§26. Real-Time Earth Magnetosphere Simulator with 3-Dimensional MHD Code

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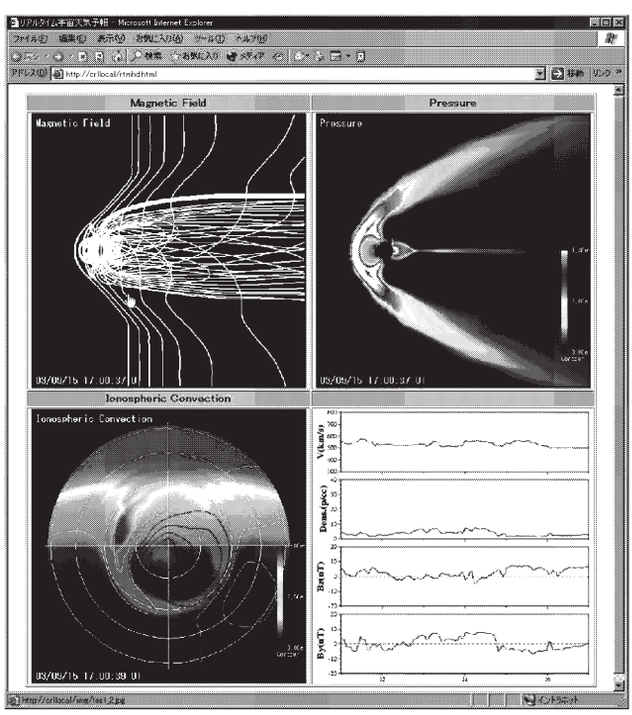
We developed a real-time numerical simulator for the solar wind-space-magnetosphere-ionosphere coupling system, adopting the three-dimensional (3D) magneto-hydrodynamical (MHD) simulation code developed by Tanaka[1]. By using the real-time solar wind data, which is available from the ACE spacecraft every minute, as the upstream boundary conditions for density, temperature, flow speed, and interplanetary magnetic field (IMF), our MHD simulation system can numerically reproduce the global response of the magnetosphere and ionosphere at the same time as in the real world. We achieved real-time 3D simulations of the solar wind-magnetosphere-ionosphere coupling system with a 44x56x60 mesh size by optimizing the parallelization and vectorization of code, and by adapting High Performance Fortran (HPF) language with eight CPUs on a super computer system located at the National Institute of Information and Communications Technology (NICT). We adopted observed ACE solar wind data as upstream boundary conditions to obtain simulation results close to the real-time magnetosphere, We visualized the simulation data at the same time as calculation using RVSLIB and the visualization data was renewed every minute. The main purpose of the Space Weather Forecast Project was to predict when and how disturbances in the space environment occur, how they develop, and to what extent they may cause damages to human systems. Our real-time MHD simulator can calculate the dynamical response of the magnetosphere and predict when geomagnetic disturbances occur and to what extent they develop. Fig.1 is a part of web page. Left top panel shows magnetic field lines, right top panels does the plasma pressure, left bottom panel does ionospheric convection (white and black line) and electrical potential, and right bottom panel does input solar wind data for most recent six hours. We showed AE indices obtained from real-time global MHD simulation ahead by about an hour from the actual time, indicating the activities of the magnetosphere about an hour in advance. The plasma temperature and density in the geo-stationary orbit are plotted in about an hour advance as an index of magnetopause crossing and as input data for the simulation model of satellite charge. We expect to be able to predict the timing of sudden commencements and occurrences of the geomagnetically induced current associated with ground-based magnetic field disturbances for practical purposes. Furthermore, if electric field distribution in the ionosphere is obtained using our simulation output data, it can be used to predict GPS positioning errors, and might possibly be applied to a flight control system. Our real-time simulation is expected to become an essential approach to forecasting space weather. Our MHD simulation code[1] could reproduce the magnetosphere activities with appropriate accuracy. We also confirmed that this code could continued running unless the solar wind conditions were intense, eg., Bz < -20 (nT). It should be noted that the intensity and region of the conductivity could be simulated qualitatively, but that they are not in agreement with ground based observation completely. The limited number of grids is one reason, and this is what should be overcome in future.

Figure1



References

1) Tanaka, T.: J. Comp. Phys., 111,(1994)381.

2)Den, M., et al.: Space Weather, 4, S06004 (2006) doi : 10.1029.