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

ACG09-01 Room:301B Time:May 27 09:00-09:30

On the application of observational data of Geostationary Meteorological Satellite 'Himawari' for geophysical researches

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On October 07, 2014 Himawari-8 was successfully lofted via an H2-A carrier rocket from Tanegashima Space Centre in Japan and put in geostationary orbit on Oct. 16. The imager on board is in good condition and almost ready to disseminate high quality data for 16 channels with high time sampling and upgraded resolution. JMA will commence its operation in the

middle of 2015, when MTSAT-2 is scheduled to complete its period of operation. JMA also plans to launch Himawari-9 in 2016. The PSR of the AHI for Himawari-9 is also scheduled to take place in a few months.

Since the observational capability of Himawari-8 increases very much compared to those of MTSAT-1R/-2, various routine services will be improved and some new products will be developed. Algorithms of routine products such as atmospheric motion vectors are being revised to prepare for the start of Himawari-8 operation. Besides these, it is expected that

scientific researches will be possible taking advantage of improved measurements. For example, mechanisms of high-impact weather will be investigated using high time resolution imager data and new monitoring mehod of volcanic activity will be developed on the basis of increased number of channels.

We hope that new researches and/or findings will be possibly appeared in unexpected fields in geosciences using Himawari-8 data. Some of the important developments of routine operational monitoring and/or forecast have been developed introducing observations and/or techniques in different fields. One of the most succesful achievements by such an introduction is

the application of GPS network data to meteorology. GEONET in Japan designed to monitor crustral movements were utilized to derive Precipitable Water Vapor (PWV) with the density of 20 km spacing; the dense PWV data, providing moisture information, are now indispensible for meso-scale models for numerical weather prediction and contributes to the better forecast of severe weather. Another is the introduction of 4D-var technique to the improvement of earthquake early warning service by Japan meteorological Agency (JMA). These applications of existing observations and/or techniques to other subjects of new academic investigation. Now, we are planning to introduce a new method to monitor volcanic activity by Himawari-8 data. New satellite observation form space is thought to be one of the powerful tools or platforms providing chances for developments of geoscience.

Himawari series are operational satellitees aimed for routine works of JMA, but there may be chances to load some other instruments in future. Speculations on some candidates for future instruments will be introduced.

Keywords: meteorological satellite

ACG09-02 Room:301B Time:May 27 09:30-09:45

Validation of MODIS cloud products using SKYNET data

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AMSR2/GCOM-W, which runs along with MODIS/AQUA in A-train satellite constellation, is capable of observing various products related to water. The integrated cloud liquid water observed over global ocean is one of such products. Validation of such product using surface observation data is a challenge because of difficulty associated with deployment of instruments over the ocean for a long period. We attempt to validate liquid water path from AMSR2 through two steps: validation of MODIS/AQUA cloud products using SKYNET data and then use of MODIS/AQUA data to validate AMSR2/GCOM-W products. As the first part, we used several types of data related to cloud observed by SKYNET to validate MODIS cloud products. For example, we derived cloud optical thickness and effective radius from the sky radiometer and compared them with MODIS products. We further calculated down welling shortwave fluxes using MODIS data and compared them with directly observed data by instruments of different field of view. Data of the microwave radiometer were also analyzed. Our results suggest that MODIS based cloud optical thicknesses of both water and ice clouds are likely to be underestimated.

Keywords: SKYNET, Cloud, MODIS

ACG09-03 Room:301B Time:May 27 09:45-10:00

Refractive index of volcanic ash material estimated from the data of satellite infrared sounder

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From the data of volcanic ash measurement by satellite infrared sounder and radiative transfer calculations, refractive indices of ash material for some volcanic clouds were estimated. For the past volcanic events of high eruption activities, a dataset of volcanic ash clouds over ocean which detected by the Atmospheric Infrared Sounder (AIRS) on board Aqua satellite was prepared. Appling the atmospheric profiles from global analysis and ash cloud parameters in radiative transfer calculations, a least square analysis for the observed and calculated brightness temperatures was carried out using 836 AIRS channels in wavenumber range between 700 cm^{-1} and 1100 cm^{-1}. A mixture of andesite and rhyolite for the ash material was considered, and a fraction of andesite was used as a retrieval parameter as well as ash optical depth, effective radius, and ash cloud height. Using the estimated cloud parameters as the fixed values, imaginary part of the ash refractive index was then estimated by iterative calculations for each AIRS channel. Final results of the spectral refractive indices were determined from the cross retrieval calculations for other measurement footprints of the same ash clouds.

Results of the imaginary part of the ash refractive indices for nine volcanos at the time of large explosions are proposed. For wavenumber range 850-1100 cm^{-1}, refractive indices of a mixture of previously proposed andesite model and the rhyolite model well represented the observed brightness temperatures. On the other hand, weak absorptions which cannot be produced by the mixture of the two refractive index models, were derived from our analysis at wavenumber around 700-850 cm^{-1}. These weak absorptions are likely due to Si-O and/or Al-O antisymmetric vibrations which have been confirmed in laboratory experiments for some silicate glass samples. Our results suggest that the detailed refractive index of volcanic ash can be estimated from the analysis of satellite infrared sounder data.

In the current IR volcanic ash algorithms of geostationary meteorological satellites and earth observing satellites, two or three infrared window channels are used for the detection and evaluation of the ash clouds and the andesite model of refractive index is assumed for the absorption property of ash material. It is expected that the refractive index of ash clouds for specific volcano estimated from the satellite infrared sounder data can improve the ash retrieval algorithms. Furthermore, the retrieved refractive index may give information regarding the diagnosis of volcanic activity by comparing the ash refractive index for the past eruption events.

Keywords: volcanic ash, satellite infrared sounder, refractive index

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(May 24th - 28th at Makuhari, Chiba, Japan)

ACG09-04 Room:301B Time:May 27 10:00-10:15

Simultaneous occurrence of polar stratospheric clouds and upper tropospheric clouds caused by blocking anticyclones

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Occurrence frequency and type of the polar stratospheric clouds (PSCs) are largely affected by atmospheric waves including planetary-scale waves, synoptic-scale waves and gravity waves. Recent studies indicated that PSCs and upper tropospheric clouds are frequently simultaneously observed. The present study statistically examined the simultaneous occurrence of the clouds which are dominant in two height regions and considered possible dynamical mechanisms. Using the 5-year CALIPSO observational data and reanalysis data over the Antarctic, it is shown that lower altitude clouds are dominant around the tropopause and the simultaneous occurrence are frequently observed in association with relatively large scale anticyclones including blocking highs in the troposphere. The composition of PSCs is investigated as a function of relative longitude to the anticyclone centers. It was revealed that relatively high proportion of PSCs containing nitric acid trihydrate (NAT) is distributed in the leeward side of anticyclones while proportion of non-depolarizing (liquid) PSCs is high on its windward side.

Keywords: polar stratospheric clouds, blocking anticyclone, CALIPSO

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(May 24th - 28th at Makuhari, Chiba, Japan)

ACG09-05 Room:301B Time:May 27 10:15-10:30

Orbital Operations Status of the GPM/DPR and the next Precipitation Measurement Mission

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The Dual-frequency Precipitation Radar (DPR) on the Global Precipitation Measurement (GPM) core satellite was developed by Japan Aerospace Exploration Agency (JAXA) and National Institute of Information and Communications Technology (NICT). The GPM is a follow-on mission of the Tropical Rainfall Measuring Mission (TRMM). The objectives of the GPM mission are to observe global precipitation more frequently and accurately than TRMM. The frequent precipitation measurement about every three hours will be achieved by some constellation satellites with microwave radiometers (MWRs) or microwave sounders (MWSs), which will be developed by various countries. The accurate measurement of precipitation in mid-high latitudes will be achieved by the DPR. The GPM core satellite is a joint product of National Aeronautics and Space Administration (NASA), JAXA and NICT. NASA developed the satellite bus and the GPM microwave radiometer (GMI), and JAXA and NICT developed the DPR.

The configuration of precipitation measurement using an active radar and a passive radiometer is similar to TRMM. The major difference is that DPR is used in GPM instead of the precipitation radar (PR) in TRMM. The inclination of the core satellite is 65 degrees, and the flight altitude is about 407 km. The non-sun-synchronous circular orbit is necessary for measuring the diurnal change of rainfall similarly to TRMM. The DPR consists of two radars, which are Ku-band (13.6 GHz) precipitation radar (KuPR) and Ka-band (35.5 GHz) precipitation radar (KaPR). The objectives of the DPR are

(1) to provide three-dimensional precipitation structure including snowfall over both ocean and land,
(2) to improve the sensitivity and accuracy of precipitation measurement,
(3) to calibrate the estimated precipitation amount by MWRs and MWSs on the constellation satellites.

Both KuPR and KaPR have almost the same design as TRMM PR. The DPR system design and performance were verified through ground tests. The results of these tests show DPR meets its specification.

GPM core observatory was successfully launched by H2A launch vehicle at 3:37 (UT), Feb. 28, 2014. DPR function and performance verification was conducted at NASA GSFC. DPR function verifications show that DPR functions are normal. Calibration data has been collected in internal calibration mode and external calibration mode using active radar calibrator (ARC). Internal calibration results were almost the same characteristic as S/C I&T test results. Results of antenna pattern measurement show there is no significant change from final test results. DPR performances are almost same as the results taken on the ground. The results of orbital checkout show that DPR meets its specification on orbit.

After completion of initial checkout, DPR entered Normal Operations and Initial Calibration and Validation period was started. JAXA conducted internal calibrations, external calibrations and phase code changes to mitigate KuPR sidelobe clutter effect. JAXA evaluated these operations results and concluded that DPR data could go public. DPR products released to the public on Sep. 2, 2014 and Normal Observation Operation period was started. JAXA is continuing DPR trend monitoring, calibration and validation operations to confirm that DPR keeps its function and performance on orbit.

The GPM Core Observatory was sized for a 3-year operational mission after 60-day on-orbit checkout period, with consumables sized to reach 5-years. JAXA, NICT and GPM users are studying future precipitation measurement mission which carries the upgraded DPR. The preliminary concept study of the upgraded DPR will be reported.

Keywords: GPM, DPR, Precipitation

ACG09-06 Room:301B Time:May 27 10:30-10:45

Scanning cloud profiling radar concept for ISS/JEM

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Spaceborne cloud profiling radars are one of the promising tools for studies on cloud-radiation interactions and cloud-precipitation interactions by providing vertical cloud profiles. The CloudSat is the first and the only satellite operating in orbit that equips the cloud profiling radar (CPR). The EarthCARE satellite, planned to be launched in 2018, also equips the cloud profiling radar (CPR) with better sensitivity than the CloudSat/CPR and the world first Doppler velocity measurement capability from space. Since both radars are nadir pointing and both satellites are sun-synchronous orbit, actual three-dimensional structure of clouds and their diurnal changes cannot be obtained from these missions.

