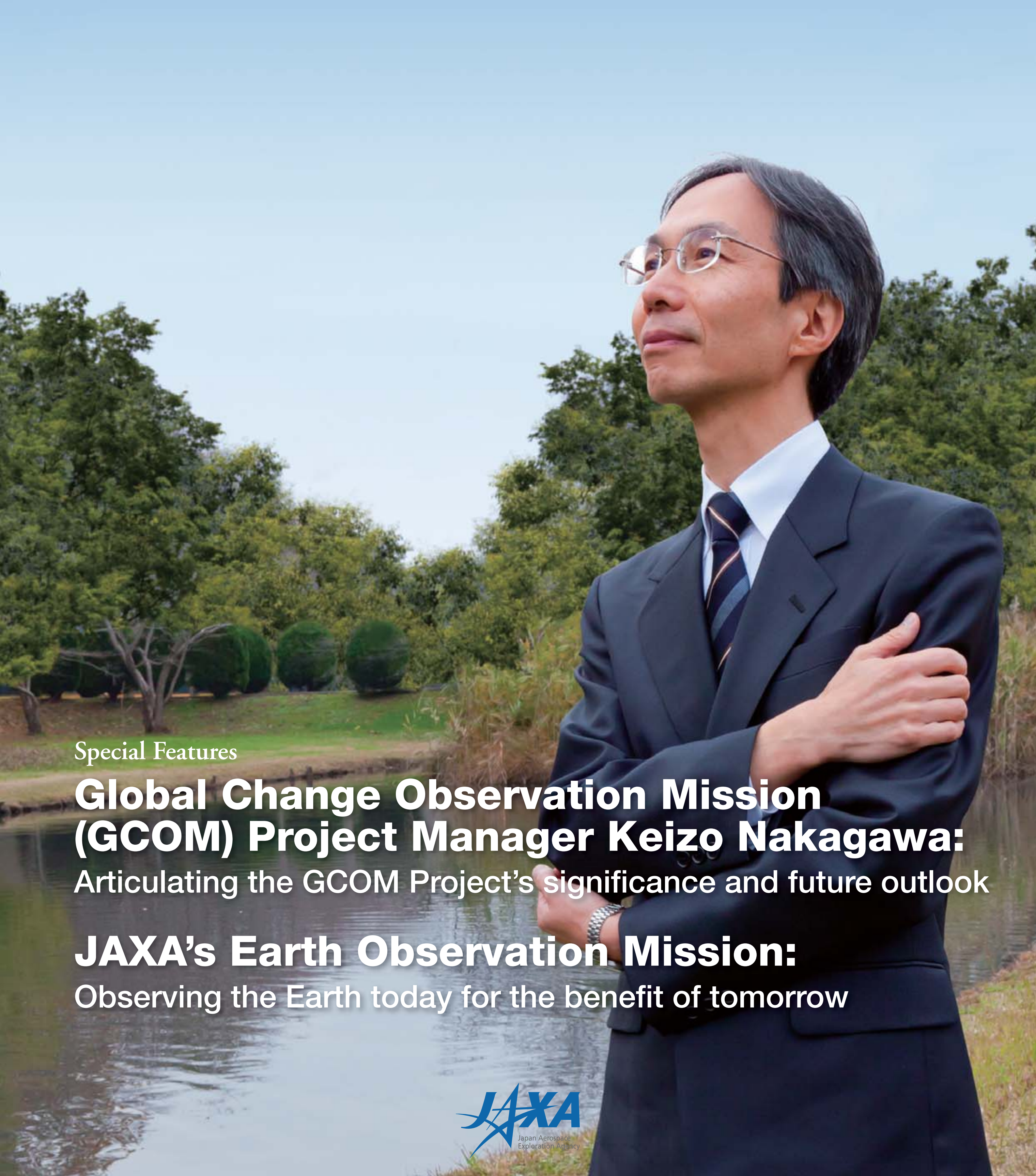
JAXA TODAY

Japan Aerospace Exploration Agency

January 2012 / No. 05



Special Features

Global Change Observation Mission (GCOM) Project Manager Keizo Nakagawa:

Articulating the GCOM Project's significance and future outlook

JAXA's Earth Observation Mission:

Observing the Earth today for the benefit of tomorrow

Contents

Welcome to JAXA TODAY

The Japan Aerospace Exploration Agency (JAXA) works to realize its vision of contributing to a safe and prosperous society through the pursuit of research and development in the aerospace field to deepen humankind's understanding of the universe. JAXA's activities cover a broad spectrum of the space and aeronautical fields, including satellite development and operation, astronomical observation, planetary exploration, participation in the ISS project, and the development of new rockets and next-generation aeronautical technology.

With the aim of disseminating information about JAXA's activities and recent news relating to Japan's space development programs to as wide an audience as possible, we launched JAXA TODAY in January 2010. In this issue, we feature an interview with GCOM Project Manager Keizo Nakagawa, and put the spotlight on JAXA's Earth observation mission, which provides crucial data used in many fields, from disaster management and climate research to cartography and food security. We hope you will find these and all the other articles stimulating and informative.

SHIZUKU—From Life-nourishing Drop of Water to Great Tidal Current

Global Change Observation Mission 1st–Water (GCOM-W1), a JAXA satellite scheduled for launch during fiscal 2012, ending March 31, 2013, has been given the nickname "SHIZUKU." In Japanese, *shizuku* means "water drop." The name was chosen after JAXA ran a campaign in July–August 2011 in which members of the public were encouraged to submit their preference for a suitable nickname for GCOM-W1. The name SHIZUKU received the largest number of votes.

A drop of water becomes rain or snow, turning into a river that nourishes the land. It flows into the sea, turns to vapor or even ice—changing its form freely. GCOM-W1's mission is to observe the Earth's water cycle—the source of all life. As a nickname that accurately expresses the essence of that mission, we hope SHIZUKU will come to be used with endearment by many people.

GCOM-W1 "SHIZUKU"

Cover Story

Tsukuba City, Ibaraki Prefecture, boasts an abundance of natural beauty and is well known as a planned "Science City," hosting a large number of research and educational institutions. It is also the home of JAXA's Tsukuba Space Center (TKSC), which retains many green areas of woods and gardens within its expansive site. In front of the pond near the Space Applications Mission Directorate offices, GCOM Project Manager Keizo Nakagawa stands casting his thoughts to the many Earth observing satellites that provide a constant flow of information about our planet.

Photo by Hiro Arakawa

Interview with

Keizo Nakagawa

Dialogue between JAXA Global Change Observation Mission (GCOM) Project Manager Keizo Nakagawa and Midori Nishiura, Executive Advisor for JAXA Public Affairs & International Relations

GCOM Project Manager Keizo Nakagawa offers his insights on the significance and prospects for the project.

“How does space development meet the needs of society? How are we contributing to a better future? These are questions that we should be thinking about constantly.”

Global Change Observation Mission 1st–Water (GCOM-W1) is the first satellite of the GCOM series, which aims to enhance understanding of the Earth’s climate change and the global water cycle. GCOM-W1—given the Japanese nickname “SHIZUKU” (“water drop”)—is scheduled for launch during fiscal 2012, ending March 31, 2013. In this feature interview, GCOM Project Manager Keizo Nakagawa talks about GCOM-W1’s advanced observation capabilities, the project’s significance and outlook, and his role in leading the GCOM Project Team.

Photo by Hiro Arakawa

Profiles

Photo by Hiro Arakawa

Keizo Nakagawa

Project Manager, GCOM Project Team
Space Applications Mission Directorate, JAXA

Keizo Nakagawa completed the doctoral program at the Department of Aeronautical Engineering, Graduate School of Engineering, Kyoto University, in 1982. In the same year, he joined the National Space Development Agency of Japan (NASDA), a forerunner of JAXA. Mr. Nakagawa previously worked on the development of the Broadcasting Satellite-3 (BS-3; nicknamed “Yuri”) and the Optical Inter-orbit Communications Engineering Test Satellite (OICETS; nicknamed “Kirari”). He was appointed to his current position in 2007.

Midori Nishiura

Midori Nishiura, an opinion leader, is the president of consulting firm Amadeus Inc., JAXA’s Executive Advisor for Public Affairs & International Relations, and Visiting Professor of International Relations & Communications at Yamaguchi University. Among many other important roles, Ms. Nishiura has served on the Advisory Board of various major companies and also sits on committees organized by government ministries and agencies. The author of many books as well as articles in leading publications, Ms. Nishiura, having conducted her own interview programs on television, is often called upon to commentate on the news.

Theme 1 | What Potential Does the GCOM-W1 Mission Hold?

Nishiura: The nickname "SHIZUKU," which was chosen for GCOM-W1 through a public campaign, is quite endearing, and rather lovely, isn't it?

Nakagawa: Yes, out of around 20,000 responses we received from the public, SHIZUKU was the overwhelming favorite. I would be very happy if this popular nickname were to help people to develop an affinity for the satellite.

Nishiura: In recent years, we have constantly heard numerous warnings about global-scale water shortages, but at the same time we have seen an increase in the number of floods and other water-related disasters around the world. What will SHIZUKU be able to achieve in relation to such climate change?

Nakagawa: Research suggests that global warming is likely to bring an increase in extreme weather events, such as droughts and floods. As in the recent example of severe floods in Thailand, there will be instances of weather phenomena that exceed previous assumptions. Hence, we need to revise the data we use to estimate rainfall and other parameters to make it more realistic.

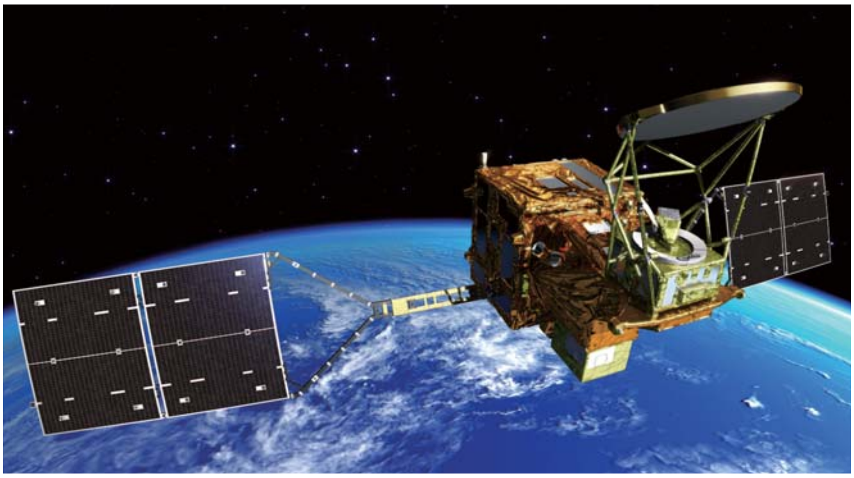
Nishiura: So, SHIZUKU will contribute to this process of data revision? How will weather forecasting be done in the future?

Nakagawa: Meteorologists and climatologists build models based on global atmospheric and ocean flows, which they use to make predictions about the future. Ideally, to make these models more precise, it would be best to have observation stations spread evenly across the entire globe. Unfortunately, uninhabited areas account for a large portion of the Earth's surface, so there is only a very patchy distribution of observation stations.

Nishiura: So, SHIZUKU will gather data from these not so easily accessible areas, such as deserts and oceans. What about moisture in the ground? Will SHIZUKU be able to measure this also?

Nakagawa: Yes, it will. By measuring the amount of moisture in the soil, we can make drought forecasts.

Nishiura: These new technologies can certainly make a serious impact on economic activities, can't they? It really reinforces the myriad ways in which water affects our lives.



GCOM-W1 "SHIZUKU"

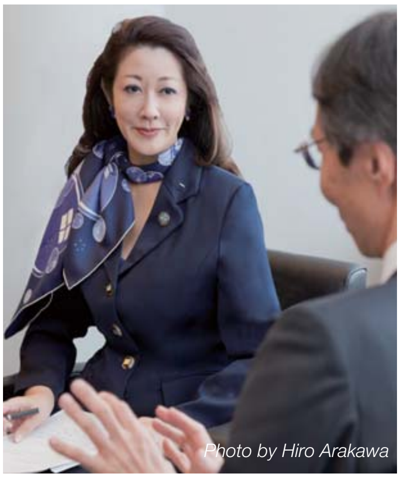


Photo by Hiro Arakawa

Overview of Global Change Observation Mission (GCOM)

The GCOM Project is tasked with carrying out global-scale, long-term observations from space of changes in the Earth's environment.

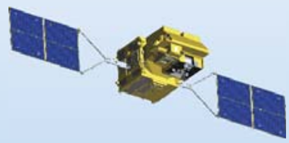
"Health Checkup" of the Earth from Space

GCOM is expected to play an important role in monitoring global water circulation and climate change, hence providing an ongoing "health checkup" of the Earth's environmental systems from space. The program comprises two satellite series—Global Change Observation Mission-Water (GCOM-W) and Global Change Observation Mission-Climate (GCOM-C).

