The Contribution of Lightning and Precipitation Currents to the Global Atmospheric Electric Circuit

Bandholnopparat Kittanapat[1], *Mitsuteru Sato[1], Yukihiro Takahashi[1], Kamogawa Masashi[2]

1. Department of Cosmoscience, Hokkaido University, 2. Global Center for Asian and Regional Research, Univ. of Shizuoka

Thunderstorms and electrified rain/shower clouds are the main current sources in the global atmospheric electric circuit (GEC). These current sources generate the upward current to the ionosphere and maintain the electrical potential gap of ~250 kV between the ionosphere and the Earth' s surface. However, the contribution of the global lightning and precipitation activities to the GEC is still poorly understood due to the difficulty of estimating the occurrence number of cloud-to-ground (CG) and intracloud (IC) discharges. In addition, it is difficult to quantitatively estimate the contribution of the global precipitation current to the GEC due to the difficulty of identifying the precipitation volume and its global distribution. This study aims to investigate the contribution of lightning and precipitation currents to the GEC. First, the global map of the IC/CG ratio (Z-ratio) estimated by the JEM-GLIMS data and the CG lightning data obtained by the WWLLN were combined to estimate the global occurrence number of the IC discharges with the time resolution of 5 minutes and with the spatial resolution of 0.2º×0.2º. Then, the estimated occurrence number of the IC and CG discharges and the precipitation data provided by the global precipitation measurement (GPM) project and the tropical rainfall measuring mission (TRMM) were used as the input parameters in the 3-dimensional model of the GEC, which we have newly developed. In this model, the average column resistance including the influence of the cloud coverage was assumed. Using this model, we estimated the fair weather electric field at the Syowa station in Antarctica, Reading station in UK, and Kakioka station in Japan. It was found that the lightning and precipitation currents in the GEC were ~80 A and ~1200 A, respectively. It was also found that the average fair weather electric field is ~ 70 V/m. The absolute value of the estimated fair weather electric field is almost consistent with the observational data. From these results, the role of lightning and precipitation current in the GEC is quantitatively evaluated, and we found that the upward current to the ionosphere generated by lightning discharges is only 6% while that induced by the precipitation is 94%.

Keywords: Lightning, Global Electric Circuit

