Towards harmonized power system control based on PV power prediction

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This paper presents the outline of the research project ''System Theory for Harmonized Power System Control Based on Photovoltaic Power Prediction (HARPS)," (PI: Jun-ichi Imura), supported by the EMS CREST research program of JST, which has started in April, 2015 for five years. According to "Long-term Energy Supply and Demand Outlook" proposed in July 2015 by METI, a roadmap to photovoltaic (PV) generation dissemination, 7% of the total electric energy and about 30% of the total electric power in Japan, which equals to 64GW of PV power generation, will be covered by a large penetration of PV in 2030. This makes an approach to install a large amount of PV generation to reduce CO_2 emission gaining momentum. Therefore, developing a new structure of control technologies to achieve a stable electric power supply using PV generation forecasts is urgent. In addition, there are needs to fundamentally review frameworks of the entire system to achieve the supply and demand balance. Electric power supply systems will be renewed after the separation of electrical power production from power distribution and transmission, and the deregulation of electricity. Developments of new mechanisms, such as demand response, from advancements in information infrastructures and home battery technologies also cause the necessity to review the frameworks. The goal of this research project is to develop a system theory for the more advanced generation electric power system control by fully exploiting demand/PV predictions and focusing on properties and functions of a middle layer. The middle layer is expected to take many different forms such as demand-side energy management systems (BEMS, CEMS, etc.), cooperative power conditioners, demand response aggregators, and balancing groups of suppliers. In particular, as a basic theory and technology to be the core of harmonized electric power systems control to enable PV introduction of 102GW, and further towards PV introduction of 330GW, we aim to develop the following fundamental theories and technologies: (i) Electric Power System Design: a system design theory composed of supply layer, middle layer, and consumer layer, (ii) Prediction Technology: a PV generation prediction technology adapted to power system control techniques that achieves a stable power supply, (iii) Control Technology: a power system control theory and technology to realize a harmonized stable power supply from the perspectives of fairness and comfort as well as the economics and environmental friendliness, by fully exploiting PV generation predictions. This research is performed from the following five viewpoints: PV power prediction, supply and demand control, consumer-side control, control of power transmission and distribution systems, and basic systems theory. The number of researchers including students is 112 (36 students). This research is performed from the following five viewpoints: PV power prediction, supply and demand control, consumer-side control, control of power transmission and distribution systems, and basic systems theory. See http://www.cyb.mei.titech.ac.jp/crest/ for the details on this project.

Keywords: Photovoltaic Power Generation, Power System, Suppy and Balanace Control

Application of the JMA data for a renewable energy management field -AIST efforts and future initiatives-

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Recently, many photovoltaic (PV) power systems have been installed in the Japan islands from an introduction of feed-in-tariff in 2012. In the current situation, over 20 GW of PV systems has been penetrated. However, renewable energy such as PV power production and wind power production has significant large temporal and spatial variations due to cloud moving and wind speed over complex topography. In order to control a total electric power system in an electric power service area, electric power service companies has to adjust other power outputs (thermal power plants (oil, coal, natural gas), hydraulic power, water pumping etc.) not only renewable energy resources. For a safety control of energy management system (EMS) using renewable energy resources, forecast and monitoring data of renewable power outputs will be necessary more and more.

National Institute of Advanced Industrial Science and Technology (AIST) develop a PV power forecast technology based on machine learning algorism (support vector machine, SVM). In this system, grid point values (GPV) of a mesoscale model (MSM) of the Japan Meteorological Agency (JMA) are used as an input data. In the current situation, solar irradiance forecast data are not included in the GPV datasets of the JMA. Therefore, we must forecast solar irradiance and/or PV power output based on a numerical prediction model. In order to forecast of PV power output, we use the SVM with both MSM GPV and solar irradiance data as an input data. To perform a bias correction, the SVM are also used in our forecast system.

Research center for photovoltaics of AIST also collaborated with the Meteorological Research Institute (MRI) of JMA and has been validated the solar irradiance forecast data from the MSM and a local forecast model (LFM). Each horizontal resolution is 5km and 2km, respectively. MSM performed 39 hours forecasts every 3 hours and LFM performed the 9 hours forecasts every 1 hour. Therefore, MSM was used day-ahead forecast and LFM are expected for short-term forecast in the EMS. From our validation of solar irradiance forecast, negative bias in summer and positive bias in winter are remained in the MSM. Actually, bias correction using the SVM is performed to reduce systematic forecast errors in AIST. Furthermore, validation results would be useful information to improve solar irradiance forecasts of the Numerical Weather Prediction[u1] (NWP). In previous study, our research group investigated the relationship between solar irradiance forecasts and cloud types in cases of large forecast errors. In PV forecasts, forecast errors are included in the model outputs because of both uncertainties of model schemes of NWP and meteorological observations when initializing models. Therefore, confidence intervals of solar irradiance forecasts are also required for users of PV power outputs (or electrical system operators). A usability of ensemble forecasts using different dataset from overseas NWP centers[u2] has been also examined. Recently, users of PV power outputs have paid attention to aerosol optical depth and/or volcanic ash not only clouds distribution because of the decrease of PV power outputs due largely to the reduction of direct normal irradiance (see a related presentation by Dr. Uno (AIST) in the section "Dynamics of eruption cloud and cumulonimbus; modelling and remote sensing" of JpGU 2016).

AIST has taken part in the Japan Science and Technology Agency (JST) Core Research for Evolutional Science and Technology (CREST) project of "Creation of Fundamental Theory and Technology to establish a Cooperative Distributed Energy Management System and Integration of Technologies Across Broad Disciplines Toward Social Application" (EMS). In this presentation, we will show our effort in the JST CREST EMS project.

Keywords: Forecast of PV power generation, Numerical Prediction Model, JMA data

Real-time distribution of Himawari 8 observational data

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On July 7, 2015, the next-generation meteorological satellite "Himawari 8" of Japan Meteorological Agency (JMA) started formal operation. Corresponding to a request from the Japan Meteorological Agency, Science Cloud project of National Institute of Information and Communications Technology (NICT) cooperates in preservation and distribution of observational data of Himawari 8, and Science Cloud unveiled the Himawari 8 Real-time Web on the same day.
Himawari 8 observes a full-disk in every 10 minutes, and a Japanese region and a target region in every 2.5 minutes. A sensor in Himawari 8 has 16 observation bands between visible light to infrared rays, and spatial resolution of 500m (band 3) at under the satellite's orbit. The data size after converted into physical values turns into about 50 times in Himawari 7, and about 400GB per day with large improvement in time and spatial resolution of the Himawari 8 sensor.
Moreover, those data is transferred from the satellite in every 10 minutes. It takes about 10 minutes after the observation to be put on the storage of JMA and converted into physical values. The data is acquired by Science Cloud in an instant mostly through SINET by National Institute of Informatics and JGN by NICT. After adjusting a color tone to improve appearance, the website has distributed observational data by HTML.
This website is developed for accesses of not only PCs but also smart phones and tablets. In addition, control by finger touch is also activated for user experience and practical use at school education. In addition, time, data, place, and zoom ratio of display are acquired in the format of URL, and a characteristic observational data is sharable through a social network etc. is also implemented.
In order to respond to many requests for a night observation, infrared rays are added as the observation result of 24 hours, although only visible light is available on July 7, 2015.
International use of observational data should be in target because Himawari 8 covers East Asia and Oceania. Therefore, the website also supports the display by eight languages with cooperation of overseas researchers.
Close to 30,000 per day users visited to the website when this website opening to the public and it has settled down on about 2,000 accesses / day after one month. However, when a typhoon approached and landed at Japan, the number of accesses reached to 5,000 /day. In addition, in the eruption of Mt. Aso on September 14, 2015, the number of accesses increased. From these things, when a certain weather event occurs, it is assumed that usage in which users check actual data by this website is created.
According to users by countries, there is much use from the People's Republic of China and the Republic of China. Since this increase is coincide with the release in Chinese, it is assumed that not only specialists but general users are interested in this service. Moreover, the program code which collects images automatically from this website was registered into the open source program share site "GitHub", and, as a result, access from the United States of America and Russian Federation increased rapidly on February 4, 2016.
The users of Himawari 8 observational data are not only specialists or researchers, but general

users all over the world across the border have interest. It is assumed that the Himawari 8
Real-time Web has an important result in which science data restricted to use of only researchers
and specialists until now is made familiar for general users.
As this background, it is assumed that the time and spatial resolution of observational data which
is advanced by Himawari 8 are overlapped to the ordinary personnel life. It is concluded that this
is a good feasible study for expanding use of science data like education sector as a result of
advancement of observation technology and development of information and communications technology.

