

RESEARCH ENVIRONMENT AND INFORMATION SERVICE OF SPACE WEATHER CLOUD

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ABSTRACT

For researches and information services of space weather, it is important to establish a comprehensive system which enables us to analyze observation and simulation data in an integrated manner. For this, we constructed recently a new computing environment called the “Space Weather Cloud Computing System” of the National Institute of Information and Communications Technology (NICT). Now, the Space Weather Cloud contains a high performance computer, a distributed mass storage system using the Grid Data Farm (Gfarm) technology, servers for analysis and visualization of data, a job service based on the RCM (R&D Chain Management) System, servers for the Solar-Terrestrial data Analysis and Reference System (STARS).

Keywords: space weather, cloud computing system, Gfarm, JGN-X, STARS

1 INTRODUCTION

Space weather is the concept of changing environmental conditions in the space from the Sun's atmosphere to the Earth's atmosphere. Space weather variations are affecting human-made infrastructures such as artificial satellite, electric power grids, Global Navigation Satellite System (GNSS), and HF radio communication (Marubashi, 1998; Lanzerotti, 2001). It is difficult to cover whole of this vast space only by existing observational framework. We need a new environment to analyze both observation data and simulation data in an integrated manner (Baker & Barton, 2008; Rankin, 2011). Adding this, the amount of data on space weather has been increasing year by year because of a remarkable increase of new data from ground-based observations, observations using spacecraft, and simulation models. We also need such a computing environment to process these big data. In order to cope with this situation, a new platform called the ‘Space Weather Cloud Computing System (hereafter Space Weather Cloud)’ has been constructed in the National Institute of Information and Communication Technology (NICT). We report details of this system and show examples of its applications.

2 OUTLINE OF SPACE WEATHER CLOUD COMPUTING SYSTEM

Figure 1 shows the general concept of the ‘Space Weather Cloud’ of NICT. The system is composed of a super computer, a distributed mass storage system basing on the Grid Data Farm (Gfarm) technology (Tatebe et al., 2001), servers for analysis and visualization of data using IDL (Interactive Data Language) and AVS (Advanced Visual Systems), a job service component based on the R&D Chain Management (RCM) System, a tool for data plot and analysis called Solar-Terrestrial data Analysis and Reference System (STARS), servers to automatically collect metadata (NICTY), streaming servers, Tiled Display Wall (TDW), etc. The Space Weather Cloud can be accessed via networks such as the Internet and the New Generation Network Testbed (JGN-X, <http://www.jgn.nict.go.jp/english/index.html>) which is a new generation network developed by NICT.

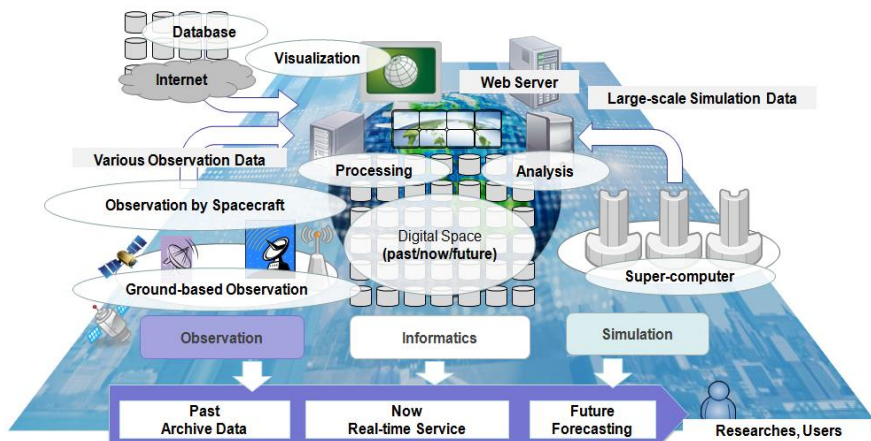


Figure 1. A conceptual diagram of the Space Weather Cloud of NICT.

3 INFORMATION SERVICES OF SPACE WEATHER CLOUD COMPUTING SYSTEM

The Space Weather Cloud provides various Web-based services for general users. Figure 2 shows our e-SW Web page (<http://e-sw.nict.go.jp/>), which is the portal of information services of the Space Weather Cloud. Several examples of the services of the Space Weather Cloud are shown in the following sections. Several contents have Japanese and English explanations. We will increase English contents of our services in near future.



Figure 2. The e-SW Web page, which is the entrance of services on the Space Weather Cloud.

3.1 Space Weather Board

The space weather board, shown in Figure 3, is a tool to enable users to customize space weather data. There is a variety of space weather users such as, satellite operators, users of Global Navigation Satellite System (GNSS), and operators of HF communication. This board will be useful for them to customize the display of plots and images on the screen, according to their individual purposes. By using this board, users can select data sets from the component list and arrange them as they want. These users can store their own arrangements in the server for their convenience.

