# P12.3 RADAR–DERIVED MICROPHYSICS RELATED TO 3D VHF LIGHTNING MAPPER DATA DURING EULINOX

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## 1. INTRODUCTION

The **EU**ropean **LI**ghtning **N**itrogen **OX**ides project (EULINOX) aimed at an improved understanding of lightning–induced NO$_X$ production within central European thunderstorms. During the intensive observation period in summer 1998 a great variety of observations were made: aircraft measurement of chemical constituents, interferometric 2D and 3D detection of VHF sources from lightning discharges, and polarization diversity Doppler radar observations. In a related paper, Höller et al. (2001, **P12.4**, this volume) exploit the EULINOX data with the aim of revised lightning parameterizations.

ONERA's interferometric lightning mapper (ITF) consisted of two VHF interferometric stations 40 km apart, each at 25 km distance from the operational center in Oberpfaffenhofen. VHF emissions from lightning flashes were detected with 1 MHz bandwidth at 114 MHz. Amplitude and direction of arrival were sampled at a 23 $\mu$s rate. The ITF system can detect negative leaders and high current discharges (intracloud recoil streamers, cloud–to–ground dart leaders and return strokes) all along their propagation paths.

DLR's C–band polarization diversity Doppler radar POLDIRAD provided 3D information on the storms' dynamical and microphysical structure and allowed for identification of different hydrometeor types in the thundercloud and accompanying anvil regions. Combination of data from ONERA's VHF interferometric lightning mapper and DLR's polarization diversity radar provided a detailed view on the evolution of the lightning activity and its relation to cloud microphysics and dynamics in space and time.

## 2. CASE STUDIES

### 2.1 The 21 July 1998 supercell

The supercell hailstorm was the right–mover of a storm splitting at about 1645 UTC over the Allgäu region in southern Germany. It intensified very rapidly and developed radar–detectable supercell characteristics such as a single persistent precipitation core, a bounded weak echo region, an echo overhang, and mesocyclonic rotation.

For a discussion of lightning and polarimetric radar parameters in this storm cf. Höller et al. (2000). Here we address correlations to the most basic radar–derived quantity, the reflectivity factor Z as well as mean vertical profiles of VHF activity.

To obtain information on the correlation between number of VHF sources $N_{\mathrm{VHF}}$ and reflectivity factor Z, volume data measured by the radar were related to the total number of VHF sources within 3 min periods starting at given volume scan times. As the radar data were interpolated onto the same 1 km$^3$ grid as used for the ITF data, the points could directly be analyzed from a scatter diagram of $N_{\mathrm{VHF}}$ versus Z.

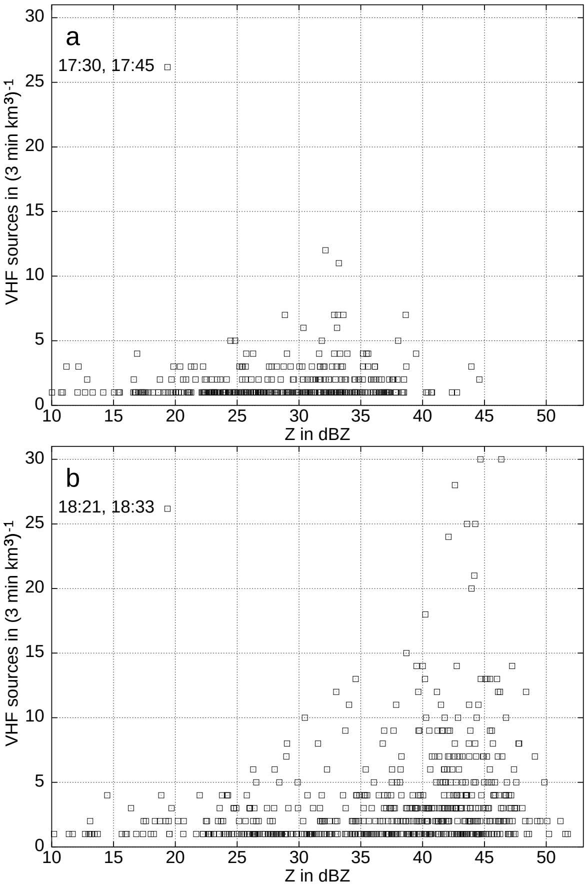

Figure 1. Scatter plot between number of VHF sources per 3 min interval km$^{-3}$ and radar reflectivity factor Z.

