Three Years of Lightning Impulse Charge Moment Change Measurements in the United States from ELF Observations

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Abstract

Automated and geographically extensive remote measurements of lightning parameters are a valuable class of tool in lightning research and understanding of the background electromagnetic noise environment. The most widely estimated parameter, aside from location and polarity, is return stroke peak current, which can be remotely estimated from the low frequency radiation [1] from lightning. Another parameter that can be measured from electromagnetic fields long distances from the lightning stroke is charge moment change (CMC), which is the product of charge transfer and the vertical distance over which that charge is transferred (and thus the units are coulomb-kilometers or C km). CMC can be remotely estimated from extremely low frequency (ELF, 3–3000 Hz) radiation [2-5], and has proven important for understanding the origins of lightning-driven high altitude electric breakdown in the form of sprites [6], is linked to heating and damage at a lightning contact point [7], and may also be connected to forest fire ignition [8].

Here we report and analyze multiple years of measurements from an automated, real time lightning Charge Moment Change network (CMCN). The CMCN combines U.S. National Lightning Detection Network (NLDN) lightning event geolocations with extremely low frequency (<1 kHz) data from two stations to provide iCMC measurements across the entire United States. About 5 million lightning events per year are measured by the CMCN. We present the statistical distributions of iCMC versus polarity, including corrections for the detection efficiency of the CMCN versus peak current. For all positive strokes, there is a boundary near 20 C km that separates seemingly distinct populations of high and low iCMC strokes. We also explore the geographic distribution of high iCMC lightning strokes. High iCMC positive strokes occur predominantly in the northern midwest portion of the U.S., with a secondary peak over the gulf stream region just off the U.S. east coast. High iCMC negative strokes are also clustered in the midwest, although somewhat south of most of the high iCMC positive strokes. Among other applications, this network is useful for the nowcasting of sprite-producing storms and storm regions. The presented results summarize and extend those described by Cummer et al. [9].

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