Complementary Roles for the GCOM-W and GCOM-C Series

GCOM-W series satellites will carry a microwave radiometer for observing water-related phenomena, including precipitation, water vapor, sea-surface wind speed, sea-surface temperature, soil moisture, and snow depth. GCOM-C series satellites will carry a multi-wavelength optical radiometer to provide surface and atmospheric measurements of phenomena involved in the carbon cycle and radiation budget*, including clouds, aerosol, ocean color, vegetation, snow, and ice.

* The radiation budget mainly comprises solar energy entering, reflected, absorbed, and emitted by the Earth.



Global Change Observation Mission 1st–Climate (GCOM-C1), which is scheduled for launch in fiscal 2015, ending March 31, 2016

Theme 2 | Advanced Microwave Scanning Radiometer 2 (AMSR2) Boasts Enhanced Capabilities


Photo by Hiro Arakawa


Photo by Hiro Arakawa

Nishiura: NASA's Aqua (EOS PM-1) satellite carried the Advanced Microwave Scanning Radiometer for EOS (AMSR-E), a Japanese-developed instrument and forerunner in water-cycle observation. After its launch in May 2002, AMSR-E provided observation data for the entire Earth for nine years and five months. It played a significant role in such areas as the monitoring of Arctic Sea ice cover, which is extremely important. Observation data provided by AMSR-E was also used in the development of Global Satellite Mapping of Precipitation (GSMaP), which provides information on global precipitation distribution. What groundbreaking innovations will SHIZUKU bring to this field?

Nakagawa: The remote sensing instrument carried by SHIZUKU is called AMSR2, and it measures weak microwave (electromagnetic) emissions from the land and ocean that comprise the Earth's surface. JAXA and its predecessor NASDA have spent more than a decade developing this type of sensor, so this will not be the first time we put one into operation. As you say, it has much in common with AMSR-E, but AMSR2 will have a higher level of accuracy. For example, we are aiming to measure sea surface temperature with a margin of error of less than 0.5°C.

Nishiura: The large antenna deployed in AMSR-E, is it even larger for AMSR2?

Nakagawa: The antenna for AMSR-E was 1.6 meters in diameter, but the AMSR2 antenna has a diameter of 2.0 meters. This size certainly puts it among the largest microwave radiometers in the world.

Nishiura: So, using this larger antenna will enable us to provide even more detailed observation data then. What other unique characteristics does AMSR2 have?

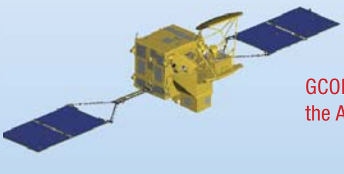
Nakagawa: Another improvement we have made is in calibration accuracy. The antenna rotates at 40 revolutions per minute (rpm), and during each rotation it scans a cold sky mirror (CSM), the Earth, and a high-temperature noise source (HTS), in that order. If the CSM and HTS have already-known fixed values, it is possible to determine the Earth's brightness temperature, which lies in between. In AMSR-E, the temperature of the HTS changed over time owing to the effects of the sun and the space environment. However, we modified the design in AMSR2 to avoid such external effects, thereby providing better measurement accuracy.

Nishiura: You have managed also to make improvements to the instrument's frequency bands, haven't you? The use of high frequency ranges between 7–89 gigahertz (GHz), which are usually used by Earth observation satellites, is now becoming common on the ground. As a result, it is becoming more difficult for satellites to differentiate between the Earth's weak microwave emissions and the radio signals from various man-made sources.

Nakagawa: Yes, absolutely. Since the 6.9GHz channel we used on AMSR-E is subject to increasing levels of noise from devices on the ground, for SHIZUKU we are using not only 6.9GHz but have also added the slightly higher frequency channel of 7.3GHz to bolster observation accuracy.

"SHIZUKU"—First Satellite in the GCOM-W Series

GCOM's global-scale, long-term observation (10–15 years) of the Earth's atmosphere, oceans, land, snow, and ice will help scientists understand the mechanisms of water circulation and climate change. GCOM-W1 ("SHIZUKU") is the first satellite in the GCOM-W series.


GCOM-W1 ("SHIZUKU") carries the AMSR2

AMSR2 Will Measure the Earth's Microwave Emissions

AMSR2 is a remote sensing instrument for measuring weak microwave (electromagnetic) emissions from the Earth's surface and atmosphere. From 700 km above the Earth, AMSR2 will provide extremely accurate measurements of the intensity of microwave emissions.


AMSR2

Theme 3

The Future of the GCOM-W Mission: Continuous Long-term Observation to Expand the Benefits of the Mission

Photo by Hiro Arakawa

Nishiura: Observing the Earth's water conditions is a must, and terribly important for the survival of humankind, but to give the mission even greater significance it is crucial to undertake continuous observations, isn't it?

Nakagawa: Although the design life of GCOM-W1 is five years, the observation data for just five years would be insufficient for many purposes. For example, the satellites of numerous countries have been observing the distribution of Arctic Sea ice for around 30 years. Only by comparing data over that length of time does it finally become possible to see that the ice cover is shrinking.

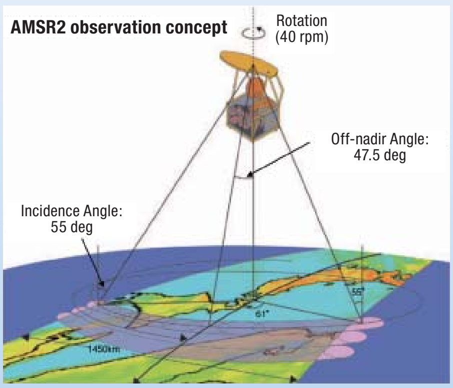
Nishiura: With five years' of data there is no way of telling if it is a short-term phenomenon, or a long-term problem. At the very least, 10 years' of accumulated data is essential. Since there is such a substantial cost involved in developing satellites, project continuity becomes even more imperative as a way of increasing the value and usefulness of the data. When SHIZUKU nears the end of its five-year design life, it would be a wasted opportunity not to launch a successor satellite in order to ensure continuous observations.

Nakagawa: Yes, that's right, particularly as it has taken us about five years to develop SHIZUKU.

Nishiura: In that case, you had better get started on the preparation of SHIZUKU's replacement soon, or you'll run out of time!

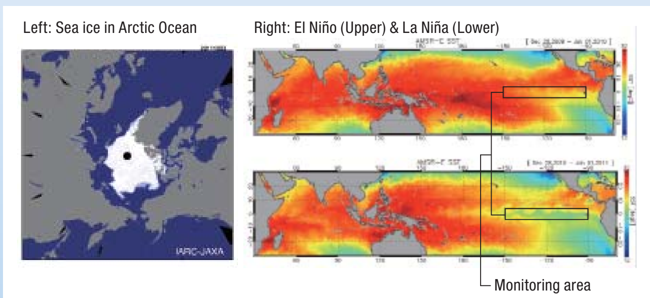
Providing Daytime and Nighttime Data with 99% Coverage of the Earth Every Two Days

Each rotation of AMSR2's antenna takes 1.5 seconds and captures data over a 1,450-kilometer swath. This conical scan mechanism enables AMSR2 to acquire a set of daytime and nighttime data with more than 99% coverage of the Earth every two days.



AMSR2 is the Successor to AMSR and AMSR-E

Researchers have significant expectations for AMSR2's role in monitoring climate change-related decreases in Arctic Sea ice cover and medium- to long-term oceanic changes, such as the El Niño/La Niña-Southern Oscillation (ENSO). AMSR2 will be the successor to the Advanced Microwave Scanning Radiometer (AMSR) and Advanced Microwave Scanning Radiometer for EOS (AMSR-E), which were highly appraised. AMSR was carried aboard Advanced Earth Observing Satellite II (ADEOS-II; Japanese nickname: "Midori II"), and AMSR-E was part of the payload of NASA's Aqua (EOS PM-1). Operation of both AMSR and AMSR-E has ended.



AMSR-E observation examples

Theme 4 | What Drives You as Project Manager?

Nishiura: The job of project manager must give you a great deal of satisfaction. At the same time, there must be a lot of difficult tasks to deal with, too, such as securing budgets, fulfilling accountability, and handling crises. I wonder what it feels like to be responsible for an entire satellite? Could you give me an insight into your role as a project manager?

Nakagawa: My first task after being appointed GCOM Project Manager was to appear before the government's Space Activities Commission to win approval for the project. The next thing I had to do was submit a budget request. In my previous roles, I had enjoyed focusing on satellite development purely as an engineer. Being project manager is very different.

Nishiura: As so many researchers and data users worldwide await the launch of SHIZUKU with anticipation, there is a lot of pressure on you to ensure that the development and launch go smoothly and the data is provided as planned.

Nakagawa: Indeed. And it is not just the technical aspects either. I do everything necessary to bring the project to fruition—recruiting personnel for the project team from other parts of JAXA, securing budget resources, all sorts of things.

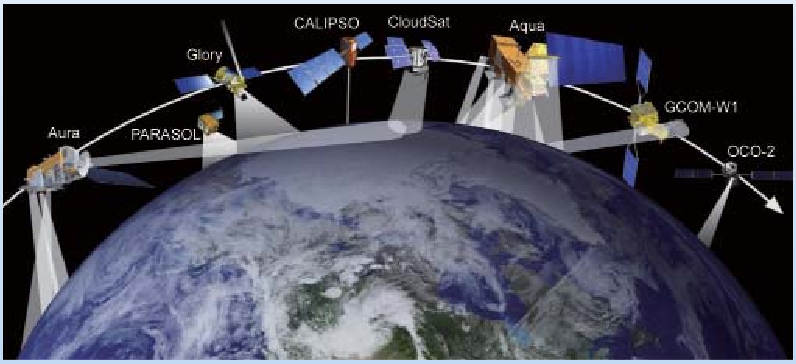
Nishiura: It's quite a job, but listening to you I can feel your great love and passion for the GCOM Project. Just before our interview, I ran into you and some of your project team returning from lunch. I detected a distinctive air of unity there. I am sure this is based on mutual trust, and your leadership too. Isn't it marvellous? Shall we end our interview by hearing your enthusiasm for the GCOM Project?

Nakagawa: At the dawn of the space age, the main drive was, for the most part, simply to go into space. Our current era is different—we must aim to utilize space effectively. How does space development meet the needs of society? How are we contributing to a better future? These are questions that we should be thinking about constantly. As a group working toward a unified purpose, we want to achieve results that will benefit all of mankind.

Nishiura: Thank you, Nakagawa-san. I wish your mission all the success it deserves from the bottom of my heart.

Participation in the NASA-led Afternoon Constellation (A-Train)

SHIZUKU will participate in the A-Train constellation of Earth observing satellites, an international project led by NASA, under which several satellites closely follow one after another along the same orbital "track." By combining the different sets of nearly simultaneous observations, scientists are able to gain a better understanding of important parameters related to climate change. This will further expand the utility of data gathered by AMSR2 for a broad range of scientific research.