In 2013, JAXA announced an opportunity for ISS (International Space Station) JEM (Japanese Experimental Module) for the 2019 launch. In order to propose a cloud observation mission that takes an advantage of the ISS/JEM, we have studied conceptual design of W-band scanning radar based on the ground-based W-band scanning radar developed by NICT. Considering that the orbit and altitude of ISS and the issues on current cloud profiling radar programs, the mission targets are defined as follows: the primary target is to fill the observation gap for the studies on climate change and global warming. Since both CloudSat and EarthCARE are sun-synchronous orbit, only early afternoon and mid-night data are available. In addition, the evaluations of the cloud effect on the global warming, information of the three-dimensional variability of clouds are essential whereas the CloudSat and the EarthCARE/CPR are nadir looking radar. The proposed mission can observe the diurnal change of clouds by ISS that is on non-sun-synchronous orbit and development of scanning radar. The secondary target is evaluation of GPM/DPR products, especially for weak precipitation (rain and snow). Considering that the sensitivity of the KaPR on GPM core satellite is 12 dBZ, snowfall observation is one of the issues of GPM mission (GPM is expected to survive until 2019). Three-dimensional observation of both cloud and precipitation can be useful for the studies on cloud-precipitation interactions.

The proposed radar system is W-band scanning cloud profiling radar. The scanning mechanism is realized by the phased array radar system; the receiver system introduced a two-dimensional array antenna consists of horn antennas. The transmitter uses the EIK as the amplifier (that is same as CloudSat/CPR and EarthCARE/CPR) and is connected to the fan-beam antenna. Therefore, wider (e.g. 8 degrees) beam is transmitted and the return signals from clouds are received by phased array antenna and sharp beam images are obtained by signal processing (digital beam forming technology). In the current design, swath width of 30 to 50 km can be achieved. The receiver antenna size is about 60 cm x 60 cm because of the constraints of ISS/JEM. For these reasons, the minimum detectable sensitivity will be about -10 dBZ. This sensitivity may not be enough for the studies on the cloud-radiation interaction but enough for the studies on the cloud-precipitation interactions.

Keywords: cloud radar, cloud-radiation, precipitation, ISS

ACG09-07 Room:301B Time:May 27 11:00-11:15

Prospect of future geostationary satellite observations for numerical weather prediction

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The revolutionary meteorological geostationary satellite Himawari-8 was launched in October 2014. The operation is planned to start in July 2015. Advanced Himawari Imager (AHI) on Himawari-8 significantly enhances spectral, spatial, and temporal measurement capability. It enables us to make detailed observation with three visible bands with 500 m or 1 km resolution and 13 infra-red bands with 2 km resolution. Furthermore imagery scanning is performed every 2.5 minutes around Japan and every 10 minutes for the full disk. Furthermore rapidly scanning imagery is produced every 2.5 minutes around Japan and every 10 minutes for the full disk. These improved functions are useful for monitoring meteorological disaster and for production of initial fields for numerical weather prediction. Among them, the highly frequent imagery had never been achieved by any other space-borne imagers and is expected to give us new knowledge that is socially and scientifically beneficial. For example, the research is under way on assimilating the rapid scan data of Himwari-8 together with ground-based radar data to accurately predict rapidly developing convective clouds and precipitation.

Even the enhanced function of Hiwamari-8, however, does not meet all of the keen requirements of weather forecasters and data assimilation community. AHI hardly makes measurements under clouds and about vertical temperature and humidity profiles. Furthermore there is an increasing need for frequent measurements of atmospheric composition and lightning. Good candidates to meet those requirements are microwave radiometers, hyperspectral infra-red sounders, ultra-violet sensors and optical lightening mappers onboard future geostationary satellites.

We will discuss the benefit of these new instruments on geostationary satellites, especially from viewpoint of the numerical weather prediction and data assimilation.

This study is partially supported by CREST, JST.

Keywords: numerical weather prediction, data assimilation, geostationary satellite, sounder

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

ACG09-08 Room:301B Time:May 27 11:15-11:30

A New Satellite System for Observing Global Weather and Water from Geostationary Orbit

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We propose a future earth satellite system for observing global weather and water, namely, a geostationary satellite equipped with i) an infrared hyperspectral sounder, ii) a microwave sounder, iii) a microwave imager, and iv) a visible-to-infrared imaging spectroradiometer. The goal of this satellite is to monitor and reveal the mechanism of continuous weather transitions from clear sky to cloud and from cloud to precipitation. Since the satellite is equipped with passive sensors covering the visible to microwave regions, it can observe atmospheric aerosols, clouds, water vapor, and temperature. Primary observation targets are temperature profile, water vapor profile, precipitable water, liquid water path of clouds, optical thickness of aerosols and clouds, cloud top temperature, and precipitation. One of the features of this system is that it allows very high-frequency full-disk observation. The target temporal observation interval is 10 min, so we name the proposed satellite Weather and Water Watch, Delta Time 10 (WWW-DT10). There remain some technical challenges, such as developing a very large microwave antenna and a full-disk scanning mechanism for microwave sensors. This system will contribute to monitoring natural disasters such as torrential rains, and also contribute to mitigating uncertainties in global model simulations by assimilating its data into the models. We will describe this system in this presentation.

Keywords: Weather, Water, Geostationary Orbit, Satellite Observation

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ACG09-09 Room:301B Time:May 27 11:30-11:45

Importance of Lightning Observations from Geostationary Orbit

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Lightning is a good proxy to represent the activities of the deep convections in the tropics and subtropics. Recent studies showed a close relation between lightning activities and typhoon (hurricane) intensities, upper-tropospheric water vapor variability, and temperature fluctuations in the tropical atmosphere. Moreover, a number of studies on the lightning data assimilation into mesoscale models presented considerable improvement in the accuracy of the weather forecast. As the importance of the lightning measurements are greatly acknowledged, a single-channel, near-infrared optical camera, named Geostationary Lightning Mapper (GLM), will be onboard GOES-R and GOES-S. In Europe, same type of the lightning detector, named Lightning Imager (LI), will be onboard MTG-I. After the launch of these geostationary satellites, which is planned within a few years, lightning activities over North and South America, Africa, Europe, the Atlantic Ocean, and the Indian Ocean will be continuously monitored. However, an installation of the lightning detector on the future MTSAT series is not planned so far. At the presentation, we will discuss the importance of lightning observations from geostationary orbit and their applications.

Keywords: lightning, geostationary satellite, data assimilation, severe weather, nowcasting

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ACG09-10 Room:301B Time:May 27 11:45-12:00

Conceptual idea for future space-borne Doppler wind lidar

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Weather affects on our daily life and provides us keys for understanding daily and/or seasonal variations, spatial variations, and climate change. Climate change has many impacts on atmosphere, biosphere, hydrosphere and so on. Climate change causes severe weather disasters such as heavy rain, strong and large typhoon, strong wind, and so on. Recently, the weather disasters are becoming more serious in many parts of the world. We live in the world dangerer than before due to weather disasters or climate change. In order to understand the global climate and to reduce the weather disasters, global numerical simulation plays a very important role. Wind is one of key meteorological elements to physical describe the global numerical simulation. Three-dimensional global wind is important to significantly improve the initial conditions for the numerical weather prediction and essential for operational weather forecast at both synoptic and regional scale. GPS-radiosonde and wind profiler radar can provide vertical wind profile. The GPS-radiosonde network is the main source of global three-dimensional wind. However, the GPS-radiosonde network is mainly on land. Weather stations on oceans and remote land areas are very sparsely distributed. Single-layer wind measurement is made by aircraft and by tracking atmosphere (water vapor or cloud) or detecting microwave backscattered from near sea-surface from space (e.g. Quickscat, MTEOSAT, MTSAT). A global observation system is urgently needed to obtain three-dimensional distribution of wind. In Japan, National Institute of Information and Communications Technology (NICT) has been studying 2-μm laser technologies and optical heterodyne detection techniques for the space-borne coherent Doppler wind lidar. NICT developed a ground-based 2-μm coherent lidar for wind and CO_2 measurements. NICT made experimental wind measurements with Tohoku University, Meteorological Research Institute, and other universities and research institute. In 2011, NICT, Tohoku University, the University of Tokyo, Meteorological Research Institute, and Japan Aerospace Exploration Agency organized a working group on future space-borne Doppler wind lidar. The working group summarized the current status of lidar technologies and scientific purposes for future space-borne Doppler wind lidar in March, 2012. The working group conducts studies on feasibility based on the summary: space-borne lidar technology, impact assessment of future space-borne lidar, and innovative space technology. In this paper, we describe the future space-borne Doppler wind lidar for the global wind measurement.

Keywords: Lidar, Space-bonre, Global three-dimensional wind, Wind measurement, Numerical Weather Prediction, Climate model

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

ACG09-11 Room:301B Time:May 27 12:00-12:15

A plan of an Earth observation satellite for the middle atmosphere dynamics and chemistry

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The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) aboard the Japanese Experiment Module (JEM) of the International Space Station (ISS) made atmospheric measurements of minor species in the stratosphere and mesosphere for about six months from October 2009 to April 2010 (Kikuchi et al., 2010). The unprecedented high sensitivity measurements using the 4-K cooled submillimeter limb sounder provided new insights into the physics and chemistry of the middle atmosphere such as the diurnal variation in stratospheric ozone (Imai et al., 2013; Sakazaki et al., 2013).

On the basis of the technology employed for SMILES, we propose a plan of an Earth observation satellite for the middle atmosphere dynamics and chemistry. Particular emphasis is placed on high sensitivity temperature measurement that was not implemented in SMILES and wind field measurement that was demonstrated by SMILES (Baron et al., 2013). We expect the mission life time for about 3 years to provide global data promoting sciences in the middle atmosphere and the lower thermosphere. Those measurements are essential to constrain advanced chemical transport models for future projection of the ozone layer.

Scientific targets using the data are as follows: 1) Clarification of heat budget and momentum budget in the middle atmosphere on the basis of high precision temperature measurements with accuracy ~1K up to 100km. Wind fields should be also derived by Doppler shift of spectral lines at least for line-of-sight. Data assimilation can be used to derive the horizontal wind filed. Characteristics of atmospheric tides in the mesosphere can be clarified. 2) Transport processes of tropospheric air into the stratosphere based on high accuracy observations of ClO and BrO that are important to ozone budget. Measurements of tracers such as H_2O and N_2O are also performed for quantitative argument of the meridional circulation. 3) Effects of solar activity on the upper atmosphere. Solar proton events in addition to periodic variations associated with the solar activity can be captured.

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Keywords: satelllte observation, middle atmosphere

ACG09-12 Room:301B Time:May 27 12:15-12:30

uvSCOPE - NO2 observation from International Space Station-

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Emissions of air pollutants have increased in the past decades in Asian region, and precise understanding of the emission source become more important to estimate the accurate amount of the emission for the view of domestic air quality, intra-continental and inter-continental long-range transport. We have been trying to detect unknown source of the local ”hot spot” of the pollution source.

In 2006, the Japan Society of Atmospheric Chemistry (JSAC) formed Commission on the Atmospheric Environmental Observation Satellite to initiate the discussion of future satellite mission for air quality. In 2014, the mission concept, a UV/VIS sensor for NO2 and absorption aerosol, was recommended from Earth observation committee to the middle class mission of exposed module of KIBO in International Space Station. Targeted spatial resolution is about 1-2 km, and focused to detect ”a hot spot of the pollution source using NO2 emission”. Overview of the mission including user requirement and the sensitivity study will be presented in this talk.

