U02-01 Room:IC Time:May 26 09:05-09:30

NASA's Earth Science Program and Cooperation With Japan

FREILICH, Michael[1*]

[1]Earth Science Div. NASA Headquarters

This presentation will highlight NASA's current and planned Earth observing capabilities, the resulting science and applications, and NASA's long-standing partnership with Japan. NASA and the Japan Aerospace Exploration Agency (JAXA) have a long history of collaboration on satellite missions. The two agencies worked together on the highly successful 17-year Tropical Rainfall Measuring Mission (TRMM). TRMM's success contributed in part to further cooperation between NASA and JAXA on the Global Precipitation Measurement (GPM) Core spacecraft, launched in 2014. Meanwhile, Japan has also been an active partner in two of NASA's Earth Observing System "flagship" missions: Terra and Aqua. Both the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) onboard Terra and Advanced Microwave Scanning Radiometer for EOS (AMSR-E) onboard Aqua were built by and are operated by JAXA. NASA and JAXA have partnered for the last several years on calibration and validation activities associated with JAXA's Greenhouse Gases Observing Satellite (GOSAT) and NASA's Orbiting Carbon Observatory (OCO0-2) missions. And in 2012, JAXA's Global Change Observation Mission ? Water (GCOM-W1) satellite joined Aqua and other NASA missions as part of the international Afternoon Constellation (A-Train). The results from these (and other) Earth observing missions are expanding our knowledge of the current state of the Earth system and our ability to predict how it may change in the future. These data also enable a wide range of practical applications that benefit society.

Keywords: TRMM, GPM, GOSAT, ASTER, AMSR-E, A-Train

U02-02 Room:IC Time:May 26 09:30-09:55

Toward a better understanding of the earth ’s climate and environment

NAKAJIMA, Teruyuki[1*]

[1] Atmosphere and Ocean Research Institute, University of Tokyo

World research communities are making effort for contribution to the global scale problems of earth’s climate change and environmental change. Space agencies are also taking leadership of making use of earth observation data as by the ESA’s Climate Change Initiative (CCI) and others. In this talk, I like to discuss data use of several satellite programs of ALOS-2, GCOM-W, GPM, GOSAT, Himawari-8 and future GCOM-C and EarthCARE. Important subjects for application of are 1) Observation of signatures of human activities and study of its climate and environment effects; 2) Observation of the earth’s water cycle and study of its application for society; 3) Observation of biosphere and study of its vulnerability due to climate change; 4) Observation of fine structure of the earth’s surface and study of its application for society. It is important to establish the maximum use of climate and environment models for providing constraints of remote sensing and for assimilation and inverse data analysis.

Keywords: Earth Observation, Climate, Environment

U02-03 Room:IC Time:May 26 09:55-10:20

New Precipitation Measurement Opened by TRMM and GPM

NAKAMURA, Kenji[1*]

[1]Dokkyo University, [2]Japan Aerospace Exploration Agency

Precipitation is one of the fundamental elements of the Earth climate system and also the major source of fresh water which is essential not only to human society but also to all ecosystems. The measurement of global precipitation is a challenge because of its high variability in space and time. The Tropical Rainfall Measuring Mission (TRMM) which is a venture between JAXA and NASA has proved the capability of precipitation measurement from space. The TRMM satellite was equipped with a radar (PR), a radiometer, etc. The combination of radar and microwave radiometer was found excellent, that is, the radar provides the structure of precipitation system, and the radiometer gives a wide coverage and frequent observations. The Global Precipitation Measurement (GPM), which consists of a core satellite with a dual-wavelength radar (DPR) and a microwave radiometer, and multiple low-orbit satellites with microwave radiometers, is an international project led by JAXA and NASA using fully the legacy of TRMM. The core satellite works to provide a reference standard for the microwave radiometers aboard other low-orbit satellites.

