Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

MGI33-P01 Room:Convention Hall Time:May 22 17:15-18:30

Visualization technique of NICT Science Cloud using large quantities of magnetosphere Global MHD simulation data

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We will present a new visualization technique by using large quantities of simulation data. The time development of 3D object with high temporal resolution provides the opportunity of scientific discovery. We visualize large quantities of simulation data using visualization application 'Virtual Aurora' based on AVS and the parallel distributed processing at 'Space Weather Cloud' in NICT based on the Gfarm technology. We show a visualization of dayside reconnection using a system of magnetic field line tracing in order to understand magnetosphere convection. On the other hand we try to make a computer graphics of magnetosphere dayside reconnection for outreach activities. In this lecture, we introduce our recent visualization for science and outreach activities.

Keywords: Visualization, NICT Science Cloud, Big simulation data, Magnetosphere

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Information services and data analysis using space weather cloud

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It is called space weather that variation of space environment affects on artificial satellites, power grids, Global Navigation Satellite System (GNSS), and so on. It is difficult to cover only for observations to cover vast domain from the Sun to the Earth. Therefore, we need a computing environment where observation data and simulation data can be analyzed together. Moreover, amount of data which we need to handle has increased every year. To resolve those situation, National Institute of Information and Communications Technology (NICT) has developed ”Space Weather Cloud computing system” which consists of a supercomputer, large storage system based on Grid Data Farm (Gfarm) technology. There are several information services using Space Weather Cloud. A web application called ”Space Weather Board” enables users to make their customized data arrangement. Three-dimensional visualization of result of real-time space weather simulation is provided from a web server in the Space Weather Cloud. A movie program on weekly summary of space weather called ”Weekly Space Weather News” is provided by a streaming server of the Space Weather Cloud. We will also report an example of analysis of the real-time simulation data of Earth magnetosphere and observation data using the Space Weather Cloud.

Keywords: cloud computing system, space weather, informatics

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A Virtual Observation Network System for Global Ground-Based Observatories

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As our ground-based global observation technology develops, the number of the observatory is getting larger. As the number increases, both maintenance of the observatories and data transfer gets harder. Most of such data transfer systems are equipped on the Internet. However, since the QoS of the Internet is not ensured in general, we need to monitor the data transfer manually, and it is one of the reasons of difficulty in operating our global observation systems.

For instance, the number of NICT space weather observatories, domestic and international, is already more than 20 and the sort of the transferred data is more than 40. The condition of the data transfer networks depends on the location of the observatory: we need to collect observation data even from the worst network condition observatory.

In order to unify such data collection networks, we have been developing a virtual observation network system for global ground-based observatories. We also equipped this network system on the small PC server, and deployed over 8 observatories of NICT space weather. The network technology used in the system is not new, but the system so far works continuously and successfully. The collected data are saved and managed in a distributed storage in the OneSpaceNet (a science cloud in NICT).

Herein we discuss the concept and design of the virtual observation network system for global ground-based observatories and demonstrate how it works.

Keywords: Earth Observation, virtual network, cloud computing

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Sharing of knowledge for collaborative analysis in the Solar-Terrestrial data Analysis and Reference System [STARS]

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Cross-sectional data analyses have become important for further understandings of Solar-Terrestrial Physics (STP) fields. There are variety types of observation target in STP fields, for example, the sun, solar wind, interplanetary magnetic field, the magnetosphere and the ionosphere of the earth. There are variety types of observation technique, for example, in-situ observations by spacecrafts, remote sensing by spacecrafts, and ground-based observations. It is hard for one researcher to be familiar with all of the observations. Usually, one researcher is a specialist in one or some types of observations and is not a specialist in the other observations. Therefore, cross-sectional data analyses require cooperative works by researchers whose own specialties are different from each other. If the knowledge and the experiences of each researcher are exchanged with each other, these exchanges boost to do collaborative analysis.

The Solar-Terrestrial data Analysis and Reference System (STARS) is a system, which realizes cross-over search and integrated analyses with combined plot of STP fields. The STARS has two special functions for cooperative works. One is Stars Project List (SPL). The other is event list database. Sharing of the SPL is useful for interactive information exchanges between researchers. The event list database provides users of the STARS crossover hints for recognizing typical STP phenomena.

