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Estimation of the global and Asian lightning activity based on the observation of ELF/VLF sferics

Kozo Yamashita^{1*}, Yukihiro Takahashi², Mitsuteru Sato², Fuminori Tsuchiya¹, Hiroyo Ohya³

¹Dept. of Geophysics, Tohoku Univ., ²Dept. of CosmoSciences, Tohoku Univ., ³Engineering, Chiba Univ

In the recent decade, many researchers have been attracted to the investigation of global lightning activity. One of the reasons is the progresses in the observation of global lightning discharges. Measurements of electromagnetic waves radiated from CGs with ground-based systems have been developed drastically.

Electromagnetic wave radiated from cloud-to-ground (CG) lightning discharge is observed as transient waveform called as atmospherics or sferics. Sferics in the Very Low Frequency (VLF: 3-30 kHz) and Extremely Low Frequency (ELF: 3-3000 Hz) bands can be detected at a receiver which is several mega-meters from CGs due to the propagation with quite low attenuation. This long propagation enables us to monitor the global CGs activity only with single or few receivers. Using observed waveform in ELF or VLF range, information not only about the location but also about the electrical properties such as polarity, peak current and charge moment (Qdl) of individual lightning stroke can be derived.

In this study, we developed new algorithm to estimate location and charge moments for relatively small Qdl events ($|Qdl| > 950$ C-km). This method is applied to the magnetic fields data observed in 1-100 Hz range obtained by global ELF observation network (GEON), Syowa station in Antarctica, Onagawa station in Japan, Esrange in Sweden, and Santa Cruz in U.S.A. Making use of the time-of-arrival method, the accuracy of geolocation and detection sensitivity is greatly modified. Thanks to this new algorithm, about a millions of CGs can be analyzed with one month (during January 2004). Global CGs distribution is derived with annual data (from October 2003 to July 2004) and about a million CGs whose Qdl are larger than 950 C-km are obtained. The results show the monthly and seasonal variation of global CGs distribution.

Furthermore, a new VLF observation network (Asian VLF observation network: AVON) is developed to monitor the activity of CGs in Southeast Asia. Observation sites of this system are located at Tainan in Taiwan, Saraburi in Thailand, and Pontianak in Indonesia. In this study, data observed at Tainan station and Pontianak station during three days (from October 13th, 2010 to October 15th, 2010) is used for the initial analysis. Using the waveforms obtained by this network, 1-3 sferics per seconds are geolocated. Median of geolocation error is estimated as 93 km comparing with WWLLN data using about 400 CGs located in the Maritime Continents. Furthermore, charge moment distribution for the CGs of > 200 C-km in the Maritime Continents is derived with a combination of CG locations obtained by AVON and the transient waveform observed by GEON.

In this presentation, we introduce the speculation of new observation network to monitor the lightning activity in Southeast Asia and demonstrate the efficiency of combination of the measurement of ELF sferics and that of VLF ones.

Keywords: lightning, sferics, ELF, VLF