DPR is a child of TRMM PR. DPR consists of Ku and Ka-band radar. The Ku-band radar is based on the PR design, but the Ka-band radar is a newly designed one. After the launch of the GPM core satellite in February 2014, DPR performance is well examined by using ground-based calibrators, and comparisons with ground-based radars, rain gauges, etc. Statistical results on global precipitation were also evaluated with TRMM PR long-term statistics. Fortunately, TRMM PR was working even after the GPM core satellite launch, and DPR data have been compared with TRMM PR data for near simultaneous observations of precipitation systems. The Ku-band radar data showed excellent consistency with PR data. It has also been proved that the Ka-band radar performance meets the engineering specifications. Weak precipitation is detected with the Ka-band radar and its profiles show clear difference from the Ku-radar, but full utilization of the Ka-radar data is yet to be demonstrated.

One of the objectives of GPM is to expand the precipitation observation coverage into mid- and high-latitude regions where no TRMM data are available. The precipitation systems are associated with mid-latitude depressions, cold outbreaks over warm sea, etc., and are very different from those in tropical regions. The techniques developed and applied to rain in tropical regions using TRMM data may not work well for mid- and high-latitude regions. Water equivalent snow rate retrieval is a challenge for GPM. The advantage of DPR is expected to appear there. More precise rain rate retrieval for rain is another objective of DPR. Currently, DPR algorithm development is on-going, and soon new results could come out.

Combining the GPM core satellite data with other microwave radiometer satellites, global precipitation maps should have wider coverage and better accuracy. This could open new and wide applications for human societies. Also, the capability of DPR to penetrate precipitation system must contribute to better understanding of the structure of global precipitation systems and its climatology.

Keywords: satellite, precipitation, Earth observation, remote sensing, TRMM, GPM

U02-04 Room:IC Time:May 26 10:20-10:45

The Global Precipitation Measurement (GPM) Mission: Advancing precipitation measurement for science and society

KIRSCHBAUM, Dalia[1*] ; SKOFRONICK-JACKSON, Gail[1]

[1]NASA Goddard Space Flight Center

Too much or too little rain can serve as a tipping point for triggering catastrophic flooding and landslides or widespread drought. Knowing when, where and how much rain is falling globally is vital to understanding how vulnerable areas may be more or less impacted by these disasters. The Global Precipitation Measurement (GPM) mission is an international constellation of satellites coordinated through a partnership with NASA and the Japan Aerospace Exploration Agency (JAXA) to provide next-generation global observations of rain and snow. The GPM mission centers on the deployment of a Core Observatory satellite that serves as a reference standard to unify precipitation measurements from a constellation of research and operational satellites. This satellite launched from Tanegashima Space Complex in Japan on January 28th, 2014 and carries advanced instruments setting a new standard for precipitation measurements from space. The GPM Core Observatory satellite measures rain and snow using two science instruments: the GPM Microwave Imager (GMI) and the Dual-frequency Precipitation Radar (DPR). The GMI captures precipitation intensities and horizontal patterns, while the DPR provides insights into the three dimensional structure of precipitating particles. Together these two instruments provide a database of measurements against which other partner satellites' microwave observations can be meaningfully compared and combined to make a global precipitation dataset.

GPM has already provided unprecedented views of typhoons, extratropical systems, light rain, snow storms and extreme precipitation. Through improved measurements of precipitation globally, the GPM mission will help to advance our understanding and modeling of Earth's water and energy cycles, improve forecasting of extreme events that cause natural hazards and disasters, and extend current capabilities in using accurate and timely information of precipitation to directly benefit society.

Keywords: GPM, GMI, DPR

U02-05 Room:IC Time:May 26 11:00-11:25

Applications of data from NASA and JAXA-NASA space missions for scientific studies in physical oceanography in Japan

EBUCHI, Naoto[1*]

[1]Hokkaido University

Applications of data obtained by several NASA and JAXA-NASA missions for scientific studies in physical oceanography in Japan are reviewed in this paper. The NASA and JAXA-NASA missions carried various sensors to observe the Earth's surface, including visible/infrared and microwave radiometers, radar altimeters, microwave scatterometers, and synthetic aperture radars. The observed data have been widely utilized by the research community in Japan to explore ocean circulation and air-sea interactions including mechanisms of Kuroshio meanders, mesoscale eddies, El Nino-Southern Oscillation (ENSO) and related tropical ocean-atmosphere systems. The data have been also utilized to drive general ocean circulation models with various spatial and temporal scales. Highlights of these studies are revelation of ocean-driven air-sea interaction mechanism over the western boundary currents, such as the Gulf Stream and Kuroshio (e.g., Nonaka and Xie, *J. Climate*, 2003; Minobe et al., *Nature*, 2008; Tokinaga et al., *J. Climate*, 2009), and composition of a dataset of the ocean-atmosphere momentum, heat, and fresh water fluxes (e.g. Kubota et al., *J. Oceanogr.*, 2002).

