P12.4 ON THE PARAMETERIZATION OF LIGHTNING BASED ON RADAR OBSERVATIONS OF THUNDERSTORMS

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1. INTRODUCTION

In recent years, interest in a better parameterization of lightning in numerical models describing thunderstorms and related processes at various scales (mesoscale to global) has increased. The NO_x-production by flashes has been recognized as an important contribution to the global NO_x-budget.

This paper investigates the use of radar measurements of microphysical and dynamical storm properties for lightning parameterizations. During the EULINOX (European Lightning Nitrogen Oxides Project; Höller and Schumann, 2000) field experiment simultaneous radar, lightning, aircraft and satellite measurements of thunderstorms were obtained. A variety of experimental tools were available during EULINOX in summer 1998. Local storms were observed by DLR's polarization Doppler radar (POLDIRAD), a Doppler radar of the German Weather Service, several National Weather Service radars, ONERA's VHF-interferometer (ITF), a Lightning Position and Tracking System (LPATS), and two aircraft instrumented with chemical and meteorological sensors. In addition to the local storm penetrations close to the radar sites, the large-scale transports of NO_x were followed by DLR's *Falcon* jet.

This data base is used for testing known parameterizations (Price and Rind, 1992, 1993) of lightning depending on cloud top height or updraft strength. Based on case study results the evolution of radar derived properties and lightning parameters inferred from different detection systems (LPATS, VHF-Interferometer, Sferics, Satellite) is demonstrated. Thus, further development of the parameterizations is investigated.

In a related paper, Dotzek et al. (2001) investigate the dependence of lightning parameters on storm microphysical properties as derived from polarimetric radar measurements for different storms. The present paper discusses the implications of these and other measurements for lightning parameterizations.

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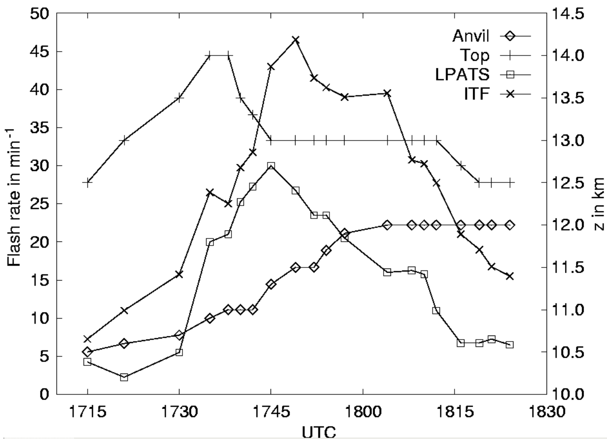

Figure 1. Time series of storm parameters and lightning characteristics for the supercell storm observed on July 21, 1998, during EULINOX. Cloud top and mean anvil level are determined from low intensity radar echo contours. LPATS strokes number and VHF-sources measured by the ITF are also shown.

2. LIGHTNING AND RADAR STORM PARAMETERS

On July 21, 1998 a severe storm moved across the main experimental area in Southern Germany close to the DLR radar site. It was studied in great detail previously (Höller et al., 2000). Its radar echo structure and lightning characteristics will be used here for testing possible parameterizations of lightning.

A time series of different storm parameters during a roughly one-hour period of storm evolution is shown in Figure 1. The ITF-sources are taken from a volume of 100 x 100 km^2 area centered around the radar site. From the radar RHI (range height indicator) scans a relatively good detection of the cloud heights was possible. These data apply to the supercell storm which dominated all other storms inside the volume in size and lightning activity.

A vigorous growth phase can clearly be detected from the height of the overshooting cloud top (about 15 km in total size). Peak cloud tops of up to 14 km above ground (0.6 km ASL) were observed around 17:35 UTC. After 17:45 the overshooting top decreased in height to 13 km. During this period of storm growth the overall anvil level of the remainder of the storm slowly increased from 10.5 to 12 km AGL.

During the period of strong overshooting the lightning activity rapidly increased as detected by both systems. The numbers given are only representing relative measures of the electrical activity as they refer to quite different phenomena (bursts and strokes). Peak lightning activity is shifted for about 10-15 min with respect to the peak cloud top development. Lightning frequency slowly decreased after 17:50 UTC whereas the cloud anvil top height remained more or less constant during the rest of the period shown.

On July 21 the temporal evolution of an individual storm was well followed by different kinds of measuring systems in the overlapping observational area close to the radar and ITF sites. Data from other observational days where storms developed in this area are added to the data base and shown in Figure 2. It can be noted that at low flash rates (<10 min^{-1}) there is considerable scatter of the data for the corresponding cloud tops. On the other hand, high cloud tops are not necessarily indicative for high flash rates. Both, high and low flash rates were observed for cloud tops around 13 km. Cloud tops higher than 14 km were not observed during the observational period.

For comparison, the functional relation as obtained from (PR) Price and Rind (1992) is indicated by the solid line. Especially for the high cloud tops, flash rate can considerably be underestimated by the PR-relationship.

3. CONCLUSIONS

These findings indicate that, when looking at the fine scale details of storm development, a simple parameterization of lightning depending on cloud top heights is problematic.

The temporal evolution of an individual storm has shown that it is obviously not sufficient to take into account a simple phase shift in time but the decrease of lightning activity has to be considered by some additional parameter. Possibly this behavior indicates that not only higher level features of updrafts and cloud top are important but also processes at mid or low levels.

A statistics of storm cells from 5 different observational days during summer of 1998 gave indication that a simple parameterization based on cloud top height can hardly describe the observations. Total flash rate tends to be underestimated for the higher clouds.

For more information on the EULINOX project see http://www.pa.op.dlr.de/eulinox/

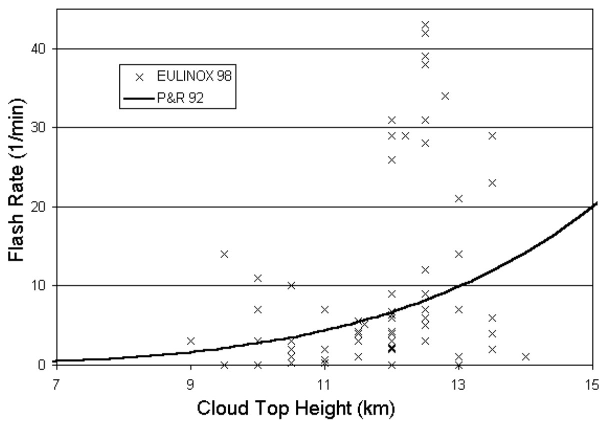

Figure 2. Scatter diagram of total flash rate derived from ITF observations against radar observed cloud tops for different clouds observed during summer of 1998.

4. ACKNOWLEDGEMENTS

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