No. 23 September 2008

International Newsletter

Research Institute for Sustainable Humanosphere, Kyoto University, Japan

= Foreword =

New Developments in Inter-University Collaborative Research Programs

Prof. Masato Shiotani
Head, Department of Collaborative Research Programs
RISH, Kyoto University

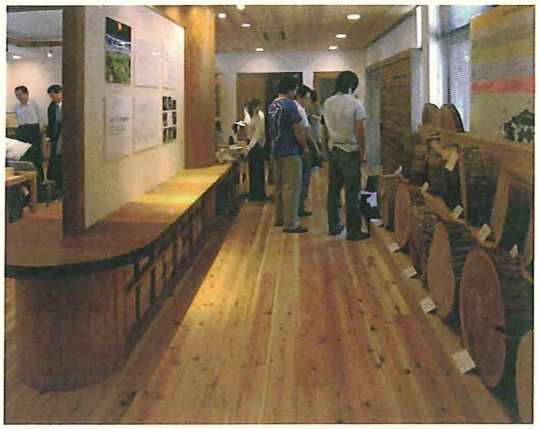
One of the unique and very important functions of the Research Institute for Sustainable Humanosphere (RISH) is to promote inter-university collaborative programs in relation to research on the humanosphere. These are led by the Department of Collaborative Research Programs, which furnishes collaborative equipment, facilities, and databases. Cooperative studies have been done using collaborative research facilities and resources such as MU (middle and upper atmosphere) radar, A-KDK (Advanced Kyoto-daigaku Denpa-kagaku Keisanki-jikken computer), METLAB (Microwave Energy Transmission Laboratory)/SPSLAB (Solar Power Station/Satellite Laboratory), EAR (Equatorial Atmosphere Radar) in Indonesia, Wood Composite Hall, LSF (Living-sphere Simulation Field) in Kagoshima, DOL (Deterioration Organisms Laboratory), and FBAS (Forest-Biomass Evaluation and Analysis System). In addition, studies using databases have been conducted on the basis of the collections of wood samples in the xylarium and the collections of digital data related to the humanosphere. An overview on this activity was reported in the International Newsletter (No. 19), and here some additional developments that have occurred since the appearance of the overview are described.

As a result of the requirement for cooperative work by RISH and the Center for Ecological Research at Kyoto University, we now have a collaborative facility called the Development and Assessment of Sustainable Humanosphere (DASH) system, which was introduced in March 2008. The DASH system consists of two subsystems, the DASH plant growth subsystem, a large greenhouse for cultivating transgenic plants including tree species, and the DASH chemical analysis subsystem, a cluster of spectrometers, a LC-IT/TOF-MS (liquid chromatography ion trap/time-of-flight mass spectrometer) for comprehensive metabolite analyses, and two GC-MSs (gas chromatography mass spectrometers) specialized for the analysis of lignin components as well as plant-derived volatile organic compounds. There is also a lysimeter in the greenhouse to monitor soil conditions.

The DASH plant growth subsystem

Due to this new arrangement, an associated collaborative facility, the Forest Biomass Analysis System (FBAS), was merged into the DASH system; FBAS is utilized for the chemical analysis of wood biomass, with special attention paid to the lignin components, to support the systematic analyses of plant metabolites, and concurrently to facilitate the cultivation of a large variety of transgenic plants. The DASH/FABS system serves domestic and international collaborative activity from the viewpoint of the ecological interaction and network between plants, atmosphere, soil, microorganisms, and insects. The development of novel material by transgenic plants is also highlighted. The use of this facility will soon be discussed in the working committee as a part of the inter-university collaborative programs of RISH.

Another important development is related to the xylarium. The wood collection at the xylarium, designated as KYOw, has been serving as the basis for the exchange of knowledge and experience in wood anatomy at national and international levels. Our activities linked to the xylarium include research into and education about wood anatomy and identification by indexing, exchange, and web page publishing of wood collections. In particular we have several precious wood collections such as Yakusugi (Cryptomeria japonica), of which the tree rings can be traced back to 1192 A. D., and a part of the central column (Chamaecyparis obtusa) of the five-storied pagoda in Horyuji temple, the oldest wooden building in the world, showing 351 annual rings dated back to the Yayoi and Asuka periods (A. D. 241–591). Unfortunately, the public space was not large enough for these wood samples to be on display, and it had been the hope of the RISH administration that such important wood collections would be used as a part of the RISH database that is open to the public via the Internet, not only for cooperative research projects but also for ordinary studies. To integrate information on wood samples and digital data so it would be available to the public, we established the Virtual Field for Humanosphere by expanding the space of the xylarium in June 2007. This facility includes PC terminals for database inquiry, an exhibition booth for the wood culture, and presentation space for visualizing research results. We welcome you to the Virtual Field for Humanosphere.