Keywords: NASA mission, JAXA-NASA mission, physical oceanography, ocean circulation, air-sea interactions

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

U02-06 Room:IC Time:May 26 11:25-11:50

Achievement of the ASTER program

YAMAGUCHI, Yasushi[1*]

[1]Nagoya University

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is a multi-spectral imaging radiometer onboard Terra, the flagship satellite of NASA's Earth Observing System (EOS) launched in December 1999. ASTER is a cooperative effort among NASA, Japan's Ministry of Economy, Trade and Industry (METI), Japan Space Systems (JSS), and National Institute of Advanced Industrial Science and Technology (AIST). Recognizing the importance of science-driven activities, we formed ASTER Science Team, which consists of Japanese and U.S. scientists, and has been closely working together with the ASTER instrument team, NASA platform operation team, and data processing and distribution agencies. We hold ASTER science team meetings regularly, the 45th meeting was held in December 2014 in Tokyo.

ASTER captures high spatial resolution data in 14 spectral bands from the visible through thermal infrared regions with 15 to 90 m spatial resolution. The VNIR subsystem has nadir and backward-viewing bands for stereoscopic observation in the along-track direction. Because of its high spatial resolution, ASTER is called as the "zoom lens" for Terra, and ASTER data are useful for validation and calibration of other Terra and satellite instruments. ASTER data are being used for many scientific and practical applications. Because the ASTER data have wide spectral coverage and relatively high spatial resolution, we can discriminate a variety of surface materials. Wide spectral coverage of ASTER allows not only detailed surface mapping but also analysis of surface physical processes. For instance, ASTER data covering from the visible to thermal infrared regions are useful to quantitatively analyze heat balance at the Earth surface in local to regional scale that is essential to study hydrological cycles in vegetated terrain and heat island effect in urban areas. These ASTER characteristics along with flexible operation have been contributing to rapid damage assessment in case of disasters.

ASTER data are being provided from the ASTER Ground Data System (GDS) of JSS in Japan and Land Processes Distributed Active Archive Center (LP DAAC) in U.S.A., a component of NASA's EOS Data and Information System (EOSDIS). Available ASTER data include the Level 1 products as well as higher level data products such as surface radiance, surface reflectance, surface temperature, surface emissivity, digital elevation model (DEM), and ortho-rectified radiance at sensor. Moreover, ASTER global digital elevation model (GDEM) was generated from the ASTER data archive and was released to public in June 2009 as contribution to Global Earth Observation System of Systems (GEOSS). The updated ASTER GDEM ver.2 was released in October 2011, and ver.3 is planned in the near future. The ASTER GDEM comprises a seamless global mesh with a 1 arc-second (30 m) grid of elevation posting that extends up to 83 degrees N and S latitudes.

ASTER obtains data by target observation based upon data acquisition requests by users. ASTER is currently acquiring approximately 518 scenes per day as an average, one scene covers an area of 60 by 60 km. As of November, 2014, ASTER had acquired about 2.7 million scenes and achieved a very good coverage of the whole land surface. In order to maximize the science return, the ASTER Science Team has been continuously monitoring the ASTER data acquisition status, generating appropriate observation scenarios, and modifying observation parameters. For instance, in addition to local observations by individual users, we have repeated six cycles of the global mapping as background data acquisition, since data acquisition efficiency decreases when the target areas become patchy. We are also conducting data acquisition for Global DEM, thermal infrared night-time global mapping, and the other observation categories on behalf of the earth science community in large.