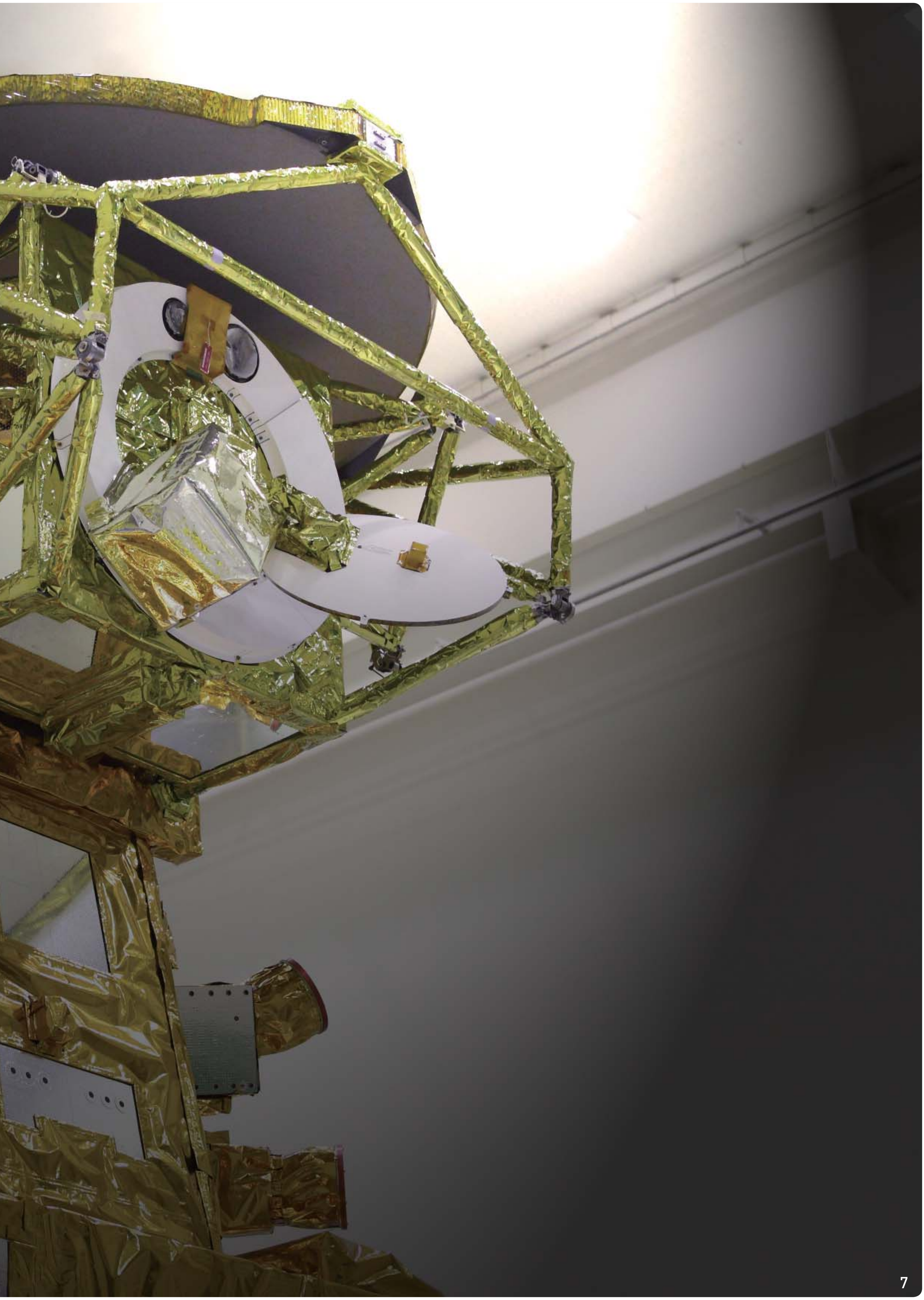


A conceptual diagram of the A-Train. SHIZUKU is shown as the second satellite from the right-hand side.

"SHIZUKU"

Global Change Observation Mission 1st–Water

The remote sensing instrument carried by SHIZUKU is called Advanced Microwave Scanning Radiometer 2 (AMSR2).



Asteroid Itokawa

Returns to the Cover of *Science*

Six Researchers Discuss Their Initial Analyses of Particles from Itokawa

The cover of the August 26, 2011, issue of *Science* features a photograph of a particle from Itokawa. This image was captured using an electron microscope. This particle of dust, measuring just 181 x 86μm, was found to contain such substances as olivine, plagioclase, and ion sulfide.

Particles from Asteroid Itokawa were brought back to Earth in June 2010 by the asteroid explorer Hayabusa, which had to overcome many crises before successfully completing its mission. Six scientific articles reporting on the initial analysis results of the sample from Itokawa were published in the August 26, 2011, issue of the American journal *Science*. From the words of the researchers—who have seen the first asteroid sample in the history of mankind—we can sense their exhilaration and expectations for more new discoveries at the next stage of analysis and discovery. Previously, the June 2, 2006, issue of *Science* also featured observation results from Itokawa provided by Hayabusa, making this second special report an even more remarkable accomplishment.

The cover of the June 2, 2006, issue of *Science* featured a photograph of Itokawa. This copy was signed by members of the Hayabusa project team to commemorate the achievement.

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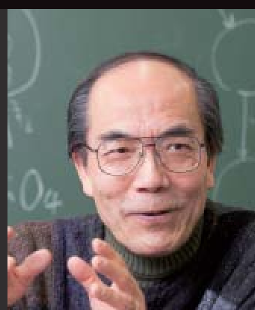

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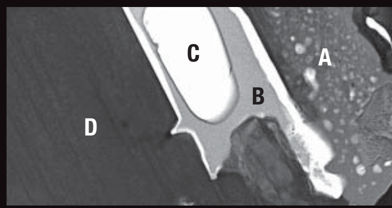
01 Itokawa Dust Particles: A Direct Link Between S-Type Asteroids and Ordinary Chondrites

For our investigation, we used an original analysis system, which enables us to obtain simultaneously synchrotron-radiation X-ray diffraction and fluorescence from a single Itokawa particle. The analysis reveals the mineralogy and the chemistry of the particle. After synchrotron-based analysis, I performed scanning electron microscope analysis, which provides information on the quantitative elemental composition of individual minerals in the particle. Analysis of mankind's first-ever asteroid sample has provided physical evidence that the most common type of meteorite found on Earth—ordinary chondrites—come from S-type asteroids. While this origin has until now been considered highly probable, it may now be stated with much greater certainty with firm evidence. Even at academic conferences, I have received applause expressing both the admiration and relief felt by astrolithologists from around the world.

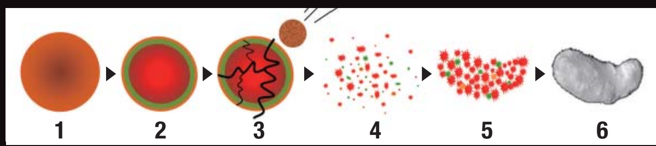
Under certain circumstances, the mineral pyroxene may reveal a record of the peak temperature experienced by the particle in the past. When interpreted together with other indicators, we estimate that the peak temperature experienced by most of the Itokawa particles was approximately 800°C. From this information we were able to extrapolate the size of the parent body and retrace the mechanism by which Itokawa was formed.

We also found evidence that many of the sample particles had been subject to heavy impacts. This presents us with a number of questions for future research, such as "When, and with what, did these impacts occur?" and "Did dust from other small bodies accumulate on the surface?" The process of trying to unravel such riddles, based on only the smallest of clues, is indeed a fascinating one.

Many Itokawa Particles Show Evidence of Catastrophic Impacts



A: Plagioclase feldspar melted by catastrophic impact, causing the formation of bubbles
B: Resin used for embedding
C: Hole
D: A magnesium-rich, low-calcium clinopyroxene



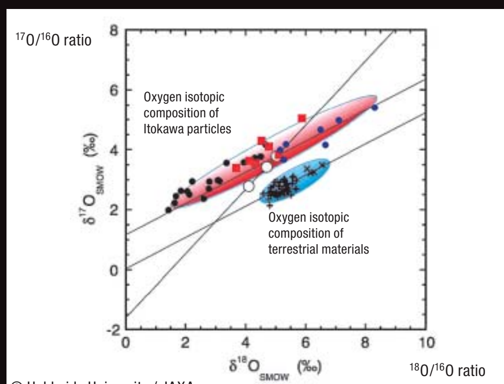
History of Itokawa's Formation
1. Primitive materials accumulate to form Itokawa's parent body→2. Reaches a size of approximately 20km in diameter→3. Heavy impacts→4. Catastrophic impacts cause the body to break up→5. Parts of the remnants accrete→6. Space weathering altered the surface; reforms into the present-day Itokawa

02 Oxygen Isotopic Compositions of Asteroidal Materials Returned from Itokawa by the Hayabusa Mission

Oxygen accounts for more than half of the elemental composition of planets. Studies of meteorites suggest that each solar system object has a unique oxygen isotope ratio. Isotopes refer to atoms that possess the same chemical properties but have differing numbers of neutrons. In the case of oxygen, three stable isotopes exist—^{16}O, ^{17}O, and ^{18}O. The ratio present among these isotopes provides crucial information about the origin of a sample.

We used the world's first isotope microscope system to analyze 28 particles from Itokawa. Our method for analyzing the oxygen atoms within the sample involved "excavation" of a crater measuring approximately 10μm in diameter on the surface of each particle by striking it with high speed atoms. We trapped each of the excavated atoms individually to measure the isotopic composition of the sample.

The oxygen isotopic composition of the sample we analyzed clearly differed from terrestrial materials, and was very similar to that found in certain types of minerals present in meteorites. From this clue, we may be able to gain a clear understanding of which meteorite came from which asteroid and the kind of celestial body from which an object originated. In the future, if we are able to conduct sample analysis of material from a carbonaceous C-type asteroid—the target of the proposed Hayabusa2 mission—we may find the key to explaining the origins of water.



Comparison of the Oxygen Isotopic Composition of Itokawa Particles and Terrestrial Materials
Reveals that the Itokawa particles have a different origin to terrestrial matter

The world's first isotope microscope system was used to analyze the sample from Itokawa.

03 | Neutron Activation Analysis of a Particle Returned from Asteroid Itokawa

The sample was irradiated with neutrons, and the emitted gamma ray was analyzed by gamma-ray spectrometry. This analytical method—called instrumental neutron activation analysis (INAA)—is able to precisely determine the sample's elemental composition. The advantages of this analysis method include: (1) the ability to analyze not only the surface but the entire sample, owing to the high penetration of neutron and gamma rays; (2) the ability to reuse a sample since it can be analyzed without being destroyed; and (3) the high reliability of data even if analysis is conducted only once. For the analysis of an Itokawa particle, where there is no room for failure or reanalysis, INAA is a particularly attractive method.

The nebular hypothesis suggests that the Solar System began as a cloud of hot gases, which cooled and agglomerated, gradually evolving into its present-day form. For our analysis, one grain of the Itokawa sample—weighing several μg—was irradiated with neutrons. During the analytical procedure, the sample was split into five small grains, which were eventually separated into two sub-samples comprising one large grain and four small grains. Separate analysis of these two sub-samples revealed similar elemental compositions, suggesting that the sample grain was quite homogeneous in its chemical composition. From our chemical data, it was confirmed that the sample preserves the chemical composition at one of the very earliest stages during the formation of the Solar System, which at the time was still composed of homogeneous gases.

Further, when we examined the quantities and ratios of nickel, cobalt, and iridium, we found that the sample has a low ratio of iridium compared with common types of meteorites. When the early Solar System's hot gases cooled, what kind of mechanism caused the depletion of iridium? We look forward to seeing a robust level of discussion around such questions.

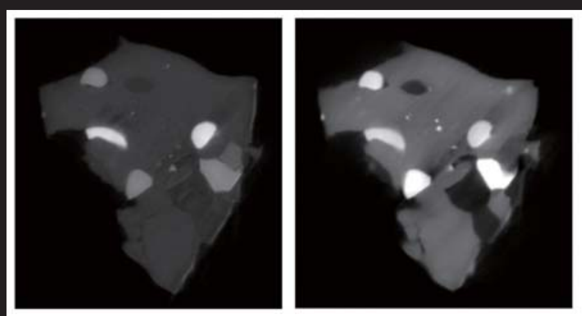
The neutron-irradiated sample grains were measured for their radioactivity over an extended period inside a low-level radioactivity laboratory. The facility used was Kanazawa University's Ogoya Underground Laboratory (OUL), which was constructed in a disused copper mine tunnel to reduce measurement noise from background radiation.

04 | Three-Dimensional (3D) Structure of Hayabusa Samples: Origin and Evolution of Itokawa Regolith

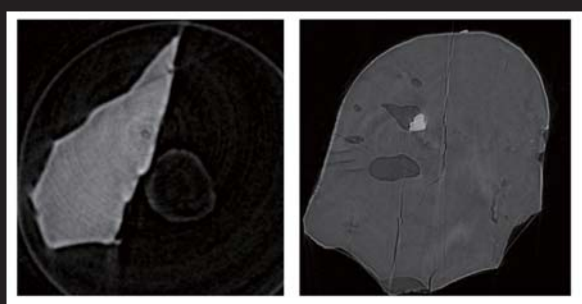
The fine, sandy material on the surface of a celestial body is called regolith. As the initial team in the preliminary-examination sequence, we conducted detailed examinations of 40 particles of Itokawa regolith. Our analysis included not only the 3D shape, texture, and internal structure but also the mineralogy of the particles. We used the results to infer the history of the sample.

For the sample analysis, we used X-ray micro-computed tomography (CT). By using the synchrotron X-ray source at SPring-8 in Hyogo Prefecture, Japan—one of the world's largest synchrotron radiation facilities—we obtained extremely high spatial resolution. This enabled us to discriminate very fine differences in shape and texture with a resolution of approximately one-thousandth of the width of a human hair. In addition, by comparing a set of CT images taken at dual X-ray energies, it was possible to analyze the mineralogy of the sample for the first time.