Keywords: Air quality, International Space Station, UV/VIS imaging spectrometer

ACG09-13 Room:301B Time:May 28 09:00-09:15

Creation of TRMM PR data by minimizing the effect of the PR hardware change

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Precipitation observation by the Tropical Rainfall Measuring Mission' s (TRMM' s) Precipitation Radar (PR) has lasted for almost 17 years. On February 28, 2014, the core satellite of the Global Precipitation Measurement (GPM) mission was launched, and the GPM Dual-frequency Precipitation Radar (DPR) started providing precipitation data succeeding the TRMM PR observation. PR and DPR not only estimate precipitation accurately both over land and the oceans but also provide information to derive precipitation characteristics (e.g., rain top height and rain vertical profile). Homogeneity of long-term PR/DPR data will be essential to study the water cycle change related to the decadal climate variability. In this study, we aim to develop a precipitation climate data from 17-year PR data. The PR data have discontinuities in quality due to the boost of the TRMM satellite altitude in August 2001 and the PR hardware (H/W) change in June 2009. In this paper, PR data are adjusted to mitigate the discontinuity of the PR H/W change.

The observation of PR temporary stopped on May 29, 2009. The PR H/W changed from A-side to B-side and the B-side observation has started since June 19, 2009, which causes the drop of noise power. The difference in noise power between 2008 and 2010 is obtained as a decrease of 0.54 dBm. This change affects a minimum detection of weak rain by PR. In the current study, the B-side PR data are adjusted to simulate the data with the characteristics of A-side PR. The simulated data are created with the additional electric power of 0.54 dBm in level-1 PR power (1B21) product. The level-2 rainfall (2A25) product is produced from the 1B21 product via products of level-1 radar reflectivity (1C21), level-2 surface cross section (2A21), and rain characteristics (2A23). The simulated data are generated from June 2009 to December 2010 and quantitatively assessed for the PR H/W change.

The simulated data produce a decrease in rain frequency and tend to mitigate the discontinuity caused by the PR H/W change. Semi-global (35S-35N) precipitation amount derived from the simulated data in 2010 decreased by about 1 %, compared with the original data. Oceanic precipitation is uniformly decreased, while land precipitation regionally decreases and increases in spite of the decrease in rain frequency. Regional dependence of land precipitation change will be examined focusing on changes of path-integrated-attenuation and rain type classification.

Keywords: TRMM, PR, Climate data

Japan Geoscience Union Meeting 2015
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Evaluation of heavy rainfall retrieval from TRMM/PR using a long-term C-band radar observation

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Over ten years of spaceborne precipitation radar (PR) measurements from Tropical Rainfall Measurement Mission (TRMM) satellite reveal a weak linkage between extreme rainfall and extreme convection: Even in regions where severe convective storms are representative extreme weather events, the heaviest rainfalls are mostly associated with less intense convections (Hamada et al. 2015, Nat. Commun.). Both the echo structures and environmental conditions suggest importance of warm-rain processes in producing extreme rainfall rates. However, there are still several questions to be addressed, such as uncertainty in the attenuation correction of the Ku-band PR especially for extreme convection. In this study, we make a statistical evaluation of TRMM/PR retrievals using a ground-based polarimetric radar, especially focusing on extreme rainfall and convection events.

We used 5-yr observation during Baiu season (May-June) by a C-band polarimetric radar at Okinawa Island, developed and operated by National Institute of Information and Communications Technology (NICT), named COBRA. The COBRA has polarization and Doppler observation functions and makes it possible to derive information about the characteristics of precipitation particles such as type and size distributions. In the analysis period, COBRA made almost continuous RHI observations with time interval of several minutes.

We make statistical comparison between the extreme events derived from TRMM/PR and COBRA, since direct comparison is quite difficult for such rare event because of very small number of simultaneous observations. Extreme rainfall and convection events are defined separately from TRMM/PR and COBRA. For TRMM/PR, extreme events are defined on a local basis with 2.5 x 2.5 degree grid cells around Okinawa, using the maximum values of near-surface rainfall rate (NSR) and 40-dBZ echo top height (ETH40) in “rainfall event” which is a set of contiguous rainy pixels of TRMM/PR measurements. Rainfall events of which the maximum NSR is within top 0.1% are defined as extreme rainfall events, while those of which the maximum ETH40 is within top 0.1% are defined as extreme convection events. For COBRA, extreme events are defined from vertical echo profiles in RHI observations. Extreme rainfall events are defined as the profiles in which rainfall rates at 1 km are within top 100, and extreme convection events are defined in similar way using 40-dBZ echo-top heights.

There are contrasting characteristics in the echo characteristics between the extreme rainfall events and extreme convection events derived from COBRA, as have been shown in our previous studies using TRMM/PR: Extreme rainfall events exhibit lower echo-top height than extreme convection events, and linear downward increase of radar reflectivity below freezing level, whereas extreme convection events exhibit slight downward decrease of Ze below freezing level. This demonstrates that the attenuation correction of TRMM/PR works, at least qualitatively, correctly, and that contaminations of surface and mainlobe clutter are of little concern for the echo profiles of extreme rainfall events. Temporal evolutions of both extreme events exhibit clear differences, indicating that extreme rainfall and convection events are associated with precipitation systems with different inherent characteristics.

Keywords: extreme precipitation, TRMM, precipitation radar

ACG09-15 Room:301B Time:May 28 09:30-09:45

Mean Features of Tropical Cyclone Precipitation from TRMM/3B42

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The mean features of precipitation distribution associated with tropical cyclones are evaluated as anomalies from environmental precipitation fields, in six tropical cyclone active basins (the western North Pacific, the eastern North Pacific, the north Atlantic, the north Indian Ocean, the south Indian Ocean, and the South Pacific), using satellite-derived daily precipitation observation. A common feature in all basins is that concentric positive precipitation anomalies extend within a 5-degree radius from the tropical cyclone center with maximum values of 70 to 100 mm/day. These distributions are well approximated by a Gaussian curve with an e-folding radius of 2.2 to 2.8 degrees. Positive precipitation anomalies are surrounded by negative anomalies in all basins, indicating suppression of precipitation due to the tropical cyclones themselves at a large distance from the center. The negative anomalies have minimum values of -2 to -3 mm/day and are distributed mainly on the equatorial side of the center. Precipitation excess frequency around the tropical cyclones is also evaluated. The western North Pacific has maximum values of excess frequencies in all basins, in which the frequency for 100 mm/day is 26 days/yr and that for 200 mm/day is 1.8 days/yr within a 1-degree radius from the center. We assume that tropical cyclones in the western North Pacific have the greatest precipitation intensity.

Keywords: Tropical Cyclone, Precipitation

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ACG09-16 Room:301B Time:May 28 09:45-10:00

Current status of the Global Precipitation Measurement (GPM) mission in Japan

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The Global Precipitation Measurement (GPM) mission is an international cooperative project to achieve highly accurate and highly frequent global precipitation observations by satellites. The GPM mission consists of the GPM Core Observatory jointly developed by U.S. and Japan and Constellation Satellites that carry microwave radiometers and provided by the GPM partner agencies. The GPM Core Observatory was successfully launched at 3:37 a.m. on February 28, 2014 (JST). The Dual-frequency Precipitation Radar (DPR) was developed by the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT), and installed on the GPM Core Observatory. The GPM Core Observatory chooses a non-sun-synchronous orbit to carry on diurnal cycle observations of rainfall from the Tropical Rainfall Measuring Mission (TRMM) satellite, while the Constellation Satellites, including JAXA's Global Change Observation Mission (GCOM) - Water (GCOM-W1) or "SHIZUKU", are launched by each partner agency sometime around 2014 and contribute to expand observation coverage and increase observation frequency. JAXA develops the DPR Level 1 algorithm, and the NASA-JAXA Joint Algorithm Team develops the DPR Level 2 and DPR-GMI combined Level2 algorithms. JAXA also develops the Global Rainfall Map (GPM-GSMaP) algorithm, which is the latest version of the Global Satellite Mapping of Precipitation (GSMaP), as national product to generate hourly and 0.1-degree horizontal resolution rainfall map. Major improvements in the GPM-GSMaP algorithm is; 1) Improvements in microwave imager algorithm based on AMSR2 precipitation standard algorithm, including new land algorithm, new coast detection scheme; 2) Development of orographic rainfall correction method for warm rainfall in coastal area (Taniguchi et al., 2012); 3) Update of database, including rainfall detection over land and land surface emission database; 4) Development of microwave sounder algorithm over land (Kida et al., 2012); and 5) Development of gauge-calibrated GSMaP algorithm (Ushio et al., 2013). In addition to those improvements in the algorithms number of passive microwave imagers and/or sounders used in the GPM-GSMaP was increased compared to the previous version. Moreover, ground validation activity using a dual Ka-band radar system developed by JAXA has been conducted along the slope of Mt. Zao in Yamagata Prefecture, Japan since Oct. 2013. The dual Ka-band radar system consists of two nearly identical Ka-band FM-CW radars, and the precipitation systems between two radars were observed in opposite directions. Sometimes DPR overpassed the Zao experimental site, and vertical profiles of rain/snow were compared with ground Ka-radar profiles. The comparison also showed that the DPR Ka-radar profiles were consistent with ground observation. After the early calibration and validation of the products and evaluation that all products achieved the release criteria, all GPM standard products and the GPM-GSMaP product has been released to the public since September 2014. The GPM products can be downloaded via the internet through the JAXA G-Portal (https://www.gportal.jaxa.jp).

Keywords: GPM, DPR, GSMaP, ground validation, satellite, precipitation

ACG09-17 Room:301B Time:May 28 10:00-10:15

Early results of Dual-frequency Precipitation Radar on Global Precipitation Measurement Core Observatory

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The Global Precipitation Measurement (GPM) Mission consists of a Tropical Rainfall Measuring Mission (TRMM)-like non-sun-synchronous orbiting satellite (GPM Core Observatory) and a constellation of satellites carrying microwave radiometer instruments. The GPM Core Observatory, which was launched on 28 February 2014 (JST), carries the Dual-frequency Precipitation Radar (DPR) developed by the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT). The DPR consists of two radars; Ku-band (13.6 GHz) precipitation radar (KuPR) and Ka-band (35.55 GHz) radar (KaPR). The DPR is expected to advance precipitation science by expanding the coverage of observations to higher latitudes than those obtained by the TRMM Precipitation Radar (PR), by measuring snow and light rain via high-sensitivity observations from the KaPR, and by providing drop size distribution (DSD) information based on the differential scattering properties of the two frequencies. For operational productions of precipitation datasets, it is necessary to develop computationally efficient, fast-processing DPR Level-2 (L2) algorithms that can provide estimated precipitation rates, radar reflectivity factors, and precipitation information, such as the DSD and precipitation type. The L2 algorithms have been developed by the DPR Algorithm Development Team under the NASA-JAXA Joint Algorithm Team.

The DPR data have been evaluated in terms of consistency with TRMM/PR data, and comparison with ground instruments. All GPM standard products have been released to the public since September 2014 after achievement of release criteria of the products. The release criteria of the DPR precipitation products is less than 50% differences of averaged surface precipitation rates between the GPM/DPR and the TRMM/PR are over the ocean. In addition, success criteria of the DPR product is defined as less than 10% difference in annual rainfall amounts compared with ground-based measurements. In this work, the current DPR evaluations using TRMM/PR data and ground rain gauge data over the Japan will be presented.

