Evaluation of improved sea surface wind products from AMSR2 on GCOM-W

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An improved version of the sea surface wind speed products (version 3 beta) from the Advanced Microwave Scanning Radiometer-2 (AMSR2) on the Global Change Observation Mission-W (GCOM-W) satellite were evaluated by comparisons with offshore moored buoy measurements, outputs from the European Centre for Medium-Range Weather Forecasts (ECMWF) Interim Reanalysis (ERA-Interim), and vector wind data from the RapidScat scatterometer (RSCAT) onboard the International Space Station (ISS). In general, the AMSR2 wind speeds agreed well with the reference data. The Root Mean Square (RMS) difference between the AMSR2 and buoy measurements was 1.13 m/s, which is close to the mission goal of 1 m/s. It is clearly exhibited that a systematic bias, which was discernible in the previous version (version 2.1) of the AMSR2 wind products, has been reduced in the latest version. Results of the triple collocation analysis suggest that the random errors in the AMSR2 version 3 wind speed are very close to 1 m/s and are smaller than those in the outputs from the numerical weather prediction (NWP) models, if random errors in the reference wind data (buoy, NWP, and RSCAT) are considered explicitly.

Keywords: AMSR2, GCOM, Microwave radiometer, Sea surface wind, Air-sea interation, Remote sensing

Validation and intercomparison for high resolution gridded product of surface wind vectors over the global ocean

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Gridded products of surface wind vectors over the global ocean are constructed using multiple satellite data by microwave scatterometers and radiometers. Our new products, called the new version of the Japanese Ocean Flux data sets with Use of Remote-Sensing Observation (J-OFURO) V3, consist of various surface parameters such as sea surface temperature and specific humidity, and have temporal and spatial resolutions with daily mean and 0.25 x 0.25 degrees and cover a period from 1988 to the current. In our new procedure to derive gridded products of wind vectors with high resolutions, we combine data from microwave radiometers as well as scatterometers such as SSMI, AMSR-E, TMI, ERS-1,2, QuikSCAT, ASCAT. These gridded products are validated using our newly-designed quality control system (QCS) in which the reliabilities for various gridded products are examined by comparison with all available in-situ measurement data by moored buoys. Validations are also made by intercomparisons with other gridded products by single satellite (QSCAT and ASCAT), numerical model reanalysis (NRA-1, JRA55 and ERA-interim) and their combined “hybrid” (CCMP) products.
Results reveal that the J-OFURO3 product has relatively higher reliability than other satellite and reanalysis ones and lower than the hybrid one(CCMP), especially in the tropical Pacific region. Intercomparisons between the J-OFURO3 and CCMP exhibit noticeable spatial features in mean differences and correlations which are clearly dependent on buoy locations. This suggests that the CCMP product constructed by procedures including assimilation of buoy measurement data has inhomogeneous reliability in space, compared with our satellite-based product. Divergence and curl fields are derived from these gridded products of wind vectors, and similar spatial features are found in the tropical Pacific region.

Keywords: Wind vector, global ocean, multiple-satellite data

High Wind Observations within Extratropical Cyclones as Observed by Different Microwave Radiometers and Scatterometers

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The validation of high wind speed measurements has proven to be extremely challenging due to the lack of surface truth, different sensor characteristics and their suitability for high wind observations, as well as different observation times. Because of this lack of surface truth, the forward models and geophysical model functions utilized in wind retrieval algorithms for different sensors are more often than not extrapolated and very hard to verify. Moreover, many high wind speed algorithms, especially from microwave radiometers, were developed with the goal of retrieving the extreme winds within tropical cyclones that would match aircraft-based high spatial resolution observations, even though the spatial resolution of the satellite observations is much coarser than that of both the aircraft-based measurements and measured physical phenomena. The implications have impact on both the operational use of high wind speed data as well as determining climatological trends and wind field characteristics.

