Feasibility study of the global MHD simulation code toward reanalysis of the space weather phenomena

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We hardly obtain the accurate 3-D image of the magnetospheric phenomena only from the observations because the direct (in-situ) observations in the magnetosphere are sparse. Numerical simulations that accurately solve physics's first-principles are powerful tools for studying phenomena occurring in the magnetosphere. Thus, the global simulation of the magnetosphere-ionosphere system can be useful to magnetospheric physics because it produces the magnetosphere's physically reasonable state. For this purpose, we need to confirm the accuracy of the simulation results. This project's final target is to present the reanalysis data in the magnetosphere-ionosphere system from the observation data and the simulation with the data assimilation technique.

There are a few global MHD simulation codes solving MHD equations in the magnetosphere-ionosphere coupled system in the world; for example, the BAT-U-RS [Powell et al., 1999], LFM [Lyon et al., 2004], and GUMICS [Janhunen et al., 2012]. Among them, the global MHD simulation code that named REPPU (REProduce Plasma universe) developed by Tanaka [Tanaka, 2015] has the prominent property; it can reproduce the ionospheric features of the magnetospheric phenomena better than other MHD codes. For example, it reproduces the realistic ground magnetic variations associated with the Sudden Commencement [Fujita et al., 2003], the westward traveling surge associated with the substorm onset [Ebihara and Tanaka, 2015], and the horse-shoe auroras in the northward IMF condition [Tanaka et al., 2017]. Since the ionospheric and ground-based observations are far-more globally arranged compared with the in-situ magnetospheric observations, the REPPU code is suitable to reproduce the appropriate grid-point data of the magnetosphere-ionosphere region by confirming the simulation results in the ionosphere with the observations. However, REPPU code uses free parameters determining the ionospheric conductivities, which can be determined from assimilation between the simulation and the observation. Thus, we try to determine the free parameters from the data assimilation.

Before applying the assimilation technique to the REPPU code, we need to know that the present REPPU code uses limited information of the IMF (only By and Bz) and solar wind velocity (only Vx) because the REPPU has been mainly used for investigating fundamental physical processes of the magnetospheric phenomena. The new REPPU code also incorporates the effect of the magnetic axis's seasonal tilt with respect to the ecliptic plane and that of the magnetic axis's rotation around the Earth's rotation axis. NICT first made this improvement for the operational space weather forecasts, and we made a new REPPU code independently of NICT to obtain the code used for the assimilation study.

As the first step toward the assimilation study based on the improved REPPU code, we compare the simulation results based on the non-assimilative parameters determined empirically and the superDARN potential data. If the comparison shows considerably good correspondence between the simulation results and the observed one, we can consider that the improved REPPU code is affordable for the data assimilation. The results will be open in the talk.

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