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2023 14)International Technical Exchange Program List

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＊所属・職名は2024年3月現在

＊Affiliation and Department displayed are current as of March 2024.

研究代表者 Principal Investigator	所属機関* Affiliation	所属部局 Department	職名* Job title	研究課題名 Project Title	頁 Page	備考 Remarks
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(Form 14-2)

Technical exchange on accelerator mass spectrometry (AMS) for accurate and precise ^{14}C measurement

Masayo Minami (ISEE, Nagoya University)

The aim of this international technical exchange program on accelerator mass spectrometry (AMS) is to enhance the accuracy and precision of ^{14}C measurements using the ISEE AMS system by facilitating the exchange of technical expertise on various AMS systems. Program members, excluding myself and Prof. Hiroyuki Kitagawa, include Dr. Wan Hong and Mr. Yong Jin Park from the Korea Institute of Geoscience and Mineral Resources (KIGAM), Korea and Dr. Yoko Kokubu from the Tono Geoscience Center, Japan Atomic Energy Agency (JAEA-Tono).

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The Division for Chronological Research, ISEE operates a 3 MV Tandetron AMS system manufactured by High Voltage Engineering Europa (HVEE, B.V., Amersfoort, the Netherlands), which was installed in 1996. This system is equipped with a recombinator (simultaneous injection system) dedicated to precise and accurate ^{14}C measurements. KIGAM operates an HVEE AMS system with a lower energy of 1 MV, installed in 2007. The 1 MV AMS system, compact with significantly lower running costs and lower manpower requirements compared to the 3 MV AMS system, is equipped with a bouncer to measure ^{14}C, ^{10}Be, and ^{26}Al. JAEA-Tono operates a HVEE AMS system with an even lower energy of 0.3MV installed in 2019, capable of measuring multiple elements, including ^{14}C, ^{10}Be, ^{26}Al, and ^{129}I. Understanding the similarities and differences between these three types of HVEE AMS systems and exchanging information about best practices, technical advancements, and operational challenges are crucial to optimizing the performance of each institute's system.

During the last fiscal year, Dr. Hong visited Japan from October 17 to 27, 2022. He inspected several AMS facilities in Japan, including those of ISEE, JAEA-Tono, and the Aomori Research and Development Center, JAEA (JAEA-Mutsu), engaging in technical exchanges aimed at achieving high precision and high accuracy ^{14}C measurements. This fiscal year, I visited Korea from November 26 to 28, 2023, and inspected the KIGAM 1 MV AMS system and discussed the ^{14}C measurement data analysis methods, especially for old samples, with Dr. Hong. During my stay in Korea, I also visited the National Research Institute of Cultural Heritage of Korea with Dr. Hong to inspect the IonPlus-made compact 0.2MV AMS system called MICADAS (Mini Carbon Dating System) shown in Fig.1. The MICADAS system is ultra-compact and does not require SF_6 insulation gas, eliminating the need for SF_6 gas tank installation. Despite the excellent high performance of the MICADAS system and the presence of automatic sample preparation system and automatic graphite devices (Fig. 2), the preparation room for ^{14}C samples was not yet adequately equipped, and the establishment of a maintenance and management system for the equipment seemed to be insufficient. Following my visit, Prof. Kitagawa also visited KIGAM twice, from November 28 to December 1, 2023, and from March 5 to 8, 2024, to exchange technical expertise for high-precision and high-accuracy ^{14}C measurements. Furthermore, from March 25 to 29, 2024, Mr. Park, a young researcher from KIGAM, visited

ISEE to learn about sample preparation methods, specifically focusing on carbon extraction techniques for ^{14}C measurements of dissolved inorganic carbon in water samples. He also visited JAEA-Tono to observe a 0.3 MV AMS system and to engage in discussions regarding AMS technical exchange with Dr. Kokubu.

Through the program, valuable technical exchanges for high-precision and high-accuracy ^{14}C measurements were achieved by inspecting each other's AMS facilities and engaging in discussions regarding sample preparation methods and ^{14}C data analysis techniques. The technical exchanges significantly contributed to shaping future guidelines for AMS measurement and operation at ISEE.

Figure 1. MICADAS, an ultra-compact ^{14}C measurement AMS system manufactured by IonPlus, installed at the National Research Institute of Cultural Properties, Korea. The photo on the left shows the PC screen used to control the MICADAS AMS system.