Stars Project List (SPL)

After a user on the STARS downloads several types of data and makes a combined plot, the information about the downloading data and the information about plotting can be stored in an XML file. The XML file is called as Stars Project List (SPL). Because an SPL contains detailed information of a combined plot, not only the user who made the combined plot but also any other users can easily make the same plot without checking data file download options and plotting options. Further, any user can modify the combined plot by adding data file or by changing plotting options.

One of the interactive ways of sharing SPL in the collaborative analysis between researcher A and researcher B is as follows. (1) The researcher A downloads data AA which the researcher A is familiar with. (2) The researcher A makes a plot about data AA and saves SPL#1. (3) The researcher A sends SPL#1 to the researcher B. (4) The researcher B receives SPL#1. (5) The researcher B easily makes the same plot based on the information stored in the SPL#1 and views the plot. (6) The researcher B downloads data BB which the researcher B is familiar with. (7) The researcher B modifies the original plot by adding data BB to the original plot and saves SPL#2. (8) The researcher B sends SPL#2 to the researcher A. (9) These processes are repeated interactively until a final combined plot is completed.

Event list database

When one researcher finds an interesting variation of typical phenomena in the plot, then the researcher recognizes it as an event. The researcher can register the event in the event list database in the STARS. Each event is described in XML. Each XML file contains detailed information (title, start/end time, comment, name who registered the event etc.). When a variety of the researcher register the events based on their own specialties, the event list database becomes rich and covered fields increase. The event list database is, in some sense, 'accumulated knowledge of specialists'.

Any user of the STARS can know the events which have been already registered by other users as well as by oneself by using quick viewing tools. It means that the accumulated knowledge of specialists is 'shared' by all of the STARS users.

In collaborative analysis, event list database provides all participants crossover hints for recognizing typical occurrences of STP phenomena.

Keywords: XML, cross-sectional studies, cooperative work, common use

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ERG-Science Center Project: Importance of the integrated data analysis system for multi-kinds of geospace data

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Recent geospace sciences use multi-kinds of data from satellites, ground, and also simulation data for integrated studies. Although each data covers some limited areas and periods, the analysis by integrating many data sets provides better perspectives of the phenomena and enhances comprehensive understanding. However, the integrated data analysis is not always easy, because the data-handling of different data sets requires tremendous effort and time. The self-describing data files and the integrated data analysis tools are essential for seamless integration for data-sets. Today, the CDF (Common Data Format) developed by NASA/GSFC is a standard data format of space science data, and many CDF files of satellite and ground-based data are archived, which free the researchers from the time-consuming working for data-handling. Moreover, the THEMIS data analysis suite (TDAS) is powerful software to process the CDF files. Users who are not familiar with the data can easily use different kinds of data sets. Considering the recent development of the CDF and TDAS in the space physics community, the ERG Science Center team has been preparing the CDF files of the ERG project data and developing the plug-in tools for the TDAS. Some of the ground magnetometer data, SuperDARN HF radar data, VLF, and CNA data can be analyzed with TDAS. We also develop the web analysis toll (ERG-WAT) that is a web-based quick-look and simple analysis system. In this talk, we report the current status of our activity and demonstrate how the plug-in tool loads and visualizes the ERG-related data.

Keywords: ERG-project, integrated data analysis tool, metadata, geospace science

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Study on a new algorithm on similar data retrieval from plasma wave spectrum observed by solar-terrestrial satellites

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In recent years, the total amount of data measured by scientific spacecraft has drastically increased as the resolution of each instrument becomes higher. It is a difficult task to find some interesting phenomena in it. It is necessary to develop a new computation method for automated classification and data analysis. There are two issues to be solved for similar data retrieval. One is to develope a method which can be applied to different types of satellite data, and the other is to increase efficiency of the retrieval method. In this study, we show how to solve these two problems, and we applied our proposed method to the plasma wave data measured by WFC-H, and WFC-L onboard KAGUYA and MCA onboard Akebono for evaluation.