Extratropical cyclones that reach hurricane force (HF) intensity are a significant threat to the safety of life at sea and a risk to cargo and vessels. Extratropical cyclones vary on scales from less than 100 km in diameter up to 4,000 km in diameter and have an average life cycle of five days from genesis to death. Associated wind conditions can range from light (10 to 20 knots), near gale (25 to 32 knots) gale force (33 to 47 knots), storm force (48 knots to 63 knots), or HF (greater than 63 knots). Knowledge of the wind structure, and in particular the frequency of occurrence and distribution of HF winds in extratropical cyclones has been greatly enhanced by data from the QuikSCAT scatterometer. Studies of the wind distribution within mature ETCs from the QuikSCAT scatterometer (cite our igarss paper) have shown there is more than a 20% probability of encountering gale force winds within 1000 km of the storm center at any time and direction for extratropical cyclones that reached the mature stage. The storm force winds can span beyond 1000 km from the storm center with the frequency decreasing significantly in the overall direction of motion. HF winds are concentrated within 1000 km radius west, south and southeast from the center relative to storm motion direction. Therefore, the spatial resolution of high winds within extratropical cyclones is suitable for all current radiometer and scatteroemter sensor observations. However, frequent observation of ETC’ s by the RapidScat and GPM sensors as well as the two ASCAT scatterometers have shown that high winds can change drastically over a 30 min time period. Therefore, any comparisons of wind retrievals by different sensors can be misleading and must be done carefully. To overcome this problem we compare composites of ETCs as obtained from wind observations from all radiometer and scatterometer different sensors.

To study the wind field distribution in these extreme ocean storm, composites of ocean surface wind speed fields were created by using a 50°x 50° wide box that was divided into 400 lat/lon grid cells. This resulted in an approximate grid resolution of 12.5 km. The grid box was centered on the storm center locations obtained from Ocean Prediction Center best track storm file.

Keywords: extratropical cyclones, high winds, scatterometer, microwave radiometer

A Category ‘6’ Trio –Supertyphoons Meranti (2016), Haiyan (2013), and Hurricane Patricia (2015)

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With peak intensity reaching 165 kts, supertyphoon Meranti was the most intense tropical cyclone on earth in 2016. Only 5 kts below the devastating super-typhoon Haiyan in 2013, Meranti was the 2nd most intense western Pacific typhoons on record. In ~2.5 days, it rapidly intensified from category-1 to an impressive, category ‘6’ (Lin et al. 2014; Lin et al. submitted 2017) intensity of 165 kts. Similar to Hurricane Patricia (185 kts, 2015, Huang et al. 2017) and Supertyphoon Haiyan (170kts, 2013), the peak intensity of these tropical cyclones are far above (30-50kts) the existing threshold (135 kts) of category-5 in the Saffir-Simpson scale. In addition, their intensity square (representing kinetic energy and a function of the Accumulated Cyclone Energy) is 140-180% higher than a ‘regular’ category 5 cyclone of 140kts. In terms of intensity cube (a function of the Power Dissipation Index), these extra-ordinary storms are 165-230% higher than a 140 kts category 5 cyclone (Lin et al. 2014; Lin et al. submitted 2017). This research highlights the importance of adding the new category ‘6’ (165-185 kts) to the current Saffir-Simpson scale, for more accurate disaster mitigation and public awareness, because these category ‘6’ TCs may carry much higher energy than regular category ‘5’ TCs (e.g. other 140kts category 5s). In addition, they were all found to be associated with very favourable sea surface temperature (SST~30C) and subsurface heat content conditions (~120-140 kJ/cm^2.). This research further explores their interaction with ocean, as well as the oceanographic origin of these extremely favorable ocean conditions.