Keywords: Global Precipitation Measurement, Dual- frequency Precipitation Radar, Tropical Rainfall Measuring Mission, Precipitation Radar, rain gauge

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ACG09-18 Room:301B Time:May 28 10:15-10:30

Ground Validation Activity for GPM/DPR Retrieval Algorithm and Products

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The core satellite of Global Precipitation Measurement Mission (GPM) is equipped a microwave radiometer (GMI) and a dual-frequency radar (DPR) which is the first spaceborne K_u/K_a-band dual-wavelength radar(KuPR/KaPR) dedicated for precise precipitation measurement. In the DPR algorithm, measured radar reflectivity is converted to effective radar reflectivity by estimating the rain attenuation. Here, the scattering/attenuation characteristics of Ka-band radiowaves are crucial.

For the purpose of algorithm validation, JAXA and NICT have been conducted the ground observation since 2011 with cooperators, using the dual Ka-band radar system. It consists of two nearly identical K_a-band FM-CW radars, and the precipitation systems between two radars were observed in opposite directions. From this experiment, equivalent radar reflectivity (Z_e) and specific attenuation (k) were obtained. Dual Ka-radar observation campaigns had been done in Okinawa, Tsukuba, Mt.Fuji, Nagaoka, and Sapporo to obtain the attenuation characteristics of various type of precipitation. The final campaign had carried out during 2014 autumn to 2015 spring along the slope of Mt.Zao, in Yamagata prefecture, targeting melting layer. Though measurement was found to need precise setup of experiment, since the retrieved k is very sensitive to the fluctuation of data, the observation was successfully finished. As a result, Z_e-k relationships for rain, wet snow, and dry snow were obtained and compared with DPR products and algorithms. The Ze-k relationship in the DPR algorithm was found to be consistent.

For the better understanding of microphysics in the melting layer, newly-developed Ground-based Particle Image and Mass Measurement System (G-PIMMS) also worked during this campaign. It can capture two-dimensional particle images by two CCD cameras which mutually arranged perpendicularly, and measure particle weight by the electronic balance at the same time. Particles are classified into perfectly melted particles, melting particles, and solid ice particles by captured images. G-PIMMS was installed different altitude on the slope of Mt.Zao, so its data shows the particle differences in the position of melting layer. We are also trying to estimate Z_e-R relationship by Ka-radar result and G-PIMMS mass measurement.

Sometimes DPR overpassed the Ground-based Ka-radar experimental site, and vertical profiles of rain/snow were compared with ground Ka-radar profiles. The comparison also showed that the DPR Ka-radar profiles were consistent with ground observation. Other instruments such as disdrometer, Parsivel, MicroRainRadar, and X-band randar in several observation points was also take data when DPR overpasses. The result of DPR product validation by those observations will be reported.

Keywords: Ground Observation, Validation, GPM, DPR, Ka-band, melting layer

ACG09-19 Room:301B Time:May 28 10:30-10:45

Production of Global Satellite Mapping of Precipitation for GPM (GPM-GSMaP) and Future Improvements

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The Glopbal Rainfall Map product is a final output in the GPM mission led by Japan and US. There, hoewever, is no standard Global Rainfall Map product between Japan and US, but developed as national products in Japan and US, respectively, to respond their national needs. Japanese Global Rainfall Map product uses the latest version of Global Satellite Mapping of Precipitation (GSMaP) algorithm, and called as GPM-GSMaP. The GSMaP algorithm produce high-resolution and high-frequent global rainfall map based on multi-satellite passive microwave radiometer observations with information from the Geostationary InfraRed (IR) instruments, and databases using accomplishments of observations by the Precipitation Radar (PR) and Lightning Imaging Sensor (LIS) onboard the Tropical Rainfall Measuring Mission (TRMM). GSMaP product has been open to public as near-real-time version "JAXA Global Rainfall Watch" (or GSMaP_NRT) and reanalysis version (GSMaP_MVK) from the JAXA web site since 2007 (http://www.eorc.jaxa.jp/GSMaP/). Output products including browse images and binary/text data are 0.1-degree grid for horizontal resolution and 1-hour for temporal resolution, and provided about four hours after observation. Number of registered GSMaP users is 1,214 as of the end of January 2015. The algorithm version of GSMaP at the point of launch of the GPM Core Observatory is version 5, and improvements of GSMaP algorithm toward Japanese standard product in the GPM mission have been implemented by the GPM Map Algorithm Team.

The GSMaP for GPM (GPM-GSMaP) product (algorithm version 6 and product version V03) has been released to public from JAXA data distribution system called "G-Portal" (https://www.gportal.jaxa.jp) since September 2, 2014. At the same time, the GSMaP products that are available at the JAXA Global Rainfall Watch web site are switched to the GPM-GSMaP products but its data format is the same as in the past GSMaP product for convenience to users. Version up of Level 1 product is scheduled for the Advanced Microwave Scanning Radiometer 2 (AMSR2), we plan to make minor version up of GPM-GSMaP in March or April 2015.

Currently, GPM-GSMaP data is only available since February 2014 from the G-Portal system, but we plan to release past period data after March 2000 as the GSMaP Climate (GSMaP_CLM) product applying same algorithm as operational one. GSMaP_CLM product needs long-term continuous meteorological information to produce look-up table, we choose Japanese 55-year Reanalysis (JRA-55) instead of Japan Meteorological Agency's Global Analysis used in operational GPM-GSMaP processing. The GSMaP_CLM product is now being processed, and will be relased to public when data is ready.

There are several requirements from users for GSMaP improvements, but the most popular ones are shortening of data latency and higher horizontal resolution. Reagrding shortening of data latency, we are currently developing rapid version of GSMaP (GSMaP_NOW) product for observation area of the geostationary satellite "Himawari" (MTSAT). The GSMaP_NOW product uses passive microwave radiometer data that is available only within one hour after obserbation. Furthermore, addition of extrapolation by using cloud moving vector of one hour forward (toward future) enables us to produce "nowcasting" rainfall map over Asian regions. The development and validation of the GSMaP_NOW system is currently underway toward start of operation in the next Japanese fiscal year.

Keywords: satellite observation, precipitation, high-resolution, high-frequent, GSMaP, GPM

ACG09-20 Room:301B Time:May 28 11:00-11:30

Satellite Data Assimilation: A Perspective

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Satellite observations play a central role in contemporary numerical weather prediction (NWP) through recent developments of advanced data assimilation methods. Data assimilation integrates observations and a numerical simulation, and aims to bring synergy. Studies have shown that satellite microwave and infrared sounder data have a significant positive impact on NWP. However, more satellite data exist than currently used in the operational NWP systems. An example includes satellite-based precipitation measurements, such as GPM data, which potentially improve NWP. However, until recently it has been a very difficult problem to improve medium-range NWP through precipitation data assimilation. Different types of satellite data can be integrated into NWP and other earth environmental simulations as data assimilation techniques keep advancing. In the future, more advanced sensors will provide orders of magnitude more data than the current sensors. For example, Advanced Himawari Imager (AHI) of the new generation geostationary satellite Himawari-8 produces two orders of magnitude more data than the currently-used geostationary satellites. As computers advance consistently, data assimilation will face the problem to integrate ”Big Data” from new sensors and ”Big Simulations” from big computers. We would expect to enter this ”Big Data Assimilation” era. Here, I believe a ”co-design” among specialists in satellite observations, data assimilation, and computer science is an important concept. In this presentation, I will present my personal perspective on the future of satellite data assimilation.

Keywords: data assimilation, satellite observation, numerical weather prediction

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ACG09-21 Room:301B Time:May 28 11:30-11:45

Hydrological Quantities Estimated By GCOM-W1/AMSR2

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The Advanced Microwave Scanning Radiometer 2 (AMSR2) on board the first generation satellite of Global Change Observation Mission - Water (GCOM-W1 or "SHIZUKU") satellite is multi-frequency, total-power microwave radiometer system with dual polarization channels for all frequency bands (Imaoka et al., 2010). AMSR2 is a successor of JAXA's Advanced Microwave Scanning Radiometer for EOS (AMSR-E) on the NASA's Aqua satellite, which was launched in May 2002. Basic concept of AMSR2 is almost identical to that of AMSR-E. The GCOM-W1 satellite was launched from JAXA Tanegashima Space Center on May 18, 2012 (JST), and has started scientific observation since July 3, 2012. We are planning to integrate the water-related parameters derived from AMSR2 with those from AMSR-E to produce long-term continuous datasets for climate change studies.

AMSR2 standard products (and their required accuracies at the end of the mission) are brightness temperature ($\pm$1.0K (systematic), $\pm$0.3K (random)), integrated water vapor ($\pm$2.0kg/m^2), integrated cloud liquid water ($\pm$0.02kg/m^2), precipitation (ocean $\pm$20%, land $\pm$80%), sea surface temperature ($\pm$0.2 ℃), sea surface wind speed ($\pm$1.0m/s), sea ice concentration ($\pm$5%), snow depth ($\pm$10cm), and soil moisture ($\pm$5%).

Please note that the release accuracies are defined as a root mean square error (RMSE) except for precipitation, snow depth, and soil moisture products. The goal accuracy of SST is also defined as a RMSE of zonal means. The accuracy of the precipitation product is defined as a relative error (RMSE/Mean in percent), and that of the snow depth and soil moisture content products is defined as an absolute mean error (AME). All the AMSR2 products achieved required release accuracies and have been released to public since May 2013 (Kachi et al., 2013). Currently, algorithm updates and reprocessing of both Level-1 (brightness temperature) and Level-2 (geophysical parameter) are scheduled in spring of 2015.

In addition to those standard products, research products are defined to extend possible utilization of AMSR2 data. Those are all-weather sea surface wind speed, high-resolution sea surface temperature, land temperature, vegetation water content, high-resolution sea ice concentration, sea ice thickness, sea ice moving vector, and soil moisture and vegetation water content based on the data assimilation methodology. Those products will be processed and distributed from the web site of JAXA Earth Observation Research Center (http://suzaku.eorc.jaxa.jp/GCOM_W/) when they are ready to release.

For global water cycle and climate change studies, continuous and homogeneous datasets are required. To fulfill those requirements, we are planning to produce consistent dataset of water-related parameters between AMSR-E and AMSR2. The latest Level-2 algorithm for AMSR2 will be applied to AMSR-E Level-1 product, and AMSR-E Level-2 products in the same format to that of AMSR2 will be processed and released to the public.

The AMSR2 standard products have been distributed through the GCOM-W1 Data Providing Service (https://gcom-w1.jaxa.jp/). The GCOM-W1 Data Providing Service System has been in operation since August 2011 in order to distribute AMSR2 standard products along with AMSR and AMSR-E standard products. Registered users can also use sftp protocol to download data automatically, as well as interactive mode. For quick look of the products, browse images of all AMSR2 brightness temperatures and geophysical parameters are available at the JAXA Satellite Monitoring for Environmental Studies (JASMES) for Water Cycle (http://kuroshio.eorc.jaxa.jp/JASMES/WC.html).

Keywords: remote sensing, micro wave, earth observation, global hydrological cycles

ACG09-22 Room:301B Time:May 28 11:45-12:00

Development of Cloud Profiling Radar (CPR) for Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) mission

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Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) is a Japanese-European collaborative earth observation satellite mission aimed to deepen understanding of the interaction process between clouds and aerosols and their effects on the Earth's radiation. The outcome of this mission is expected to improve the accuracy of global climate change prediction.