Figure 2. View of the ^{14}C sample preparation room at the National Research Institute of Cultural Heritage, Korea. On the left, automated sampling system connected to GC-MS; on the right, automated graphite equipment (AGE 3).

(Form14-2)

Technology exchange on the state-of-art weather radar data analysis

Nobuhiro Takahashi (ISEE, Nagoya University)

1. Background and purpose of this project

Recent advances in meteorological radar technology have expanded the range of its application and required new analysis techniques. In Japan, phased array weather radar technology have been applied for ground-based and spaceborne system. Japan is one of the top runners of this field and ISEE is actively conducting analyses using phased array radars. The PI of this project is the leader of multi-parameter phased array weather radar (MP-PAWR) development. In Taiwan, multi-frequency (S-, C-, X-band) radar network was deployed nationwide and utilized for the operational and scientific purposes. This radar network is quite unique in the world and the National Taiwan University (NTU) and National Center for Disaster Research (NCDR) are the key institutes on radar analysis.

From the scientific viewpoint, phased array weather radar is expected to reveal uncovered three-dimensional structure and dynamics of rapidly changing convective systems and multi-frequency radar can provide accurate precipitation estimation and cloud physical processes. In this proposal, we will conduct the technology exchange of both types of radar to clarify the cons/pros of both radar systems for better understanding the precipitation systems. In particular, by exchanging the analytical products and their analysis tools, we will find further improvement of radar analysis of both side and will discuss about the future observing system using radar on the selection of frequencies, scanning strategy, combination of radars, analysis procedure and so on.

2. Scope of the project

In this project, we plan to discuss the following items:

1) Exchange the latest weather radar technology (ground based, airborne and spaceborne)
 phased array weather radar (ISEE)
 spaceborne dual-frequency radar (ISEE)
 multi-frequency (S-, C-, X-band) weather radar network (NTU, NCDR)
2) Lecture and training of analysis for phased array weather radar data
 Visualization of 3D structure, dual Doppler, VAD, vertical pointing, radar calibration
3) Lecture and training of analysis for multi-frequency weather radar
 combination of S-, C-, X-band radars for quantitively precipitation estimation
 utilization of multi-frequency radar for disaster prevention
4) Development of young researchers
 radar analysis training using actual observation data
5) Discussion about future the future observing system using radar
6) site visit: MP-PAWR site (Saitama University) and cloud radar, wind profiler and SAR at National Institute of Information and Communications Technology (NICT)

3. Schedule

Professor Jou and Dr. Jung visited ISEE in July. The detailed schedule is listed below:

July 11 Taipei to Nagoya

July 12 A.M. #1. Introduction of members

#2. Introduction of phased array radars in Japan (Takahashi)

P.M. #3. Hardware and data product from MP-PAWR (Takahashi)

#4. Calibration of MP-PAWR (Takahashi)

#5. Discussion about calibration issue (All)

July 13 A.M. #6. Analysis of MP-PAWR data (Takahashi)

P.M. #7. Discussion on MP-PAWR data analysis (All)

#8. Lecture by Dr. Jung (Extreme Precipitation Events: Physics and Prediction)

July 14 A.M. #9. Data analysis using actual MP-PAWR data

#10 Presentation of ISEE's student (During lab's Colloquium, 15:00-)

July 15-16 off

July 17 #11 Continue the data analysis and moved from Nagoya to Tokyo

July 18 #12 Visiting NICT and MP-PAWR site and discussion with Toshiba (Fig. 1).

Tokyo to Nagoya

July 19 Nagoya to Taipei

Fig. 1. Pictures during the NICT visit (left) and MP-PAWR site visit (right) on 18 July, 2023.

4. Achievements

The most valuable achievement is the progresses of the understanding of phased array radar system. Deep discussion on the evaluation of the MP-PAWR data helped to improve the calibration method and evaluation method. In addition, possible deployment of MP-PAWR was discussion. During the discussion, the differences between MP-PAWR and conventional MP radar and the advantages of the MP-PAWR are clarified.

5. Presentations and books

Takahashi, N., M. Miyairi and K. Kato, 2023: Analysis of precipitation systems by using MP-PAWR, 9B.3, 40th Conference on Radar Meteorology, American Meteorological Society, Minneapolis.

Takahashi, N. and H. Hanado, 2023: Evaluation of vertical air motion from CPR by multi-parameter phased array weather radar, ESA-JAXA EarthCARE pre-launch workshop, Frascati.