The Virtual Field for Humanosphere

= RISH International Symposium =

VTT-RISH Joint Symposium – VTT-RISHJointSymposium –

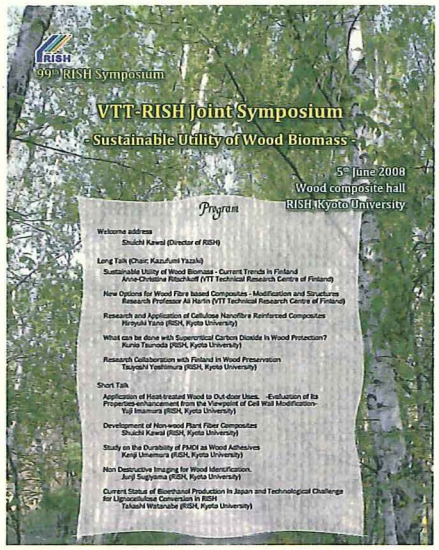
Prof. Kazufumi Yazaki

A joint symposium between RISH and the VTT Technical Research Center of Finland was held under the title of "Sustainable Utilization of Wood Biomass" on 5 June 2008 in the Wood Composite Hall of RISH (Uji). Two invited key speakers, Professor Anne-Christine Ritschkoff and Research Professor Ali Harlin from VTT, visited RISH to attend the symposium.

Both RISH and the VTT Technical Research Center of Finland have been active in the field of wood biomass research and plant secondary metabolism, and researchers at these institutions have collaborated on numerous projects. To promote these activities, on 20 March 2007 RISH and the VTT Technical Research Center of Finland agreed to a 5-year contract titled the "General Memorandum for Academic Cooperation" under the special research field designated as "Science for Sustainability."

As a kick-off meeting to celebrate this contract, the VTT-RISH Joint Symposium was organized to discuss the sustainable utility of wood biomass in June 2008 at the Uji Campus of RISH (organizer, Kazufumi Yazaki). This was the 99th RISH symposium in the serial symposia organized by our institute to explore the many scientific aspects of the sustainability of human life on planet Earth.

The humanosphere is defined as four vertical regions of the Earth that support human activity, the ground human habitat, the forest-sphere, the atmosphere, and the space surrounding them. To support human activity, exploration of innovative sciences and technologies that contribute to establishing a solar energy-dependent sustainable society amenable to the environment is necessary. It is widely accepted that plants play key roles in achieving these



prospects, and thus the contribution of plant sciences to the humanosphere is strongly anticipated.

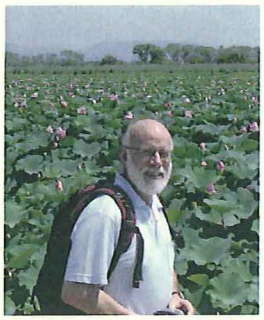
With the sharing of research topics at the 99th Symposium on Sustainable Humanosphere that focus on the utilization of wood biomass as materials, future collaboration is being encouraged. At the symposium, five lectures and five short talks were presented by two guests from Finland and eight members from RISH, and ca. 50 scientists including fellows of several companies attended and enjoyed the presentations. There was very active discussion after each talk, and new collaboration has now been planned. The next joint symposium will be organized by VTT in Finland.

We give sincere thanks for the grant from the International Exchange Program of Kyoto University, which helped us to present this international symposium.

= Visiting Professor =

Space Plasma Research Activities at RISH

Prof. Bertrand Lembège
Visiting Professor from France



I am currently visiting RISH during the period May 7th to November 6th, 2008.