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Ocean Color from GCOM-C and Himawari-8

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JAXA polar orbit satellite, Global Change Observation Mission for Climate (GCOM-C) which carries Second-generation Global Imager (SGLI) will be launched in 2017. SGLI will have 19 bands from near-UV (380 nm) to thermal infrared (12 um) wavelengths with 1150-km swath width. A key characteristic of SGLI for the ocean color observation is high spatial resolution (250 m). JMA geostational meteorological satellite, Himawari-8 has been in regular operation since July 7, 2015. Himawari-8 carries Advanced Himawari Imager (AHI) which has six spectral bands from visible to shortwave infrared wavelengths (470 nm, 510 nm, 640 nm, 856 nm, 1610 nm, and 2257 nm) with 500-m (640-nm band), 1-km (470, 510, and 856-nm bands), and 2-km (1610, and 2257-nm bands) spatial resolution.
Characteristics of the AHI for the ocean-color observation are high temporal resolution (10 min for the full-disk observation), small number of spectral bands, and relatively lower signal-noise-ratio (SNR) than general ocean-color sensors because the main target of AHI is meteorological observations. We have developed empirical ocean-color algorithms for SGLI and AHI spectral response (Murakami et al., OSJ 2015 fall meeting).
The SGLI 250-m spatial resolution can be advantage in monitoring of fine structures of coastal areas and front of currents, and detection of local phenomena such as red tide. However, they can change quickly and sometimes cannot be tracked by the temporal resolution of SGLI (once/2-day). Accuracy of ocean color estimate from instantaneous AHI measurements (every 10 min) is relatively worse due to the limited number of bands and low SNR. This study shows, however, the random noise can be reduced by averaging for about one hour (i.e., six scenes) when the 1- or 2-km scale phenomena can be assumed to be stable for an hour. Daily movement of front structures can be detected by the hourly AHI ocean color. Effective use of high spatial resolution data of the polar orbit satellite such as GCOM-C and high temporal resolution data of the geostationary orbit satellite such as Himawari-8 will be required in the next step.

Keywords: GCOM-C, SGLI, Himawari-8, Ocean color

Ocean color remote sensing of Chromophoric Dissolved Organic Materials (CDOM) for Second-generation GLobal Imager (SGLI) onboard the Global Change Observation Mission-Climate satellite (GCOM-C)

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Ocean is a large reservoir of the dissolved organic carbon on the Earth, storing approximately 38,000 PgC. Satellite observation methodologies have been developed by various researchers and space agencies and been offering a synoptic view of an optical proxy of the colored dissolved organic materials (CDOM) in the surface ocean on various temporal and spatial scales (e.g. from local and daily to global inter-annual scales). Second generation GLobal Imager (SGLI) onboard Global Change Observation Mission –Climate satellite (GCOM-C), to be launched by Japan Aerospace eXloration Agency (JAXA), also intends to measure CDOM in the surface ocean over the next several years, and a satellite algorithm for the new sensor was developed. The algorithm was based on a coupling of ocean colour inversions. One of the challenges in such inversion procedure has been to separate optically similar signals between CDOM and other detrital materials. Two empirical separations of these materials, different in terms of the degree of complexity in the algorithm, was tested. It was shown that a moderate complexity, rather than most simple nor complex, might give the best retrieval of CDOM under a current limitation in our ability to model every bio-optical processes.

Keywords: Ocean color, CDOM, SGLI, GCOM-C, remote sensing

Examples of Multi-Satellite Analyses for Advancing Earth System Science

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This presentation will describe NASA’s current and planned Earth observing capabilities, the resulting science and applications,and NASA’s long-standing partnership with Japan, with particular emphasis on the revolutionary use of multi-satellite heterogeneous and homogeneous constellations. NASA and the Japan Aerospace Exploration Agency (JAXA) have a long history of collaboration on satellite missions and are cooperating on several Earth observing constellations. NASA and JAXA have partnered for the last several years on calibration and validation activities associated with JAXA’s Greenhouse Gases Observing Satellite (GOSAT) and NASA’s Orbiting Carbon Observatory (OCO0-2) missions. And in 2012, JAXA’s Global Change Observation Mission - Water (GCOM-W1) satellite joined Aqua and other NASA missions as part of the international Afternoon Constellation (A-Train). The results from these (and other) Earth observing missions are expanding our knowledge of the current state of the Earth system and our ability to predict how it may change in the future. These data also enable a wide range of practical applications that benefit society.