Keywords: Big data, Real-time processing, Satellite, Himawari
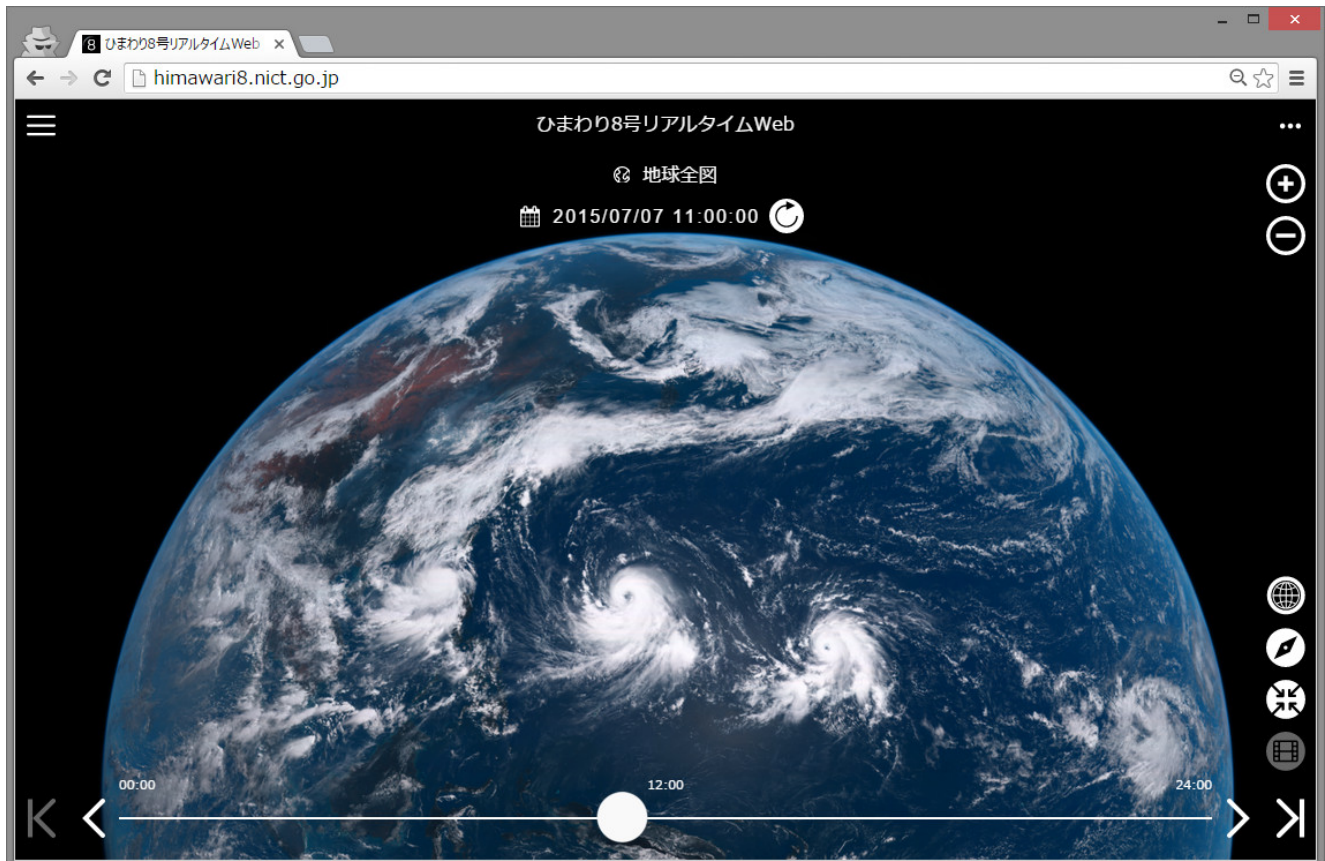
Land surface temperature retrieval from Himawari-8

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1 .Introduction
Land surface temperature (LST) is one of the key parameters in land-atmosphere interaction of various scale. Therefore, understanding the variation characteristics of LST has a crucial role to solve environmental issues of desertification or urban heat island. Oku et al. [1],[2],[3] proposed a retrieval method of LST over the Tibetan Plateau using GMS-5 and calculated land surface energy fluxes by their proposed method. The newly launched Japanese Geostationary Satellite, Himawari-8 supplies data of improved horizontal, temporal and spectral resolution. Using these data, it is expected that Himawari-8 can observe the smaller scales such as urban area in Japan, and can resolve various phenomena in urban area concretely. In this study, a new retrieval method of LST using Himawari-8 data was developed for applicable to smaller scales such as urban area in Japan.

2. Calculation algorithm of LST
Estimation of LST from a geostationary weather satellite requires information of thermal infrared radiation from the land surface. Because thermal infrared radiation cannot transmit clouds, we need to exclude clouds from satellite data as preprocessing. Therefore, we firstly constructed the clouds detection algorithm using 7 Himawari-8 spectral bands and made cloud mask products. Next, we simulated various land surface and atmospheric conditions using the radiative transfer model Rstar6b for determining best calculating LST equation and best combination of thermal infrared Himawari-8 bands. Furthermore, we developed LST equation fitted with satellite zenith angle by simulating some viewing zenith angle situations. And also, thermal infrared radiation observed by the sensor is influenced not only by land surface temperature but also by land surface emissivity and water vapor. Therefore, Estimation of LST requires information of land surface emissivity and water vapor. So, we constructed estimation method of land surface emissivity and water vapor. Accordingly, a new retrieval method of LST using only Himawari-8 data was developed.

3. Results
To evaluate accuracy of LST calculated by our method, comparisons were made around Japan between retrieved LST by our method and MODerate resolution Imaging Spectrometer (MODIS) LST product (Collection-5) provided by NASA. Consequently, retrieved LST reasonably overestimated with MODIS LST product (Collection-5) which has a feature of underestimating with observed LST in hot and humid environment. Furthermore, cloud detection method constructed in this study was also evaluated by comparison with MODIS cloud mask product and AMeDAS actual sunshine duration data. Consequently, our cloud detection method was confirmed in urban regions that is difficult to detect clouds. Construction of retrieval method of LST using Himawari-8 geostationary satellite data enables high temporal resolution and global scale observations of LST compared to the polar orbit satellite data.

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Keywords: Satellite metorology, Remote sensing, Land surface temperature

Database of Weather Charts for Hundred Years: Construction of long-term data archives on weather charts created by Japan Meteorological Agency

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Weather charts are valuable resources to represent the history of meteorological observations in Japan because of their importance on understanding and prediction of weather based on the integration and visualization of meteorological observations on the ground and in the upper atmosphere. We started the construction of a long-term data archives for weather charts that have been created by Japan Meteorological Agency (JMA) and its predecessors since March 1, 1883 for about 134 years, and released a website called "Database of Weather Maps for Hundred Years" (http://agora.ex.nii.ac.jp/digital-typhoon/weather-chart/).