This is shown in Fig. 1 a for the growing phase of the storm (1730, 1745 UTC) and in Fig. 1 b for its early decaying stage (1821, 1833 UTC). In all four volume scans the highest observed reflectivities interpolated to the cartesian 1 km$^3$ grid were in the range from 50 to 52.5 dBZ. In the developing stage of the storm, no VHF data points are found for Z $\geq 43$ dBZ. Instead, weak VHF activity is found with usually less than 10 VHF sources per 3 min interval and per km$^3$. The peak of the scattered points

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is located at roughly 32 dBZ. The number of sources decreases slower towards lower reflectivity factors than to higher dBZ–values. This skewness towards the higher values of Z is also found during the decaying stage of the storm in Fig. 1 b. But now the reflectivity in grid boxes with VHF sources extends up to about 52 dBZ and the VHF activity itself also has increased substantially: many grid boxes contain 10 or more sources per 3 min interval and per km$^3$ with a peak value of 30. In addition, the location of this maximum has shifted towards higher reflectivity factors. Instead of 32 dBZ in the early stage, the scatter plot now peaks at 45 dBZ and then drops off very sharply with increasing Z. This can be explained (Dotzek et al., 2001) by the fact that during late stages of cloud development, most VHF sources are emitted from the radar–derived hail region of the decaying supercell.

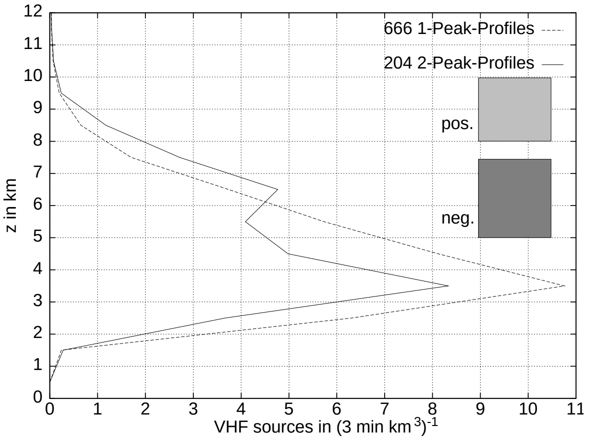

Figure 2. Average (1700–2000 UTC) vertical VHF profiles with 1 distinct maximum (dashed) or 2 maxima (solid). Shaded boxes mark probable locations of main charge layers.

Vertical profiles of VHF sources integrated over 3 min intervals and the 1 km$^3$ grid (chosen to coincide roughly with the radar scan volume and time interval) have been analyzed for the presence of peak levels. From 1700 to 2000 UTC, 666 vertical profiles were single–peak profiles. In another 204 cases two peaks were found. Then one and two–peak profiles were averaged separately. The dashed line in Fig. 2 gives the average of all one–peak profiles, and the solid line the average of the two–peak profiles. In both cases a low–level maximum at 3.5 km height is most pronounced. The solid curve, however, shows a secondary maximum at 6.5 km AGL which corresponds to the −15°C level of 21 July 1998. Yet in neither of the average profiles do we find an upper–level maximum near the −30°C region inside the cloud where we would expect the main positive charge level of a Cb–tripole.

## 2.2 The 26 June 1998 cells

On this day with many isolated non–supercell storms, there was a large cell from 1500 UTC to 1830 UTC, nearly all the time in the 3D–reconstruction zone of the ITF, and with high flash rates up to more than 80 min$^{-1}$.

## 3. DISCUSSION

For the vertical structure of lightning VHF activity our results indicate that in some parts of the cloud VHF signatures showing a preference for one or two levels of high activity appeared to be present. However, other parts of the cloud showed a large vertical variability of enhanced VHF emissions. Following Dotzek et al. (2000) we can state that the real electrical structure of thunderstorms is far more complex than the simple tripole concept, although the physical processes leading to the tripole are likely to be present in some parts of the thundercloud.

The strong VHF activity near the freezing level within this supercell storm remains an open issue. On the one hand the data indicate that the lower (secondary) positive charge layer of the Cb–cloud was overwhelmingly active in this special case. Physical evidence for this assumption is given by Dotzek et al. (2001) and Pike (2000) as well as in a different context by Shepherd et al. (1996) who also observed strong electric fields and charges near the melting layer in the stratiform part of mesoscale convective systems. The authors argue that melting–charging mechanisms could be responsible for that.

## 4. CONCLUSIONS

**1.** A strong lower positive charge center near 0°C was observed in the 21 July supercellular storm,

**2.** with proceeding storm evolution, VHF activity becomes more intense and is linked to increasing values of the reflectivity factor,

**3.** simultaneously, VHF activity becomes more related to the hail region within the precipitation core.

## ACKNOWLEDGEMENTS

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