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Study of Forecasting the Geostationary Plasma Environment and Satellite Surface Charging by Using a Real-time Magnetosph

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In recent geostationary satellites, the bus voltage has become higher (>100 V) than before, and this induces new types of satellite anomalies, e.g., the sustained arcing caused by surface charging. The surface charging is induced by the hot plasma injected from the plasmasheet in the magnetotail into the geostationary orbit during substorms (so-called substorm plasma injection). Therefore, it is important to study methods of forecasting the geostationary plasma environment (mainly the substorm plasma injection) and the resultant satellite surface charging. A real-time magnetospheric simulation has been routinely carried out on the super computer system at National Institute of Information and Communications Technology (NICT). This simulation calculates the magnetosphere by the three-dimensional magnetohydrodynamic (MHD) method using the real-time solar wind data observed by the Advanced Composition Explorer (ACE) spacecraft at the Lagrangian point L1. Since the solar wind reaches the Earth about one hour after it passes the ACE spacecraft by its average speed, this simulation calculates the conditions of the magnetosphere about one hour before.

To confirm whether the simulation reproduces the substorm plasma injections, We compares the simulation data at the midnight point of the geostationary orbit and the data observed in the night side (MLT: 21-3 hour) by the geostationary satellites of Los Alamos National Laboratory (LANL). As the result, the simulation frequently reproduced the substorm plasma injections about one hour before. That means the enhancements of the simulation pressure were consistent with those of the electron pressure about one hour later. Since the electron temperature is a key parameter for the surface charging potential, we have proposed a new method of estimating the upper limit of the electron temperature from the simulation data. Using the electron temperature, we are able to estimate the worst surface charging potential of the geostationary satellites about one hour before.

To examine how accurately the simulation can forecast the substorm plasma injections, I evaluate the correlation of the pressure enhancements between simulation and observation data by varying time delays and intervals. Here we consider that the substorm plasma injection is generated when the pressure is enhanced over a threshold value. If we take the threshold 0.5 nPa, the forecast accuracy, whether the substorm plasma injection is generated or not, was about 83 % where the delay is 25 minutes and the interval is 55 minutes in the best of all other combinations of delays and intervals.

Keywords: Real-time magnetospheric simulation, Geostationary plasma environment, Spacecraft charging, Space weather