The core part of this database is weather charts purchased from Japan Meteorological Business Support Center. Weather charts were uniformly extracted and converted so that they can be searched by date. Continuous from the beginning is the surface weather chart around Japan or Asia Pacific, and the type of weather charts has been gradually increasing to reach eight at the latest. In general it can be considered as continuous time series, but weather charts are significantly missing for twenty days in September 1923, which seems to be the result of fire at the Central Meteorological Observatory in Tokyo after Great Kanto Earthquake on September 1. The website was publicly released on November 2015, after an experimental release on January 2014 with a credit stating that this database is based on the usage of data from JMA according to the data policy of JMA.

The original plan was to construct the database of weather charts that are geometrically corrected (georeferenced). The manual geometric correction of weather charts is infeasible for more than 100,000 weather charts, so the key is the development of an automated process for the geometric correction. As a result, weather charts after August 1958 could be processed to a satisfactory level, so we took advantage of geo-browsers such as Google Earth, Google Maps and Cesium to show the overlay of georeferenced weather charts.

The next challenge is to improve the usability of the database. Search by date was the first search method being implemented, but more advanced search methods were missing due to the lack of metadata. Hence we implemented four methods to improve the findability of weather charts. First, we added search for the description of "daily weather charts" from JMA to enable keyword search on relevant weather phenomena. Second, we integrated with other databases of "Digital Typhoon," to provide a variety of access methods such as weather charts of the day of typhoon landfalls, or weather charts of the day of disasters that satisfy a set of criteria. Third, we created short narratives on relevant weather charts with the help of NPO Weather Caster Network to access weather charts of historical events and extreme observations (29 cases) or major typhoons (19 cases) through the narrative of weather charts. Fourth, we used an image browser with synchronized timelines called "SyncReel," to offer efficient access to past weather charts by scrolling horizontal timelines.

A challenge for the future is the mining of information embedded within weather charts. Automatic extraction by software does not work for weather charts on which lines are written multiple times. Instead, we should rely on the power of human through the activity of crowd-sourcing or citizen science, where scientists and citizens can take part in the activity of information extraction from weather charts after considering the following issues. First, we need training for the proper interpretation of data such as different unit of pressure. Second, we need to clarify contribution

to science about how historical weather charts can contribute to scientific discovery, because this is where citizens are motivated to contribute to the activity.

Keywords: weather chart, database, geometric correction, georeference, historical resource, citizen science

Investigating long-term trends of climate change and their spatial interactions with local environments through data mining techniques

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Climate change is a global phenomenon but is also modified by regional and local environmental conditions. Climate change displays apparent regional variations. For instance, mountainous regions are usually more sensitive to climate change than flat and low elevation regions. Unique landscape structures of land masses, oceans or water bodies, dominant air flows, topographies and elevations can have significant impacts on local meteorological conditions and thus lead to distinct regional patterns of climate change. Moreover, climate change exhibits remarkable cyclical oscillations and disturbances, which often mask and distort the long-term trends of climate change we would like to identify. Traditional analytical methods based on the comparisons between minimum, average and maximum values of temperature and precipitation are not capable of separating long-term trends from cyclical fluctuations and abrupt changes or capturing temporal dynamics or regional patterns of climate change. As a result, it is almost impossible to study long-term interactions between meteorological conditions and underneath landscape, vegetation and topography by simply analyzing the records of temperature and precipitation. Therefore it is desirable to apply an effective data analysis method to break down the climate variations into individual processes, i.e., cyclical, long-term and abrupt components. Only with this type of data mining and pre-processing is it feasible to investigate spatial patterns and interactions between climate change and regional environmental factors.

In this paper, we attempted to apply computational data mining approaches that were developed in recent years. In particular, we synthesized advanced signal processing and denoising techniques to extract long-term trends of climate change. In specifics, we experimented with the empirical mode decomposition (EMD) technique to extract long-term change trends from climate data that contained significant cyclical oscillations. We then applied 2.5D surfaces, 2.0D contours, and cross-station similarity plots to examine and visualize spatial variations of the extracted change trends over regions, biomes and weather-stations to reveal modifications of climate change at regional and local scales. We conducted a case study to investigate the climate change in Inner Mongolia, China based on the daily records of precipitation and temperature at 45 meteorological stations from 1959 to 2010. The EMD curves effectively illustrated the long-term trends of climate change. The 2.5D surfaces, 2.0D contours and cross-station similarity plots revealed that the change trends of temperature were significantly different from those of precipitation. Noticeable regional patterns and local disturbances of the changes in both temperature and precipitation were identified. These regional patterns and local disturbances were also confirmed by the similarity statistics. In brief, no simple statements could be made concerning either increasing or declining trends of temperature and precipitation over Inner Mongolia. The trends of change were modified by regional and local vegetation covers and topographical characteristics. Our findings provide very convincing evidences to support the IPCC predictions that the climate change varies significantly by location and through time. The data-mining based statistical-cum-visual method is very effective in revealing spatial patterns of regional and local climate changes. The methods developed in this study are also suitable for investigating long-term trends and spatial patterns of other ecological processes that are noted with cyclical or seasonable fluctuations.

Keywords: climate change, regional variation, trend analysis, data mining

Development of three-dimensional dynamic object extraction and tracking method and its application to the analysis of localized heavy rain system

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The development of the ground-based radar observation instrument such as phased-array meteorological radar has enabled the acquisition of the data on three-dimensional structure of the raincloud system. In particular, the phased-array is able to sample the data at the time interval as short as 30 Sec, and thus it helps to understand the whole process of development of localized heavy rainfall systems starting from precursor (the first echo) to the main rainfall event.
We extended a method of 2D dynamic object extraction and tracking for time-series images (e.g., Honda et al. 2002) to that of 3D objects, and applied it to the phased array meteorological radar data. As a result of modeling of the object points sampled from the data after the threading at the value of 30dBZ, we observed the first echoes of heavy rainfall events are extracted the independent components at each event, and extracted the development of clouds in complex shape as the increase of the number of components.
In addition, we considered the hierarchical data model that is composed of "snapshot object", "real object", "object family", and currently constructing the interactive query and visualization system that will be utilized in exploring the collection of object information to find spatio-temporal patterns of clouds related to heavy rainfall.

Keywords: spatio-temporal, data mining, object extraction, meteorological radar, modeling

Real-time Data Processing via Gfarm/Pwrake and Applications on the NICT Science Cloud

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This paper is to present a technology to perform parallel data processing on parallel storage system, which has been developed at NICT (National Institute of Information and Communications Technology), Japan. The NICT science cloud is an open cloud system for scientists who are going to carry out their informatics studies for their own science. The NICT science cloud is not for simple uses. Many functions are expected to the science cloud; such as data standardization, data collection and crawling, large and distributed data storage system, security and reliability, database and meta-database, data stewardship, long-term data preservation, data rescue and preservation, data mining, parallel processing, data publication and provision, semantic web, 3D and 4D visualization, out-reach and in-reach, and capacity buildings.
In the present study, Gfarm/Pwrake is used for the big-data processing. The Gfarm is one of the parallel storages system developed in Tsukuba University. The Pwrake is a task scheduler designed for the Gfarm. With combination of two technologies, real-time data processing is easily constructed on the NICT Science Cloud. Several examples to use this Gfarm/Pwrake real-time data processing are discussed for meteorological satellite data processing, weather radar data processing, and other real-time data processing's.

Overview of ionospheric total electron content (TEC) monitoring system using dense GNSS receiver networks

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We are operating an ionospheric total electron content (TEC) monitoring system using dense GNSS receiver networks on the NICT Science Cloud system. We have automatically collected more than 7000 ground-based GNSS receivers' data in the world, and converted into two-dimensional TEC maps. High-resolution TEC maps are available in Japan, North America, and Europe, where GNSS receivers are densely deployed. These TEC maps and global TEC maps are available through the web site, http://seg-web.nict.go.jp/GPS/DRAWING-TEC. These high-resolution TEC maps make it possible to get a full view of 100-1000 km scale ionospheric disturbances. Recently, we developed a real-time TEC monitoring system by processing streaming data of GEONET, which is a ground-based GNSS receiver network in Japan provided by Geospatial Information Authority of Japan. TEC are calculated within a delay of several minutes.