Keywords: ASTER, NASA, EOS, Terra, remote sensing, earth observation

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

U02-07 Room:IC Time:May 26 11:50-12:15

First Steps Toward Space-based CO_2 Measurements: GOSAT, OCO-2, and GOSAT-2

CRISP, David[1*] ; SHIOMI, Kei[2] ; KUZE, Akihiko[2] ; YOKOTA, Tatsuya[3] ; MATSUNAGA, Tsuneo[3]

[1]Jet Propulsion Laboratory, California Institute of Technology, [2]Japan Aerospace Exploration Agency, [3]National Institute for Environmental Studies

Human activities including fossil fuel combustion, land use change, and cement production are now adding more than 40 billion tons of carbon dioxide (CO_2) to the atmosphere each year. These emissions have increased the atmospheric CO_2 concentration by more 40% since the beginning of the industrial age. Interestingly, precise measurements from a global network of greenhouse gas monitoring stations indicate that less than half of the CO_2 emitted by these human activities stays airborne. The rest is apparently being absorbed by natural processes at the surface, whose identity and location are poorly understood. Ground-based CO_2 measurements accurately record the global atmospheric CO_2 budget and its trends but do not have the resolution or coverage needed to identify the *sources* emitting CO_2 into the atmosphere or the natural *sinks* absorbing this gas. This information is critical to any carbon management strategy.

One way to improve the resolution and coverage of CO_2 measurements is to collect high resolution observations of the column-averaged CO_2 dry air mole fraction (X_{CO2}) from space. The NASA Orbiting Carbon Observatory (OCO) and the Japanese Greenhouse gases Observing SATellite (GOSAT, nicknamed *Ibuki*) were the first two missions designed to collect space-based observations of X_{CO2} with the sensitivity, coverage, and resolution needed to quantify CO_2 fluxes on regional scales over the globe. The GOSAT and OCO-2 teams have collaborated closely since 2004 to cross calibrate the measurements and cross validate the retrieved products from these missions.

GOSAT was successfully launched on 23 January 2009 and has been returning global measurements of CO_2 and methane (CH_4) since late April of that year. The OCO mission was lost on 24 February 2009 when its launch vehicle malfunctioned and failed to reach orbit. Immediately after the loss of OCO, the GOSAT scientists, engineers, and managers from JAXA and NIES, invited the OCO team to contribute to the analysis of measurements collected by the GOSAT Thermal And Near infrared Sensor for carbon Observations-Fourier Transform Spectrometer (TANSO-FTS). NASA responded by reformulating the OCO science team as the Atmospheric CO_2 Observations from Space (ACOS) team and encouraged this collaboration. Since 2009, this effort has provided an independent GOSAT X_{CO2} product as well as valuable insights into X_{CO2} retrieval algorithms, calibration methods, and validation techniques.

On 2 July 2014, GOSAT was joined by the NASA Orbiting Carbon Observatory-2 (OCO-2), which was successfully launched from Vandenberg Air Force Base in California. In early August, OCO-2 joined the 705-km Afternoon Constellation (A-Train), just ahead of Japanese GCOM-W1 satellite. Its instrument, a 3-channel, imaging grating spectrometer, was then cooled to its operating temperatures and started collecting almost one million soundings over the sunlit hemisphere each day. Between 15 and 30% of these measurements are sufficiently cloud free to yield precise, full column estimates of X_{CO2}. Initial deliveries of calibrated OCO-2 spectra to the NASA Goddard Earth Science Data and Information Services Center (GES DISC) began on December 30, 2014. Routine deliveries of X_{CO2} to the GES DISC are expected to begin on 30 March, 2015.

The GOSAT and OCO-2 teams are continuing to work closely together to cross calibrate the measurements and cross validate the data products from these two missions so that they can be combined to enable more comprehensive studies of CO_2 sources and sinks. As the GOSAT and OCO-2 products are harmonized, this team will turn its focus on their next goal, the GOSAT-2 Mission, which will measure CO_2, CH_4 and carbon monoxide (CO). This presentation will summarize the capabilities of these three missions and highlight the scope of the collaboration needed to integrate their data products into a precise, continuous climate data record.

Keywords: Carbon dioxide, Orbiting Carbon Observatory-2, Greenhouse gases Observing SATellite, OCO-2, GOSAT, Ibuki