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Lightning Discharge Current Derived from ELF Magnetic Field Waveform Data

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Cloud-to-ground (CG) discharge is one of the types of lightning discharges and has strong peak current and exponential decay current typically. Since it is not easy to predict exact occurrence time and location of CG discharges, the direct measurement of CG discharge current is difficult. It is well known that CG discharges sometimes hit tall towers locating in big cities. Thus, the CG discharge current can be measured by using Rogowski coil, which can sense the induction magnetic field produced by the discharge current flowing at the tower structures. However, such Rogowski coil is generally huge, and the measurement system is expensive. In addition to this, it is not possible to measure the current of CG discharges that occur arbitral time and location though it is possible to measure the current only for the CG discharges that hit the tower equipping the Rogowski coil. Lightning discharges can emit strong electromagnetic waves in the ELF and VLF range. Especially, the wavelength and attenuation rate of ELF waves in the frequency range of 1-100 Hz is extremely long and low, respectively. So, it is possible to monitor global lightning activities even from a single observation site. From this reason, we have installed ELF observation systems recording 1-100 Hz magnetic field waveform data continuously at four observation sites in the world. Using these ELF data, we can detect the transient Schumann Resonance waveforms excited by intense CG discharges, and we can also estimate occurrence time, location, and polarity of these CG discharges in a global scale. In order to examine the ELF waveforms when the CG discharge current was measured, we have compared ELF data obtained at Onagawa observatory with the CG current waveform data measured by a Rogowski coil installed at a tall tower at Mt. Ogami in Japan. We have analyzed the ELF and CG current data obtained in the winter season of 2009. Then, it is newly found that the ELF waveforms are quite comparable to the waveforms of CG discharge current. Since the distance between two observation sites are about 300 km, the ELF waveform measured at Onagawa is supposed to be the induction magnetic field perturbation directly induced by the CG discharge current. Though the absolute values between ELF magnetic field perturbations and the discharge currents are not yet evaluated, this new finding implies that the ELF measurement near thunderstorm must provide a powerful tool to measure discharge current easily and to estimate total charge for arbitrary CG discharges. At the presentation, we will show the results derived from the comparison of the waveforms between ELF magnetic field perturbations and CG discharge currents more in detail, and will discuss the future observation and analysis plans.

Keywords: lightning, discharge current, ELF wave