Method of calculation of the CMC from the ELF measurements

Having a possibility of multi-site recordings of the (E) field associated with CG flash incidents we can obtain relevant field changes (ΔE) related to such event and characteristic for the particular LLDN station. These E-field measurements together with the knowledge of the position of each measurement station enable us to calculate three-dimensional (3D) charge and its amount that is transported from the charge source to the ground during CG lightning stroke. Hence, we are able to dispose six different E-field records while the number of searched unknown parameters equals only four (x, y, z, Q).

Hence, at the beginning we need to use the following expression for describing the analytical relationship between the ΔEzp拉开 from electrostatic lightning discharge model and set of four searched parameters related also to the fixed 2D location of the particular LLDN station:

$$\Delta E^z = \frac{Q}{\sigma(x - x_0,y - y_0,z)} \left( \frac{2 - z}{x - x_0} + \frac{(y - y_0)^2}{y - y_0} + \frac{z^2}{z} \right)$$

In the next step the appropriate numerical method should be used for final finding of the four searched parameters (x, y, z, Q) properly representing the considered lightning CG stroke. This procedure is based on some maximum likelihood probabilistic methods. It should be noted that the best fit setting of these parameters minimizes a Chi-square function given by the following equation:

$$\chi^2 = \sum \frac{(\Delta E^z - \Delta E^z_{p拉开})^2}{\sigma^2}$$

(1)

where $$\Delta E^z$$ is the standard deviation of the measurement $$\Delta E^z_{p拉开}$$ due to experimental error. As a result of the above calculation, we obtain the station coordinates for each flash. Next we calculate the current moment change (CMCهلب) using the following equation:

$$CMC_{E^z,LF} = \zeta z + Q$$

(2)

At the end, we have identified the type of every event as a return stroke (RS) or a continuing current (CC). The criterion was the rise time (t) of the ΔE-field change signal involved in the considered CMC. If this time was below 3 ms then the flash was identified as the RS, otherwise it was identified as the CC.