From a comparison of the sample with lunar regolith, we were able to identify properties specific to a low-gravity celestial body. Regolith is formed by the impacts of meteoroids on the surface of an asteroid. Within the Itokawa sample, we found regolith particles with rounded edges, which may be a result of abrasion as grains migrate during impacts. Such information—providing valuable insights into the characteristics of asteroids—would never have been obtainable by astronomical observation or meteorite analysis.



An example of X-ray CT images taken at dual X-ray energies. Mineralogy was identified by observing differences in gray shading.



A particle with sharp edges (left) and one with more rounded characteristics (right)

05 | Incipient Space Weathering Observed on the Surface of Itokawa Dust Particles

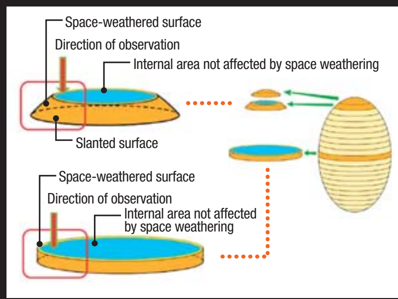
Although asteroids and meteorites are thought to have similar origins, mystery has surrounded differences in the surface color and solar reflectance spectra of the most abundant types of meteorites and asteroids. Theories have suggested that these differences are due to a phenomenon called "space weathering," which leads to changes in the surface of asteroids owing to such actions as sputtering by solar wind particles and micrometeorite bombardment. Through analysis of the Itokawa sample, we were able to obtain conclusive evidence to support the space weathering theory.

Within the results of our observations, as shown in the figure to the right, we found nanoparticles enriched in iron, sulfur, and magnesium in a thin surface layer on certain types of mineral in the sample. It is interesting that such a layer had formed despite the absence of these elements in the host mineral species. This suggests that vaporization of neighboring minerals had occurred and the layer had formed from deposits of the recondensed vapor. From these observations of the space weathering texture (layered structure), we inferred the process by which space weathering occurred on Itokawa. At the next stage of research it will be necessary to verify whether this texture actually forms by way of the inferred process.

Furthermore, if we were able to clarify—through experiments and sample observation and analysis—the amount of time required for the space weathering seen in the sample, by measuring an asteroid's spectra we may be able to estimate the period it has been exposed to space weathering. It may also provide a new perspective from which to re-examine the space weathering of lunar samples that have been investigated over many decades.

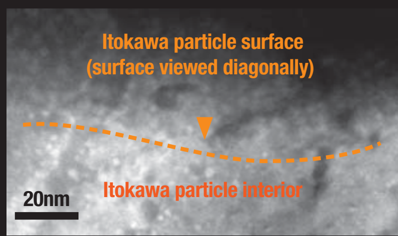
Method Used for Observations of the Surface of Itokawa Dust Particles

The dust particles were each embedded in epoxy resin and ultra-microtomed (sliced) into 0.1 μm thick sections using a diamond blade. Images of these sections taken using an electron microscope enabled observation of cross-sections of the area around the dust-particle surface.



Electron Microscope Image of Itokawa Dust-Particle Surface

The numerous bright spots that appear on and just below the particle surface are iron-rich nanoparticles measuring up to a few nanometers (nm), which were produced by space weathering.

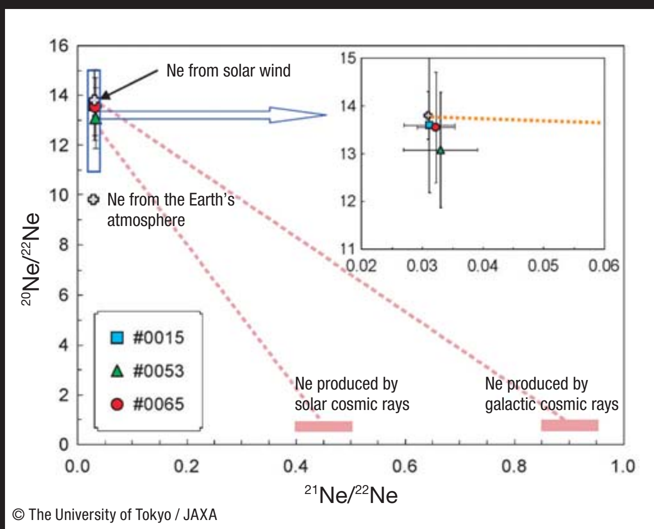


06 | Irradiation History of Itokawa Regolith Material Deduced from Noble Gases in the Hayabusa Samples

We measured the presence of a group of chemical elements called "noble gases" in rocky grains retrieved from the surface of Itokawa. The noble gases in the grains were composed of implanted solar wind and those produced by exposure to energetic particles, such as solar and galactic cosmic rays. By measuring these gases, we were able to estimate how long the sample grains had been exposed to the space environment.

Using such noble gases as helium, neon, and argon as clues has the following advantages: (1) these elements are not chemically reactive; (2) they can be detected even in very small amounts; and (3) their isotopic composition varies greatly depending on their origins or the process by which they were produced. This has been a key method of analysis supporting the research of meteorites and cosmic dusts, and scientists have accumulated a very large amount of data through the measurement of noble gases. The main drawback of this method is that heating must be applied to extract the noble gases, meaning the sample is lost through melting.

After analyzing the sample grains, we proposed that Itokawa is continuously shrinking. Our consequent prediction that Itokawa would disappear within one billion years seems to have created much interest among those who read our research paper. In addition to such factors as shocks sustained from meteorite impacts and surface particles being electrostatically ejected, the question, "What mechanism is causing Itokawa to shrink?" is likely to have scientific significance. Furthermore, we believe that it is a topic deserving further verification through experiments.



Neon emitted from the sun was present in the three Itokwa sample particles analyzed (#0015, #0053, and #0065)

Mamoru Mohri

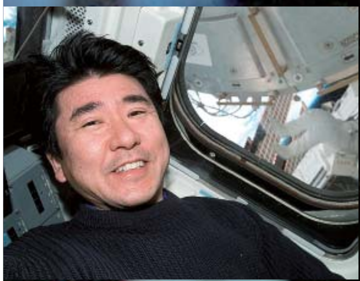
"I am extremely grateful for the contribution of the Space Shuttle, which provided a superb quality ride and superior payload capacity. Thanks to the Space Shuttle, I was able to perform some wonderful tasks, including space experiments and Earth observation."

Astronaut Mohri carries out an amateur radio experiment aboard the Space Shuttle Endeavour in September 1992

Chiaki Mukai

"I feel some sadness that we have reached the conclusion of the Space Shuttle Program, which ushered in an era of high-capacity transportation for human space flight. For the rest of my life I will treasure the memories of two Space Shuttle flights and serving as backup crew for two other missions during the Shuttle's heyday."

Astronaut Mukai conducts a plant experiment during her mission aboard the Space Shuttle Discovery in October–November 1998



Takao Doi

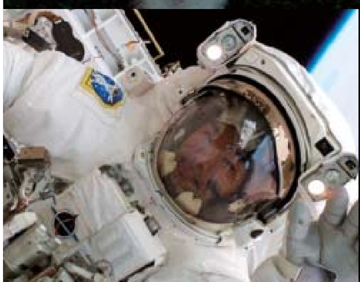
"Since its first flight in 1981, the Space Shuttle has continued to expand our dreams for space. The realization of JEM Kibo was made possible by this magnificent spacecraft."

Astronaut Doi in the Space Shuttle Columbia flight deck in December 1997

Koichi Wakata

"The knowledge gained by humankind from the experience of operating the Space Shuttle provided a great boost to opening up the space frontier safely and economically. I am sure that this knowledge will continue to benefit worldwide efforts to further the development of human activities in space."

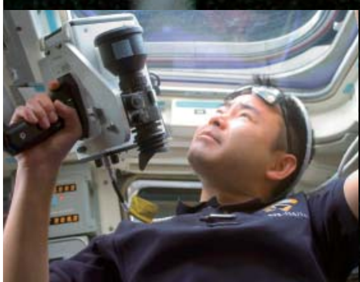
Astronaut Wakata operates the Space Shuttle Discovery's robotic arm in October 2000



Soichi Noguchi

"It is a pity that we will no longer be able to see the gallant figure of the Space Shuttle, which played a key role in such projects as the assembly of JEM Kibo. My first space flight was aboard the Space Shuttle, so I feel both nostalgia and gratitude."

Astronaut Noguchi performs an EVA in August 2005



Akihiko Hoshide

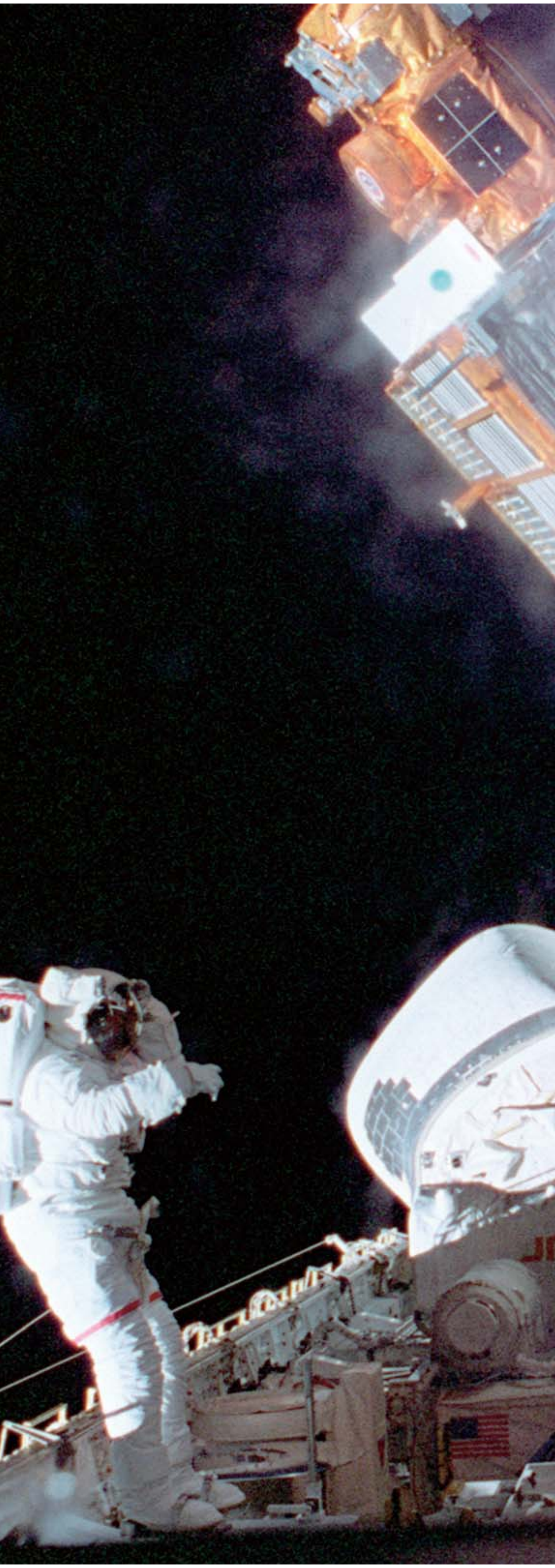
"I feel very fortunate to have flown aboard the Space Shuttle Discovery. I want to continue to utilize the knowledge and experience I gained as a Shuttle Mission Specialist in Japan's space development programs."

Using a handheld laser ranging device, Astronaut Hoshide measures the distance and approach speed between the Discovery and the ISS in June 2008

Naoko Yamazaki

"Manned space development is entering a new phase. I hope that by using the knowledge gained through the Space Shuttle Program, such development will have a positive impact on the lives of people on Earth."

Astronaut Yamazaki performs preparations for the transfer of an observation rack to the ISS in April 2010



The Space Shuttle Program: An Important Chapter in the History of Human Space Flight

Messages Paying Homage to the Space Shuttle— Carrying the Dreams of Countless People for 30 Years

Astronauts Manually Retrieve Drifting Spacecraft

On November 25, 1997 (Japan Standard Time), two astronauts began an unparalleled extra-vehicular activity (EVA). NASA's Shuttle Pointed Autonomous Research Tool for Astronomy-201-04 (SPARTAN-201-04)—a solar observing spacecraft designed to perform remote sensing of the solar wind that originates in the sun's corona—had failed to execute a maneuver after being deployed using the Space Shuttle's remote manipulator arm, and had begun drifting in space. The astronauts were given the task of manually retrieving this unmanned spacecraft.

This photograph shows astronauts Takao Doi (right) and Winston Scott (left) waiting to capture the approaching SPARTAN spacecraft, which weighed approximately two tons and was orbiting the Earth at a speed of approximately 7.7km per second. Astronaut Doi recalls the scene: "We had stood in Space Shuttle Columbia's payload bay for about two hours, watching as the Columbia approached SPARTAN. Our orbit had passed through one cycle of daytime and nighttime. I happened to look up, and there it was—the gold-colored SPARTAN gleaming in the sunlight."