Takahashi, N., T. Ushio, F. Mizutani and H. Hanado, 2024: Phased array weather radar developed in Japan, Advances in Weather Radar, ed. V. N. Bringi, K. V. Mishra and M. Thurai, IET, pp. 1-40.

IPS Time-dependent Tomography Boundaries for SUSANOO 3-D MHD, and Comparison with the IPS-driven ENLIL Model

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Nagoya University stay from 2023 07 24-30

The UCSD time-dependent 3-D reconstruction computer-assisted tomography program has long been used since the year 2000 with ISEE interplanetary scintillation (IPS) data to provide global velocity, density, and magnetic fields throughout the inner heliosphere (Jackson *et al*., 2020 and references therein). These IPS analyses have been used to study heliospheric structures, both co-rotating and coronal mass ejections (CMEs) to out past the orbit of Mars. IPS data provide a depiction of the propagating structures from both archival ISEE data sets or as used in forecasting analyses from ISEE data in near real time. The kinematic UCSD model conserves mass and mass flux from an inner boundary usually set at 15 solar radii (Rs) and iteratively fits IPS data to observed lines of sight of velocity or scintillation (g-level) used as a proxy for density. Since the IPS data contains the effects of fast transient structures as well as those that corotate, the time-dependent model allows the density and velocity features of CMEs imbedded in the solar wind to be mapped outward from the solar surface inner boundary.

In more recent years, an inner boundary provided by the UCSD kinematic model has been used to drive the 3-D MHD (magnetohydrodynamic) ENLIL model (Odstrcil and Pizzo, 1999) at its inner boundary at 21 Rs (Jackson *et al*., 2015). Unlike the UCSD model, 3-D MHD models have an advantage in that they contain far more physics including heating, and thus this includes an outward expansion from the inner boundary. 3-D MHD models also have the ability to be modified by magnetic fields. As a demonstration of this analysis in Figure 1a, we show the forecast of a CME from the UCSD kinematic model that in and ecliptic cut that erupted from the Sun on March 10, 2022, as it was observed just 13 hours prior to its arrival at Earth. This same CME using the UCSD inner kinematic model boundary is depicted by the ENLIL 3-D MHD model in Figure 1b. Many of the dense features present in the inner heliosphere are shown at the same approximate locations in these two figures. The spacecraft BepiColombo (□) at 0.42 AU was approximately aligned with the STEREO spacecraft at 1 AU and the Solar Orbiter (●) was aligned at 0.45 AU with Earth-based L1 satellites. Both inner heliospheric spacecraft registered the CME arrival about one and a half days before it reached 1 AU, certifying the ecliptic presence and approximate shape of the CME in the inner heliosphere (Jackson *et al*, 2023). The ENLIL model in this analysis has been carefully adjusted to show the same approximate values as the UCSD iterative model.

SUSANOO is a more recent sophisticated 3-D MHD heliospheric model developed by Shiota *et al*., (2014) that contains an added spheromak-type flux rope (Shiota and Kataoka, 2016). Our intent in Nagoya was to provide the same UCSD IPS kinematic input boundaries for this model and operate as we do ENLIL to study the model differences and the benefits of each. We were successful in this work using the same time period as shown in Figure 1. Our project included:

1) Presentation and modification of the ENLIL model at UCSD to mimic the UCSD kinematic model and the arrivals of material at Earth as shown in Figure 1b.
2) Installation of our UCSD kinematic model on ISEE computers to provide the digital tomographic boundaries for SUSANOO, from the volumetric data.
3) Operation of the SUSANOO 3-D MHD model at ISEE, Japan for the March 2022 time period using the digital boundaries inputs from the UCSD IPS model.
4) Preliminary digital comparisons of both modeling efforts and correlations of these analyses made in preparation for presentation of these SUSANOO modeling results.

