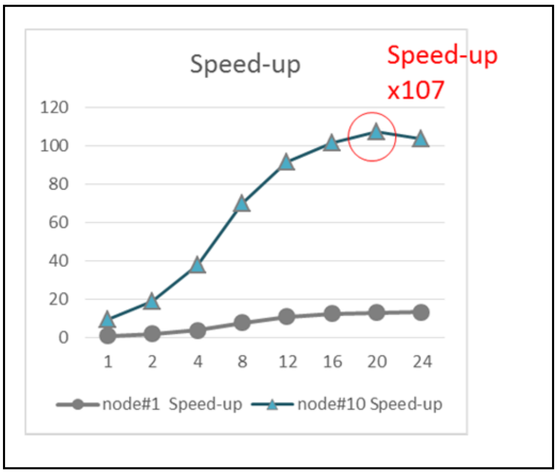
# Japanese URSI Commission H (Waves in Plasmas)
# Activity Report
# July - October, 2013

## [1] Status of projects related with plasma wave observation

1. NICT Science Cloud

NICT Science Cloud has been developed for space plasma studies. Three outstanding developments were achieved during this period.




(1) Large Scale data processing technique for space plasma data analysis is developed on the NICT Science Cloud. This technique is applied for two types of space plasma data, GEOTAIL PWI data and KAGUYA PWI data, to achieve more than 100 times higher speed data processing than via traditional way.

(2) A Data collection (transfer) system, named WONM (World-wide Observation Network Monitoring) system is complete and under operation. We set this system to more than 10 observatories, including Antarctica and equatorial observatories for ionospheric observations.

(3) Data and program storage service is ready. We could successfully store several types of plasma wave data and other STP (Solar-Terrestrial Physics) data on the NICT Science Cloud, including GEOTAIL, AKEBONO, KAGUYA satellites.

## [2] Recent Meetings

1. 11th International School/Symposium for Space Simulations (ISSS-11), Jhongli City, Taiwan, July 21-27, 2013.
2. IAGA 2013, Mérida, Yucatán, México, August 26-31, 2013.
3. AP-RASC 2013, Taipei, Taiwan, September 3-7, 2013.

## [3] Future Meetings

1. COSPAR Symposium on "Planetary Systems of our Sun and other Stars, and the Future of Space Astronomy", Bangkok, Thailand, November 11-15, 2013.

2. International CAWSES (Climate and Weather of the Sun-Earth System)-II Symposium, Nagoya, Japan, November 18-22, 2013.
3. 6th VERSIM (VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere) workshop 2014, 20-23 January 2014, University of Otago, Dunedin, New Zealand.

## [4] Recently Published Papers (July 2013 – October 2013)

1. **Murata, K. T., Watanabe, H., Ukawa, K., Yamamoto, K. and Zettsu, K., The NICT Science Cloud -- A Challenge of Science Data Crawling via NICT Science Cloud and Discussion toward Linked Open Data --(in Japanese), IEICE-AI2013-18, IEICE-SC2013-12, IEICE-113, No.178(AI), No.179(SC), pp.19-24, 2013.**

   In the Solar-Terrestrial Physics (STP), it is pointed out that circulation and utilization of observation data among researchers are insufficient. One of the reasons is that the data formats of STP observation data are not common. This is not only the issue of STP data but also of other natural science data. To archive interdisciplinary researches, we need to overcome this circulation and utilization problems. Under such a background, the Solar-Terrestrial data Analysis and Reference System (STARS) has been designed and developed by the authors' group. In the present study, we designed meta-data of the STARS along with the RSS1.0 document. In order to describe the meta-data of the STARS beyond RSS1.0 vocabulary, we defined original vocabularies for the STARS resources using RDF Schema. Our system works as follows. The RSS1.0 documents generated on data sites are automatically collected by a meta-data collection agent. The agent extracts meta-data to store them in an XML database. The XML database provides advanced retrieval processing that has considered property and relation.

