Calculation of the cloud-to-ground lightning dipole moment and its verification based on radio ELF observations and electric field measurements in VLF range

Thunderstorm Charges and Currents

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We present two methods of the dipole moment calculation of the cloud-to-ground lightning discharges and conclusions derived from the comparison of the two methods.

The first method is based on the recordings of the horizontal magnetic field component of the ELF electromagnetic field generated by atmospheric discharges. The knowledge of the amplitude of the recorded impulse (the magnetic flux density) and the distance from the ELF station (information about discharge location is obtained by the second method) allows calculating the electric dipole moment of the source p_{ELF}. This method was presented by Kulak et al. (J. Geophys. Res., 2010) and used by Nieckarz et al. (J. Geophys. Res., 2011) and Kulak et al. (J. Geophys. Res., 2012).

The second method uses multi-station ground-based measurements of lightning-generated electric field variations for the purpose of the lightning flash location and the analysis of the lightning charge structure. It was applied and described by Krehbiel et al. (J. Geophys. Res., 1979). We used 6 stations called the Local Lightning Detection Network (LLDN) in the Warsaw region during summer 2009. The location of the stations did not change during the measurement period. This method and the data were used in the evaluation of multiple ground flash charge structure and described by Barański et al. (Atmos. Res., 2011). The recorded variations of the electric field together with the time of their occurrence allow calculating the electric charge value and the 3D location for each cloud-to-ground lightning discharge within the region of operation of the LLDN. Based on the calculated z component and electric charge, we have calculated the electric dipole moment p_{VLF}.

In the conclusions we present and discuss the results obtained by the two methods, focusing especially on the negative return stroke (RS) and continuing current (CC) lightning discharges. Initial analysis shows that the correlation between the charge moment calculation (CMC) obtained by the two methods for negative CC and RS is equal to +0.19 and +0.59, respectively. We discuss the reasons for the difference in these two correlation values and possibilities for future research based on simultaneous use of both methods.