The EarthCARE spacecraft, which weighs approximately 2,250kg and goes along a Sun-Synchronous 400km-hight orbit around the Earth, accommodates four instruments which are to observe the Earth's clouds, aerosols and radiation. The observation data acquired simultaneously by the four sensors will be processed into a variety of synergy products including vertical profiles of clouds and aerosols, microscopic cloud parameters, radiation fluxes and so on. As one of those instruments, the Cloud Profiling Radar (CPR) is the world's first space-borne Doppler cloud radar jointly developed by the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT). The CPR which has a 2.5m-diameter main reflector and W-band 1.5kW transmitter and receiver, will provide the vertical velocity as well as the vertical structure inside clouds. The other payloads on the satellite are the Atmospheric Lidar (ATLID) for vertical structure measurement of clouds and aerosols, the Multi-Spectral Imager (MSI) for horizontal distribution measurement of clouds and aerosols, and the Broad-Band Radiometer (BBR) for measurement of radiation fluxes at top of the atmosphere. ATLID, MSI, BBR and the base-platform of the spacecraft are developed by the European Space Agency (ESA).

In Japan, the critical design review of the CPR has been completed in 2013 and CPR proto-flight model is currently being manufactured, integrated, and tested. After handed-over to ESA, the CPR will be installed onto the EarthCARE satellite with the other instruments. After that the CPR will be tested, transported to Guiana Space Center in Kourou, French Guiana and launched by a Soyuz launcher in JFY2017.

Keywords: Cloud, Aerosol, Radiation, EarthCARE, CPR, Cloud Profiling Radar

ACG09-23 Room:301B Time:May 28 12:00-12:15

Preparation status of GCOM-C science mission

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Global Change Observation Mission for Climate (GCOM-C) which carries Second-generation Global Imager (SGLI) is planned to be launched in Japanese Fiscal Year (JFY) 2016 (from April 2016 to March 2017). SGLI has middle spatial resolution (250 m to 1000 m), wide swath (1150 km to 1400 km), 19 bands from near-UV (380 nm) to thermal infrared (12 um) wavelengths, and two-channel (red and near infrared) slant view polarization observations. It consists of two components, Visible and Near-infrared Radiometer (VNR) which scans 1150 km by push-broom telescopes, and Infrared Scanner (IRS) which scans 1400-km swath by rotating 45-degree mirror. The VNR consists of two sub-components, VNR-non polarized (11 bands) and VNR-polarized (2 bands) telescopes. The polarization telescopes can tilt along track directions from +45 to -45 . The 250-m resolution will provide enhanced observation capability over land and coastal areas influenced remarkably by the human activities. The polarization and multidirectional observations will enable us to retrieve aerosol information over land. After the design phase (until 2012), JAXA GCOM-C1 project is starting the satellite and sensor manufacturing, characterization, and development of the calibration and correction algorithms.

SGLI will provide many standard products, 9 land-area products, 8 atmosphere products, 7 ocean products, and 4 cryosphere products which aim to contribute to environment monitoring and climate researches. In addition to the standard products, research products, such as net primary production, land cover, radiation flux, redtide and so on, have been identified. All of the standard products will be open to public freely one-year after the launch by JAXA standard data portal, G-portal. There are special near-real time data flows from the Svalbard receiving station and direct downlink capability. Our science team is constructing and refining the validation plan (instruments, measurements, data analysis flow, group coordination and so on) until the launch to achieve accuracy targets which are requested by the GCOM user committee.

Data product development has been conducted by JAXA and GCOM-C Principal Investigators (PIs). The PI team has been organized in summer 2009 as the first research period (Sep. 2009 - Mar. 2013), and followed by the second research period (Apr. 2013 - Mar. 2016). In the current second research period, we are intensively conducting development of the standard algorithm (operational processing codes) and validation preparation for the first version of the standard products which will be evaluated and released until one year after the satellite launch. The next collaboration research (Apr. 2016 - Mar. 2019) will be announced in the autumn 2015, and we will concentrate our effort on the preparation of the launch version algorithms, post-launch calibration and validation, and application of the GCOM-C products.

Keywords: GCOM, GCOM-C, SGLI, remote sensing

ACG09-24 Room:301B Time:May 28 12:15-12:30

Validation Plan of GCOM-C/SGLI Standard Products

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GCOM-C (Global Change Observation Mission -Climate) project aims to observe a global, long-term climate change and environmental change of the Earth, to implement Global Change Observation Mission (GCOM) as with GCOM-W (-Water). GCOM-C satellite, carrying a SGLI (Second generation Global Imager) sensor, is scheduled to be launched in the end of Japanese Fiscal Year 2016 and is designed to conduct optically-based measurements related to the atmosphere, ocean, cryosphere and land.

29 geophysical parameters are defined as GCOM-C/SGLI standard products, which are essential for achieving the goals of GCOM mission. The accuracies of each SGLI product are divided in 3 phase for the observation project: release threshold accuracy, standard accuracy and target accuracy. The 'release threshold accuracy' is the minimum level for the first data release at 1 year after launch. The 'standard' and 'target' accuracies correspond to full- and extra success criteria of the mission within 5 years after launch respectively. The release threshold accuracies of the standard products are basically evaluated through the comparison with those derived from other satellite sensors at same spatial coverage and temporal periods and/or with ground-based observation network such as flux tower site data, AERONET, buoy data and so on. For the evaluation of the standard and target accuracies, several field campaigns are also being prepared.

In this presentation, we are going to introduce an outline of validation plan for GCOM-C/SGLI standard products and discuss the possible collaboration of in-situ data and validation methods between atmosphere, ocean, cryosphere, and land category of GCOM-C and between other satellite such as EarthCARE and GOSAT.

Keywords: GCOM-C, SGLI, validation, standard product

ACG09-25 Room:301B Time:May 28 12:30-12:45

Ocean colour remote sensing of marine euphotic depth

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The euphotic depth is defined as a depth where Photosynthetically Available Radiation (PAR) at the sea surface decreased by 1% during its propagation into a water column. While a large amount of ocean colour signal detected by satellite originates from the ocean surface and cannot directly retrieve the euphoric depth, it is a challenge to estimate the euphotic depth by satellite remote sensing. In addition, PAR is defined as the radiance integrated over a range of wavelength (often 400-700nm), while the operational ocean colour satellites only observe the radiance at discrete wavelengths. Thus, it is even a challenge to estimate PAR, hence, the euphotic depth eventually. Furthermore, phytoplankton in the ocean, which is a photosynthetic organism, utilizes radiance at the all solid angles around it for photosynthesis, therefore consideration of radiance at all solid angles is a particular importance in considering the attenuation of PAR when retrieving the euphoric depth, while the ocean colour satellite detects radiance originating only from a certain solid angle, thus showing another challenge. In order to solve these problems for the satellite estimation of the euphotic depth, extensive radiative transfer simulations were conducted. Results show (1) the diffuse attenuation of PAR at the sea surface has a certain relationship with that averaged over euphotic zones, (2) the diffuse attenuation of PAR, which is wavelength-integrated property, can be estimated from an ocean colour measurement at a discrete wavelength, (3) the diffuse attenuation of PAR originating from the all solid angles has a relationship with that of PAR originating from a certain range of solid angles. Using these findings above, a satellite ocean colour algorithm was developed to estimate the euphotic depth. In this presentation, details of the methodology will be demonstrated, and global variability of the euphoric depth will be shown.

Keywords: Ocean Colour, Satellite Remote Sensing, Euphotic Depth, Photosynthetically Available Radiation

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(May 24th - 28th at Makuhari, Chiba, Japan)

ACG09-26 Room:301B Time:May 28 14:15-14:30

DEVELOPMENT OF AVOBE GROUND BIOMASS ESTIMATION ALGORITHM FOR GCOM-C1/SGLI BASED ON MULTI-ANGLE OBSERVATION DATA

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Japan Aerospace Exploration Agency (JAXA) will launch new Earth observation satellite GCOM-C1 in near future. GCOM-C1 will be equipped Second-generation Global Land Imager (SGLI) as core sensor. Since SGLI can observe nadir and off-nadir angle with along track direction simultaneously, it is expected to retrieve forest Above Ground Biomass (AGB) using bi-directional spectral data.

For the estimation of forest AGB, difference of bi-directional reflectance of each observation angle caused by forest canopy structure will be key information.

Authors have been developed basic AGB estimation algorithm for SGLI. This algorithm is based on the empirical model related to the relationship between reflectance shift on the Red-NIR plane for different viewing angle and AGB.

Since the algorithm requires the bi-directional reflectance on fixed observation geometry, we have also developed bi-directional reflectance simulator, BiRS, which employ not only sun-target-sensor geometry but also forest structure based on canopy structure model.

In this paper, a preliminary result of ARG estimation using MODIS multi-pass composite data is described. Daily TERRA/AQUA MODIS data covering East Asia (8 tiles of MOD09GA/MYD09GA product) during June, July, August of 2010, totally 1472 scene have been processed. In order to obtain the available pairs of nadir and off-nadir viewing data, cloud and aerosol flag were examined and masked unusable pixels that were contain cloud or dense aerosol. For the usable data pair, using the simulator BiRS, satellite observed reflectance converted to estimated reflectance on fixed sun-target-sensor geometry. Using the converted reflectance, AGB on the pixels were calculated. After these processing, all 92 days usable pixels AGB were composited.

Keywords: Above Ground Biomass, BRDF, Optical sensor, GCOM/SGLI

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ACG09-27 Room:301B Time:May 28 14:30-14:45

Harmonic analysis of desertification processes measured by vegetation greenness data from GIMMS3g NDVI

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Desertification is a spatio-temporal process caused by both natural climate changes (e.g. drought) and anthropogenic disturbances (e.g. overgrazing and excessive agricultural developments). To monitor this, long-term remote sensing observations are useful for finding vegetation activities using by vegetation indices such as Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI). Previous remote sensing studies have sometimes ignored detailed desertification processes. As unstable vegetation conditions on the edge of deserts, the observed time series data in those areas tend to produce anomalies. To overcome this issue, it is beneficial to focus on phonological process by vegetation indices because such anomalies may represent the vegetation conditions on land. The aim of this study is therefore to understand the desertification process by identifying phenological events using long-term historical remotely sensed imagery. Harmonic analysis is applied to Global Inventory Modeling and Mapping Studies (GIMMS) 3g NDVI time series for 1981-2012. GIMMS3G data is an update version of GIMMS NDVI data covering recent 31 years. Harmonic analysis is a decomposition technique which allows extracting individual harmonic oscillation terms from time series data. This model can assess the statistical significance of each decomposed wave term through Fisher's test and has a great advantage compared to related models such as the seasonal-trend decomposition model and structural time series models. Using these methods, we investigate vegetation phenological signals around the boundary of deserts. The harmonic analysis approach provides insights into long-term desertification processes from the interpretation of the amplitude and phase terms of the individual harmonic terms.