Keywords: TEC monitoring system, dense GNSS receiver network, GEONET real-time data

The Systems Design and Project Status of the HAKUTO Micro Lunar Rover for Possible
Skylight Exploration

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This paper describes the project status of HAKUTO rovers, its systems and the results of the field
experiment. HAKUTO is the Japanese team participating in the Google Lunar XPRIZE. This team is
consisted of a venture company, Tohoku university and pro bono members.
The Google Lunar XPRIZE is an unprecedented competition, challenging privately funded teams to
accomplish three main goals: successfully land a spacecraft on the lunar surface, run the rover on
the lunar surface at least 500 meters, and transmit high-definition video and image back to earth.
HAKUTO has developed a small and lightweight dual rover system to fulfill the above Google Lunar
XPRIZE requirement. Demonstration of rovers' performance in space environment is verified by
conducting thermal vacuum testing, vibration testing, and field testing at Nakatajima sand dune.
Furthermore, HAKUTO plans to explore caves beneath the lunar surface for potential lunar
habitation. Currently, HAKUTO is preparing the Flight Model rovers which are supposed to be
launched in 2017.

Keywords: Moon, Rover, HpFP, Skylight Exploration, UDP, TCP/IP
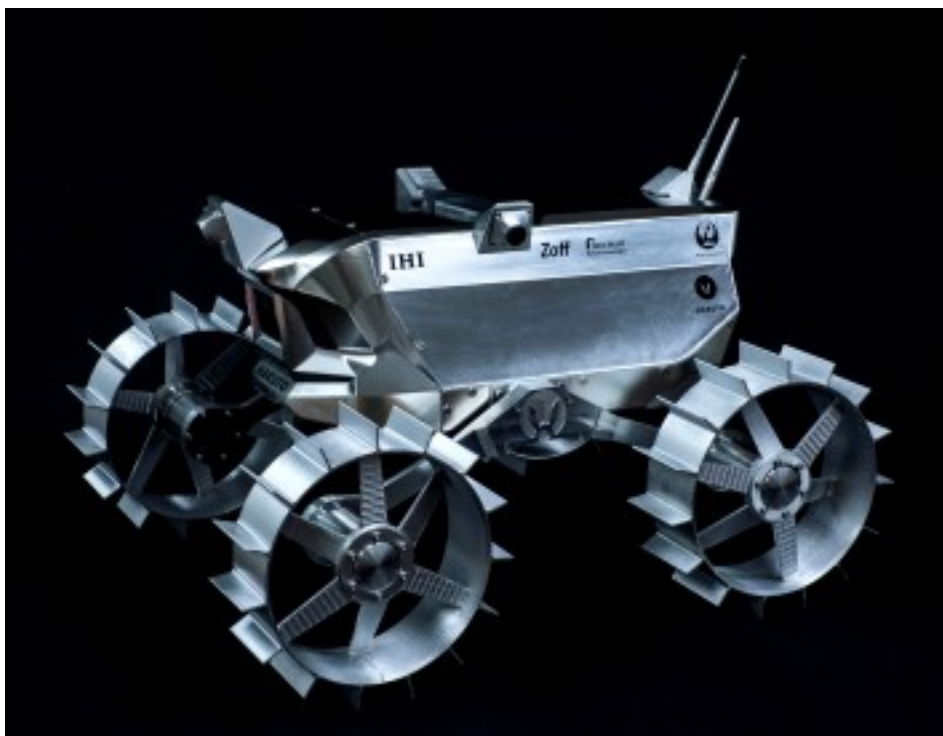
HpFP: A new protocol for LFNs with packet-loss based on UDP -A basic concept and detailed design of the protocol

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For LFNs (Long-Fat Networks) with 10 Gbps or more and satellite networks with large latency, a variety of TCP-based protocols have been proposed which show high performance on large latency network conditions. However, such TCP protocols are essentially unable to archive large bandwidth on high latency networks accompanied with packet-losses that are inevitable on practical LFNs or satellite networks. To overcome this issue, we designed a new data transfer protocol on TCP/IP transport layer built on top of UDP: High-performance and Flexible Protocol (HpFP). It constantly monitors latency (RTT) and packet losses, and conducts rate control and retransmission control based on them to enable higher bandwidth data transfer than 10 Gbps even on packet-loss conditions over LFNs. The basic concepts are addressed and protocol design of the HpFP are discussed. An applications to tansfer many data files in small size (e.g., 1MB x 10000 files) with almost wire-rate bandwidth (10 Gbps) is also addressed.

Current Status and Future Challenges of the Japan Data Exchange Network JDXnet

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In Japan, about 1200 high-sensitivity seismic observation stations and about 120 broadband seismic observation stations are installed , and by using these stations the quick detection and determination of the location and magnitude of the small and large earthquakes which occured in and around Japan . These broadband and high sensitivity seismic observation have been carried out by 9 National Universities, JMA , NIED , JAMSTEC, AIST etc. JDXnet (Japan Data eXchange network) is the nationwide real-time data exchange and distribution network of these seismic stations. Currently, JDXnet is constructed by using wide-area L2 network of SINET4 and JGN-X as a backbone network, and connect many agency and university and exchange real-time data that each agency has collected from each observation stations. We will introduce the current status and future challenges that should be addressed future of this JDXnet.

Keywords: seismic data exchange, seismic observation network

3D modeling and Web3D display of near-surface geophysical survey results

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Near-surface, mainly composed of man-made strata, weathered layers, and Holocene soft sediments, inherently implies small-scaled irregular or various structures. Accordingly conventional geotechnical boring information is inadequate to reconstruct surface 2D geology of the region of interest because of their sporadic distribution, rough log description, and insensitiveness of SPT N-values to lithofacies. In contrast, near-surface geophysics can provide high-resolution, quantitative, and reliable information to the near surface as continuous 2D or 3D profiles. The authors have been developing near-surface geophysical investigation techniques for delineating internal detailed structure in man-made strata up to 3 m, and have demonstrated the usefulness of Web3D rendering of 3D geophysical models reconstructed by integrating various types of surface data. The surface data incorporated in our 3D model consisted of GPR aided by high-precision VRS-GNSS positioning system, non-contact type high-frequency surface wave measurement, ultra-shallow seismic reflection survey, and high-resolution DC resistivity survey. Surface DSM of the site was generated from MMS (Mobile Mapping System) data. We also built a surface orthophotograph with Agisoft Photoscan. Surfer and Voxler provided by Golden Software were utilized to make a 3D surface model. In addition, we developed a Web3D system which can render combined 3D models without any plug-ins based on WebGL. The Web3D system was quite helpful to understand spatial orientation for a near-surface heterogeneous structure.

Keywords: Geophysics, Near surfaces, 3D modeling, Web3D

Scatter Plot-Based Color Map for Multivariate Data Visualization and its Application to Geofluid Simulation Data

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To understand simulation data from the perspective of multivariable is important in numerical simulation study. This study proposes a new multi-dimensional color map which enables users to extract and visualize characteristic feature with their empirical and intuitive judgment. In the proposed method, data points which represent characteristic feature are selected in a couple of 2-dimensional scatter plots. Extracted data in each 2-variable space are assigned to different color components such as hue, saturation and/or brightness, respectively, in order to classify and specify the characteristic features from multivariate data. We applied the method to high-resolution geofluids simulation data with advices of domain specialists. As a result of case studies, characteristic structures such as ocean currents, eddies and clouds are intuitively extracted and clearly represented with their physical properties. In this presentation, we explain the proposed method in detail and demonstrate the way to use for actual application.

