), rising high up into the warmer lower stratosphere. The cold ring-shape seems to result from weaker upper-level winds, in contrast to cold-U/V shapes which are typical for stronger upper-level winds. Therefore, formation of a distinctive cold ring in the IR imagery should be considered among indirect signatures of possible storm severity, e.g. side by side with features like cold-U/V shape.

IV. AKNOWLEDGMENTS

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V. REFERENCES

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