2. **Isoda, F., Murata, K. T., Fukazawa, K., Watanabe, H., Ebihara, Y., Saita, S., Kubota, Y. and Kimura, E., High Time Resolutional Visualization of Earth's MHD Simulation(in Japanese), Journal of Visualization Society of Japan, Vol.33, Suppl.No.2, pp.247-248, 2013.**

   The high time and spatial resolution visualizations in 3D of the global MHD simulations are presented. The Virtual Aurora, is a tool designed based on the AVS, is developed on the purpose of adapting to the parallel processing with the distributed file system, Gfarm/Pwrake to process huge amount of simulation data files. The new technique is included, as the tracing of fluid elements. It will helpful for understanding the convection in the magnetosphere.

3. **Murata, K. T., Isoda, F., Fukazawa, K., Watanabe, H., Tatebe, O., Tanaka, M., Kimura, E., Yamamoto, K., Ukawa, K., Muranaga, K. and Suzuki, Y., A New Visualization Method of Big Data Era on Science Cloud(in Japanese), Journal of Visualization Society of Japan, Vol.33, Suppl.No.2, pp.255-256, 2013.**

   The NICT Science Cloud is a cloud system designed for scientific researches, and expected as a new infrastructure for big data sciences. Not only parallelization of CPU as in super-computers, but I/O and network throughput parallelization are crucial for the big data science. A high-performance visualization system is constructed on the NICT Science Cloud using Gfarm/Pwrake middleware. We examined performance of this parallel visualization environment for a set of computer simulation with 1000 files (2.3TB in all). After setting higher priority to access to local file on local disk, we finally achieved 124 times higher visualization using 192 core cpu.

4. **Watanabe, H., Murata, T., Isoda, F., Tatebe, O., Tanaka, M., Kimura, E., Ukawa, K., Muranaga, K. and Suzuki, Y., New Visualization in Big Data Era on Science Cloud(in Japanese), Journal of Visualization Society of Japan, Vol.33, Suppl.No.2, pp.71-72, 2013.**

   During these 50 years, along with appearance and development of super-computers, numerical simulation is considered to be a third methodology for science, following theoretical (first) and experimental and/or observational (second) approaches. The variety of data yielded by the second approaches has been getting more and more. This paper is to propose a cloud system for informatics, which has been developed at NICT (National Institute of Information and Communications Technology), Japan. We first introduce the NICT science cloud. We next demonstrate the efficiency of the science cloud, showing several scientific results which we achieved with this cloud system. Through the discussions and demonstrations, the potential performance of sciences cloud will be revealed for any research fields.

5. **Isoda, F., Murata, T., Watanabe, H., Fukazawa, K., Yamamoto, K., Kubota, Y., Kasai, Y., Sato, S., Ukawa, K., Muranaga, K., Suzuki, Y., Kurosawa, T., Kimura, E., Tatebe, O. and Tanaka, M., NICT Science Cloud: Big-data Analyses via Parallel and**

**Distributed Processing Technique for Earth and Space Science(in Japanese), IEICE-PRMU2013-62, IEICE-113, No.230, pp.29-34, 2013.**

Science cloud is a cloud system designed for scientific researches, and expected as a new infrastructure for big data sciences. Not only parallelization of CPU as in super-computers, but I/O and network throughput parallelization are crucial for the big data science. One of the typical structures of science cloud is a scalable cluster in which multiple clusters in a cloud are connected with high-speed network. In the present study, we study a performance of parallelization of both CPU and I/O inside a cloud as a first step to the high performance scalable clusters. In case with few processes executed on each computational node (server), parallelization efficiency is almost 100%. This high efficiency is expected to maintain in larger-scale cluster systems such as those with 30 servers. On the other hand, under the condition of multi-processes on each node, the present parallelization does not show good performance due to the congestions of I/O. Parallelization efficiency is as low as 15.6. New techniques of decentralization of I/O within each node are required in the next step.