When SPARTAN got within about 30 centimeters of Columbia, the two astronauts simultaneously grappled each end of the drifting spacecraft with their hands and secured it to the Columbia's payload bay.

*These messages were received from each of Japan's astronauts to commemorate the retirement of the Space Shuttle fleet in July 2011.

Satoshi Furukawa

"I wish to pay tribute to the Space Shuttle and NASA, which have played a vital role in the advancement of science and technology. I will do my best on this long-duration mission on the ISS to ensure that the Shuttle's achievements lead to a new era of manned space development." (This message was received from Astronaut Furukawa at the end of June 2011 while he was serving a long-duration mission aboard the ISS.)

Astronaut Furukawa photographs the Space Shuttle Atlantis through a window in the Russian service module, Zvezda, in July 2011

This photograph shows astronauts Takao Doi (right) and Winston Scott (left) waiting to capture the approaching SPARTAN spacecraft.

Observing the Earth Today for the Benefit of Tomorrow

JAXA's Earth Observation Mission

Grasping environmental changes to help predict the future; observing natural disasters to assist disaster management; protecting forests and water resources—JAXA works to address these and other issues by developing, launching, and operating Earth observing satellites, which investigate changes in the atmosphere, land, and oceans. The data gathered by Earth observing satellites is used in myriad ways to support our lives now and in the future. Such uses include measuring the distribution of greenhouse gases, studying climate change, and observing floods and earthquakes. In this special feature, we introduce JAXA's Earth observation mission, which is working to expand knowledge for the benefit of future generations.

Toru Fukuda (Right)
Jun Gomi (Left)

Advanced Land Observing Satellite (ALOS) Played an Important Role in Determining the Extent of Damage from the Great East Japan Earthquake

Please explain the situation when you carried out emergency observations following the Great East Japan Earthquake.

Fukuda: Although ALOS reached the end of its operating life 40 days after the earthquake, during those 40 days ALOS captured more than 400 scenes (images) of the disaster-affected areas. In addition, we received over 5,000 scenes taken by satellites from other countries. I see this as not only reciprocation for the observations of disasters in many countries ALOS was able to carry out over the past five years but also as a reflection of the goodwill built up through JAXA's active participation in such international cooperation frameworks for disaster management as Sentinel Asia and the International Charter "Space and Major Disasters."

Jun Gomi

Director of the Satellite Applications and Promotion Center (SAPC), JAXA

Involved in the promotion of satellite utilization, including the provision of support related to environmental issues and cartography, and the development and operation of disaster management systems

Gomi: SAPC responds to requests from central and local government agencies dealing with disasters. We delivered data sets that included pre-disaster images together with scenes taken each day after the earthquake, including data received from overseas. This information proved useful for determining the extent of damage over a wide area and managing disaster response. Since the government agencies we were providing data to had no capacity available for image analysis, we needed to supply information that could be used immediately.

Do the images taken by ALOS provide any specific advantages?

Gomi: Even among the world's high-resolution Earth observing satellites, ALOS boasts a particularly broad observation swath of 70 kilometers. This makes it an extremely useful satellite for gathering information on the damage situation over a very wide area during a disaster on the scale of the Great East Japan Earthquake.

Fukuda: When disaster strikes, in many cases aircraft-based observation cannot function sufficiently owing to such factors as weather conditions in the disaster-affected region or due to safety considerations. Hence, satellites perform an important role thanks to their capabilities for continuously providing observation data over a wide area even at night and during adverse weather.

Satellites Utilized in an Expanding Range of Fields

This disaster once again underscored the importance of satellite observation.

Fukuda: Emergency observation is of course vital, but in fact it is also important to have a good understanding of pre-disaster conditions. As part of our response to

Toru Fukuda

Director of the Earth Observation Research Center (EORC), JAXA

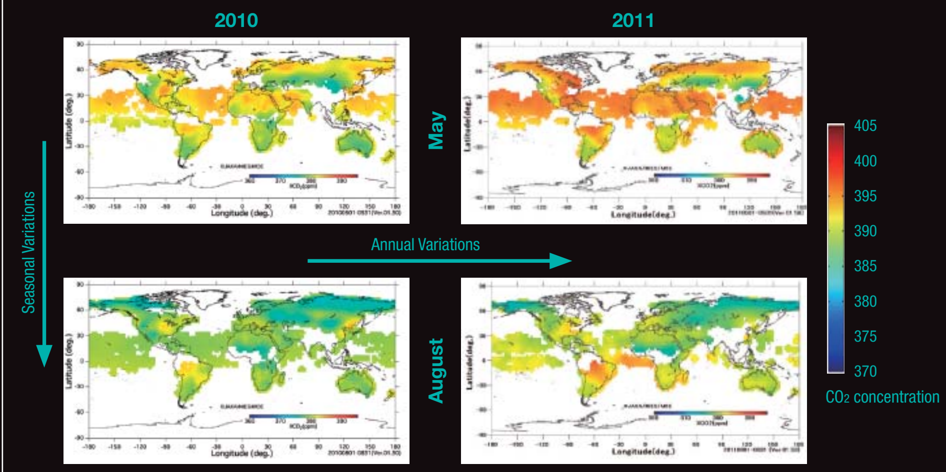
Involved in such areas as the processing, validation, and analysis study of data from Earth observing satellites and the provision of such data

the earthquake and tsunami, we are providing central and local government agencies with a large number of images taken before the disaster. Ongoing observation is also crucial. Some of the disaster-stricken areas remained waterlogged for a long time. Tracking what was happening to this water was a task suited to satellites.

Gomi: Prior to the disaster, Earth observation images taken by JAXA were generally only used by central government agencies and a limited number of local government agencies—particularly those in areas where disasters had occurred previously. However, in the wake of this disaster I think that there has been a substantial shift forward—many more organizations are now looking to make full-fledged use of satellite images. From now on we will likely see satellites utilized in an expanding range of fields.

Specifically, in what kind of fields do you anticipate satellites being used?

Gomi: We are already seeing satellite use increase in such fields as disaster management, cartography,



Global Distribution of CO_2 Concentration Based on Observations by GOSAT in May and August 2010 and 2011

The map was produced by dividing the Earth's surface into 250km squares and assigning colors based on the month's averaged observation data for each square. Blue indicates low CO_2 concentration and red indicates high concentration.

Observation data from GOSAT reveals not only annual variations in CO_2 concentration but also seasonal variations. The maps for August—corresponding to summer in the northern hemisphere—show many areas at high latitudes with low CO_2 concentrations compared with other months. This is thought to be significantly influenced by plant photosynthesis.

agriculture, and sea-ice observation. At present, preparations are underway for the monitoring of ships navigating in each country's territorial waters and exclusive economic zone (EEZ)—an issue that is beginning to generate greater international attention. In the field of satellite-based cartography, in addition to increasing private-sector use, the Japan International Cooperation Agency (JICA) is promoting a joint mapping project by three African countries.

Fukuda: Within the mapmaking process, it is essential to have a very precise understanding of where the observed location is on the Earth's surface. Data from ALOS offers the world's highest precision, and since it enables mapmaking to be carried out even when there is no surface reference marker, ALOS data is beginning to be used extensively. Maps with a scale of 1:25,000 can be created using data from ALOS, but needs are emerging for larger scale maps. Further enhancements in precision are required to meet such needs. Hence, we are conducting research that can be applied in ALOS-3, one of our successor satellites.

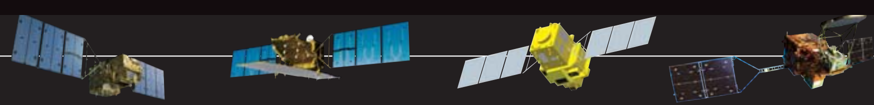
JAXA's World-leading Technology for Water Observation

There is also a role for Earth observing satellites in monitoring global-scale climate and environmental change.

Fukuda: In Earth observation over recent years, cooperative projects between Japan and countries in Asia have been particularly numerous. One serious issue that we are working to address is how to manage climate change and the disasters that are occurring as a result of such change. Approximately half of the world's large-scale disasters involve floods and other water-related phenomena. It is possible that such disasters are related to global warming. When precipitation patterns change, this can lead to disasters and also cause damage to agriculture. I strongly believe that satellites can play an extremely important role by looking at these types of problems globally from a "bird's-eye view."

Gomi: Greenhouse Gases Observing Satellite (GOSAT) is one of the satellites we operate that typifies such global-scale observation. By using GOSAT data, researchers are able not only to ascertain the annual variation in CO_2 concentration distribution

Viewing Land, Oceanic, and Atmospheric Changes from Space



	Greenhouse Gases Observing Satellite (GOSAT; IBUKI) (Launched: January 2009)	Advanced Land Observation Satellite-2 (ALOS-2) (Launch: Scheduled for FY2013) To take over radar observation previously carried out by ALOS (ended operations in May 2011)	Advanced Land Observation Satellite-3 (ALOS-3) (Launch: Scheduled for FY2015 or later) To take over optical observation previously carried out by ALOS (ended operations in May 2011)	Global Change Observation Mission 1st–Water (GCOM-W1; SHIZUKU) (Launch: Scheduled for FY2012) To follow on from AMSR-E (suspended observations in October 2011), which was carried by NASA's Earth observing satellite Aqua (EOS PM-1)
Global warming (greenhouse gases)	●			
Forest monitoring		●		
Sea ice and glacier monitoring		●	●	●
Weather prediction and climate change (sea surface temperature, water vapor, precipitation, snow and ice, cloud, aerosol)				●
Disaster observation (earthquakes, floods, droughts, volcanic eruptions, forest fires)	●	●	●	
Cartography			●	
Food security (agriculture, fisheries)		●	●	●
Public hygiene		●	●	
Maritime–space cooperation		●		●

but also seasonal fluctuations. It has also confirmed our understanding of the major impact that plant photosynthesis has on CO_2 concentrations.

Furthermore, in 2012 we will launch GCOM-W1, which will observe the global water cycle. Since water is increasing in some areas and decreasing in others, there is a need to conduct precise measurements. JAXA is a world leader in technology related to water observation. For over nine years we operated AMSR-E, which is the predecessor of AMSR2—the main instrument to be carried by GCOM-W1. In addition, the Tropical Rainfall Measuring Mission (TRMM), a joint satellite mission between JAXA and NASA, has been operating for 14 years. Its Precipitation Radar (PR) instrument was a world first, and is still the world's only space-borne radar providing continuous precipitation observation.

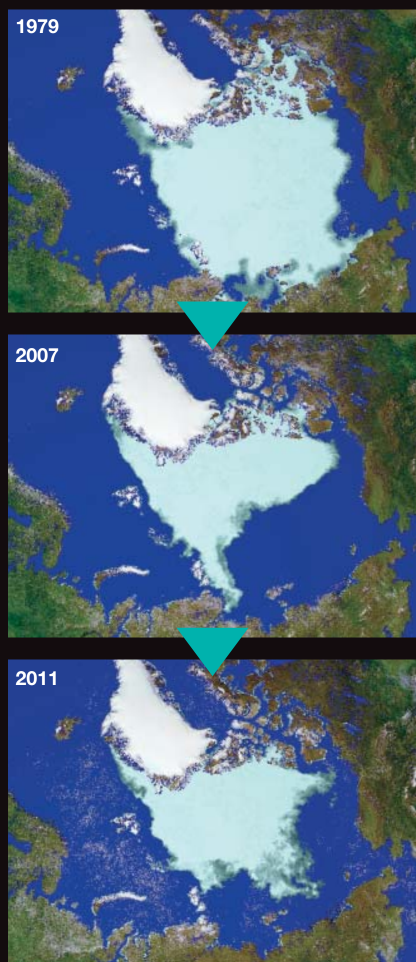
Leveraging Japan's Technological Capabilities to Help Improve People's Lives

Please tell us about key issues affecting Earth observation in the future.

Gomi: I see three main issues. The first one is continuity of observation. Although this presents significant challenges for Japan and other countries, I think it is vital to take a planned, systematic approach. The second issue is data fusion. Rather than completing missions based on the operation of a single satellite, we are now in an era where several missions are conducted involving the use of multiple satellites. It is also an era where we are able to combine satellite data with data from ground-based observation rather than relying on satellite data alone. The third issue is international coordination. Space-related activities worldwide simultaneously involve collaboration and competition. Since all countries face budgetary constraints, international cooperation is becoming even more important. Within this environment, I think that the key for us is to determine how Japan can further develop the satellite and sensor technologies in which it has proven strengths.