Keywords: Feature extraction, Visualization

Color map
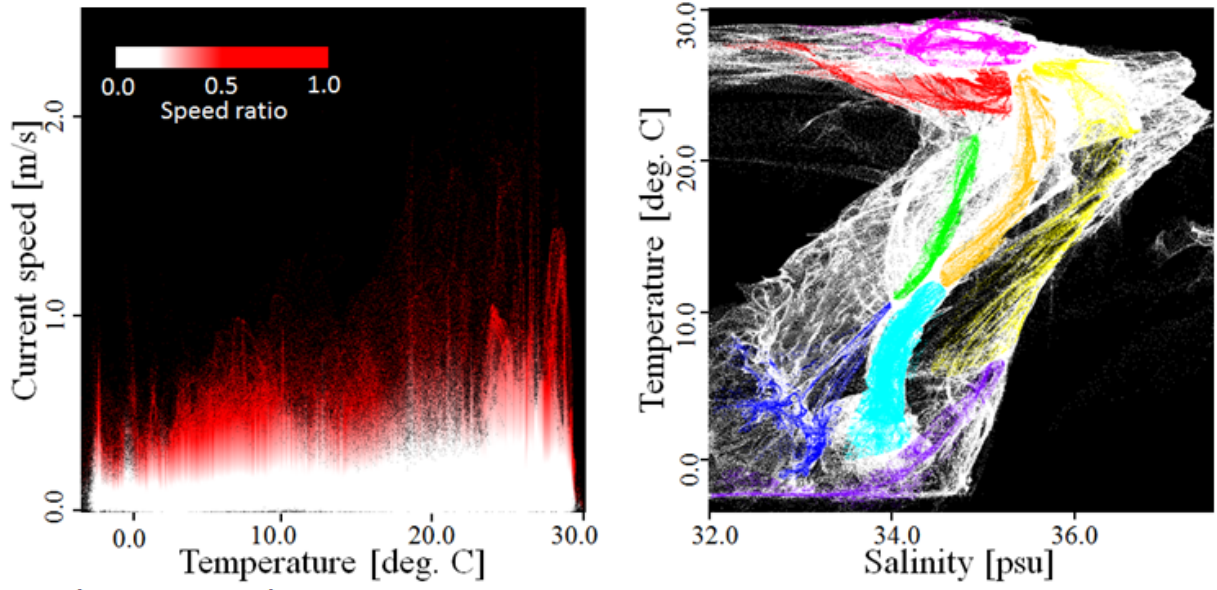
Visualization result
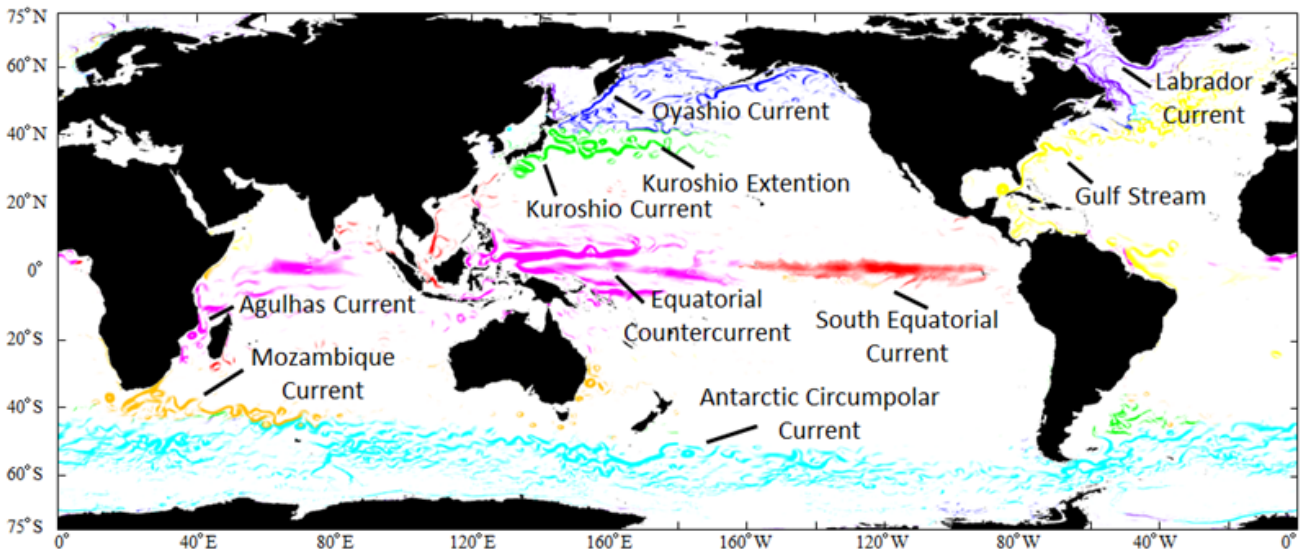
Open simulation data system for Jovian magnetospheric research

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Recently there are a lot of good Jovian observation data by HIASAKI. On the other hand, thanks to the development of computer system, we can perform the parameter survey simulation of Jovian magnetosphere (which is not so high spatial resolution). Thus it is good time to collaborate the simulation with observation in Jovian magnetospheric research and we have started to create the simulation database of Jovian magnetosphere. In this simulation database we store the basic configuration of magnetosphere under the several constant solar wind dynamic pressures and IMFs, and realistic solar wind conditions from the modeling and observation. Additionally, we will also run the simulation with the specific solar wind condition for the experimental data. Now the simulation data is stored in our own server system. The basic simulation data size is 3 GB and the variation of solar wind condition is a few hundred then it is expected that the total data size will be ~100 TB including the calculation of quasi-steady state of magnetosphere. We also plan to add the high spatial resolution simulation to the database, then the total data size will become around 1 PB. It is important to create the environment of analyzing these data. We now plan to use the NICT Science Cloud or cloud (hosting) computer resources of supercomputer center of university. In this presentation we will show the simulation database of Jovian magnetosphere and discuss how to create and maintain it.

Keywords: Jovian magnetosphere, Numerical simulation, big data

Data archive and integrated data analysis tools developed by ERG Science Center

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The ERG (Exploration of energization and Radiation in Geospace) is a Japanese geospace exploration project. Its core component is the ERG satellite, an inner magnetosphere satellite with the full set of particle and field instruments currently scheduled to be launched in FY2016. The ERG project consists of the satellite observation team, the ground-based network observation team, and the integrated data analysis/simulation team. Besides these research teams, ERG Science Center (ERG-SC) has been organized to play an essential role in managing the data center for all kinds of scientific data as well as promoting close collaborations of the three teams and other research projects. Thus the goal of ERG-SC is to maximize scientific output from the ERG project. For studies of geospace, where different plasma populations are interacted with each other via cross-energy and cross-regional coupling processes, the integrated data analysis combining various kinds of data sets is key to comprehensive understanding of multi-scale dynamical processes. A standard data format and integrated data analysis tools are essential to realize the seamless data analysis environment for the science community. The ERG satellite data of Level-2 (calibrated, in physical unit) and higher levels and the ground observation network data are archived in the NASA CDF format and basically open freely to the international science community. Together with scientific data, the data files in CDF carry a set of metadata. The metadata set is designed to provide data users with the concise description on the data themselves as well as some useful information used by data analysis software visualizing/analyzing the data. The integrated data analysis tool is developed on the basis of the Space Physics Environment Data Analysis Software (SPEDAS) in collaboration with the THEMIS and IUGONET teams. It should be noted that other satellite project data for geospace, such as THEMIS, Van Allen Probes, and MMS can be easily combined with SPEDAS if the ERG data are also converted to the CDF format. Thus the integrated data analysis using many kinds of data is truly realized through SPEDAS with the standardized data archive in CDF. Other useful tools, such as the ERG Web Analysis Tool (ERGWAT), Conjunction Event Finder (CEF), and the numerical solver tool of the dispersion relation for plasma waves in geospace have also been developed by ERG-SC to contribute to scientific researches related to the ERG project.

