

Charge moment change distribution of lightning discharge and occurrence probability of terrestrial gamma-ray flashes

Hiromi Kase[1]; Yukihiro Takahashi[2]; Takeru Uno[3]; Akihiro Yoshida[2]; Kozo Yamashita[1]; Mitsuteru Sato[4]

[1] Geophysics, Tohoku Univ.; [2] Dept. of Geophysics, Tohoku Univ.; [3] Tohoku Univ.; [4] Hokkaido Univ.

Terrestrial Gamma-ray Flashes (TGFs) are gamma-ray emitting phenomena associated with lightning discharge. TGFs have a duration time of a few msec and an energy range of a few 10 keV-20 MeV. RHESSI satellite observed over 170 TGFs per year from 2002 to 2005. Although the individual characteristics of lightning associated with TGFs have been investigated to some extent, the relationship between the TGF occurrence and the charge moment change (CMC) of parent lightning discharge has not been examined in global scale.

Tohoku University has been measuring ELF magnetic field in the frequency range of 1-100 Hz at 4 sites located globally. We derived the CMC of lightning discharge generating TGFs from the ELF waveforms and the timings of TGFs listed by RHESSI observation. 174 TGF events were observed by RHESSI in 2004. We analyzed 141 events whose ELF data at 3 stations are available. We estimated lightning location based on the time of arrival method. Detection Limit of the CMC with global uniformity was 187 C-km.

As a first step, we estimated occurrence frequency of global lightning as a function of CMC for the first time. Occurrence frequency is smaller as CMC is larger. Occurrence frequency of global lightning are $1.30 \times 10^9 \pm 5.49 \times 10^4$ per year and $41 \pm 1.14 \times 10^{-3}$ per sec. It in the range of 0-100 C-km, 100-200 C-km are $1.17 \times 10^9 \pm 3.42 \times 10^4$ and $1.16 \times 10^8 \pm 1.08 \times 10^4$. We derived that 90 % of lightning occur in the range of 0-100 C-km. And it larger than 600 C-km is 0.01 %.

We analyzed 141 events observed in 2004 and identified 7 TGFs with ELF sferics. We assume the other 134 TGF events are related to smaller lightning discharge whose CMC are less than the detection limit of 187 C-km. We derived the occurrence probability of TGFs based on the occurrence frequency of lightning discharge as a function of CMC. Relative occurrence probabilities of TGFs in the ranges of 0-200 C-km, 200-400 C-km and 400-600 C-km to that occurrence number of lightning are 0.27 \pm 0.023 %, 1.28 \pm 0.52 % and 1.53 \pm 1.53 %, respectively, assuming the emission cone angle of gamma-ray as 15 deg. Occurrence probabilities of TGFs for positive flashes are 5.4 \pm 0.47 %, 25.6 \pm 10.5 %, and 30.7 \pm 30.7 %, respectively. Although occurrence probability of TGFs in the range of 200-400 C-km is higher than it in the range of 0-200 C-km, we cannot conclude if the occurrence probability of TGFs depends on CMC value of parent lightning due to the limited number of the analyzed events. So we need to analyze relationship between lightning and TGFs for more large number of events.