First, in order to reduce the amount of data retrieved, we need to define the characteristic parameters of the data. In general DCT or Wavelet is applied for natural picture to extract the characteristic quantity. In the present study, we applied DCT transform to the spectrogram data and extracted DC and low frequency part of AC components as characteristic quantities. It is noted that the characteristics of spectrogram of the plasma wave measured by solar-terrestrial satellites are different from the ones of natural image data, that is, the transformed components of the spectrogram using DCT are mainly left in the first row and first column.

Faced with a large number of observation data, retrieval using walkthroughs is impossible. In order to improve the efficiency, we adopted multi-dimension index as a solution. The multi-dimensional index is mainly used for similar image retrieval, to reduce computation time for retrieval from large amount of multi-dimensional characteristic parameters. In our study we use the algorithm named SR-Tree, which combines the advantages of the S-Tree and R-Tree. In the presentation, we introduce the way to put SR-Tree in the retrieval of satellite spectrum data.

Keywords: plasma wave, similar data retrieval, database, scientific satellite

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Development of a package of correlation analysis and statistical tests for various solar-terrestrial environment data

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The Earth's upper atmospheric variations are generated under both the influences of the lower atmosphere and solar activity. Then, in order to clarify the generation mechanism of the atmospheric variations, we need to perform the integrated analysis of various observation data. However, various ground-based observation data and their databases of the upper atmosphere have been maintained by each institution that conducted the observations so far. Therefore, when researchers try to perform the comprehensive analysis of several kinds of observation data, there have been several problems of data search, acquisition, and analysis.

In order to solve the above problems, the "Inter-university Upper atmosphere Global Observation NETwork: IUGONET" project was initiated in 2009 by the five Japanese universities and institutes (NIPR, Tohoku University, Nagoya University, Kyoto University, and Kyushu University). This project is proposed to construct a metadata database of observation data maintained by each institution and to develop the IUGONET Data Analysis Software (UDAS). This software is a plug-in software for THEMIS Data Analysis Software suite (TDAS) written in IDL, and can easily display several time-series plots of various observation data such as geomagnetic field, aurora, and neutral wind.

With the aid of the IUGONET metadata database and the analysis software (UDAS), we can access easily the data or database maintained by each research institution, and can perform the comprehensive analysis of various data sets in different fields. The UDAS has a lot of tools to display time series plots of various observation data, but does not include statistical test tools for correlation analysis of a pair of observation data. In this study, we aim to develop a package of statistical tests to judge whether the correlation analysis results are statistically significant or not. In the future, we plan to implement the statistical test package into the IUGONET analysis software (UDAS).

The statistical test package consists of five parts: First is calculation of cross correlation and decorrelation test for the value of correlation coefficient, second is power spectrum and coherence analyses and test for the coherence value, third is anomaly analysis to investigate the deviation from the reference variation with the dominant frequency in both the data determined from the coherence calculation, fourth is to judge whether the distribution of two data is the same or not, and fifth is to check whether observation data has significant trends (decrease or increase) or not. Due to changes of the observation condition or failures of instruments, observation data generally contain missing values and the time interval is not necessarily constant. Therefore, this package of statistical test includes several data processings such as linear interpolation and exclusion of missing value, in order to align the number of two subject data points.

To evaluate the effectiveness of our developed statistical test tools in this package, we applied the trend test to the long-term variation in the altitude distribution of meteor echoes obtained from the meteor wind radar at Kototabang. This instrument has been operated for a long period from November 2002 to present by the Research Institute for Sustainable Humanosphere, Kyoto University. As a result, the altitude of the maximum meteor echoes does not show a significant trend (decrease or increase) between 2003 and 2011 on the basis of the trend test at significant level of 1%. This result suggests that the altitude distribution of the density of the upper atmosphere around the meteor height almost do not change during this period. Therefore, it can be concluded that global warming is not recently in progress.