Open Science using Big Data obtained by Japanese Antarctic Research

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Syowa Station, Antarctica, can now be reached via Intelsat satellite link , whose band withd is 3Mbps for 24hs. Most observation systems are controlled from Japan and summary data can be viewed in real time. Although hi-resolution raw data has to be shipped from the station using Shirase and we have to wait for the precise analysis by the investigators. Satellite link can carry more than 10TB every year. Thus huge amount of data can be transfered and open not only for research community but also for public.
 National Institute of Polar Research is now preparing for servicing DOI indexing for the antarctic observation data. This will archiving more widely opened data accessibility of the Antarctic observation data and will accelerate science opportunity.
Current status of our data policy and provision will be presented in this talk.

Keywords: Antarctic Research, Database, Open Science
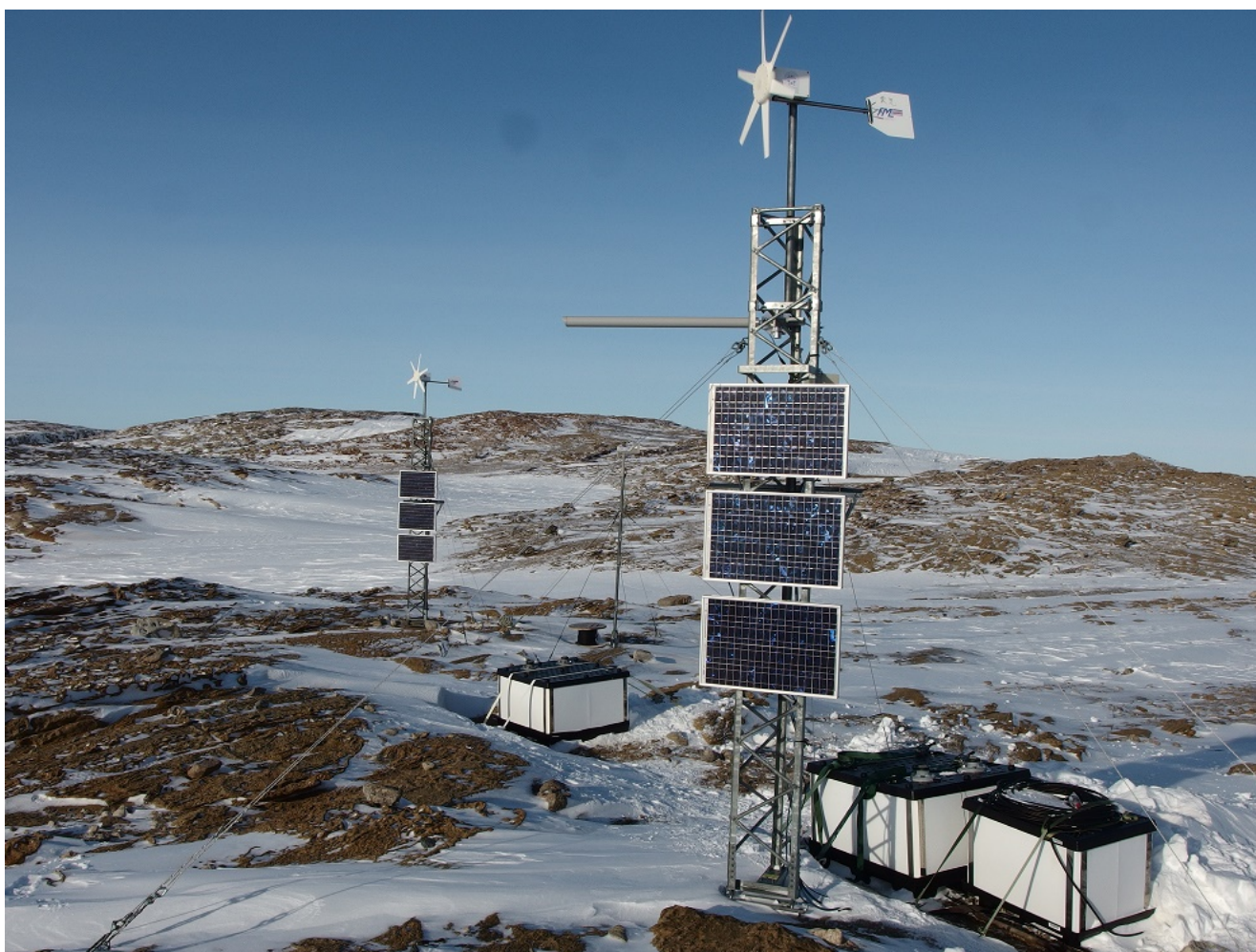
"Big-data" and "Open-data": Two key words to support future science

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A pioneering computer scientist Jim Gray proosed "the Fourth Paradigm: Data-Intensive Scientific Discovery" in 2008. Increasingly, scientific breakthroughs will be powered by advanced computing capabilities that help researchers manipulate and explore massive datasets. The speed at which any given scientific discipline advances will depend on how well its researchers collaborate with one another, and with technologists, in areas of eScience such as databases, workflow management, visualization, and cloud computing technologies.

The data intensive science, which is often called "data driven science", is a methodology to start science at data, not to data; Data is a starting point. This idea implies that all of the necessary information are included in the data. In these days, this kind of concepts have been presented and discussed in books, papers, web and other media. This means that the "Opinion for All" is correct unexpectedly as James Surowiecki mentions. This is a concept recently denoted as "collective intelligence".

To the author, "big data", "data oriented science", "data driven science", "collective intelligence" and "information commons" in science seem to be directed to a certain objective. What is required to order to move in this direction is "open data"; all of the scientific data should be open and accessible to any researchers. Data scientists who have any technologies for big data would be motivated to analyze these open data, even if they are not specialist of the domain fields. Nobody knows what will be derived, or nothing new will be exracted. To examine this, anyway, data must be open.

Simulation on spectral cross-calibration of NDVI from MODIS, ASTER, and Landsat 5-TM

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Spatio-temporal changes in terrestrial vegetation are of significant importance for understanding
environmental issues including global warming. Numerous earth observation satellites have been
launched and operated for monitoring the earth surface. For example, the series of the Landsat
satellite that provides 30m patial resolution (Landsat 5-Thematic Mapper (TM), Landsat 7-Enhanced
Thematic Mapper Plus (ETM+), and Landsat 8-Operational Land Imager (OLI)) have been operated since
1980s. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) (15m spatial
resolution) and Moderate Resolution Imaging Spectroradiometer (MODIS) (250m spatial resolution)
onboard Terra have made measurements of the earth surface for more than 16 years. The spectral data
obtained by the multiple sensors can provide long term monitoring of terrestrial vegetation over
regional/global scale. The sensor specification such as spectral response function, however, shows
differences across sensors, resulting in producing systematic errors in the data product (e.g.
vegetation indices). It deteriorates the consistency among the data product of vegetation indices
from multiple sensors. We developed the cross-calibration algorithm for reducing the errors among
Enhanced Vegetation Index (EVI) due to differences between spectral response functions of MODIS and
Visible and Near-infrared Imaging Spectrometer (VIIRS) (375m spatial resolution). The algorithm was
implemented to actual sensor data of MODIS and VIIRS that were Climate Modeling Grid resolution
(0.05 by 0.05 degree) for the cross-calibration and showed potential utilities of the developed
algorithm [Obata et al., *Remote Sens*., 8(1), 2016].
In this study, equations of Normalized Difference Vegetation Index (NDVI) for ASTER and Landsat
5-TM are cross-calibrated with reference to MODIS NDVI based on the developed algorithm. The
hyperspectral reflectances derived by Earth Observing-1 Hyperion are used to simulate reflectances
of the multispectral sensors. We then evaluate systematic errors among NDVIs between MODIS and
ASTER/Landsat 5-TM and show results of the NDVI cross-calibration.