Fukuda: In addition to such fields as disaster management and climate change research—the principal areas in which Earth observation has been utilized to date—I want us to provide information that can be used in fields with close connection to people's daily lives. For example, Earth observation can be applied to food security-related fields, such as agriculture and fisheries. Among the more challenging areas are public hygiene and healthcare-related fields, such as communicable disease and water contamination. Since the fields I have mentioned are all subject to serious impacts from climate change, I want us to continue efforts to produce useful information. I think that data fusion can play an important role in achieving this goal. We need to abandon compartmentalized approaches and utilize a variety of satellites and methods. I want us to approach research and development with a level of enthusiasm commensurate with a statement like, "Japan will be the leader in this satellite technology or in this data production method."

Distribution of Arctic Sea Ice Observed by AMSR-E



The image taken in 2011 shows the disappearance of sea ice from the coast of Siberia and largely unobstructed sea channels between islands in Canada's northern archipelago. Observation data from AMSR-E also reveals that in the summer of 2011, the concentration of sea ice was the lowest ever recorded. AMSR2, which will be carried by GCOM-W1, is scheduled to continue these observations.

Global Change Observation Mission 1st–Climate (GCOM-C1) (Launch: Scheduled for FY2015)

Global Precipitation Measurement Mission (GPM) / Dual-frequency Precipitation Radar (DPR) (Launch: Scheduled for FY2013)
To follow on from Tropical Rainfall Measuring Mission (TRMM) / Precipitation Radar (PR)

Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) / Cloud Profiling Radar (CPR) (Launch: Scheduled for FY2015)

User Interview 01: Utilizing ALOS and Looking Forward to Successor Satellites

For Applications from Cartography to Monitoring Crustal Change, ALOS Provides a "Snapshot" of the Earth

Geospatial Information Authority of Japan (GSI)

Hiroshi Mashiko
Deputy Director of
International Affairs Division
Planning Department
GSI

Masayuki Yamanaka
Chief of
Earth Deformation
Observation Section
Space Geodesy Division
Geodetic Department
GSI

Ritsu Okayasu
Technical Official
Basic Map Division
National Mapping Department
GSI

Utilizing ALOS Data for Mapping Remote Islands

GSI uses image data captured by ALOS from 700 kilometers above the Earth to produce and revise the 1:25,000 scale maps that comprise Japan's national basic map. A single aerial photograph can only capture a square of up to 7km across, whereas ALOS provides a much broader image covering an area measuring 70km × 35km. Using observation data from ALOS, we have revised map information for remote islands and other inaccessible areas that had not been updated for an extended period.

Providing Support from Space for the Lives of People in Developing Countries

In collaboration with JICA, GSI is involved in surveying and cartography projects as part of Japan's overseas development assistance (ODA) programs. In such projects, by utilizing satellite image data provided by ALOS, the need for aerial photography—which incurs significant costs in time and resources—is eliminated. Furthermore, in cases where there are disputes between neighboring countries it is often not feasible to conduct aerial surveys. Hence, for many countries in Africa and other regions that have large land areas, the benefits are substantial.

Using PALSAR to Help Understand the Mechanisms Driving Volcanic Eruptions and Earthquakes

Using data gathered by Phased Array type L-band Synthetic Aperture Radar (PALSAR)—an instrument carried by ALOS—we monitor changes in the Earth's crust, including those related to volcanic eruptions and earthquakes. In situations where it is problematic to install ground-based observation equipment, satellite observation is a particularly useful method, and is helping to improve understanding of the mechanisms that drive volcanic eruptions and earthquakes.

At present, JAXA is developing ALOS-2, which will carry an even more advanced L-band synthetic aperture radar instrument and will be able to carry out day-and-night and all-weather observation. JAXA is also drawing up plans for ALOS-3, which will carry an advanced optical sensor. We are looking forward to utilizing the capabilities of these successor satellites to ALOS.

ALOS observation data (taken on July 16, 2006)

A contour map prior to revision (top) and the updated map after revisions based on data from ALOS (bottom). Revisions were made to the airfield, roads, and buildings.

ALOS' Contribution to Environmental Protection

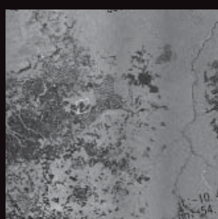
ALOS exceeded both its design life of three years and its target life of five years. During its five years and three months of operations, which ended in May 2011, ALOS captured 6.5 million scenes (images) worldwide. It not only contributed through observations of major disasters but also in a range of environmental fields. Below are several examples of ALOS' contribution to environmental protection.

November 2008

- The contribution of images from ALOS to deforestation prevention is highly praised, and a letter of appreciation is received from the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA).

December 2008

- Start of a project involving ALOS observations of World Heritage Sites



Observation of deforestation in the Amazon region

Angkor Wat (Cambodia)

User Interview 02: Utilizing ALOS and Looking Forward to Successor Satellites

Protecting Japan's Land through a Combination of Day-to-day and Disaster Observation

National Institute for Land and Infrastructure Management (NILIM)

Masaki Mizuno
Senior Researcher
Erosion and Sediment Control Division
Research Center for Disaster Risk Management
NILIM

ALOS Provides Broad-area Landslide Data After the Great East Japan Earthquake

At the Erosion and Sediment Control Division of the Research Center for Disaster Risk Management, which is part of NILIM, since February 2008 we have used observation data from ALOS for two main purposes—for long-term monitoring and observation of sediment movement during normal conditions, and for emergency observation immediately following a disaster.

In observation during normal conditions, by gathering regular data for a specific location, we may be able to prevent the occurrence of a landslide if we find early indications of minor ground movements. In the case of the Great East Japan Earthquake, which struck on March 11, 2011, by March 14 ALOS had taken images of all areas that had experienced very strong tremors. In addition to taking images of coastal areas, which sustained severe damage from the tsunami, ALOS also provided images of the broad area exposed to very intense shaking, including mountainous regions. Only ALOS provided this full data set, which proved extremely valuable.

ALOS' Successors Expected to Provide Even Greater Contribution to Disaster Observation

At NILIM, we are eagerly anticipating the early commencement of operations of the two successor satellites to the ALOS mission—ALOS-2 and ALOS-3.

When disaster strikes over such a wide area as the Great East Japan Earthquake, it is difficult to conduct thorough checks of mountainous areas even using aircraft. In the case of a typhoon, storm, or flood, adverse weather prevents the use of aircraft. During a volcanic eruption, volcanic gases, ash, and cinder often prevent aircraft from approaching the crater. However, the L-band synthetic aperture radar instrument to be carried by ALOS-2 is usually unimpaired by clouds and is able to carry out observation even in the situations described above. ALOS-3 will carry an advanced optical sensor with a maximum resolution of 0.8 meters, making it possible to discern a mass of collapsed rocks caused by slope failure. This will enable us to carry out very precise investigations of landslide disasters. When the successor satellites to ALOS are launched and begin operation, I am sure that they will provide an even greater contribution to disaster observation and management in Japan and abroad.

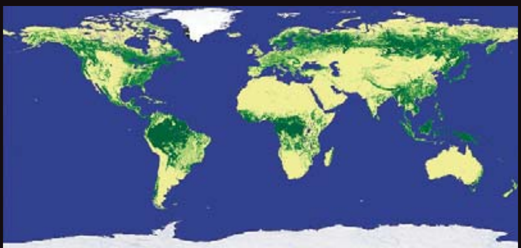
After

Prior

Images taken by ALOS of the Hanokidaira area of Shirakawa City, Fukushima Prefecture. The bottom image was taken prior to the Great East Japan Earthquake. The top image was taken on the day following the earthquake (March 12, 2011), and shows the aftermath of a landslide.

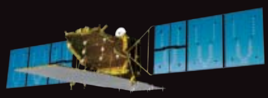
October 2010

- Signing of a cooperation agreement with the Ramsar Secretariat related to wetland research utilizing ALOS
- Release of a global forest distribution map. ALOS contributes to forest protection and efforts to curb illegal logging.

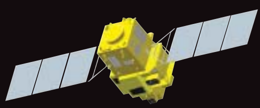


Global forest distribution map. Green indicates forest, and yellow indicates unforested areas

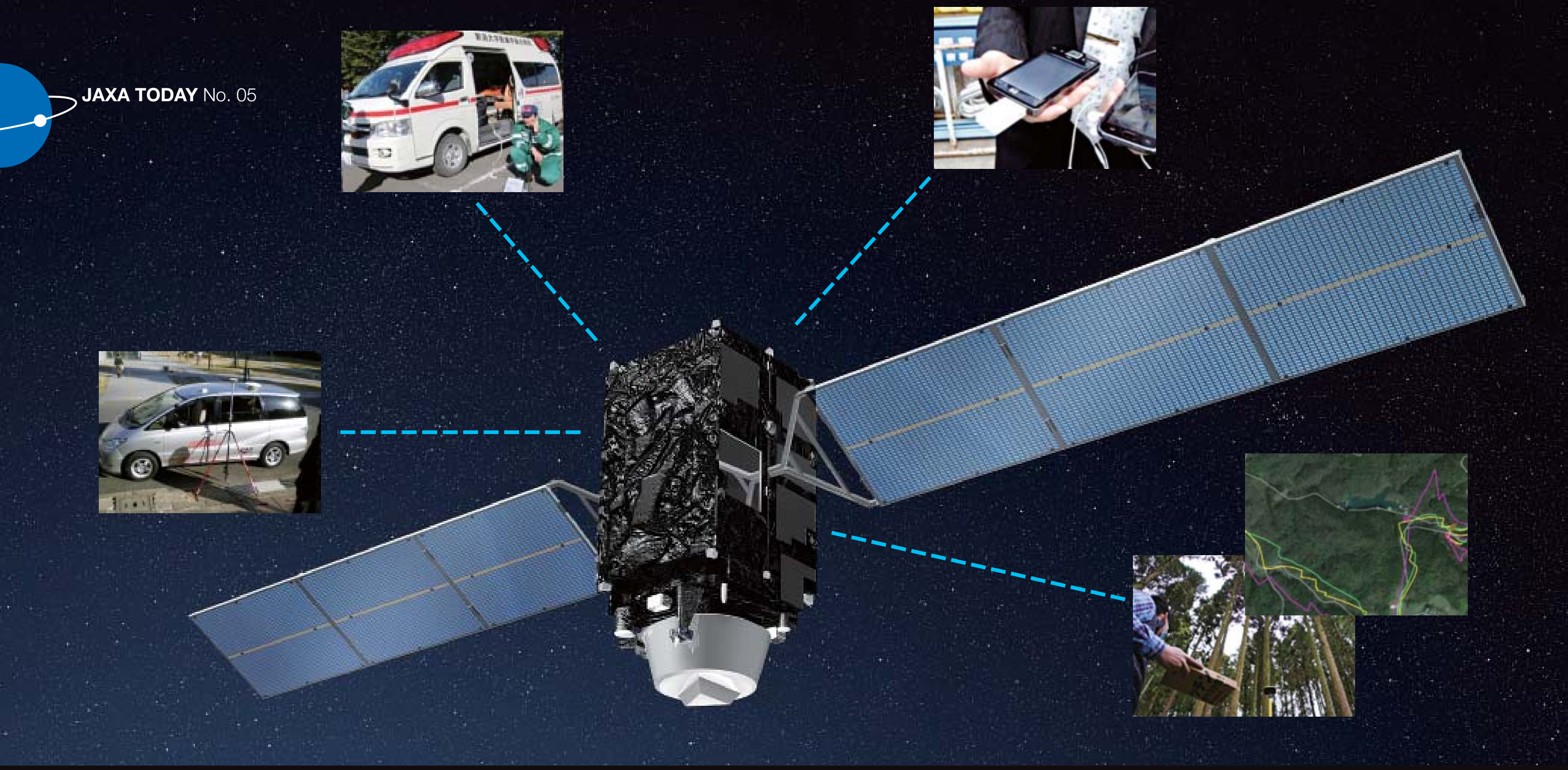
The technologies nurtured by ALOS will be further advanced by its successors.



ALOS-2 features state-of-the-art radar



ALOS-3 to carry an advanced optical senor



MICHIBIKI—

Japan's First Positioning Satellite

Guiding Society to a New Future

Quasi-Zenith Satellite-1—also known by its Japanese nickname "MICHIBIKI"—was launched in September 2010. An array of demonstration experiments utilizing data from MICHIBIKI commenced in January 2011, which aim to develop practical applications of the Quasi-Zenith Satellite System (QZSS). JAXA received over 100 experiment theme proposals from a diverse range of business enterprises and other organizations, which have expressed interest in participating in QZSS application development. In this article we provide an overview of utilization experiments currently underway.

