COMPARISON OF TWO COLD-SEASON MESOSCALE CONVECTIVE SYSTEMS

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I. INTRODUCTION

Mesoscale convective systems (MCS) are known to occur within a large variety of thermodynamic environments (e.g. Evans and Doswell, 2001). While MCS have been observed in association with both strong and weak vertical shear profiles, most of them seem to develop with rather high instability. As a consequence, only a few severe mesoscale convective systems forming in association with weak instability have been described (e.g. Van Den Broeke et al., 2005; Kruzdlo and Cope, 2005).

In January 2007 and March 2008, two mesoscale convective systems moved across portions of Central Europe. Both MCS were embedded in winter storms named “Kyrill” and “Emma” and associated with widespread severe weather. However, the influence of organized convection on the severity of the large-scale storms is not easy to estimate as damage reports and wind measurements often cannot be related to the convective process alone. Doing a comparison of the two MCS, we try to analyse the environmental conditions that enabled deep moist convection and effect the occurrence of severe weather.

II. THE MESOSCALE CONVECTIVE SYSTEMS

Regarding their size and lifetime, the MCS seem to be comparable as they moved along a 1500 km long path in approximately 14 hours as indicated by detected lightning. They were characterized by a narrow, around 700 km long convective line that showed several large bowing segments during its lifetime (FIG. 1). The both showed a “parallel stratiform structure” (Parker, 2006).

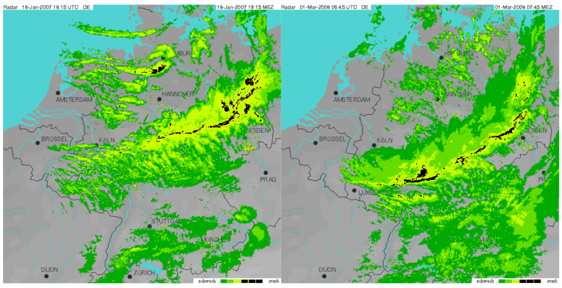

FIG. 1: Radar images of the Kyrill (left) and Emma (right) MCS.

Observations and rawinsonde data as well as numerical models indicate weak instability in the warm air mass. Low-level warm air advection due to an indirect thermal flow my have contributed to the weakly capped instability ahead of the cold front. The structure of the convective systems is comparable to simulations by Weisman and Davis (1998) for MCS development affected by strong and deep vertical wind shear. Bowing segments are frequently observed along the leading edge of MCS due to the development of convective cold pools (e.g. Weisman and Davis, 1998). Such cold pools in the wake of the leading convective line developed in both cases. For the winter season, the cold pool was quite well-developed, with a temperature difference up to 13 K along the leading convective line of the Kyrill event. Furthermore, the intense and persistent leading convection indicates that the cold pool was balanced by the environmental vertical wind shear. The horizontal vorticity of environmental vertical wind shear can balance the horizontal vorticity generated by the cold pool, leading to more upright and persisting convection (Weisman and Davis, 1998).

Both lines developed quite different during the following hours. During the Kyrill storm, the convective line stalled across central Germany. The passage of the bowing lines over south-eastern Germany was associated with frequent lightning and strong precipitation, but decreasing winds that did only slightly turn to the west. It seems that the cold pool of the MCS increased the low-level stability and reduced the vertical impulse transport. As the rear inflow jet was likely directed to the east, it did not produce the strongest gusts at the ground along the flow-parallel portions of the convective line. In contrast, this was observed along a narrow path along the northern bowing segments. It is suggested that this was closely related to the mid-level jet streak that was spreading eastward across central Germany, leading to strong forcing especially at the cyclonic flank of its nose. Accordingly, lightning was detected only along a narrow path just to the north of the jet streak’s nose. This may indicate the influence of larger-scale circulations on the mature MCS as suggested by Coniglio (2003).

The Emma MCS had a larger line-normal propagation and crossed southern Germany. Lightning was detected across most of the convective line. In contrast to the Kyrill case, the gust front clearly produced the strongest wind gusts and was accompanied by a strong turn of the wind direction to the north-west. This was likely related to the mid-level jet streak that was spreading southward across Germany as the mid-level trough was amplifying. As a consequence, the rear inflow jet did likely contribute on the wind gusts at the leading edge of the convective system.

III. RESULTS AND CONCLUSIONS

The development of the two MCS seems to indicate that their propagation and severity is closely related to the lift associated with the synoptic-scale flow. We suggest that instability is generated by the thermal indirect circulation underneath the mid-level jet streak. The ageostrophic winds at low levels may lead to differential temperature advection within a saturated, moist-neutral stratified air mass in the warm sector of the low pressure system. The instability becomes deeper for situations with strong lift due to strong mid-level quasi-geostrophic forcing.

Severe wind gusts along the leading line of the convection seem to be related to the large scale forcing as well. When the forcing mechanism disables the convection to move on, the cold pool may lead to low-level stabilization and therefore weakening winds as observed for the Kyrill case.

IV. REFERENCES

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