Keywords: Desertification, GIMMS3g, NDVI, Harmonic analysis

ACG09-28 Room:301B Time:May 28 14:45-15:15

Six-year-long GHG observation by GOSAT and three-year carbon flux estimation

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The Greenhouse gases Observing SATellite (GOSAT) has operated for about six years since January 23, 2009. During the past six years, all of the GOSAT standard data products were opened to general users, and many of them went through several updates. From the spectral data that GOSAT collected, the concentrations of major greenhouse gases (GHGs), namely carbon dioxide (CO_2) and methane (CH_4), were retrieved, and their precisions (excluding biases) are now about 0.5% and 0.7%, respectively. These concentration data were used to estimate the monthly surface fluxes of CO_2 and CH_4 on sub-continental and ocean-basin scales in the first three years of GOSAT operation (2009 - 2012). The concentration data were also utilized to monitor GHGs' temporal and spatial changes. Various reports on the results of GOSAT data analysis have appeared in peer-reviewed journals so far.

In 2014, GOSAT went through some technical difficulties in the functioning of its solar paddle and sensor pointing mechanism, and the characteristics of the Fourier transform spectrometer onboard were therefore altered to some degree. The influence of this alteration on the retrieved concentrations has been detected.

In this presentation, we will summarize the six-year-long GHG observation by GOSAT and present the global distributions and variations of the GHG concentrations and the surface flux estimates. We will explain the changes in the characteristics of the GOSAT data products after June 2014 owing to the influence of the technical difficulties. Also, we will touch on the current status of researches conducted within the framework of the GOSAT Research Announcement.

Keywords: greenhouse gases, carbon dioxide, methane, column concentration, flux, GOSAT

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ACG09-29 Room:301B Time:May 28 15:15-15:30

GOSAT operation and data processing toward a decade-long observation in orbit

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Since its launch in January 2009, the Greenhouse gases Observing SATellite (GOSAT) has been leading the observation of greenhouse gases from space. Multiple teams from more than 10 countries have been working on independent CO_2 retrievals, with errors of 2 ppm, over much of the globe. These datasets not only reduce the uncertainty regarding the global CO_2 flux but also detect plant fluorescence using high resolution spectra, presenting patterns of gross primary productivity. This has provided a new viewpoint on the carbon cycle.

After its 5-year designed life operation, GOSAT has enough propellant for orbit control to extend its operation and no significant degradation has been detected in both the satellite-bus systems and mission instruments. In May 2014, one of the two solar paddles stopped its rotation causing a reduction in the power supply, but the solar paddles and four batteries still provide enough power to operate both the Thermal And Near infrared Sensor for carbon Observations Fourier Transform Spectrometer (TANSO-FTS) and the Cloud and Aerosol Imager (TANSO-CAI). From September 2014, the pointing settling down of TANSO-FTS became unstable due to lubricant aging and on January 26, 2015, the primary pointing system was switched to the backup one. After a two-month interval, GOSAT returned to normal operation with target and glint observations. Despite two anomalies in 2014, after calibration and correction in the level 1B data processing, TANSO-FTS has been continuously providing constant-resolution spectra.

After the successful launch of OCO-2 in July 2014, measurements from the two independent instruments can be compared to distinguish common forward calculation errors such as line parameters, aerosol scattering, and ocean glint reflections from instrument-specific errors. This capability provides additional constraints on aerosol scattering, which is the largest uncertainty in CO_2 retrieval from space. During the first 5-year operation in orbit, GOSAT has demonstrated the effectiveness of satellite greenhouse gases (GHG) observation with careful calibration and validation. Now, the GOSAT observation pattern has been modified for new findings that are only possible with satellite measurements. GOSAT has an agile pointing system, permitting a large number of custom targets per orbit at the expense of spatial context. Regional monitoring, such as for CO_2 from mega-cities, CH_4 from oil fields, and volcanic CO_2 by target modes, will help to determine the GHG emissions in more detail. By extending glint observations over the sea, more data can be obtained to compare the off-shore background and densely populated land areas.

Keywords: greenhouse gases, Carbon Dioxide, methane, calibration, mega city, regional emission monitoring

ACG09-30 Room:301B Time:May 28 15:30-15:45

Optimization of the GOSAT/TANSO Observation Plan for X_{CO2} and P_{surf} Accuracy Improvement

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TANSO (Thermal And Near-infrared Sensor for carbon Observation) onboard GOSAT (Greenhouse gases Observing SATellite) has been acquiring mainly carbon dioxide (CO_2) and methane (CH_4) absorption spectra globally since 2009.

Using GOSAT ACOS Level 2 standard products, we consider the accuracy of X_{CO2} (CO_2 column density) and P_{surf} (surface pressure) as the differences between the apriori and the retrieval results, and investigate the relationships between these accuracy and the observation condisitions (SNR, surface albedo, observation geometry, aerosols, etc.).

This investigation will contribute to revising the GOSAT operation plan and to improving the accuracy of the X_{CO2} and P_{surf}.

Keywords: greenhouse gass, big data, accuracy improvement, satellite remote sensing, optimization

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ACG09-31 Room:301B Time:May 28 15:45-16:00

On the optimal design for a global high-resolution surface CO_2 flux inversion model

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We devised an iterative inversion framework that is optimally designed for estimating surface CO_2 fluxes at a high spatial resolution using a Lagrangian-Eulerian coupled tracer transport model and atmospheric CO_2 data collected by the global reference in-situ network and satellite observations. In our inverse system, the Lagrangian particle dispersion model FLEXPART was coupled to the Eulerian atmospheric tracer transport model (NIES-TM) and an adjoint of the coupled model was derived. Weekly corrections to given prior fluxes are calculated at a spatial resolution of the meteorology driver of FLEXPART (0.1 degrees) via iterative optimization. The hourly terrestrial biosphere fluxes are simulated with the VISIT model using the CFSR reanalysis. Ocean fluxes are calculated using a 4D-Var assimilation system based on the surface pCO_2 observations. Fossil fuel (ODIAC) and biomass burning (GFAS v1.1) emissions are given at original model resolutions (0.1 degree), while terrestrial biosphere and ocean fluxes are interpolated from a coarser resolution. Flux response functions (footprints) for observations are first simulated with FLEXPART. The precalculated flux response functions are used in forward and adjoint runs of the coupled transport model. We apply Lanczos process to obtain truncated singular value decomposition of the scaled tracer transport operator. The square root of covariance matrix for surface fluxes is constructed by implementing two algorithms. The first algorithm uses a lookup table to store precalculated covariance matrix elements implemented as Gaussian function of a great circle distance between grid points. This algorithm appears to produce highly accurate results but it is becoming computationally expensive when implemented at a high spatial resolution. The second (faster) algorithm, which is based on an implicit diffusion operator with a directional splitting in latitude, longitude and time, was also tested. The covariance operator of the second algorithm approximates Matear function rather than Gaussian, the analysis of its singular value spectra and the singular vectors however shows that the resulting covariance matrix has very similar properties to Gaussian covariance matrix. In our method, the prior and posterior flux uncertainties are evaluated using singular vectors of scaled tracer transport operator. The weekly flux uncertainties at a resolution of 0.1 degree and flux uncertainty reduction due to assimilating single shot GOSAT X_{CO2} data were estimated for a period of one year. We demonstrated that our application of a coupled tracer transport model in adjoint-based assimilation system provides an efficient way to increase spatial resolution of the inverse model.

Keywords: remote sensing, carbon dioxide, data assimilation, inverse modeling

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ACG09-32 Room:301B Time:May 28 16:15-16:30

A study of satellite remote sensing algorithm for aerosol using multi-wavelength and multi-pixel data

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Aerosol is an important atmospheric constituent for determining the earth's radiation budget, especially perturbation by the human activity, so accurate aerosol retrievals from satellite is useful.

We have developed a new satellite remote sensing algorithm to retrieve the aerosol optical characteristics using multi-wavelength and multi-pixel information of satellite imagers (MWP method), and directly combining with the radiation transfer calculation, Rstar (Nakajima and Tanaka, 1986, 1988), numerically solved by each iteration step of the non-linear inverse problem, without using LUT (Look Up Table) with several constraints. Retrieved parameters in our algorithm are aerosol optical properties, such as aerosol optical thickness (AOT) of fine and coarse mode particles, a volume soot fraction in fine mode particles, and ground surface albedo of each observed wavelength. We simultaneously retrieve all the parameters that characterize pixels in each of horizontal sub-domains consisting the target area.

Then, we applied this algorithm to GOSAT/CAI imager data. The sensor has a characteristic band at wavelength 380nm, whose surface reflectance is low at land, and that is useful to distinguish aerosol from cloud by aerosol absorbing property over land and ocean. For the retrieval over ocean, it is necessary to correct the observed radiance at 380nm, because the observed radiance at the wavelength is affected by water leaving radiance by the light scattering in water and chlorophyll fluorescence. We added a process of radiative transfer in water including an effect of chlorophyll-a (Ota et al., 2009) into Rstar (done by Morimoto in 2015). For land, we compared retrieved and surface-observed AOTs at the CAI pixel closest to an AERONET (Aerosol Robotic Network) or SKYNET site in each region. Comparison at several sites including urban area indicated that AOTs retrieved by our method are in agreement with surface-observed AOT within 0.07. As for ocean cases, the retrieved AOTs were positively correlated with those also retrieved from GOSAT/CAI by 2-channel method (Higurashi and Nakajima, 1999). Our future work is to extend the algorithm for analysis of AGEOS-II/GLI and GCOM/C-SGLI data.

Keywords: Satellite remote sensing, Aerosol

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ACG09-33 Room:301B Time:May 28 16:30-16:45

Monitoring and detection of carbon cycle change using an integrated observation, modeling and analysis system

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There is an increase in number of observational platforms for monitoring atmospheric greenhouse gases (GHGs) such as satellites, aircrafts, ships, and ground stations. However, due to lack in measurement accuracy or observational ”blank area” in time and space high uncertainty remains in carbon budget estimations. Promotion of next-generation GHGs observing satellites is an urgent task for improving the observational data coverage and accuracy. Integrating such reinforced observations into improved data assimilation systems would be indispensable to reduce the carbon source/sink estimation uncertainties.

The purpose of our study is to produce our best estimations of carbon budget, to detect carbon cycle changes that might be appearing globally and in the Asia-Pacific under changing climate, and to timely provide scientific knowledge for developing mitigation and adaptation policies.

We are developing an integrated carbon observation and analysis system based on satellite, airborne, and ground-based observations, and atmospheric and terrestrial carbon cycle models. Aircraft observations of atmospheric CO_2 are strengthened based on the ”Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL)” project, particularly for south and southeastern Asia. Atmospheric transport modeling, inverse modeling, and assimilation methods are being tested and improved for better utilization of reinforced observation data from the Asia-Pacific region. Regional net carbon fluxes between atmosphere and land are estimated by both ”top-down” approach (with inverse models) and ”bottom-up” approach (with surface flux observation network data (e.g. AsiaFlux) and terrestrial ecosystem models). Results from different methods are compared, and similarities and differences of estimated carbon budgets are discussed.

We will present current issues for better constraints of global, continental, and regional carbon budgets, detection of carbon cycle change particularly in the Asia-Pacific region, and need of future satellite missions for better understanding of the global and regional carbon cycle.