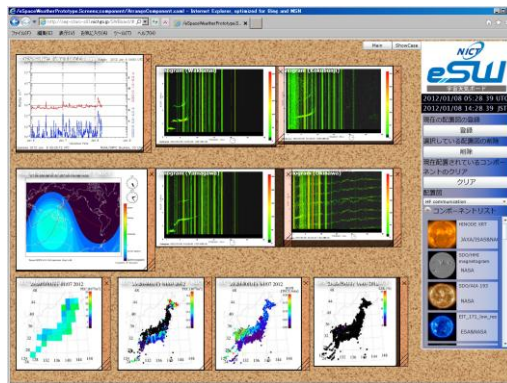


Figure 3. An example of the Space Weather Board Web page (customized to see ionospheric data).

3.2 3D View of Real-time Space Weather Simulation

NICT developed magneto-hydrodynamic simulation codes covering the region from the solar corona to the terrestrial ionosphere (Nakamizo et al, 2009; Den et al., 2006; Shinagawa, 2011). We run the simulation in a real-time basis. The results of the simulations are sorted and displayed by the 3D-visualization system of the Space Weather Cloud. Users can access real-time and archived data through the 3D view Web page.

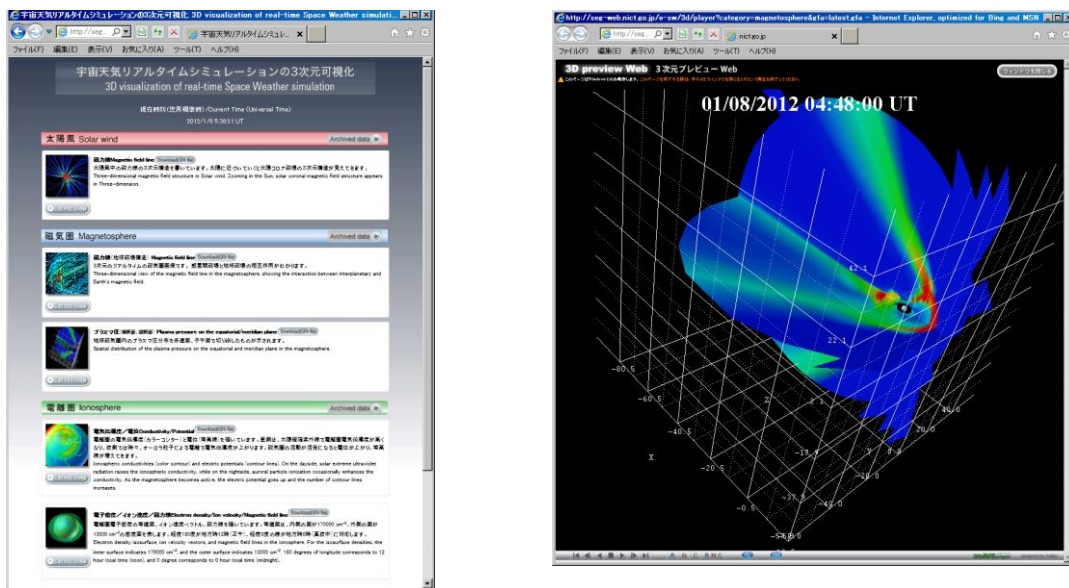


Figure 4. The Web-page of 3D view of real-time space weather simulation (left panel) and an example of the 3D view of the terrestrial magnetosphere (right panel).

3.3 Weekly Space Weather News

The concept and terminology of space weather are unfamiliar to general public. To improve this situation, we have started a movie program on the weekly summary of current conditions of space weather, under the name of 'Weekly Space Weather News.' It is delivered by streaming from the server of the Space Weather Cloud. Brief explanations of technical terms of space weather are also provided to help understanding the contents. Examples of scenes of the program are shown in Figure 5.



(a) Opening of 'Weekly Space Weather News'



(b) Outline of space weather of the week



(c) Detail information of space weather of the week



(d) Explanation on terminologies of space weather

Figure 5. Scenes of 'Weekly Space Weather News.'

4 SUMMARY

The data volume of space weather is increasing year by year by adding new data from many satellites, ground-based observational networks, numerical simulations etc. It is urgent to construct a computing platform to efficiently process both observation and simulation data together (Baker & Barton, 2008; Hey et al., 2009; Rankin, 2011). Our cloud computing system will be an example to meet the demand, and it is expected that new knowledge on the space weather will be extracted from our data intensive studies using the Space Weather Cloud.

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