I am on leave from Centre de recherches des Environnements Terrestre et Planétaires (CETP) at Velizy located near Paris (France), where I have a position of Research Director under the auspices of Centre National de la Recherche Scientifique (CNRS). My laboratory (initally named CRPE, before CETP) and the University of Kyoto have a long history of collaboration and friendship since several tens of years, very well illustrated and stimulated by two eminent scientists: our former Director of CETP (Prof. Roger Gendrin) and the former director of RISH (Prof. Hiroshi Matsumoto) recently elected at the Presidency of Kyoto University.

The first time I visited Japan in 1980 for a meeting in Nagoya, was also for me the time I had the pleasure for visiting Kyoto University and for discussing with Prof. Matsumoto and the members of his team. Two years later (I982), a decisive turn occured in my career to focuss my activity on numerical simulation in space plasmas, starting by a 3-years stay in UCLA (USA) and meeting there Prof. Yoshiharu Omura. Since this time, a close relationship has been established with Prof. Omura, animated by strong common interest in Plasma Physics, in techniques of numerical simulations, but also in co-organizing sessions in international meetings.

Under the invitation of Prof. Kawai (RISH Director), I have the pleasure of working with Prof. Yoshiharu Omura and other scientists and students on Space Plasmas using the techniques of numerical simulation. My main research field is focussed on the physics of collisionless shocks which I like to share with colleagues and students at RISH, by providing several seminars and taking time for unformal discussions. Such a natural shock exists in our nearby magnetic environment (magnetosphere) and forces the solar wind (ionized particles emitted continuously from the sun) to slow down considerably. It plays the important role of a natural "shelter" and avoids us to be "bombarded" by very energetic particles emitted from the sun. Moreover, similar shocks also exist in the universe where plasma physics plays a key role such as in solar physics, planetary and interplanetary physics, in heliospheric physics and astrophysics. These simulations of shocks are stimulating deep analysis of rich experimental results issued from mono- and multi-spacecrafts such as GEOTAIL and CLUSTER missions, these are compared with.

I have also a strong interest in other

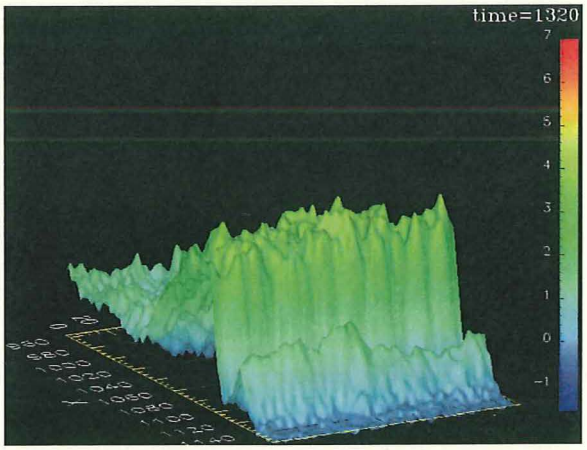


Fig.1: 3D Plot of magnetic field issued from full Particle numerical Simulation which help to reproduce artificially and to analyze the natural Terrestrial bow shock (large jump on the figure) in space plasmas. Such simulations require very large scale supercomputers.

topics such as the magnetic reconnection (MR), the 3D full particle simulations of the global magnetosphere, and the physics of electrostatic solitary waves (ESW) commonly observed in our magnetospheric environment. I appreciate regular discussions with Prof. Omura's students on their Phd thesis topics, while stimulating their interest /curiosity (2D/3D hybrid simulations of instabilities expected in the downstream side of the terrestrial bow shock , features/statistics of ESW in the diffusion region of MR, and identification of magnetic nulls in the MR region).

During my stay at RISH, I am quite pleased to participate to National Japanese meetings at Chiba (June 26th-30-th) and at Tohoku (October 9th-12th). These meetings have been completed by a working visit at Nagoya University. My stay at RISH allows me also to refine with Prof. Y. Omura the co-organisation of the forthcoming 9th International School of Space Simulation (ISSS-9 to be held in Paris, 2009 July 3rd-10th), to prepare choice of sessions to be proposed for the next URSI General Assembly, and to discuss innovative ideas for promoting the use of numerical simulations in the wide range of space plasma fields.

