

Contribution of Rainfall and Lightning Activities to the Fair Weather Electric Field Evaluated by 3D GEC Model

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Lightning and precipitation are the main current sources in the global atmospheric electric circuit (GEC). The lightning and precipitation currents maintain the electrical potential gap of ~ 250 kV between the ionosphere and the Earth's surface. However, the contribution of lightning current to the GEC is not well understood due to the difficulty of estimating the global occurrence number of 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 rain volume and its global distribution. The purposes of this study are to estimate the global occurrence number of IC discharges and to investigate the contribution of lightning and precipitation currents to the GEC. Firstly, the global Z-value map obtained by the JEM-GLIMS spaced-based mission and the cloud-to-ground (CG) lightning data obtained by the WWLLN were combined to estimate the occurrence number of the global IC discharges with the time resolution of 5 minutes and with the spatial resolution of $0.2^\circ \times 0.2^\circ$. Then, the estimated occurrence number of the global IC and CG discharges and the precipitation data provided by the global precipitation measurement (GPM) project were used as the input parameters in a 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 total GEC current and the fair weather electric field at the Syowa station on March 16, July 20, and September 29, 2014. It is found that the average lightning and precipitation currents in the GEC were ~ 70 A and ~ 670 A, respectively. It is also found that the average fair weather electric field at the Syowa station 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 current in the GEC is quantitatively evaluated, and we found that the upward current from thunderclouds to the ionosphere generated by lightning discharges is only 9% while that induced by the precipitation is $\sim 91\%$.