Keywords: IUGONET, analysis software, correlation analysis, statistical test, meteor, trend

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Data management for the International Polar Year 2007-2008

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Diverse data accumulated by many science projects make up the most significant legacy of the International Polar Year (IPY2007-2008). The Polar Data Center (PDC) of the National Institute of Polar Research (NIPR) has a responsibility to manage these data for Japan as a National Antarctic Data Center (NADC) and as the World Data Center (WDC) for Aurora. During IPY, a significant number of multidisciplinary metadata records have been compiled from IPY- endorsed projects with Japanese activity. A tight collaboration has been established between the Global Change Master Directory (GCMD), the Polar Information Commons (PIC), and the newly established World Data System (WDS).

Keywords: International Polar Year, National Antarctic Data Center, Data Management, Metadata Portals, Polar Information Commons, World Data System

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Various applications of Markov random field model to earth sciences

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Recent development of measurement and observation techniques makes it possible to obtain a large amount of spatial and temporal data sets in earth sciences. However, it has still been difficult to extract geological and geophysical information, because available data usually have large noise and uncertainty. Therefore, the statistical analyses of data sets are essential for the objective and quantitative geological and geophysical interpretation. The Markov random field (MRF) model is a Bayesian stochastic model using a generalized form of Markov chains that is often applied to the analysis of images, particularly in the detection of visual patterns or textures (e.g., Geman and Geman 1984). The MRF model assumes that the spatial or temporal gradients of physical properties are relatively small compared with the measurement noise and analytical uncertainty. The MRF model acts as a low-pass filter to extract accurate spatial or temporal variations of physical properties. By the Markov chain Monte Carlo (MCMC) approach, this model can determine the appropriate bandwidth from the statistical properties of the observed data. Recently, several studies have used the MRF model to extract the true physical properties from noisy observational data sets, for example, in brain science (e.g., Watanabe et al. 2009). By the Bayesian probabilistic approach and their flexible formulation, the MRF model has a potential to deal with non-statistical uncertainty. Moreover, it can incorporate prior information into analyses quantitatively. We apply the MRF model to two inversion problems in earth sciences: one is a pressure-temperature inversion from compositional data of zoned minerals (Kuwatani et al., in press), and the other is an inversion of fluid distributions from observed seismic velocity structure. In this presentation, we will discuss effectiveness and broad applicability of the MRF model in earth sciences.

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Simulation and Visualization of Liquid Gallium Convection

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In order to investigate the effect of magnetic field and rotation to liquid metal convection, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and Hokkaido University have collaboratively performed laboratory experiment for liquid gallium convection. Since the opacity of liquid gallium is high enough to prevent us from using optical measuring equipments, Ultrasonic Velocity Profiling (UVP) technique is employed for the experimental measurement. However, since the UVP can provide us only the information of one-dimensional distributions of fluid velocity, we have no means of studying three-dimensional spatial structures of magnetic and velocity fields which are essential for getting the convective properties.

In this work, we made a complemental numerical study, with using Earth Simulator 2, on liquid metal convection which can reproduce the laboratory experiment. In addition, for the multilateral and multidimensional analysis on the simulation data, we developed an original visualization software named ”Gallium Field Visualizer (GFV)”. The GFV visualization enables us to study three-dimensional structures of the liquid metal convection, which can not be obtained in laboratory experiments.

As the numerical setting, we adopted a rectangular box with the same aspect ratio as the vessel used in the laboratory experiment and analyzed the thermal convection for the following three models: i) the model with no magnetic field and no rotation, ii) the model only with magnetic field, and iii) the model only with rotation. In the model i), we confirmed that the convective structure is gradually changed from the coherent one to the turbulent one with the increase of the Rayleigh number for the system. In the magnetized model ii), which has almost the same initial setting as the actual laboratory experiment, we found the formation of the convective roll structure which was discovered in the experiment. Furthermore, the GFV visualization yielded additional findings, that is the helical flow along the convective roll and the concentration of magnetic fields by the convective conversing flow. For the model iii) which precedes the laboratory experiment, the convective roll breaks up into the smaller scale columnar vortices aligned with the rotation axis with the increasing rotation velocity. When applying the particle tracer function installed in the GFV, we found the helicity reversal in the vortex column between upper and lower portions of the simulation domain.