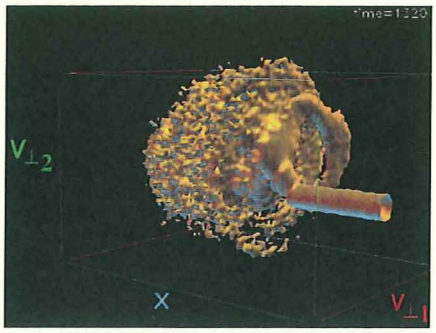


Fig.2: Corresponding iso-surface of the ions density through the simulated shock (same time as Fig.1)

I already have visited Japan several times since 1980, including 2-3 months stay at ISAS (Sagamihara in 1999), and at Tsukuba University (in 2005). However, it is my first "long" stay in RISH and I am really enjoying my current visit in particular in the area of Kyoto-Uji very rich in history. This stay represents also an excellent opportunity for me to discover more about traditional music instruments (play and manufacture), painting art and the landscape beauty in Japan. At least, I would like to thank my friends and colleagues at RISH, in particular Prof. Omura, for the very nice welcome and for making my stay so enjoyable and so rich. Deep thanks are also addressed to Mrs. Koyama and Mrs. Kita for their patience to my numerous questions and for resolving all points so smoothly.

= Post-doctoral fellow =

Ionospheric tomography experiment using beacon TEC data obtained using a network along 135°E longitude over Japan

Prof. Dr Smitha V Thampi
JSPS Postdoctoral Fellow (Foreign Researcher)

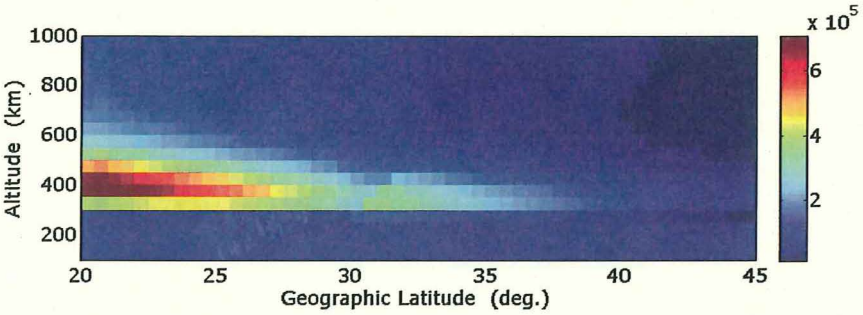
I am presently pursuing my post-doctoral research at RISH as a JSPS Fellow since April 2008. My major area of work includes the investigations of the terrestrial ionosphere using the Total Electron Content (TEC) data. The coherent beacon transmissions from Low Earth Orbiting Satellites (LEOS, at an altitude of ~1000 km) provide the simplest way to measure the Total Electron Content (TEC) from satellite to ground. It is now well-established that these TEC data obtained from a chain of ground-based receivers aligned along a particular meridian can be effectively used for the tomographic imaging of the latitudinal distribution of electron densities in the meridional plane, which gives a snap-shot picture of the ionosphere with a very good spatial coverage. During the past, there had been several successful tomography experiments from various regions. During my doctoral work in India, I was mainly involved in the Indian tomography experiment, called CRABEX (Coherent Radio Beacon Experiment), which studied the equatorial and low-latitude ionosphere along the 77-78°E meridian. My work included the development of the necessary inversion algorithms, the forward modeling and simulations to test the sensitivity of the algorithms, and the generation of actual tomographic images. Apart from the tomographic imaging, the TEC measurements (both from CRABEX and GPS) were directly used to study the 'space weather' processes including Equatorial Spread F, which is very important in the context of space-based navigation and communication.

Presently, we are initiating a new beacon experiment along the Japanese longitudes. A novel digital receiver was designed and developed for receiving the beacon transmissions from the LEOS by Prof. Mamoru Yamamoto, and recently a chain of these digital receivers has been established mainly for the tomographic imaging of the ionosphere over this region. Three receivers were installed at Shionomisaki (33.45° N,135.8°E), Shigaraki (34.8°N,

136.1°E) and Fukui (36°N,136°E), which continuously track the LEOS, to obtain simultaneous TEC data from these three locations. These are used for tomographic reconstruction. The images can reveal the temporal evolution as well as the day-to-day variability of the mid-latitude ionosphere. For instance, we can have images of the medium-scale traveling ionospheric disturbances (MSTIDs) that is known to be frequently occurring in the summer nighttime over Japan. In the first phase of our experiment itself we have observed few events of wave-like perturbations in TEC from all the three stations, which could be the signatures of MSTIDs. The proposed study also intend to investigate the field-aligned irregularities (FAIs) over equatorial and low-latitude regions and the coupling between various atmospheric regions mainly using the Equatorial Atmospheric Radar, MU radar and GEONET TEC network of Japan.