Satoshi Kogure

Mission Sub-Manager
Satellite Applications and Promotions Center
JAXA

From Technical Verification to Application Demonstration

From December 2010, MICHIBIKI began technical verification. This phase of development included not only evaluation of the technical characteristics of the satellite's signals, but also the steady accumulation of data to verify the effectiveness of the signals from a broad range of environments, including urban canyons (created by tall buildings) and mountainous forests. JAXA received the co-operation of a variety of organizations in gathering this data, including universities, Japan's Forestry Agency, surveyors, and transportation companies. After internal evaluation by JAXA, the data was shared with participating research institutions. JAXA plans to release the data to the public through its QZ-vision web site.

In June and July 2011, JAXA lifted the alert flag* that had been placed on signals from MICHIBIKI, thus allowing the signals to be utilized by general users for the first time. This marked the start of the application demonstration phase of development, during which JAXA and participating organizations will investigate the ways in which MICHIBIKI can contribute to the enrichment of ordinary people's lives.

The Asia Oceania region is uniquely well placed to reap early benefits from the new era of multiple global navigation satellite systems (GNSS). Recognizing this, in 2009 JAXA proposed the concept for the "Asia Oceania Multi-GNSS Demonstration Campaign," and was instrumental in the establishment of Multi-GNSS Asia (MGA), an international body whose aim is to promote the aforementioned campaign. MGA also works to promote the development and popularization of applications for next-generation GNSS.

* An alert flag indicates to receiving devices that the signals cannot be used.

Case Study 1

Development of a Disaster-response System to Receive Emergency Alerts Anywhere, Anytime

NTT DATA CORPORATION

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In collaboration with other companies and a university, NTT DATA CORPORATION is currently engaged in experiments using MICHIBIKI that aim to contribute to the development of real-time disaster-response applications that utilize small-capacity, multi-destination data delivery from satellites. Below, we introduce an experiment involving a disaster-response system that will enable users to receive disaster alerts anywhere, anytime, and that will provide emergency-evacuation instructions.

Providing Real-time Information Even When Ground-based Communications Are Disrupted

Since 2009, as part of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) program to coordinate the promotion of space utilization, NTT DATA, Asia Air Survey Co., Ltd., PASCO CORPORATION, Keio University, and other partners have been collaborating in the development of real-time disaster-response applications under the Red Rescue Project. This experiment was undertaken for the purpose of developing a disaster-response system that can receive urgent messages at all times and in any location. The experiment combined a message transmitting and receiving system that utilizes MICHIBIKI's L1-Submeter-class Augmentation with Integrity Function (L1-SAIF)*—a GPS augmentation signal—with the Indoor Messaging System (IMES), which can transmit positioning data and other information even indoors. Since this system uses satellites for message transmission—hence it is able to send and receive data even when ground-based communications facilities suffer outages—it provides a high level of resilience during disasters.

* L1-SAIF: A GPS augmentation signal that contains such information as positioning correction data and GPS integrity data

Practical Application to Fill the Information Vacuum in the Immediate Aftermath of a Disaster

In March 2011, at an underground shopping mall located on the east side of Yokohama Station we conducted a demonstration experiment, which used a MICHIBIKI-compliant satellite receiver and a smartphone. The system used in this experiment involves messages received via MICHIBIKI's L1-SAIF signals being relayed from the satellite receiver to an end-user's smartphone. Whereupon, a smartphone application provides disaster information, displays an evacuation route, and enables the user to confirm their safety. One of the aims of the experiment was to test whether or not the user could evacuate by following the route displayed in 3D on the smartphone screen. The experiment result confirmed that it is possible to provide effective evacuation guidance through such a system.

We plan to continue conducting demonstration experiments for this system, including a range of disaster scenarios in addition to earthquake and tsunami scenarios. Hence, we aim to practically apply this system as a tool for filling the information vacuum that often occurs in the immediate aftermath of a disaster.

Experiment conducted at Yokohama Porta underground shopping mall on the east side of Yokohama Station

Case Study 2

Aiming to Bolster the Use of IT in the Agricultural Sphere through the Development of a High-precision Automated Guidance System for Farm Machinery

HITACHI ZOSEN CORPORATION

Masayuki Kanzaki

Senior Head Engineer
GPS Solution Department
Business & Product Development Division
Machinery & Infrastructure Headquarters
Hitachi Zosen Corporation

The objective of the "Demonstration Experiment of the Quasi-Zenith Satellite-Based Precision-Guidance System to Promote the Use of IT in Agriculture"*, which is being conducted by Hitachi Zosen Corporation, is to utilize MICHIBIKI's GPS augmentation signals in the automated operation of farm machinery, and thereby promote the application of

IT in the agricultural sphere. In this brief overview, I will explain the intentions behind our adopting an agricultural theme for our research.

* Part of an investigative research project commissioned by MEXT, relating to Earth observation and other technologies

Realizing Agriculture Optimized for Crops by Applying Control Technology with Centimeter-level Precision

Hitachi Zosen first began developing GPS receivers for use in ships 25 years ago. Since then, we have built up a record of achievements in such areas as automotive navigation systems for emergency vehicles and the project led by Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) to develop a network of GPS ocean-wave meters. For this experiment, we participated in the IT Automated Guidance Working Group convened by the Satellite Positioning Research and Application Center (SPAC; for details, please refer to the inset article on this page). The reason we chose the automated operation of farm machinery as our research theme was because MICHIBIKI provides the opportunity to realize control down to centimeter-level precision. Hence, we considered that we could achieve the greatest impact by applying this technology to the agriculture sphere.

If we are able to achieve centimeter-level control accuracy, by combining this with remote-sensing technology for growth management, it becomes possible to apply water, pesticides, and fertilizer to crops at the optimum level and only in the places necessary.

After Successful On-farm Demonstrations, We Are Expanding Our Sights to Include Overseas Promotion of the Technology

In February 2011, we successfully conducted an experiment at Tsukuba in which we ran a tractor—equipped with GPS and MICHIBIKI antennae—in a straight line. Then in September, we operated Hokkaido University's autonomous agricultural machinery in a driverless experiment. Using GPS alone, the margin of error was 1–10 meters, whereas using GPS in combination with MICHIBIKI reduced the margin of error to the range of a few centimeters. In a demonstration experiment carried out in a field at Kamifurano, Hokkaido, observers from the agricultural sector showed a high level of interest in control technology for farm machinery that would enable precise operation anytime, day or night. Some of those present said that they would like to utilize such a system as soon as possible.

We are also looking to promote technology for the automated operation of farm machinery in other countries covered by MICHIBIKI's signals, including Australia and countries in Asia. Potentially, the results of these demonstration experiments could generate significant change in agricultural practices, both in Japan and around the world.

The experiment was held in February 2011 at the National Institute for Rural Engineering, in Tsukuba, with antennae for GPS and MICHIBIKI fitted to the top of the tractor's cab.

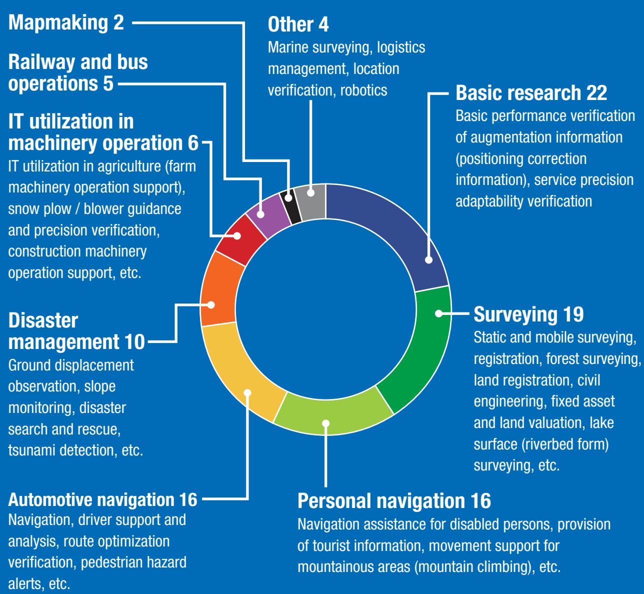
Satellite Positioning Research and Application Center (SPAC) Works to Expand the Use of MICHIBIKI through the Promotion of Demonstration Experiments by Private-sector Companies

Shigeru Matsuoka

Deputy General Manager
PNT Application and Promotion Division
Satellite Positioning Research and Application Center (SPAC)

SPAC works in collaboration with companies and other organizations involved in the field of positioning satellites to promote the utilization of satellite positioning technology and application research in this field. In response to our call for proposals for demonstration experiments, by August 2011 we had received more than 100 applications covering a diverse range of topics, including surveying, automotive navigation, disaster management, and robotics. Such a high level of interest shows that the use of MICHIBIKI by industry is quickly becoming a reality.

Demonstration Experiments Using MICHIBIKI: Number of Themes by Category (As of September 2011)



Mika Ochiai
Administrator,
Space Environment Utilization Center, JAXA
Currently posted to the Space Applications Section (SAS), UNOOSA
In charge of the Human Space Technology Initiative

50th
Anniversary

United Nations Office for Outer Space Affairs (UNOOSA) Contributes to the Peaceful Uses of Space

On June 2, 2011, an Astronauts and Cosmonauts Panel titled "The Future of Humankind in Space" was held at the City Hall of Vienna. On the far left-hand side is the co-chair of the panel Takao Doi from Japan, who serves as the Chief of the Space Applications Section (SAS) of UNOOSA. On the far right-hand side is the other panel co-chair, Franz Viehböck from Austria. The other members of the panel were (starting third from the left): Alexey Leonov (Russia), Leland Melvin (United States), Chiaki Mukai (Japan), Claude Nicollier (Switzerland), Sheikh Muszaphar Shukor (Malaysia), Thomas Reiter (Germany), Yang Liwei (China), and Yi So-yeon (South Korea).

UNOOSA, in Vienna, Austria, promotes programs to facilitate space development for the benefit of all humankind.

Adoption of the Declaration on the Fiftieth Anniversary of Human Space Flight and the Fiftieth Anniversary of the Committee on the Peaceful Uses of Outer Space (COPUOS)

UNOOSA serves as the secretariat for the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) which is the General Assembly's only committee dealing exclusively with international cooperation in the peaceful uses of outer space. UNOOSA has the dual objectives of supporting the intergovernmental discussions in the Committee and its Scientific and Technical Subcommittee (S&T) and Legal Subcommittee and of assisting developing countries in using space technology for development. UNOOSA has, for over half a century, dedicated itself to bringing the benefits of space to humankind.

The year 2011 marked the 50th anniversary of the first human space flight—by the Russian Cosmonaut Yuri Gagarin—as well as the 50th anniversary of the first meeting of COPUOS. Accordingly, at the UN Office in Vienna, Austria, a commemorative segment was included in the 54th session of COPUOS on June 1, 2011, to celebrate these anniversaries. During this commemorative segment of the session, COPUOS adopted the "Declaration on the Fiftieth Anniversary of Human Space Flight and the Fiftieth Anniversary of the Committee on the Peaceful Uses of Outer Space." The declaration included a reference to the achievements to date of humankind's activities in outer space, recognized the necessity of space science and technology and their applications to sustainable long-term development, and reaffirmed the importance of international cooperation.

Utilizing the ISS for the Advancement of Science and Technology

With such objectives as contributing to the enhancement of people's lives throughout the world and promoting world peace, UNOOSA has been implementing a variety of capacity-building activities such as organizing workshops and seminars to promote space science and technology in the world. Under its newest Human Space Technology Initiative (HSTI), which was launched in 2010, by highlighting the activities of the International Space Station (ISS), UNOOSA is aiming to create awareness of utilizing human space technology and its applications as well as to build capacity in microgravity education and research.

During the commemorative segment celebrating the 50th anniversaries of the first human space flight and the first COPUOS meeting, a video message was delivered from inside JEM Kibo by the six astronauts and cosmonauts on board the ISS.

Dr. Yasushi Horikawa
Dr. Horikawa joined NASDA—one of the predecessor organizations of JAXA—in 1973. In 1987, he began working on the development of JEM Kibo. From 2005 he served as an executive director of JAXA, and in 2009 was appointed as Technical Counselor. Dr. Horikawa has been elected to serve a two-year term as chair of COPUOS starting in June 2012.

Dr. Kuniaki Shiraki
Dr. Shiraki was involved in the development of many of Japan's satellites, including NASDA's first satellite, Engineering Test Satellite I (ETS-I; Japanese nickname: "KIKU 1") and the Ionosphere Sounding Satellite (Japanese nickname: "UME"), as well as the H-I Launch Vehicle. He has been involved in the ISS program since the preliminary study in 1984.

Attending the award ceremony were Takahisa Sato (second from right) representing the MFD project team; Mitsushige Oda (second from left) representing the ETS-VII project team; and Professor Jun'ichiro Kawaguchi (third from right), Kuninori Uesugi (right), Hitoshi Kuninaka (third from left), and Shin'ichiro Nishida (left) from the Hayabusa project team.