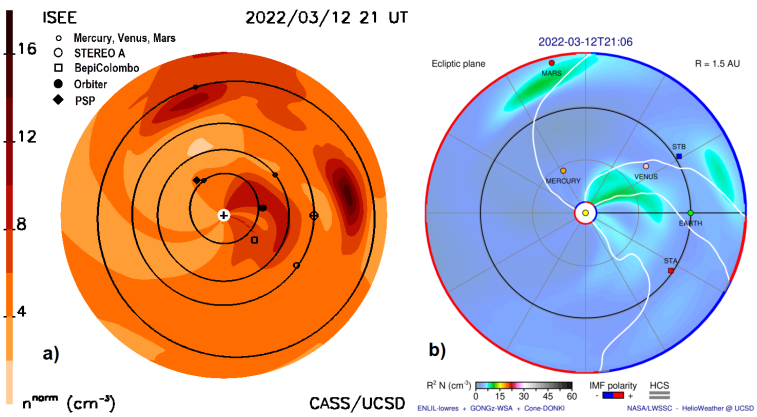

Figure 1. Ecliptic cuts of heliospheric density for **a)** the UCSD kinematic model, and **b)** the ENLIL 3-D MHD model out to and beyond the orbit of Mars are shown. Earth is depicted on its orbit to the right. The positions of all the inner planets as well as their orbits and the listed interplanetary spacecraft are shown in a). These same planets and spacecraft are shown in b). An r^{-2} density fall-off is imposed in these cuts relative to 1 AU to show structures near and far from the Sun at approximately the same scale.

In Figure 2 we show the results of our efforts by comparing the UCSD kinematic model ecliptic cut densities with the SUSANOO 3-D MHD model ecliptic values as driven by the UCSD boundaries. In some ways the SUSANOO model that shows vector magnetic fields is more sophisticated and to the point. The most damaging Earth-directed portion of a CME is the magnetic field strength that couples with Earth's geomagnetic field and this is shown for the SUSANOO model. The UCSD modeling effort supports all three vector fields, but since these fields are provided by only a radial field at the UCSD inner boundary, the present near Earth are only those that are radial and tangential in heliographic RTN (radial, tangential, and normal) coordinates; thus only a small component of the tangential field component can couple with Earth's geomagnetic field. The SUSANOO 3-D MHD model can include a spheromak input field in its initiation scheme, and this has three field components at the source surface that can be overlaid onto the UCSD field. In this scenario not only can the velocities and densities be adjusted to fit the IPS observations and *in-situ* measurements, but so can the field components of the ambient wind and the overlaid spheromak be adjusted to fit the *in-situ* measurements at Earth and at the other spacecraft that record these fields. In this way both the background solar wind components as well as the CME field components can be accurately depicted and forecasted to provide the result measured globally. Thus, we have succeeded to put in place the mechanism whereby the timing of the field change can be forecast using UCSD tomographic technique with SUSANOO so that it can be compared with other 3-D MHD techniques. Although low resolution now, as these analyses are refined, modified to fit observed and *in-situ* measured values better, and combined with more data worldwide, they can enable a far better global depiction of basic plasma parameters. These include velocity, density, and magnetic field components of both the background solar wind as well as those in CMEs.

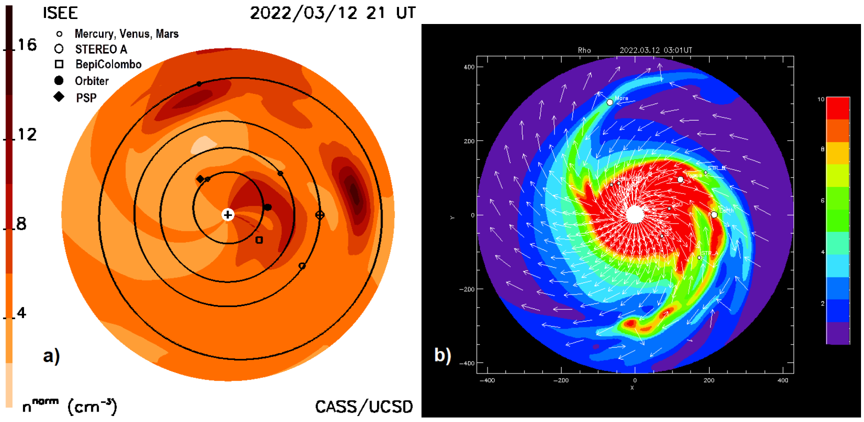

Figure 2. Ecliptic cuts of heliospheric density for **a)** the UCSD kinematic model as in Figure 1a, and **b)** The SUSANOO 3-D MHD model out to and beyond the orbit of Mars. All the inner planets and the same interplanetary spacecraft are shown. In this figure ecliptic magnetic field directions from the UCSD modeling effort are superimposed as vectors. The SUSNANOO analysis is shown at 2022/03/12 03UT, and at this time the earlier May 8 2022 CME has gotten to Earth with the May 10 CME event closer to the Sun than in a).

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