Development of a 3-dimensional global ionospheric electrostatic potential solver using IGRF model

*Takuya Ijuin[1], Akimasa Yoshikawa[2]

1. Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2. Department of Earth and Planetary Sciences, Kyushu University

In order to investigate a magnetosphere-ionosphere-atmosphere coupling system, we developed a global ionospheric electrostatic potential solver that implements the international geomagnetic reference field (IGRF) model [e.g., Alken et al., 2020] as the background magnetic field structure by adopting the magnetic apex coordinates [VanZandt et al., 1972; Richmond, 1995]. By assuming equipotentiality of magnetic field lines, this solver can be reconstructed 3-demensional distribution of electric field and current density after solving electrostatic potentials with 2-demensional elliptic partial differential equations. Input parameters of the solver are the neutral wind that gives dynamo electric fields in the atmosphere-ionosphere coupled system, and distribution of field-aligned currents (FACs) at the high-latitudinal region (Region-1 FAC and Region-2 FAC) that gives boundary condition coupling to the magnetospheric dynamics. At the present stage, we calculate a distribution of conductivities by using NRLMSISE-00 [Picone et al., 2002] and IRI-2016 [Bilitza et al., 2017] for electron number densities and temperatures, and Ieda [2020] for collision frequencies.

Most of conventional potential solver has been adopted uniform and/or dipole magnetic field model. Moreover, ionosphere is regarded as an infinitely thin layer. Such approximation can be validated at high latitude ionosphere. However, at low and mid latitudinal region, there exist big differences between dipole field and realistic magnetic field and 3-dimensional coupling between ionosphere and atmosphere is inevitably required.

The newly developed solver is not only highly suitable for the MHD simulator through the magnetosphere-ionosphere coupling at high latitudes, but also enables us to reproduce the ionosphere-atmosphere coupling dynamics at mid and low latitudes. In this talk, we will introduce the details of the development process of this solver and report the initial results of numerical simulations.

Keywords: potential solver, ionospheric simulation, magnetosphere-ionosphere-atmosphere coupling

