Virtual Earth Magnetosphere System: A new research environment for Earth and space science based on VR system and network database

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In the present study, we propose a Virtual Earth Magnetosphere System (VEMS), which is a new research environment with integration of observation data analyses and computer simulations.

The VEMS is constructed on programmable and interactive visualization tools which work on personal or higher computers. The visualization tool provides with various kinds of visualization environments, such as drawing contour lines, streamlines, volume rendering, orthogonal slice and other visualizations. An interactive function is also required in this system, such as changing the scale, rotating and translating.

The axes in the VEMS are given in form of space (x, y, z) and time (t). Therefore, the VEMS provides with a 3-dimensional visualization environment dependent on time.

In the present study, we construct the VEMS on a 3-dimensional visualization tool, Application Visualization System AVS/Express Developer (hereafter AVS). The AVS, which has a programmable, interactive, visual environment and time-dependent visualization, can visualize a lot of data simultaneously without any recompilation.

As a first step of the VEMS construction, we set the Earth sphere with coastlines at the center of viewer window in the AVS. Then, we draw magnetic field lines in the 3-dimensional space, which is derived from either observation-based models or computer simulations. Herein we adopt the magnetic field data which is obtained from a global MHD simulation. The setting of the Earth sphere and drawing of magnetic field lines are fundamental steps, therefore common for the VEMS. On the next step, we customize the VEMS for our individual research purpose. We map a lot of observation data and computer simulation data depending on the target of phenomena.

The VEMS must provide comprehensive research environment for Earth and space science researchers to achieve new scientific findings. Since the VEMS has time axis, we can investigate time-dependent behaviors of the Earth magnetosphere. We can also examine the Earth magnetosphere at the period when researchers are interested in. For example, in the present work, time sequential aurora image data could be mapped on an assigned time. This visualization is present as long as data exists; if the data file does not exist during this period, the aurora image does not appear.

This system also provides environment to study correlations between magnetospheric events since the VEMS can visualize a variety of data simultaneously. In the present study, for example, we attempt to identify the location of AKR using the VEMS. It is believed that, when the intense aurora breaks up, auroral kilometric radiation (AKR) is generated on the magnetic field lines the foot points of which the intense aurora area is located on the Earth surface. We could successfully identify the time-dependent location of the AKR source region in the 3-dimensional space.

Another application of the VEMS is to obtain initial conditions for secondary computer simulations; the computer simulations are performed either on the VEMS or super computers. For example, in the present work, we obtained the AKR source region as an initial condition for study of the propagation from the source region. Then, we can trace the AKR ray-paths in the system using the models of plasma density and magnetic field lines.

One of the developments of the VEMS is its application to Virtual Reality (VR) systems. Since the VEMS is visualization system in 3-dimensional space, VR system is better than computer display to experience the Earth magnetosphere. Another development of the VEMS is its connection with STARS network database system. If we use STARS, we can download observation data files through network and can plot any data on the VEMS.