6. **Murata, T., Isoda, F., Watanabe, H., Ukawa, K., Muranaga, K., Suzuki, Y., Kurosawa, T., Kimura, E., Tatebe, O., Tanaka, M., Yamamoto, K., Nagatsuma, T., Tsugawa, T., Sato, S. and Kasai, Y., NICT Science Cloud: Data Collection, Database and Data Processing of Global Earth and Space Observation Networks(in Japanese), IEICE-PRMU2013-61, IEICE-113, No.230, pp.23-28, 2013.**

   This paper is devoted to present an operation system to acquire, to transfer and to storage data for world-wide observation networks, which is named as "NICTY/DLA" and "WONM (Wide-area Observation Network Monitoring) system, developed in NICT (National Institute of Information and Communications Technology). These systems provide us with easier management of data collection than legacy systems by means of autonomous system recovery, periodical state monitoring, and dynamic warning procedures. We have equipped world-wide observatories for space weather prediction and research works with this system connected with the NICT Science Cloud. We will discuss this challenging system, especially from the viewpoint that we easily operate world-wide observatories on a web application.

7. **Nagatsuma, T., Murata, K. T., Yamamoto, K., Tsugawa, T., Kitauchi, H., Kondo, T., Ishibashi, H., Nishioka, M. and Okada, M., Operation of data acquisition, transfer**

and storage system for world-wide observation networks, International Forum on Polar Data Activities in Global Data Systems, Program and Abstracts, pp.110-111, 2013.

This paper is devoted to present an operation system to acquire, to transfer and to storage data for world-wide observation networks, which is named as "WONM (Wide-area Observation Network Monitoring) system, developed in NICT (National Institute of Information and Communications Technology). This system provides us with easier management of data collection than legacy systems by means of autonomous system recovery, periodical state monitoring, and dynamic warning procedures. We have equipped world-wide observatories for space weather prediction and research works with this system connected with the NICT Science Cloud. Demonstration and discussion will be presented concerning with this challenging system, especially from the viewpoint that we easily operate world-wide observatories on a web application.

8. Murata, K. T., Watanabe, H., Yamamoto, Isoda, F., Kimura, E., Tatebe, O., Tanaka, M., Ukawa, K., Muranaga, K. and Suzuki, Y., The NICT Science Cloud: distributed storage system and parallel data processing applicable for polar research data, International Forum on Polar Data Activities in Global Data Systems, Program and Abstracts, pp.108-109, 2013.

Data-oriented science is considered as the forth paradigm for coming big data science, including polar research. The NICT Science Cloud is designed and constructed as a basis for data-oriented science since 2010. In the present paper, we discuss the basic concepts behind the NICT Science Cloud, especially focusing on big-data processing. We demonstrate information and communication technologies (ICT) designed to transfer, steward, process and publicize large-scale data acquired and analysed in solar-terrestrial physics.

9. Y. Katoh and Y. Omura, Effect of the background magnetic field inhomogeneity on generation processes of whistler-mode chorus and broadband hiss-like emissions, J. Geophys. Res., doi: 10.1002/jgra.50395, 2013.

By a series of self-consistent electron hybrid code simulations, we study the effect of the background magnetic field inhomogeneity on the generation process of whistler-mode chorus emissions. Chorus with rising tones are generated through nonlinear wave-particle interactions occurring around the magnetic equator. The mirror force plays an important role in the nonlinear interactions, and the spatial inhomogeneity of the background magnetic field is a key parameter of the chorus generation process. We have conducted numerical experiments with different spatial inhomogeneities to understand properties of the chorus generation process. We assume the same initial condition of energetic electrons at the magnetic equator in all simulation runs. The simulation results reveal that the spectral characteristics of chorus significantly vary depending on the magnetic field inhomogeneity. Whistler-mode emissions are generated and propagate away from the equator in all simulation runs, but distinct chorus elements with rising tones are only reproduced in the cases of small inhomogeneities. In the simulation that had the smallest inhomogeneity, we find excitation of broadband hiss-like emission (BHE) whose amplitudes are comparable to discrete chorus elements found in other simulation runs.

