

Occurrence rate of cloud-to-ground lightning flashes as a function of charge moment change

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Lightning is an atmospheric discharge phenomenon and has two prominent types such as Intracloud (IC) and Cloud-to-Ground (CG) discharge. The global lightning activity has been monitored using optical observation from the satellite and sferics observation from the satellite or the ground. The global occurrence rate of lightning was estimated to be 65 flashes/s by Mackerras et al. [1998]. Christian et al. [2003] estimated to 44 +/- 5 flashes/s. These global flash rates include IC and CG. Charge moment change (CMC) of CG discharge can be derived from ELF sferics waveform. CMC distribution of CG discharge has been reported by some previous studies [Fullekrug, 2002; Williams et al., 2007; Sato et al., 2008]. However, they don't derive the distribution less than 500-1000 C-km, which may be attributed to the detection limit of ELF waves. We derive the CMC distribution of global CG discharge for both polarities in the range from almost 0 C-km for the first time. Also we estimate the global CG flash rate.

We have been operating ELF network observation system at 4 sites located globally. The CMC distribution is obtained from three parts based on data set in the system. As a first step, we analyze CG discharges detected at 3 sites for a year in 2004. We derive the CMC distribution only more than 900 C-km. Secondly, we use CG discharges over 10 pT detected at 3 sites for a month on January in 2004 and connect the data detected for a month and the data for a year with range of 900-1000 C-km. In this step, the CMC distribution larger than 300 C-km is surely obtained. Finally, we calculate the CMC distribution less than 300 C-km with respect to each polarity. The distribution of negative and positive CG discharge is calculated referring to figure 1 showed by Cummer and Lyons [2004] and figure 2 of Cummer and Lyons [2005], respectively.

In this way, we derived the global CMC distribution of negative and positive CG discharges, respectively. The global flash rates of -CG and +CG are estimated to be ~17 flashes/s and ~1 flashes/s, respectively. The total global flash rate is ~18 flashes/s. According to Christian et al. [2003], the global flash rate is estimated to be 44 +/- 5 flashes/s and the IC/CG ratio is calculated to be nearly 6:1 in the southern Great Plains, ~2.5:1 at coast based on the CG flash density computed from NLDN. Using these estimates, we calculated the global CG rate of ~6-14 flashes/s. Because the optical observation from the satellite may not detect small CG flashes under thundercloud, we suppose that the global CG flash rate could be larger than ~6-14 flashes/s. We can regard the global CG rate of 18 flashes/s is well reasonable comparing former studies. The -CG/+CG ratios within a range of 0-200 C-km, 200-1000 C-km and 1000-2500 C-km are ~30:1, ~5:1 and ~0.5:1, respectively. These ratios indicate that CG discharge with a smaller CMC occurs more commonly with negative and CG with a larger CMC occurs more with positive.