The 14 July 2010 severe Mesoscale Convective System event over parts of central Europe

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I. INTRODUCTION

Each year numerous thunderstorms evolve in Germany which reveal different degrees of organization, ranging from short-lived, pulsating thunderstorms to long-lived and damaging supercells. Quite often those thunderstorms grow upscale and form extensive convective systems, so called "Mesoscale Convective System (MCS)". Houze (1993) classified an MCS as "a cloud system that occurs in connection with an ensemble of thunderstorms and produces a contiguous precipitation area ~ 100 km in horizontal scale in at least one direction".

On 14 July 2010 a significant MCS developed over parts of central Europe and crossed all of northeastern France, Bene-lux and Germany (Fig. 1). Damaging wind gusts, isolated large hail and at least three tornadoes were reported, causing three fatalities.

II. PRESENTATION OF RESEARCH

In this poster we concentrate on two different phases in the life of the MCS: First, a well organized squall line exhibiting a sharp reflectivity gradient and a significant rear inflow jet during the mature phase over Benelux and Northwest Germany. Second, the outflow dominant phase with decreasing severity over Central/East Germany.

Among other things we investigate how external changes (environmental synoptic set-up and daytime driven boundary layer modification) but also internal ones (strength of the rear inflow jet, temporal development of the cold pool and depth of the effective inflow layer) assisted in the transformation of the MCS.

Thereafter, features that are important in the operational forecasting process will be discussed in respect of how well defined their appearance was. I.e. the development of a wake low/mesohigh, cold U-shapes, central warm spots along the anvil-layer and the mature phase of embedded bow echoes (with attendant nicks like the rear inflow jet).

Subsequently we evaluate different nowcast tools by looking on their useability in the preparation of better forecasts and their support in the operational warning process.

Finally the thermodynamic and kinematic environment of the line will be evaluated, leading to some interesting subitems with this event: The limited amount of large hail reports, the late occurrence of tornadic thunderstorms and the concentrated swaths of damaging winds. Also differences between the northern and southern part of the line will be addressed. The "Corfidi vector approach" will be used to explain the variable motions of the MCS (Corfidi et al., 1996).

This research will be carried out with an extensive archive of surface, remote-sensing and model data (COSMO-EU, WRF), visualized by NinJo.

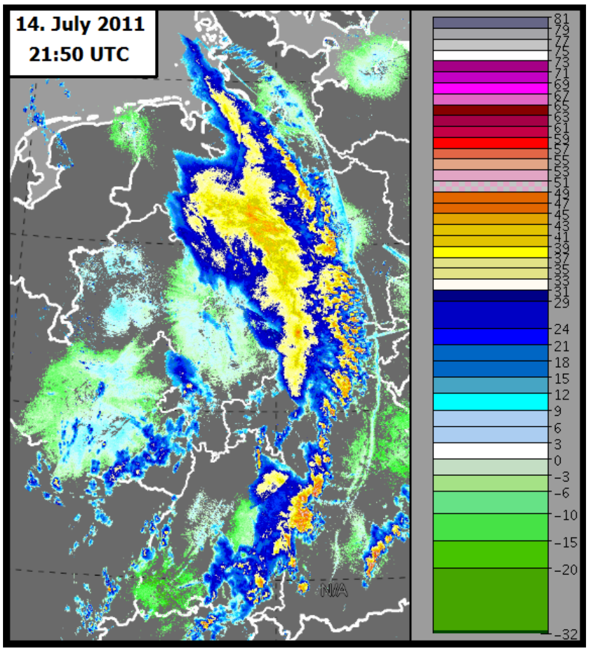

FIG. 1: Squall line over Germany in its decaying stage, 14.07.2010, 21:50 UTC. Colors represent reflectivity in dBz (-32 dBz, 81 dBz).

III. RESULTS AND CONCLUSIONS

During the study of this event it became clear that both, the external (environmental) conditions but also the internal organization of the MCS played a major role during the different stages of the severe and long-lasting MCS. Over Northeast France the MCS formed out of a cluster of showers and storms (broken line formation, Bluestein and Jain, 1985), gained rapid organization and finally revealed a classic structure of a mature mesoscale convective system with an embedded bow echo over Benelux and Northwest Germany. The gradually developing cold pool, but also the approach of an intense 40 m/s mid-level jet assisted in the formation of a strong rear inflow jet (RIJ) over Belgium and Luxembourg. The RIJ was also supported by the development of a book-end vortex at the northern side of the bow echo (Fig. 2).