10. **D. Summers, R. Tang, Y. Omura, and D. H. Lee, Parameter spaces for linear and nonlinear whistler-mode waves, Phys. Plasmas, 20, 072110; doi: 10.1063/1.4816022, 2013**

    We examine the growth of magnetospheric whistler-mode waves which comprises a linear growth phase followed by a nonlinear growth phase. We construct time-profiles for the wave amplitude that smoothly match at the transition between linear and nonlinear wave growth. This matching procedure can only take place over a limited "matching region" in ðNh=N0; ATÞ-space, where AT is the electron thermal anisotropy, Nh is the hot (energetic) electron number density, and N0 is the cold (background) electron number density. We construct this matching region and determine how the matching wave amplitude varies throughout the region. Further, we specify a boundary in ðNh=N0; ATÞ-space that separates a region where only linear chorus wave growth can occur from the region in which fully nonlinear chorus growth is possible.

11. **Y. Miyoshi, R. Kataoka, Y. Kasahara, A. Kumamoto, T. Nagai, and M. F. Thomsen High-speed solar wind with southward interplanetary magnetic field causes relativistic electron flux enhancement of the outer radiation belt via enhanced condition of whistler waves, Geophys. Res. Lett., 40, 1–6, doi:10.1002/grl.50916, 2013**

    Relativistic electron flux in the outer radiation belt tends to increase during the high-speed solar wind stream (HSS) events. We demonstrate that during HSS events with the southward interplanetary magnetic field (IMF)-dominant HSS (SBz-HSS), relativistic electrons are accelerated by whistler mode waves; however, during HSS events with the northward

IMF-dominant HSS, this acceleration mechanism is not effective. The differences in the responses of the outer radiation belt flux variations are caused by the differences in the whistler mode wave–electron interactions associated with a series of substorms. During SBz-HSS events, hot electron injections occur and the thermal plasma density decreases due to the shrinkage of the plasmapause, causing large flux enhancement of relativistic electrons through whistler mode wave excitation. These results explain why large flux enhancement of relativistic electrons tends to occur during SBz-HSS events.

12. **K. Sakaguchi, Y. Kasahara, M. Shoji, Y. Omura, Y. Miyoshi, T. Nagatsuma, A. Kumamoto, A. Matsuoka, Akebono observations of EMIC waves in the slot region of the radiation belts, Geophys. Res. Lett., 40, 1-5, doi:10.1002/2013GL058258, 2013**

    Akebono observed electromagnetic ion cyclotron (EMIC) waves in the deep inner magnetosphere at L = 2.5 – 5 at altitudes of 3,300 − 8,700 km. The mode conversion, i.e., L mode (He+ band) → R mode (He+ band) → L mode (O+ band) was clearly identified from the equator to high latitudes. In addition, rising tone structures are found, recently identified as EMIC triggered emissions, which could lead to bursty precipitation of relativistic electrons. First, the ion composition ratio (H+, He+, O+) = (83%, 16%, 1%) are estimated from polarization analysis. Second, minimum resonant electron energies with the observed EMIC waves and triggered emissions are estimated to be ~1–10 MeV. The satellite trajectory during the wave observation was primarily through the slot region of electron radiation belts. The collocation implies possible contribution of EMIC waves to formation of the slot region of radiation belts after a magnetic storm.

13. **M. N. Nishino, M. Fujimoto, Y. Saito, H. Tsunakawa, Y. Kasahara, M. Kawamura, M. Matsushima, F. Takahashi, H. Shibuya, H. Shimizu, Y. Goto, K. Hashimoto, Y. Omura, A. Kumamoto, T. Ono, S. Yokota, Type-II Entry of Solar Wind Protons into the Lunar Wake: Effects of Magnetic Connection to the Night-side Surface, *Planetary and Space Science*, 87, 106-114, doi:10.1016/j.pss.2013.08.017, 2013.**

    Recent observations by KAGUYA revealed that type-II (T2) entry of the solar wind protons into the near-Moon wake occurs when the IMF is dominated by the non-radial components (i.e. BY and/or BZ). Nishino et al. (2013) categorized T2 entry into two cases; T2 entry with magnetic connection to the lunar surface (T2MC) and T2 entry into magnetically detached regions (T2MD). Strong electron acceleration (up to several hundred eV to 1 keV) along the magnetic field associated with the T2 entry is prominent when the field line has its both ends in the solar wind, that is, when the magnetic field is detached from the lunar surface (T2MD). On the other hand, no significant electron acceleration is found in the T2MC cases although an enhancement of the electron flux associated with the T2 proton entry is evident. They also reported that the T2 entry process takes place even under radial (BX-dominated) IMF condition. These results indicate that, while the T2 entry of solar wind protons into the wake itself does not require a special IMF condition but is a rather general phenomenon, the characteristic energy of associated electrons does show a strong dependence on the magnetic connectivity to the lunar surface.