Keywords: NDVI, Cross-calibration, MODIS

Utilization of Elevation and Borehole Data of Hanoi City, Vietnam

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In Hanoi, the capital of Vietnam, environmental problems (land subsidence, flood, groundwater pollution and so on) have been increasing in recent years. The main reason is rapid urbanization and water control. In the rainy season, flooding occurs by heavy rain. Because the discharging water system is very old. Sometimes, buildings are sinking under the ground slowly because of the subsidence. The reason is excessive pumping of groundwater. Hanoi city is depend on the groundwater for the daily life water. These problems are related to the geography and subsurface structure of Hanoi city.

In this study, we collected the elevation data and borehole data through Hanoi University of Mining and Geology. Firstly, we need to generate the DEM (Digital Elevation Model) using the elevation data. DEM is a digital representation of ground surface topography and the most important element of topographic analysis. Secondly, we analyzed the borehole data for well construction of Hanoi city. We input it the developed borehole database for share with Vietnamese researcher. Finally, we constructed the 3D geological model of Hanoi city and visualized it using GRASS GIS.

Research area is the center part of Hanoi city, Vietnam and covers a range of lat. 21°00'00" to 21°04'22.5" and long. 105°47'30" to 105°51'52.5". The coordinate system is VN2000. Hanoi is located on Red River Delta, this area is underlain by the Pleistocene and the Holocene sedimentary rocks. The Pleistocene rocks are divided into the Lechi Formation, Hanoi Formation and Vinh Phuc Formation. The Holocene rocks are divided into the Hai Hung Formation and Thai Binh Formation.

49 maps of an elevation survey points were collected through Hanoi University of Mining and Geology. The scale of this map is 1:2,000. The research area is 8km x 8km, and the number of survey points is 16,745. We generated a DEM based on the surface estimation method, we call it BS-Horizon (Nonogaki et al., 2008). The very subtle elevation gaps are significantly recognizable on it.

160 borehole data of Hanoi city was collected through Hanoi University of Mining and Geology. Each borehole data is a non-core drill data for the well construction. We picked up some information from the borehole data. The well name and drilling point can be found from the borehole data. The drilling point was described as the EPSG Geodetic Parameter Dataset (28418, Datum; Pulkovo 1942, Projection; Gauss-Kruger zone 18). Each thickness and lithofacies can be found from the borehole data. However, the description of lithofacies were not standardized. Therefore we unificated the geological description by Japanese standard, JASIC (Japan Construction Information Center Foundation) description. We classified 30 types of descriptions.

We outputted each geological boundary surface data from the borehole data and estimated DEMs of the geological boundary surfaces for 3D geological modeling using the same method of the topographic DEM.

The spatial distribution and the relation of geological units are expressed in the logical model based on the fundamental field data and the knowledge. The 3D geological model is composed the DEMs of the geological boundary surfaces and the logical model. We visualized the 3D geological model using GRASS GIS.

In this study, we constructed the 3D geological model using the borehole data of Hanoi city. This

is useful not only for the elucidation of geological structure of Hanoi city but also for the
provision of the basis data to various fields. It is important to consider the urban sustainability
of Hanoi city as in improvement of urban infrastructure and disaster prevention. Future works of
this study are to develop the accessible 3D geological modeling system using Web-GIS.

Keywords: DEM, Borehole data, 3-D geological model

Development of software " COREROKU " to support the geological analysis by high-quality core sampling information

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1.oyo corporation

High-quality core sampling system is currently being evaluated in dam constructions and landslide controls where severe geological risk assessment is required in order to perform a highly accurate geological analysis. Core samples taken from high-quality core sampling system provide fine deformation structure and detailed geological change. The quality and quantity of geological information taken from those samples are well suited for application as compared to a usual boring survey. On the other hand, by the development of digital photography technology, more high-definition and large capacity image information are becoming available immediately after sample collection. It is expected to link image information with interpretation information as a database. However, the core samples deteriorate rapidly due to its observation, analysis and environmental condition. Therefore, it is necessary to make speedy information acquisition for an efficient analysis. New software "COREROKU (Koaroku)" is under development to solve these issues for operational efficiency of high-quality geological interpretation, quantify and data compiling. The most representative feature of "Koaroku" is a quick visualization of columnar section and graphs by arbitrarily combined indices. This feature enables to take panoramic view of whole geological situation at early core observing stage which is expected to support professional engineers to make more quantitative analysis for time reduction and operational efficiency. This software is expected to be an information sharing tool in practical business.
In data entry function of "COREROKU (Koaroku)", high-definition core sample images are used as a background image and core sample observation is recorded in clear and easy procedure. Main indices for data entry are type of surface structure, gravel shape trace, particle size, sedimentary structures, inclusions required for sedimentary facies analysis , a variety of test information for statistical analysis and not limited to basic interpretation indices corresponding to the JACIC basic criteria column. It is possible to enter surface structure data , mapping and stereo structural analysis when borehole-wall images are collected. In addition, columnar section and geological structure information can be imported to a three-dimensional geologic analysis system and used for analysis.
In this presentation, we will refer to our developing software including new function and performance being explored in ongoing operations.

Keywords: High-quality core sampling, geological analysis, information processing, software, COREROKU

Browsing System for Borehole Data and Geological Map using FOSS4G

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After the 2011 off the Pacific coast of Tohoku Earthquake, disaster mitigation is a growing concern among the public. In particular, subsurface geological condition in urban areas is one of the biggest public concerns. However, most of existing geological Web services provide insufficient data for assessing subsurface geological condition. In order to improve public understanding of subsurface geological condition, a browsing system for geological data were developed focusing on intelligibleness and user-friendliness based on Free Open Source Software for Geoinformatics / Geospatial. The system shows high-reliable borehole data and a geological map accessible to the public on the Web using the Leaflet JavaScript library. The borehole data are mainly provided in XML/PDF format, which are compliant with the specifications of borehole data by Japan Construction Information Center Foundation (JACIC). These were obtained by the drill surveys conducted in the northern part of the Chiba Prefecture by the Geological Survey of Japan (GSJ). The geological map was provided in a tile set of PNG images. The map was generated by computer drawing from a three-dimensional geological model, which was constructed based on borehole data and geospatial data such as Digital Elevation Models (DEMs). Future works are to implement functions of searching database for borehole data, generating geological cross section, and visualizing geological model in three- dimensions.

Automatic extraction of frequency sweep rate of chorus from a huge data set of Akebono

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Chorus emission is one of the most popular plasma waves observed in the Earth's magnetosphere. It has a distinctive feature in spectrum, that is, frequency sweep in a very short time period. The chorus is known to be generated at the magnetic equator and propagates to higher latitude along a magnetic field line. Its generation mechanism has been controversial for many years. In recent years, a theory was proposed that growth of the chorus is caused by a non-linear mechanism. An important point of the theory is a dependence of the frequency sweep rate on wave amplitude.
We performed a statistical analysis of the dependence using data obtained by the Akebono satellite. The Akebono satellite had observed plasma waves in the inner magnetosphere for 26 years. In order to find chorus emissions in the huge data set automatically, we adopted a modified template matching to the data set. One of the essential modifications is that intensity distribution of the template is determined according to that of target chorus elements. By this method, we successfully extracted chorus elements. We, then, investigated relations between frequency sweep rates and wave amplitudes of the extracted chorus elements. As a result, positive correlation is found between them.