Keywords: Atmospheric greenhouse gas, Carbon cycle, Integrated analysis system, GHGs observing satellite

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ACG09-34 Room:301B Time:May 28 16:45-17:15

Measuring Atmospheric Carbon Dioxide from Space: Early Results from the NASA Orbiting Carbon Observatory-2 (OCO-2)

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Fossil fuel combustion, deforestation, and other human activities are now adding about 40 billion tons of carbon dioxide (CO_2) to the atmosphere each year, enough to increase the CO_2 concentration by 1% per year. Interesting, ground based measurements show that, on decadal time scales, less than half of this CO_2 remains in the atmosphere. The rest is apparently being absorbed by natural *sinks* in the land biosphere and ocean, whose location and identity are poorly understood. The ground based greenhouse gas monitoring network has grown steadily over the past 50 years and now has the capability to accurately track the rapid buildup of CO_2. However, this network still does not have the resolution or coverage needed to identify or quantify CO_2 emission sources or natural sinks on regional scales.

One way to improve the resolution and coverage is to collect high resolution global measurements of the column-averaged CO_2 dry air mole fraction (X_{CO2}) from space. The Japanese Greenhouse gases Observing Satellite (GOSAT, nicknamed *Ibuki*) has been collecting these measurements since 2009. Last summer, GOSAT was joined by NASA's Orbiting Carbon Observatory-2 (OCO-2), which was successfully launched from Vandenberg Air Force Base in California on 2 July 2014. After completing a series of spacecraft check-out activities and orbit raising maneuvers, OCO-2 joined the 705 km Afternoon Constellation (also known as the A-Train) on August 6, 2014. Its 3-channel imaging grating spectrometer was then cooled to its operating temperatures and a series of calibration and validation activities was initiated. This instrument's rapid sampling, small (<3 km^2) sounding footprint, and high sensitivity, combined with the observing strategy, are expected to provide improved coverage of the ocean, partially cloudy regions, and high latitude continents than earlier missions.

In early October, OCO-2 started routinely collecting almost one million soundings over the sunlit hemisphere each day. As expected, over 10% of these soundings (100,000/day) are sufficiently cloud free to yield full column estimates of X_{CO2}. For routine science operations, the instrument's bore sight is pointed to the local nadir or at the *glint spot*, where sunlight is specularly reflected from the Earth's surface. Nadir observations provide the best spatial resolution and yield more cloud-free X_{CO2} soundings over land. Glint observations have much more signal over dark, ocean surfaces, yielding much more complete coverage of the globe. The initial observation sequence alternates between glint and nadir observations on consecutive 16-day ground-track repeat cycles, so that the entire sunlit hemisphere is sampled in both modes at 32-day intervals. OCO-2 can also target selected surface calibration and validation sites to collect thousands of soundings as the spacecraft flies overhead. The primary surface targets include well calibrated surface sites, such as Railroad Valley, Nevada, and Total Carbon Column Observing Network (TCCON) stations, which make precise measurements of CO_2 and other trace gases from the ground. Both OCO-2 and GOSAT use these sites as critical elements of their calibration and validation programs. Observations of these sites are now being used to cross calibrate the GOSAT and OCO-2 instruments and to cross validate their products, so that they can be combined in CO_2 flux inversion experiments. The OCO-2 team started delivering calibrated, geo-located, spectra to the NASA Goddard Earth Sciences Data and Information Services Center (GES-DISC) on 30 December, 2014. They will start delivering estimates of X_{CO2} and other products derived from these spectra before March 30, 2015. This presentation will describe these early products and near-term plans for a continuing close collaboration with the GOSAT team.

Keywords: Orbiting Carbon Observatory-2, OCO-2, Carbon Dioxide, CO2, Remote Sensing

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ACG09-35 Room:301B Time:May 28 17:15-17:30

The Status of NIES GOSAT-2 Project

MATSUNAGA, Tsuneo[1*] ; MORINO, Isamu[1] ; YOSHIDA, Yukio[1] ; SAITO, Makoto[1]

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GOSAT-2, the successor to Greenhouse Gases Observing Satellite (GOSAT), is a Japanese earth observation satellite being developed by Ministry of the Environment, Japan Aerospace Exploration Agency (JAXA), and National Institute for Environmental Studies (NIES) and to be launched in FY2017. It will measure column concentrations /amounts of atmospheric CO2, CH4, CO, and black carbon by a Fourier transform spectrometer (FTS-2) and a multispectral imager (CAI-2).

NIES GOSAT-2 Project is responsible for
? Algorithm development for FTS-2 SWIR Level 2 products such as CO2, CH4, and CO column concentrations/amounts
? Algorithm development for Level 4 products such as CO2 and CH4 flux
? Development and operation of Level 2 ? 4 product processing and distribution system (named G2DPS)
? Validation of selected GOSAT-2 products
? Data application studies such as atmospheric science, carbon cycle science, and climate change/air pollution related policies
? Outreach and capacity building activities

The algorithm for FTS-2 SWIR Level 2 gas column concentrations/amounts products will be based on that of GOSAT. Preliminary investigations suggest that thanks to the SNR improvement in some FTS-2 bands, random errors of GOSAT-2 XCO2 and XCH4 estimates will be several tens of percent smaller than those of GOSAT.

One of important challenges of GOSAT-2 is to provide global CO2 and CH4 flux products with higher spatial resolution and less uncertainty than GOSAT. The development of a new flux estimation system using sophisticated atmospheric transport model such as NICAM-TM and inversion scheme such as 4D-Var, as well as terrestrial biosphere and fire models, have been attempted to meet this challenge.

G2DPS is a dedicated data system for GOSAT-2 and independent from GOSAT Data Handling Facility (GOSAT DHF). G2DPS is divided into two parts, Basic Component and Processing Component. The preliminary design of G2DPS Basic Component already started and that of Processing Component will follow soon. The definitions of GOSAT-2 higher level products to be generated by G2DPS are currently being discussed with JAXA and GOSAT-2 Science Team members.

The GOSAT-2 validation plan is currently being discussed. Its basic idea is based on GOSAT experiences and data from ground-based high resolution FTS at TCCON sites will be critical to GOSAT-2 Level 2 product validation. To obtain more FTS data in the area with no TCCON sites so far, a three-year project to place a new TCCON site with a high resolution FTS in Southeast Asia has started in 2014.

Atmospheric pollution is a new and very important issue for GOSAT-2. A prototype of the atmospheric pollution monitoring system targeting east asian countries using GOSAT-2 CAI-2 data is being developed using GOSAT CAI data.

More details of NIES GOSAT-2 Project activitieswill be given in the presentation.

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ACG09-P01 Room:Convention Hall Time:May 27 18:15-19:30

Cloud-top Height Esimation Method by Geostationary Satellite Split-Window Measurements Trained with CALIPSO data

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We released a database of cloud top height and visible optical thickness (CTOP) with one-hour resolution over the tropical western Pacific and Maritime Continent, by using infrared split-window data of the geostationary satellites (MTSAT) (http://database.rish.kyoto-u.ac.jp/arch/ctop/). We made lookup tables for estimating cloud top height only with geostationary infrared observations by comparing them with the direct cloud observation by CloudSat (Hamada and Nishi, 2010, JAMC). We picked out the same-time observations by MTSAT and CloudSat and regressed the cloud top height observation of CloudSat back onto 11 micro m brightness temperature (Tb) and the difference between the 11 micro m Tb and 12 micro m Tb of MTSAT. The database contains digital data and quick look images from Jul 2005 to real time and the area in 85E-155W (MTSAT2) and 20S-20N.

Though the CTOP dataset is particularly useful for the upper tropospheric clouds, it has one serious problem. The cloud radar onboard CloudSat cannot well detect the optically thin cirrus clouds composed of small ice crystals and misses a certain part of cirriform clouds in the upper troposphere. In order to overcome this weakness, we are now making next version of the CTOP by using the lidar data (CALIOP) onboard CALIPSO satellite. One problem on the use of lidar observation is that they observe very thin cirrus formed around the tropopause. The main purpose of CTOP dataset is to provide the top height of clouds that originate from cloud clusters including cumulonimbus and nimbostratus, not of in-situ cirrus clouds formed near the tropopause. To exclude the very thin tropopause cirrus, we define cloud-top height of CALIOP observation as the height at which the optical depth accumulated from the cloud top is 0.2, instead of the CALIOP cloud top itself. With this criterion we can succeed in estimating the top height of cirruiform clouds, but it has another problem for thick clouds like cumulonimbus. For such clouds, the height of accumulated optical depth 0.2 is considerably lower than the real cloud top, possibly due to rather small number of large cloud particles near the top. Therefore, the estimation using CloudSat data is closer to the real top for the thick clouds, while that using CALIOP data is closer for cirriform clouds. So we are now making a lookup table with using both CloudSat and CALIPSO data to estimate cloud-top heights both for thick and thin clouds seamlessly.

Keywords: cloud top, geostationary satellite, split window, cirrus, tropical meteorology

ACG09-P02 Room:Convention Hall Time:May 27 18:15-19:30

Improvement of GSMaP with multi-channel geostationary meteorological satellite observation for oceanic precipitation

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The Global Satellite Mapping of Precipitation (GSMaP) produces accurate precipitation data with high time and spatial resolution (per 1hour, 0.1 degree) by utilizing the satellite microwave radiometer. At the time and place which all microwave radiometer satellites are not available, the GSMaP estimates where the precipitation area observed before that time will moves by using a cloud moving vector retrieved from the infrared brightness temperature (IR Tb) observed by the geostationary meteorological satellite (GMS). However this method has some possibility of mistaking a destination of precipitating cloud with vertical shear of environmental wind, and uses only IR1 channel of the GMS observation to calculate the cloud moving vector. Therefore, we made a new data which can estimate precipitation probability globally with high temporal and special resolution by using IR1 and water vapor (WV) channel of GMS observation, called precipitation potential map (PPM), and then improved the accuracy of GSMaP precipitation areas by utilizing the PPM (JpGU meeting, 2014).

Since it is difficult to distinguish small precipitating cumulus from non-precipitating stratus only with cloud top height information obtained from IR1 and WV channels, the past PPM has low accuracy of estimating precipitation area for low cloud. Therefore this study first tried to improve the accuracy of PPM for low cloud by adding multi-channel information obtained from Meteosat Second Generation (MSG2). The utilization of GMS multi-channel observation is important from the point of view of preparing next-generation GMS, Himawari-8, Himawari-9, GOES-R series, and Meteosat Third Generation. Next we included the modified PPM into GSMaP precipitation detection algorithm to improve GSMaP precipitation area and precipitation intensity product, and investigated the accuracy of modified GSMaP precipitation product by comparing them with precipitation radar (PR) of Tropical Rainfall Measurement Mission (TRMM) as it is truth. We will intend to explain the result of case study of tracking precipitation system over the ocean under vertical wind shear with modified and non-modified GSMaP. In these areas and conditions, we can expect that the GSMaP estimates the precipitation area more accurately by utilizing the potential map. In these circumstances, we can expect that the GSMaP precipitation estimation becomes more accurate by utilizing the PPM.

We used five geostationary satellites, MSG2, METEOSAT, GOES-West, GOES-East, and MTSAT-1R. All geostationary satellite data is released from the Center for Environmental Remote Sensing, Chiba University (CEReS). Global Satellite Mapping of Precipitation (GSMaP)_MVK and GSMaP_NRT (v6.000.0) was used as satellite observation of precipitation with the microwave sensor. The GSMaP products are produced by Earth Observation Research Center (EORC) in Japan Aerospace Exploration Agency (JAXA). We used near surface rain observed by the precipitation radar of the Tropical Rainfall Measurement Mission (TRMM PR; 2A25, V7) as truth.