14. **K. H. Lee, Y. Omura, and L. C. Lee, Electron acceleration by Z-mode and whistler-mode waves, Phys. Plasmas, 20, 112901; doi: 10.1063/1.4829439, 2013.**

    We carried out a series of particle simulations to study electron acceleration by Z-mode and whistler-mode waves generated by an electron ring distribution. The electron ring distribution leads to excitations of X-mode waves mainly in the perpendicular direction, Z-mode waves in the perpendicular and parallel directions, and whistler-mode waves mainly in the parallel direction. The parallel Z- and whistler-mode waves can lead to an effective acceleration of ring electrons. The electron acceleration is mainly determined by the wave amplitude and phase velocity, which in turn is affected by the ratio of electron plasma to cyclotron frequencies. For the initial kinetic energy ranging from 100 to 500 keV, the peak energy of the accelerated electrons is found to reach 2–8 times the initial kinetic energy. We further study the acceleration process by test-particle calculations in which electrons interact with one, two, or four waves. The electron trajectories in the one-wave case are simple diffusion curves. In the multi-wave cases, electrons are accelerated simultaneously by counter-propagating waves and can have a higher final energy.

15. **Y. Omura and Q. Zhao, Relativistic electron microbursts due to nonlinear pitch-angle scattering by EMIC triggered emissions, J. Geophys. Res., doi: 10.1002/jgra.50477, 2013.**

    We show that the anomalous cyclotron resonance between relativistic electrons and electromagnetic ion cyclotron (EMIC) triggered emissions takes place very effectively near the magnetic equator because of the variation of the ambient magnetic field. Efficient precipitations are caused by nonlinear trapping of relativistic electrons by electromagnetic wave potentials formed by EMIC triggered emissions. We derive the necessary conditions of the wave amplitude, kinetic energies, and pitch angles that must be satisfied for the nonlinear wave trapping. We have conducted test particle simulations with a large number of relativistic electrons trapped by a parabolic magnetic field near the magnetic equator. In the presence of coherent EMIC-triggered emissions with increasing frequencies, a substantial amount of relativistic electrons is trapped by the wave, and the relativistic electrons at high pitch angles are guided to lower pitch angles within a short time scale much less than a second, resulting in rapid precipitation of relativistic electrons or relativistic electron microbursts.

16. **M. Shoji and Y. Omura, Triggering process of electromagnetic ion cyclotron rising tone emissions in the inner magnetosphere, J. Geophys. Res., 118, 5553–5561, doi:10.1002/jgra.50523, 2013.**

    Spacecraft observations and simulations show generation of coherent electromagnetic ion cyclotron (EMIC) triggered emissions with rising tone frequencies. In the inner magnetosphere, the spontaneously triggered EMIC waves are generated by the energetic protons with large temperature anisotropy. We reproduced EMIC triggered emissions in the Earth's magnetosphere by real scale hybrid simulations with cylindrical magnetic geometry. We obtained spontaneously triggered nonlinear EMIC waves with rising frequencies in the H+ band of the EMIC dispersion relation. The proton holes in the phase space are formed. We have also derived the theoretical optimum wave amplitude for triggering process of the EMIC nonlinear wave growth. The optimum wave amplitude and the nonlinear transition time show a good agreement with the present simulation result. The nonlinear wave growth over a limited time forms a subpacket structure of a rising tone emission. The formation process of a subpacket is repeated because of a new triggering wave generated by the phase-organized protons, which are released from the previous subpacket. Then, the EMIC triggered emission is formed as a train of subpackets generated at different rising frequencies.