The numerical simulation and three-dimensional visualization of the liquid gallium convection could provide us not only the information complemental for the laboratory experiment, but also the new findings which might serve as guides for future experiments. This work demonstrates that the collaborative research in simulation, 3D visualization and laboratory experiment should promote further understanding of the liquid gallium convection.

Keywords: MHD, Numerical Simulation, Scientific Visualization, Liquid Metal Convection, Geodynamo

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Visualization Software for Immersive Virtual Reality Environment based on VR Juggler

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To analye large scale 3-dimensional data, the modern virtual reality (VR) technology will play important roles in future simulation studies. Various VR visualizations programs have been developed to date, including our original VR visualization software VFIVE. However, almost all of the previous VR software are based on CAVElib which is a de facto standard commercial library for VR environments. To overcome practicall difficulties of CAVElib, we are developing a new visualization software based on VR Juggler which is an open source free software libray, instead of CAVElib. Our recent development of new VR visualization software based on VR Juggler that will replace VFIVE will reported in the talk.

Keywords: visualization, virtual reality, CAVE, VR Juggler

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A proposal of new visualization style: Interactive analysis of multiple movie files with fixed view points

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A challenge in supercomputer simulations is the difficulty of visualization which is usually applied as a post process, after the simulation.

Data size, data complexity, and data transfer time are rocket up as the scale of a simulation grows.

To overcome the difficulties of the post-process visualization, we propose a new visualization style.

This is a kind of real time visualization in which visualizations are applied in the simulation time on the same computer, which means there is no need of the post process for the visualization.

However, a serious problem of the real time visualization method is that you cannot interactively change the viewpoint or visualization parameters of the output images or a movie.

To resolve this, we propose to place thousands (or millions in future) of view points, surrounding the target simulation region.

Each camera has multiple visualization parameters and therfore produces multiple visualization movies from the view point, in accordance with the advancement of the simulation time.

The output of simulations in this visualization style are thousands to millions of movies with the size of order of TB, rather than raw numerical data of the size of order of PB.

To analyze the output data, a special ”movie player” is required that can play a movie, extracting proper sequence of images from the thousands of movie files.

The player should be able to interactively analyze the data by smoothly changing the virtual view point, to realize smooth rotation or zooming.

To demonstrate this new visualization style, we have developed prototype programs and applied them to a simulation data of seismic wave propagation by Prof. Furumura (U. Tokyo).

Focusing the simulation region, 130 camears are placed on a surrounding spherical surface with the Yin-Yang grid point distribution.

We can smoothly, or interactively, see the wave propagation process from any position among 130 viewpoints by smoothly changing the viewpoint by typing a key on the keyboard.

Keywords: data visualization

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Spatio-temporal modelling of Vegetation Index using MapReduce and Hadoop

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Aiming at constructing a large-scale spatio-temporal data mining system in the Earth Science filed, MapReduce and Hadoop, which is a framework for distributed data system, was examined. Extraction of time series data from a GIMMS dataset (images of vegetation indices) and temporal modeling using logistic function via ML method was implemented on Hadoop and MapReduce and its scalability was examined.

Keywords: data mining, Hadoop, MapReduce, GIMMS

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Evaluation of uncertainty using Evidential Support Logic, case study of the research on estimation of uplift rate

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Various uncertainties exist in the data using in the research of geomorphology and geology. When the development process of the geological environment is restored using the data with these uncertainties, the result of the model or simulation inevitably includes uncertainties derived from the uncertainties of data. Especially, in the geological environment model dealing with chronological change of the site (Site Evolution Model) which consists from various kinds of data, the quality assessment/control in each data is important.

In this study, the factors of the uncertainties occured in the process of data acquisition for the estimation of uplift rate, which is one of the data for drawing the topographic evolution, are analyzed by using Evidential Support Logic (ESL). The result of this study is assumed to be used as a tool for extracting the factor of uncertainties in the planning of the investigation, and for controlling the quality of results in the implementatin of the investigation.