During this period, I have participated in the Japan Geosciences Union Meeting, which was held at Tokyo. Apart from that, I could visit the MU radar facility of Shigaraki, which is definitely a memorable event for me. I could also visit few historical places like Mimurotoji Temple, in the beautiful and historical Kyoto. I am enjoying my current visit to Japan, both scientifically and socially.

It is my pleasure to express my heartfelt gratitude to my host Prof. Mamoru Yamamoto, for providing such a good opportunity and also for the constant support and encouragement. I also thank Ms. Tomako Eto for helping me in many ways. Thanks are due to all my colleagues and friends at RISH. I am expecting that my visit to RISH will definitely widen my perspective and open up new pathways to explore the mysteries of space.



The tomographic image on 2008 August 01, 0245 UT. The color-axis represents the electron densities in cm^{-3}.

= Post-doctoral fellow =

There is no end to learning

Dr. Wang Yue
JSPS Postdoctoral Fellow (Foreign Researcher)

In April 2004, I came to Japan and began my master course at Kyoto Perfectural University (KPU), and I received the degree of Ph.D. in agriculture at KPU in February 2008. My research focused on the mechanical properties of wood in response to rapid temperature changes. Since April 2008, I have been conducting new research at the Research Institute for Sustainable Humanosphere (RISH) at Kyoto University under a JSPS postdoctoral fellowship. This has been a good chance for me to experience new laboratory surroundings and create a new view on the research I want to do. Now, my research is about the structural and mechanical adaptation of reaction wood in response to environmental changes.

Trees control the shape of their stems in response to growth stresses that occur during the process of wood formation. Reaction wood is formed in response to mechanical stress, which may be the result of wind exposure, excess of snow, soil movement, etc., and the reaction wood helps to position newly formed parts of the plant optimally, which is an interesting phenomenon.Reaction wood is defined by the Internation Association of Wood Anatomists (IAWA) as wood with distinctive anatomical and physical characteristics, formed typically in parts of leaning or crooked stems and in branches, that tends to restore the original position of the branch or stem when it has been distrubed. This means that trees have qualitative changes by nature and forme themselves in more stable state for adapting to the environment. I believe that reaction wood can help us to understand the structure-properties relationships, which can improve the stability of biomass materials. Though I am a sentient being with a brain for thinking, I cannot qualitatively change myself to adapt to the environment, which leads me to conclude sometimes that plants are smarter☺.

In fact, my present research is related to but not identical to my past research, so in a few months, I have gained a great deal more knowledge on the anatomical structure of wood, because understanding the anatomical features allows me to define reaction wood, and I have mastered more skills in chemical treatment of wood, such as the analysis of carbohydrate, lignin structure, and the like. During this process, I had to face failure many times. Fortunately, the staff members,

The measurement of growth stress. My supervisor, Prof. Sugiyama Junji, is shown cutting bark from a tree.

researchers and students at RISH are being very kind to me. They have told me about their experiences with experimental methods, which helped me to avoid a lot of unnecessary effort and allowed me to acquire new knowledge as quickly as possible. Even though it took them one or two years to gain these experiences, they taught me every detail without any reservation, so I would like to express my appreciation to the staff members and students of the Laboratory of Biomass Morphogenesis and Information for giving me a lot of advice on my research.

As soon as I got the Ph.D. degree, I thought I could relax because I had gained special knowledge that would allow me to resolve problems of wood. However, soon after I began associating with the staff members and researchers of the laboratory where I am working, I realized that I was like the frog in the shallow well (quoted from the old Chinese fable). Now, I am very happy that I can work at a high-level laboratory.

Whenever you are, wherever you are, whatever you do, there is no end to learning.