JAXA's Frontier

Next Chair of COPUOS: Dr. Yasushi Horikawa

JAXA Technical Counselor Dr. Yasushi Horikawa has been elected as the next chair of COPUOS, making him the first Japanese to serve in this role. During Dr. Horikawa's two-year term as chair, commencing in June 2012, COPUOS will deal with a broad range of agenda items relating to the peaceful use of outer space. Prior to his appointment, Dr. Horikawa made the following remarks.

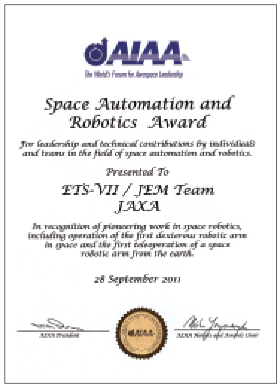
"Established in 1961, COPUOS is now a large committee with 70 member countries as of the end of January 2012. The committee's main functions are to review and draft the rules and principles for the peaceful use of space, and report to the United Nations General Assembly. In recent years, the committee's agenda has included such issues as the reduction of space debris, response to natural disasters, the use of nuclear power systems, and the long-term sustainability of space activities. The committee chair plays a key role in ensuring that the committee provides a forum in which all member countries are given an equal opportunity to express their views and participate in discussions. At present, we are seeing an acceleration in the commercial use of outer space—including activities undertaken by private-sector companies—in such areas as the launch of communications satellites and Earth observing satellites. This is likely to further increase the necessity for the establishment of appropriate rules. All COPUOS member countries must cooperate to build a long-lasting framework for the peaceful use of space. This not only includes countries with advanced space programs, such as Japan, but also newly emerging countries that have only recently become members of COPUOS."

JAXA Technical Advisor Dr. Kuniaki Shiraki Receives the 35th Allan D. Emil Memorial Award

The Honours and Awards Committee of the International Astronautical Federation (IAF) selected JAXA Technical Advisor Dr. Kuniaki Shiraki, the former Executive Director for Human Space Systems and Utilization Mission Directorate, as the recipient of the 35th Allan D. Emil Memorial Award. Committee chair Sir Martin Sweeting said the award recognizes Dr. Shiraki's "outstanding contribution to space transportation technology and to the success of the International Space Station." The Allan D. Emil Memorial Award is presented to people who have made an outstanding contribution to space science, space technology, space medicine, or space law. Dr. Shiraki becomes the second individual from Japan to receive the award as a sole recipient. The first sole recipient from Japan was Dr. Shigebumi Saito, who was honored in 1994. Dr. Saito was appointed executive director of Japan's National Space Development Agency (NASDA; currently part of JAXA) in 1969, and served as President of the Japanese Rocket Society from 1975 to 1977. The President of the IAF, Berndt Feuerbacher, presented the award to Dr. Shiraki during the closing ceremony of the 62nd International Astronautical Congress (IAC), held October 3–7, 2011, in Cape Town, South Africa.

Robotic Arm Technology Team and Hayabusa Project Team Honored by the American Institute of Aeronautics and Astronautics (AIAA)

The American Institute of Aeronautics and Astronautics (AIAA) presented the 2011 AIAA Space Automation and Robotics Award to the JAXA team responsible for the development and operation of pioneering space robotics technology, which was utilized in Engineering Test Satellite VII (ETS-VII; Japanese nickname: "KIKU-7") and JEM Kibo. The award was accepted by representatives of the team at a ceremony on September 28, 2011, in Long Beach, California. Specific achievements recognized by this award include the first operation in space of the dexterous robotic arm as part of the Manipulator Flight Demonstration (MFD), which was conducted in the Space Shuttle Discovery's cargo bay during STS-85 (launched on August 7, 1997) in preparation for the launch of JEM Kibo; and the first teleoperation from the Earth of a space robotic arm, which was performed on ETS-VII (launched on November 28, 1997). As part of the same awards, the Hayabusa project team received the 2011 AIAA Space Operations and Support Award. This award recognizes the outstanding efforts of the team in overcoming many space technological and operational problems, and honors the critical contributions of team members, which ultimately led to the successful sample return from Asteroid Itokawa despite numerous difficulties encountered during the long Hayabusa mission.


AIAA
The World's Forum for Aerospace Leadership
Space Automation and Robotics Award
For leadership and technical contributions by individuals and teams in the field of space automation and robotics.
Presented To
ETS-VII / JEM Team
JAXA
In recognition of pioneering work in space robotics, including operation of the first dexterous robotic arm in space and the first teleoperation of a space robotic arm from the earth.
28 September 2011
AIAA President

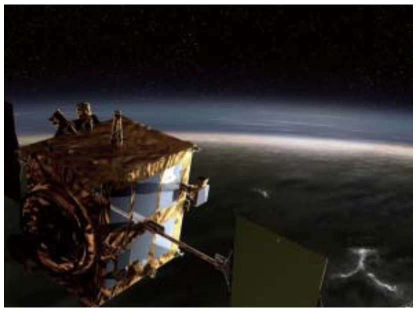
The 2011 AIAA Space Automation and Robotics Award citation

Akatsuki Performs Trajectory-control Maneuvers while Passing Perihelion

On December 7, 2010, Japan's Venus Climate Orbiter Akatsuki (PLANET-C) failed to enter its planned orbit around Venus, and is presently on an orbital course around the sun. Consequently, JAXA has been reviewing options for a new rendezvous with Venus and a second attempt at insertion into orbit around the planet. As part of this process, JAXA conducted two test thrusts*1 of Akatsuki's orbital maneuvering engine (OME) on September 7 and 14, 2011. As a result, it was found that the specific impulse available from the OME would be insufficient for orbital maneuvering. Damage to the OME, which occurred during the attempted orbital insertion, appears to have worsened during the intervening period, hence JAXA decided to abandon the use of the OME for future maneuvers. Based on these circumstances, in preparation for a future orbital insertion around Venus, Akatsuki performed a series of three trajectory-control maneuvers on November 1, 10, and 21, 2011, using the spacecraft's reaction control system (RCS) thrusters, when it passed perihelion—the point nearest to the sun—in its current orbit. Akatsuki's status is normal, and JAXA plans to analyze telemetry data*2 acquired during these maneuvers as it works toward a new rendezvous with Venus.

*1 The objective of the first test thrust was to obtain a quantitative understanding of attitude disturbance (the occurrence of propulsion that is inconsistent with the engine's intended propulsion direction). The thrust duration was approximately two seconds as planned.
The second test, focusing on the status of the OME thrust, lasted approximately five seconds as planned.
*2 Telemetry data provides information on the status of a spacecraft and its onboard equipment.

Akatsuki Project Team web site: http://www.stp.isas.jaxa.jp/venus/top_english.html



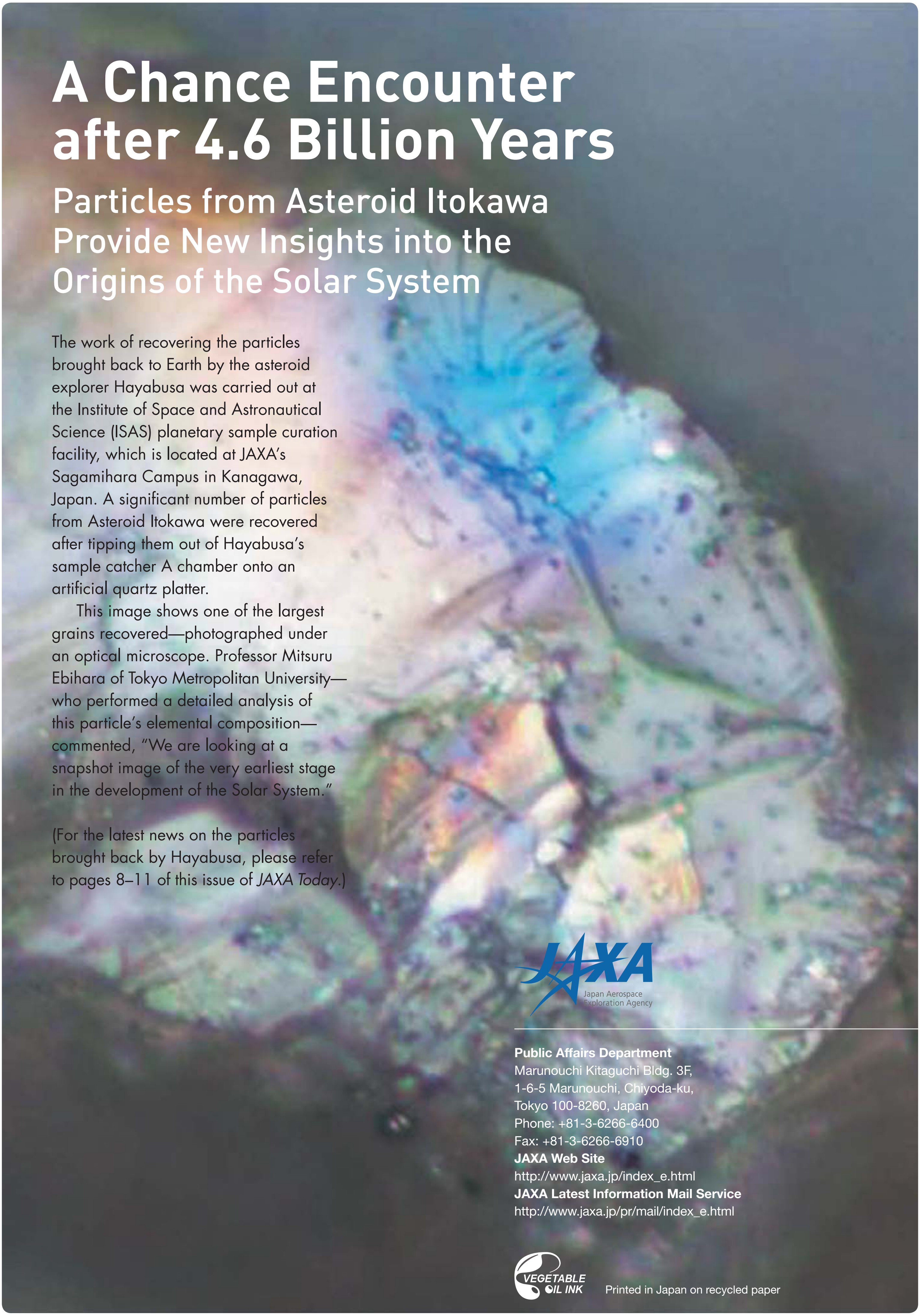
An illustration depicting Akatsuki exploring the Venusian climate
©Akihiro Ikeshita

The 18th Session of the Asia-Pacific Regional Space Agency Forum (APRSAF-18) Held in Singapore

18TH APRSAF
ASIA-PACIFIC REGIONAL SPACE AGENCY FORUM
SINGAPORE

APRSAF-18 was held December 6–9, 2011, in Singapore, with approximately 280 participants drawn from 28 countries and regions as well as 11 international organizations. The session's theme was "A regional collaboration for tomorrow's environment." In a keynote address to the plenary session, Dr. Tetsuhiko Ikegami, Chairman of the Space Activities Commission (SAC) at Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT), expressed gratitude for satellite images of disaster-affected areas provided by several countries immediately following the Great East Japan Earthquake. Dr. Ikegami emphasized the usefulness of such programs as Sentinel Asia (Disaster Management Support System in the Asia-Pacific Region) and Satellite Applications For Environment (SAFE), and noted that Japan's Basic Plan for Space Development ranks cooperation with Asia as an issue of the highest priority. Among presentations on recent space-related activities, Japan reported on its programs to address climate change, promotion of the use of JEM Kibo by Asian partners, and the contribution in Asia of MICHIBIKI, the First Quasi-Zenith Satellite (QZS-1). Japan also proposed the launch of a new project for the utilization of JEM Kibo, which gained a very positive response.

APRSAF-18 was held December 6–9, 2011, in Singapore.



A Chance Encounter after 4.6 Billion Years

Particles from Asteroid Itokawa Provide New Insights into the Origins of the Solar System

The work of recovering the particles brought back to Earth by the asteroid explorer Hayabusa was carried out at the Institute of Space and Astronautical Science (ISAS) planetary sample curation facility, which is located at JAXA's Sagamihara Campus in Kanagawa, Japan. A significant number of particles from Asteroid Itokawa were recovered after tipping them out of Hayabusa's sample catcher A chamber onto an artificial quartz platter.

This image shows one of the largest grains recovered—photographed under an optical microscope. Professor Mitsuru Ebihara of Tokyo Metropolitan University—who performed a detailed analysis of this particle's elemental composition—commented, "We are looking at a snapshot image of the very earliest stage in the development of the Solar System."

(For the latest news on the particles brought back by Hayabusa, please refer to pages 8–11 of this issue of *JAXA Today*.)

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