Both, surface data but also remote-sensing data all indicated a well structured bow echo with a transient wake low, a descending rear inflow jet (RIJ) during the mature phase and a rapidly expanding postfrontal stratiform rain shield with attendant cold pool. For instance, by looking on 3D radar data, the typical conceptual model of radar reflectivity in a mature mesoscale convective system, consisting of a leading convective line, a transition zone and a trailing stratiform area, could be found (Fig. 3, cf. Smith et al., 2009).

Due to the favorable environment with a strong vorticity maximum, intense shear and a warm and moist prefrontal air mass, this part of the MCS evolved into a progressive and damaging squall line as it advanced to the northeast.

For operational forecasting, both the developing wake low but also the descending RIJ were a good indicator for the onset of damaging surface wind gusts, which occurred within a concentrated swath. However, in modified satellite data, no hints were detected that a pronounced and long-lived U-shape structure evolved, which could have assisted the operational forecaster. The bow echo gradually decayed over the North Sea, as the supply of warm and humid air from the south was cut off by the eastward moving MCS.

Nevertheless, the Corfidi-vector approach would have helped forecasters to expect a progressive line of storms, as it indicated rapid thunderstorm acceleration.

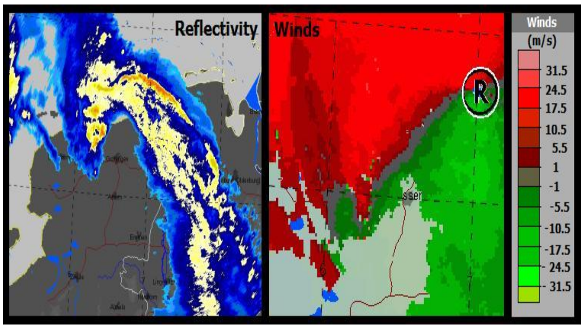

Fig. 2: Book-end vortex visualized by the radar station of Emden. The left picture shows reflectivity while winds can be inferred from the right picture (red- away from the radar).

Over central Germany, the environmental dynamic forcing became much weaker, as the mid-level short wave moved to the north and hence caused the MCS to progress into a diffluent streamline pattern. In addition the thermal horizontal differences weakened (from 18 K to 6 K in night hours) and the persistent wind from easterly directions advected drier air from Eastern Europe to the west. Both factors supported the weakening of the system.

Interesting aspects were gained when making use of different nowcasting tools. For instance, the visualization of pressure tendency is helpful to get an idea of the conditions of the squall line. In addition the isallobaric wind shows the direction and strength of MCS propagation. The attenuation of the system was followed by the transformation from a “strong front pressure fall / weak rear pressure rise”- pattern to a “weak front pressure fall / strong rear pressure rise”-pattern.

The isobars from the data of surface weather stations revealed the typical pressure pattern for the passage between the mature and decaying stage of a squall line system: a pre-squall mesolow, a mesohigh directly in the rear of the leading convective line and a wake low behind the trailing stratiform area (Fujita, 1955).

By looking on the reflectivity image, visualized are also weak reflectivities (negative dBz-values), it is possible to identify the outflow boundary (gust front). This is very helpful since the outflow triggered new convection at the leading edge of the squall line. Furthermore the running away of the gust front from the convective line over Middle / East Germany gave notice of the decay of the MCS.

Moreover, the development of the ratio of convective to stratiform rain fraction can be inferred from 3D reflectivity images. Thereby, the transformation of a narrow convective line (not shown here) to a line with a distinctive trailing stratiform area (Fig. 3) can be followed .

Finally, the knowledge about the propagation velocity of the MCS, inferred from lightning or radar data gives an idea of the strength of the RIJ. The slowdown of the squall line over eastern Germany may be an indicator for the decay of the system.

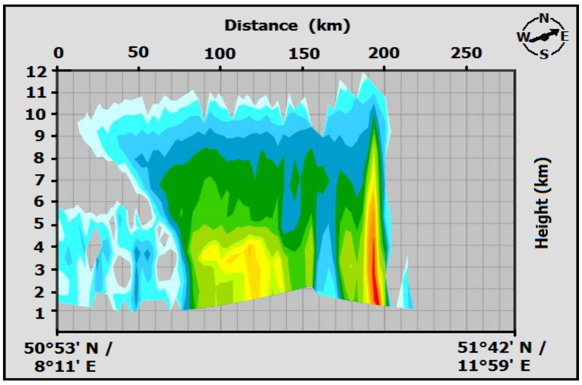

Fig.3: 3D reflectivity image showing the typical appearance of gustfront, leading convective line, transition zone and trailing stratiform area (14.07.2010, 21 UTC).

IV. ACKNOWLEDGMENTS

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