= Student from Abroad =

My study in Japan on the biosynthesis of lignin and lignans in plants

Safendrri Komara Ragamustari
Ph.D. Student from Indonesia

Lignin and lignans play important roles in plants. The former is important for maintaining mechanical strength, and the latter are indispensable for plants, mainly for defense against pathogens and stress. Lignin and lignans are also related to the humanosphere. Lignin is an important factor in the pulping process for paper production and significantly affects pulping efficiency. According to the World Wildlife Fund (WWF), paper consumption in Europe alone has increased six-fold over the last 50 years and is projected to continue to increase, resulting in the urgent need to increase the efficiency of paper production. As for lignans, many of them have been revealed to have potency in the medical treatment of cancer, giving us an alternative source for new anticancer drugs discovery. In 2003, the World Health Organization (WHO) reported that the mortality rate caused by cancer could increase by 50% by 2010. New anticancer drugs, combined with other agents, may turn many cases of rapidly fatal cancer into manageable chronic illness. Therefore, it is important to seek ways to control lignin and lignan biosynthesis in plants. However, to do so, better understanding of their metabolic pathways, including the genes involved, is needed.

My current research at RISH is dedicated to tackle the above phenomena from a basic science perspective. In my research, I carry out expression and characterization of recombinant proteins related to the corresponding target genes. The main method I use in the characterization is Gas Chromatography-Mass Spectrometry (GC/MS)-based kinetic analysis. The plants used in the research were chosen due to their characteristic of producing significant amounts of lignin/lignan.

A "Shimadzu GCMS QP-2010 Plus" unit used for kinetic analysis of the recombinant proteins

My first research topic is focused on the characterization of three recombinant cinnamyl alcohol dehydrogenases (CADs) isolated from *Carthamus tinctorius* (benibana). CADs catalyze the last reductive step in lignin monomer biosynthesis, which are the building blocks of lignin. The CAD-encoding cDNAs were isolated from a cDNA library prepared from *C. tinctorius* developing seeds. The conclusion of this research is that one of the CADs is dominant in lignin biosynthesis, whereas the other two are thought to be related to plant defense mechanisms.

My second research topic is

on the biosynthesis of podophyllotoxin, a lignan that has received interest due to its anticancer characteristics. The goal of this research is to elucidate *O*-methyltransferases (OMTs) involved in podophyllotoxin biosynthesis. Seven prospective OMT-encoding cDNAs were isolated from a cDNA library prepared from *Anthriscus sylvestris* (shaku) leaf buds. Thus far, we have found that one of the OMTs is possibly involved in lignin biosynthesis. Characterization of the remaining OMTs to find ones involved in podophyllotoxin biosynthesis is still underway.

I would like to express my immense gratitude to my supervising professor, Professor Toshiaki Umezawa, and to all of the staff members and students in my laboratory and at RISH, who have guided me through my study. Under their patient and overwhelming support, I have conducted my research. In addition, I also cannot disregard the support that I have received from my family. I am very grateful and happy that my family is with me in Japan, as my life in Japan would be less colorful without them.

I am studying at Kyoto University under the Monbukagakusho scholarship program. I feel very lucky to be given this chance, as Kyoto University is one of the best universities in the world. Combined with the cultural richness that Kyoto has to offer, my stay in Japan has been a unique experience. I am excited and looking forward to the remaining time I have to study and learn here.

= Student from abroad =

From Radio Waves to Atmospheric Science – My Iterdisciplinary Rsearch at RISH

Xinan Lin
Master Course Student from China

I never thought my graduate research would be related to atmospheric science, since my major in college was electronic engineering. My interest is in electromagnetic waves and their propagation. When I first came to this Laboratory as a visitor, Professor Tsuda showed me, with warm enthusiasm, his research on radio occultation (RO) technique, with which one could extract the vertical profiles of the atmosphere's temperature, pressure, and humidity from radio waves refracted by the atmosphere. This is a totally new realm for me, since in textbooks electromagnetic waves are described only as being propagated in a vacuum or at a constant dielectric. However, concomitant with the altitude, the atmosphere, we can conclude it a varying dielectric, in which the propagation of electromagnetic wave is extremely complicated. Learning about this complexity of electromagnetic wave propagation stimulated me and made me thirst for a challenge in this new realm.

