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Studies of geospace environment modeling by the GEMSIS project

Takashi Kikuchi[1*], Satoshi Masuda[1], Kanako Seki[1], Yusuke Ebihara[2], GEMSIS Group[1]

[1]Solar-Terrestrial Environment Laboratory, [2]Institute for Advanced Research

We started the research program: GEMSIS (Geospace Environment Modeling System for Integrated Studies) in 2007 to build a geospace model that matches ground-based and satellite observations. Research activities are carried out by three subgroups: GEMSIS-Sun, -Magnetosphere and -Ionosphere, each focusing on fundamental issues in individual research field. Below are summarized research activities carried out by the subgroups during the GEMSIS phase 1 (FY 2007-2009).

[GEMSIS-Sun]
(Team members: Satoshi Masuda, Takashi Minoshima, Yoshizumi Miyoshi, Kanya Kusano, Satoshi Inoue)
In Phase 1, the main goal of GEMSIS-Sun was to understand particle acceleration mechanisms in solar flares. To achieve this, we developed a numerical model of energetic particles with the drift-kinetic Vlasov equation. This code calculates the time-evolution of the particle distribution function with actual coronal parameters and it provides us with useful information to understand the particle acceleration mechanisms. In addition to this, GEMSIS-Sun carried out the research on active phenomena in the solar corona through data analyses based on multi-wavelength observations.

[GEMSIS-Magnetosphere]
(Team members: Kanako Seki, Yoshizumi Miyoshi, Sinji Saito, Yukinaga Miyashita, Takanobu Amano)
Aiming at understanding the dynamics of the inner magnetosphere during the geospace storms, the GEMSIS-Magnetosphere working team has addressed the development of new physics-based models for the global dynamics of the ring current (GEMSIS-RC model) and radiation belt (GEMSIS-RB model). Integrated data analysis studies on such topics as supply mechanisms of ring current ions and relativistic electron accelerations are also conducted using various types of geospace observations from space and from the ground. Some results are applied to studying the forecasting of radiation belt variation.

[GEMSIS-Ionosphere]
(Team members: Yusuke Ebihara (Institute for Advanced Research, Nagoya University),Takashi Kikuchi, Masaaki Ieda, Yasutaka Hiraki, Atsuki Shinbori, Tomoaki Hori, Nozomu Nishitani), (Collaborators: Tomoyuki Higuchi (The Institute of Statistical Mathematics), Genta Ueno (The Institute of Statistical Mathematics), Shin-Ichi Ohtani (Johns Hopkins University, Applied Physics Laboratory)
During magnetic storms, the ionosphere is in a high voltage state caused by an excess input of electromagnetic energy from the magnetosphere. In phase 1 of the GEMSIS-Ionosphere project, the primary goal was set to model the electric potential for the purpose of understanding the Sun-Earth system. Because of irregularly distributed observatories and insufficient number of them, it has been a challenging work to reconstruct the electric potential distribution. We initiated two

different challenges. One is an inductive scheme using data from the SuperDARN radars and ground magnetic fields. The other is a deductive scheme by applying Ohms law for given electric currents flowing along a field line (field-aligned current) and the ionospheric conductance. One of the advantages of our deductive scheme is to solve the potential in the whole sphere under the realistic geomagnetic field. We developed a realistic model of the large-scale field-aligned current on the basis of 190,000 data sets of field-aligned current observations obtained by the DMSP and DE2 satellites. The data were sorted by the solar wind condition and tilt angle, providing realistic field-aligned currents having sharp boundaries. Data analysis efforts have also been made in terms of quantitative evaluation of transmission of electromagnetic energy, auroral breakup and magnetotail reconnection during substorms, inner magnetosphere-ionosphere coupling, and magnetosphere-ionosphere coupling system.

Keywords: Geospace modeling, Integrated studies, Solar flare particles, Storm ring currents, Radiation belt particles, Ionospheric electric potential