Keywords: chorus emission, Akebono satellite, automatic extraction

In-situ visualization for spherical simulations using Yin-Yang grid and its variant

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We propose an in-situ visualization method for computer simulations in the spherical geometry using the Yin-Yang grid. Numerical data that are produced by supercomputer simulations are usually stored in a disk system before visualization processes. While the post-process visualization approach is becoming impractical these days due to the exponential growth of the simulation size, another approach to the visualization, called in-situ visualization, is gaining attention. In the in-situ visualization, both the simulation and visualization are applied simultaneously on a supercomputer. The output of an in-situ visualization is a set of two-dimensional images, rather than three-dimensional numerical data. The size of the output in an in-situ visualization is not a serious bottleneck on the contrary to the post-process visualizations. In this study, we focus on supercomputer simulations in the spherical geometry that uses the Yin-Yang (or recently proposed Yin-Yang-Zhong) grid.Although the Yin-Yang grid system was originally proposed for geodynamo simulations, it is applied in various fields such as geophysics, astrophysics, image processing, and so on, and the data are visualized in the post-process. The demands to visualize them with the in-situ method will be intense in future. Although general-purpose visualization applications with built-in in-situ visualization features exist, they are difficult to use on a supercomputer. Therefore, we propose an in-situ visualization method that has the following functions:(i) It is suitable for Yin-Yang(-Zhong) grid simulations; (ii) it has minimum visualization features; (iii) it is easy to use for simulation researchers; and (iv) it does not damage the simulation speed. We report the development of a Fortran90 library for this in-situ visualization method and its applications to MHD (magnetohydrodynamics) simulations in the spherical geometry.

Keywords: scientific visualization, in-situ visualization, spherical system, Yin-Yang grid, Yin-Yang-Zhong grid

New data transfer technique from Syowa via INTELSAT

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A communications satellite (INTELSAT) data receiving system with a 7.6m-diameter parabolic antenna was installed at Syowa Station in February 2004. So far, data transfer have been carried out using from the Antarctica station using the satellite network. The current bandwidth of the INTERSAT for data transfer between Syowa and NIPR (National Institute of Polar Research) in Tokyo is 3 Mbps. Since there is inevitable latency (RTT 500 msec) in between Syowa and NIPR, general file transfer applications, such as FTP, rsync, rcp and so on, don't show good throughput. It is due to restriction of TCP function on networks with large latency (and packet-loss). The SteelHead provided by Riverbed is one of the WAN accelerators for long-distance data transfer. It intercepts TCP on both sides of the network, and accelerates TCP connection replacing with its own data transfer technologies.
The other role of the SteelHead is to control QoS of multiple data tarnsfers. Several projects at Syowa Station in many research fields are conducted so far, and data transfers are independent in principle. There needs a traffic control of network connections between Antarctica and Japan. Network managers at NIPR give priorities to each data transfer project, and the SteelHead allocates bandwidth to each network connection. However, this QoS control simply sets highest and lowest bandwidth. Total traffic could be lower than 3 Mbps in case that several traffics are lower than the given maximum bandwidth according to the QoS table.
Herein we propose a new data transfer protocol to work on the transport layer; the HpFP (High-performance and Flexible Protocol). This protocol is a connection-oriented protocol to works on the top of UDP. It provides us with a stream-type of reliable data transfer. Inside the HpFP, there are several ingenious attempts. One of the attemps is to set an internal target throughput to control pacing of sending packets. This parameter setting is time-dependent; the target throughput is derived from information of network monitored by the HpFP. The HpFP is able to detect unused bandwidth at every moment, then dynamically allocates the HpFP data connection. We discuss how effectively the HpFP covers the unused bandwidth on the condition of SteelHead control on the INTERSAT networks.

High-performance and Real-time Processing of Sensing Data via NICT Science Cloud

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In many scientific fields, most data are digitized and handled on computers and networks. The data files are getting larger in size and numbers. Science clouds, which are equipped with both flexibility and specialty applicable for countless scientific studies, are called upon to play important roles as an infrastructure of big-data sciences and inter-disciplinary studies. The NICT Science Cloud is designed to work with functions of data crawling and transfer, data preservation and management, and data processing and visualization. We have developed applications, tools, systems and services designed for these three functions (especially for Earth and space environmental sciences) installed on the NICT Science Cloud. By applying these functions to each sensing project, researchers are able to advance their studies. In this paper, we first introduce the NICT Science Cloud. We next report our 2-years applications of the cloud system based on several long durational satellite data processing. Finally, I propose a design to make progress of various types of sensing projects; real-time data processing and archived data processing of remote sensing and satellite observations.

Cyber Earth: A new technical approach for global studies of Earth

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In the present paper, the author proposed a concept of the Cyber Earth as a basic approach for the global understanding of the Earth system. In order for our global understandings from a variety of observation and simulation data of Earth sciences, we need a methodology to analyze huge size of big science data. The Cyber Earth is a concept to declare that, for our global understandings, mash-up of information and communication technologies for big data plays an important role. This concept is based on several technological ideas, such as data centric/intensive science, the fourth paradigm, science cloud, big-data science. All of the data, observation data and simulation data, are once transferred and stored on a science cloud system. Data preservation and data stewardship is important since most of the data is so precious that they are never observed again at the observed time and location. Big data processing, including visualization, is also important. The data processing must be applicable for any types of digital data from either Earth observation or simulation. Integrated data processing technology for such variety of data type is preferable. The Cyber Earth is composed of three methodologies; the Network Earth, the Digital Earth and the Virtual Earth. The Network Earth is a concept that role of network is important for data transfer and collection to the cloud. For global monitoring we often build up global observatories on the Earth. Integrated operations and easy management of the remote sites are significant for labor-saving. The Digital Earth is a concept that long-term data preservation is one of the most expected functions to a science cloud. Data files must be saved and managed under DR (disaster recovery) environment. Easy data publication should be functionally synchronized with data preservation. The Virtual Earth is a concept that every digital data must be processed or visualized to be shown on the same framework with other data. Inter-disciplinary data preview, in space and/or in time, makes our global and functional understanding of the Earth system. Immersive visualization may work effectively to understand or discover any interactions between data.

A high-bandwidth virtual remote storage (HbVRS) system on long fat network (LFN) and its application

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Science cloud is a cloud system specialized for data intensive/centric science, which is based on a concept of the fourth paradigm proposed by Jim Gray in 2009. However, only a few science cloud systems have ever yielded tremendous scientific results so far. High-bandwidth storage I/O is one of the important issues to be overcome for big data sciences. In the study, we propose a high-bandwidth virtual remote storage (HbVRS) tool using a distributed file system (Gfarm) and a UDP-based data transfer protocol (HpFP). The tool is based on our examination of parallel HpFP data transfer in 10 Gbps using a long-distance 10G network (long fat network: LFN) between Japan and USA crossing the Pacific. We installed an application to draw a set of time sequential graphic files using the tool on the NICT Science Cloud. We successfully read data files in order of time sequence from a virtual storage as fast as more than 20 Gbps. The present results suggest that client hosts connected with a long fat network will be able to access to big data stored in cloud storage wherever over the world it is located. An application is demonstrated using the HbVRS.

STARS touch: A web-application for time-dependent observation data designed for world data systems

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In 2008, the International Council for Science (ICSU) established the World Data System (WDS) to ensure the long-term stewardship and provision of quality-assessed data and data services to the international science community and other stakeholders. One of the objectives of the WDS is to support and make progress of interdisciplinary and cross-over studies data analyses covering a variety of research fields. In 2010, the NICT Science Cloud, which is one of the projects of the National Institute of Information and Communications Technology (NICT), has initiated a sub-project to realize the WDS's concept of the interdisciplinary data activity. In this paper, we demonstrate potential capability of our Web application for interdisciplinary data analysis, which is now operated on the NICT Science Cloud. In the initial stage of the system development, we constructed a basic concept and an initial design of the Web application, taking into account our long-term experiences in data-oriented activities under the WDC (World Data Center) system of the ICSU, which was an ICSU's data program operated from 1957 to 2008, preceded the WDS. Based on our design, we have implemented the Web application for data plots on the basis of the HTML5 and the Ajax technologies. Data plots can be previewed on the Web application with higher usability and better handleability than those of traditional data-plot tools developed for multiple-datasets. We finally discuss feasibility and potential usefulness of the Web application for future interdisciplinary data-analysis activities of the WDS.