I became a member of this Laboratory as I wished. In the first few moths, the work confused me to some extent; my first research project seemingly had nothing to do with my favorite topic, electromagnetic waves. I was asked to program some codes to search for adjacent spots observed by radio occultation and radiosonde (weather balloon), analyze their differences, and decide whether the results of using the radio occultation technique were accurate enough to be useful. I compared dozens of atmosphere profiles of temperature and humidity which showed the excellent accuracy of the radio occultation technique. Though I felt some unwillingness to participate in this work at that time, I have to say I do appreciate having had the experience, because it helped me to realize that what I will research is not a field totally independent from the rest, but instead that my field is connected to a variety of topics from space science to meteorology.

The broader name for my current research is satellite-based GPS meteorology. The low earth orbit (LEO) satellites retrieve radio signals from the 28 civilian GPS satellites in higher orbits. As the LEO and GPS satellites rise above the horizon or set relative to each other, receivers measure the changes in frequency of the radio signals as the signals pass through different layers and densities of Earth's atmosphere. From these frequency measurements, it is possible to compute the refraction angles of the radio waves, and from those bending angles, vertical profiles of the atmosphere's temperature, pressure, and humidity can be extracted. The advantage of this technique is the global distribution of observational spots, especially in the oceans and polar areas. Atmospheric scientists will be able to use these vast collections of data to analyze or verify the atmospheric model that may answer the question of whether Earth is becoming warmer. Meteorologist will be able to improve their predictions of storms like typhoons. And we, who study how to convert data of radio waves to atmosphere profiles, are working somewhere in the middle of what satellite engineers and atmospheric scientists and meteorologists are doing, I believe.

Currently, our research includes verification of the resolution of the radio occultation technique, a direction that may be on the cutting edge in this field, which could help atmospheric scientists use the RO data in a more efficient way.

Finally, I do appreciate the International Newsletter of RISH, which provides me an opportunity to share my experience at RISH. Many of the people working at the laboratories at RISH are researching interdisciplinary subjects, and working at these laboratories is a perfect chance for students to learn how to apply their own knowledge beyond their majors. I hope more students will take part in RISH's excellent research in the future.

= News Topics =

Establishment of a "Forum for a Sustainable Humanosphere"

Assoc. Prof. Tsuyoshi Yoshimura

Chairman's talk at the first general meeting (Prof. Gyosuke Meshitsuka)

There has been an increasing demand for reliable future projections based on an accurate understanding of current conditions, and for the presentation of problem-solving measures that will contribute to the construction of a society that is capable of sustainable development. Based on this situation, RISH was established in 2004, and the scientists at RISH have been conducting research under four "Humanosphere Missions" aimed at the creation of Humanosphere sciences. To create a tight network for diverse research activities related to Humanosphere sciences, we have just established the "Forum for a Sustainable Humanosphere". On 12 July 2008, the first general meeting of the forum was held at the Kyoto University Clock Tower Centennial Hall with 584 kick-off members. At the meeting, Prof. Gyosuke Meshitsuka, Tokyo Kasei University, Member of the Science Council of Japan, was selected as chair of the forum, and the chair nominated Dr. Tetsuya Sato, Special Senior Researcher at the Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology, and Prof. Shuichi Kawai, Director of RISH, as vice chairs. After the acceptance of Regulations, the 100th RISH Symposium consisting of three speakers, Dr. Tetsuya Sato, Dr. Akemi Kurotani, Japan Aerospace Exploration Agency, and Prof. Hiroyuki Yano, RISH, was held at the venue with approximately 200 participants.

The goal of the Forum is to broadly promote "sustainable Humanosphere sciences" that will act as a platform for the construction of a Sustainable Humanosphere, and to promote the education and training of students and young researchers in Japan and around the world. Specific activities will include sharing the latest information based on educational and research activities at RISH. In the words of the Forum mission statement, Forum members will be able to (1) "Create information" through the shared use of RISH's functions (equipment and facilities) by researchers from across Japan and around the world, and through participation in joint research projects; (2) "Accumulate information" through the effective use of the Humanosphere database; and (3) "Transmit and exchange information" through Humanosphere symposiums and other venues.

Dr. Akemi Kurotani at the 100th RISH Symposium

Through the Forum's activities, we hope to promote a broad exchange of information regarding the current issues and future outlook in relation to Humanosphere sciences. We are determined to see this Forum become an organization that can provide signposts for humankind to follow in building a recycling-oriented society that is capable of sustainable development.

The Forum is now inviting members from around the world. Please contact the Forum through its e-mail address, forum@rish.kyoto-u.ac.jp.

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