Keywords: geostationary meteorological satellite, precipitation, GSMaP

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A greenhouse gas retrieval algorithm for GOSAT TANSO-FTS SWIR using polarization information

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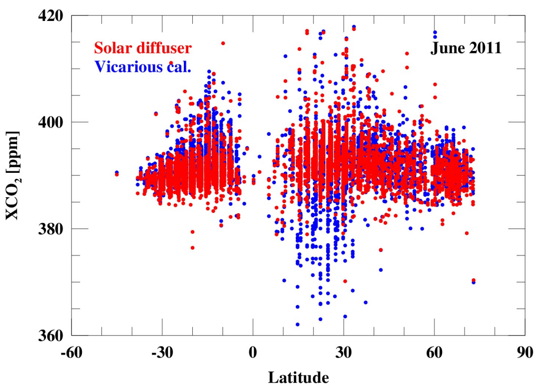
TANSO FTS is a Fourier transform spectrometer onboard the Greenhouse Gases Observing Satellite (GOSAT), which is in orbit after the launch in January 2009. TANSO-FTS measures two orthogonal polarizations of solar backscattered spectra at three narrow bands in the short wave infrared (SWIR). It is expected that by using the polarization information, undesirable effects of cloud and aerosols on greenhouse gas retrievals are corrected more effectively, and the accuracy of the retrievals is improved. So far, no retrieval algorithm has been realized which uses polarization information of TANSO-FTS. In this study, for the first time, we present retrieval results of column-averaged concentrations of carbon dioxide (XCO_2) from polarized TANSO-FTS SWIR spectra.

Accurate radiometric calibration of the two polarized spectra is one of the most crucial factors for successful retrievals from TANSO-FTS spectra. With a simulation study conducted under the idealized situation that there is no calibration error in calibration coefficients of TANSO-FTS, we showed that the polarization information increases the information content of the aerosols and reduces retrieval errors in XCO_2. In fact, degradation of the sensor is not avoidable. Unless the calibration coefficients are evaluated after the launch with sufficient accuracy, polarization information of TANSO-FTS will not improve the XCO_2 retrievals.

In this study, retrievals of XCO_2 were compared using several calibration coefficients evaluated in different methods. The figure shows XCO_2retrievals from TANSO-FTS measurements over land in June 2011. Blue dots in the figure are results obtained with calibration coefficients evaluated from vicarious calibration reported by Kuze et al. (TGRS, 2014). We also tried to evaluate calibration coefficients from the solar calibration data by analyzing polarization properties of the solar diffuser panel. Retrievals of XCO_2 with the solar diffuser calibration are plotted by red dots in the same figure. Comparing these results obtained with two different calibration coefficients, we found that the values of XCO_2 with the vicarious calibration tend to scatter toward a low concentration in the Sahara desert. On the other hand, this tendency is hardly seen in XCO_2 retrievals with the solar diffuser calibration. Also, some high XCO_2 regions are observed in South America and Southern Africa in the retrievals with the vicarious calibration, which are not seen in the retrievals with the solar diffuser calibration.

Our result indicates that the calibration coefficients make a marked difference in retrieved XCO_2 if the polarization information is used. We plan to analyze more observations, and to try another calibration technique, such as ocean glint observations.

Keywords: satellite observation, carbon dioxide, GOSAT



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Evaluation of Satellite-Borne Radar, Lidar, and Imager Algorithm for Retrieval of Cloud Microphysical Properties

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We developed algorithm for the retrieval of effective radius (R_{eff}) and cloud water content (CWC) of clouds by using collocated CloudSat 94 GHz cloud radar, CALIPSO lidar and MODIS imager. Main aim of the study is to evaluate uncertainties of the algorithm. The radar and lidar retrieval algorithm was initially developed by Okamoto et al., (2010) for ice cloud region detected by radar and lidar. And Sato and Okamoto (2011) extended the range of applicability to the ice regions detected radar or lidar. Then Okamoto et al., (2014) further extended the algorithm by introducing optical thickness (τ_{vis}) information from MODIS that can be applicable to both ice and water clouds, and rainy regions detected radar or lidar. Here RL and RLI denote radar or lidar algorithm and radar/lidar with τ_{vis} algorithm from imager (RLI). Major source of uncertainties in the RL is the treatment of radar only detected clouds and precipitation where lidar signal is totally attenuated and we introduced empirical formula in radar-only region derived from ground-based Doppler cloud radar observations.

In this presentation, cloud microphysics of convective clouds was analysed in September 10, 2006 over the Pacific Ocean. We examined the vertical distribution of R_{eff}, CWC, τ_{vis} as well as cloud water path (CWP). By using τ_{vis} as a constraint, R_{eff} is ~ 50 μm smaller than RL results and ~ 300 μm smaller than RL results in the water cloud region below ~ 5 km. Responding to this trend, IWC was 0.5 g/m^3 larger and LWC was 0.01 g/m^3 larger compare to the RL ones. We also compared τ_{vis} and CWP between from MODIS, RL, and RLI.

Instead of retrieved τ_{vis}, MODIS reflectance was also combined with RL and we examined the uncertainties in the both versions of RLI algorithms, due to the possible variability of ice particle shape and orientations.

In 2017, the joint European and Japanese satellite mission EarthCARE, which will carry a Doppler cloud radar, high-spectral resolution lidar, multi-spectral imager, and broadband radiometer, is scheduled to launch. We discuss how to use Doppler information to reduce the retrieval errors. The algorithm described above will be adapted to the standard algorithm.

Keywords: synergy, radar, lidar, imager, cloud microphysics

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Current status and development of Cloud analysis algorithms based on EarthCARE/MSI observation

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Clouds and aerosols are the major uncertainty in the understanding of the Earth's climate system. An improvement of understanding and better modeling of the relationship of clouds, aerosols and radiation are therefore prominent part in climate research and weather prediction. It is important to obtain the global data of clouds and aerosols occurrence, structure and physical properties that are derived from measurements of solar and thermal radiation.

EarthCARE (Earth Clouds, Aerosols and Radiation Explorer) is one of the future earth observation mission of ESA and JAXA. This mission aims at understanding of the role that clouds and aerosols play in reflecting incident solar radiation back into space and trapping infrared radiation emitted from Earth's surface. These observations are needed to improve the precision of climate variability prediction.

The mission will achieve the objectives by measuring the vertical structure and horizontal distribution of clouds and aerosols globally. The satellite will carry four instruments for observations of clouds and aerosols; Atmospheric Lidar (ATLID), Cloud Profiling Rader (CPR), Multi-Spectral Imager (MSI) and Broad-Band Radiometer (BBR). MSI provides across-track information on clouds and aerosols with channels in the visible, near infrared, shortwave and thermal infrared. Two products based on CLAUDIA [Ishida and Nakajima, 2009] and CAPCOM [Nakajima and Nakajima, 1995; Kawamoto et al., 2001] are advanced in this study. In this presentation, current status and development of algorithms will be introduced.

Keywords: EarthCARE, MSI, cloud, aerosol

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Early phase retrieval of aerosol optical characteristics by Himawari-8

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Himawari-8 is a geostationary meteorological satellite launched in October 2014 by. It equips an imager, called Advanced Himawari Imager (AHI). Himawari-8/AHI is a latest imager as a geostationary satellite. For example, AHI has 16 bands from visible (0.47um) to thermal infrared (13.3um) Moreover, AHI can observe East Asia, South-East Asia, Oceania, and West Pacific area as often as 10 min. The resolutions of sensors are as fine as 0.5km for 0.64um, 1.0km for 0.47um, 0.51um, and 0.86um, and 2.0km for 1.6um to 13.3um. These high resolution and high frequent observation are very unique for geostationary satellite. We are selected as "Himawari-8's data quality evaluator" by JMA, and now JAXA is receiving Himawari-8's data.

In this study, we have retrieved aerosol characteristics from Himwari-8's data. As a package of aerosol retrieval, we used REAP (Higurashi and Nakajima, 1999), and retrieved aerosol optical thickness and Angstrom Exponent over the ocean. We need to assume some of the parameters of aerosol in the satellite remote sensing when we make Look Up Table. We have assumed bimodal-lognormal distribution as a size distribution. Mode radii and standard deviations are cited by Fukuda et al (2013)'s value. mode radius for coarse mode is 3.86um and that for fine mode is 0.148um. Standard deviation for coarse mode is 2.0 and that for fine mode is 1.56. Complex refractive indexes are calculated from AERONET (Aerosol Robotic Network) observations. We used AERONET data in Anmyon (126.330E, 36.539N), Baengnyeong (124.630E, 37.966N), Fukuoka (130.475E, 33.524N), Gangneung WNU (128.867E, 37.771N), Shirahama (135.357E, 33.697N), and Yonsei University (126.935E, 37.564N), and we calculated the average value; 1.51 + i$*$0.0226 for 0.64um and 1.53 + i$*$0.0233 for 0.86um. As a threshold of cloudiness, we applied CLAUDIA's threshold test concept. (Ishida et al., 2009) However, some of the thresholds are tuned for Himawari-8. We will also compare our result with ground truth obtained by AERONET.

Keywords: Himawari-8, aerosol

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Cloud detection algorithm using TIR spectra for improving gas retrievals from GOSAT data

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Thermal And Near-infrared Sensor for Observation (TANSO) onboard Greenhouse gases Observing SATellite (GOSAT) consists of Fourier Transform Spectrometer (FTS) and Cloud and Aerosol Imager (CAI). Greenhouse gas concentrations are retrieved from the shortwave infrared (SWIR) bands and the thermal infrared (TIR) for scenes judged to be cloud and aerosol free through the cloud screening procedure with CAI observations. However, CAI does not operate during nighttime although TIR data can be obtained. Moreover, it has no sensitivity for cloud and aerosol heights which must be measured to decrease the currently reported gas concentration biases. Therefore, we developed an algorithm to detect optically thin clouds and dust aerosols with their heights from TIR data. The algorithm used in this study was based on a cirrus detection technique called CO2 slicing method, modified as described below. The weighting functions which represent sensitivity profiles were calculated at each channel in the TIR band of GOSAT. The channels were reconstructed as sets of several spectral channels for each height level based on the peak heights of the weighting functions. Subsequently, the channel combinations were optimized based on simulation studies for several temperature profile patterns for each latitude and temperature at 500 hPa. The observed data were analyzed using these optimized channels. Global tropospheric cloud amounts and cloud properties such as cloud top heights and optical thickness were validated using CALIPSO data.

Monthly mean cloud amounts from GOSAT data were compared with those from CALIPSO. Results show some differences of cloud amounts and heights between GOSAT and CALIPSO, which might be caused by surface temperature biases, the difference of sensitivity of sensors, the inverse layer, and marine stratocumulus clouds. However, the horizontal distributions of clouds derived using the slicing method resembled those obtained from CALIPSO and it was revealed that the slicing method algorithm has high sensitivity compared with TIR threshold cloud screening which is currently adopted as the cloud screening method for GOSAT data in nighttime. Cloud properties were also compared for coincident observation between GOSAT and CALISPO and the results showed that the accuracy of cloud detection is improved drastically by the new approach presented in this study. Clouds with optical thickness less than 0.1 are detectable using this method. Based on these results, the slicing method algorithm developed for this study seems to be useful for cloud screening. It is expected to improve the accuracy of greenhouse gas observations.

Keywords: satellite remote sensing, greenhouse gas, cirrus