Keywords: TRMM, GPM, GOSAT, ASTER, AMSR-E, A-Train, Constellations, Small-Satellites, International Space Station

From Satellite Data to Informatics –Towards The Development of Satellite-based Real-Time Informatics in Community Satellite Processing Package (CSPP)

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In cooperation with the United States National Oceanic and Atmospheric Administration (NOAA) and National Aeronautic and Space Administration (NASA), Cooperative Institute for Meteorological Satellite Studies (CIMSS) of Space Science and Engineering Center (SSEC) is continuing to develop NASA-supported International MODIS/AIRS Processing Package (IMAPP) and NOAA-funded Community Satellite Processing Package (CSPP). These community software packages are to provide both official and users developed algorithms and processing codes for the optimal and broad use of international polar orbiter satellite and geostationary satellite data collected from NOAA/NASA S-NPP, GOES-R, EUMETSAT METOP series, and Japanese Meteorological Administration (JMA) Advanced Himawari Imager (AHI).

This paper starts with the overview of ~16 years (2000-2016) of success of IMAPP and CSPP as a pathway to the development of a freely available software package to transform MODIS, AIRS, AMSU, VIIRS, CrIS, and ATMS Raw Data Records (RDRs) (i.e. Level 0) to Sensor Data Records (SDRs) (i.e. Level 1), SDRs to Environmental Data Records (EDRs) (i.e. Level 2) and Information Data Record (IDRs) in support of Terra, Aqua, Suomi NPP and subsequently the JPSS and GOES missions under the CSPP framework.

Moreover, the current innovations in the development of Information Data Record (IDR) from single or multiple EDR and other ancillary and auxiliary data, to become the foundation of CSPP informatics. Examples of real-time applications using EDRs and IDRs in nowcasting and nearcasting of severe weather, aviation operation and air quality monitoring are to be highlighted. Summary is given to conclude this community effort in facilitating the user-friendly end-to-end calibration, navigation, product generation and information integration that are suitable and freely available to all users of meteorological and environmental satellites.

Keywords: Community satellite processing package, Sensor Data Record; Environmental Data Record; Information Data Record, Nowcasting; Nearcasting

Sustainable Development Goals (SDGs) and Earth observations-JAXA's activities for SDGs

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In adopting the 2030 Agenda for Sustainable Development in September 2015 at a High-level Political Forum on Sustainable Development, world leaders agreed that a global indicator framework was necessary to measure, monitor and report progress towards the 17 transformational Sustainable Development Goals (SDGs) and 169 associated Targets.
To track progress towards these Goals and Targets, the global indicator framework must capture the multi-faceted and ambitious aspirations for the continued development of nations and societies. Effective reporting of progress toward these indicators will require the use of multiple types of data, both what we have in hand - traditional national accounts, household surveys and routine administrative data –and new sources of data outside national statistical systems, notably Earth observation (EO) and geospatial information (GI), and ‘Big Data’ in general.
The integration of all these data can produce a quantum leap in how we monitor and track development and advance the well-being of our societies. Since Earth observation and geospatial information are often continuous in their spatial and temporal resolutions, their use in SDG monitoring can prove essential in capturing the sustainability of developments underpinning the SDG framework. Earth observation and geospatial information, which include satellite, airborne, land- and marine-based data, as well as model outputs, will expand monitoring capabilities at local, national, regional and global levels, and across sectors.
Earth observation and geospatial information can significantly reduce the costs of monitoring the aspirations reflected in the goals and targets, and make SDG monitoring and reporting viable within the limited resources available to governments. Beyond the SDG framework, these same data can provide developing countries and regions with increased capacity to acquire, analyse and utilise information for a broad range of policy-making purposes.
The Japan Space Exploration Agency (JAXA) is actively promoting use of satellite-based Earth observations for SDGs through the Comittee on Earth Observation Satellites (CEOS) and the intergovernmental Group on Earth Observations (GEO) in cooperation with national statistical office and related ministries and agencies, and UN and other interantional organizations. Current status of JAXA activities for exploring the applications of satellilte based Earth observations to SDGs and their prospects will be presented.

Keywords: SDGs, Sustainable Developmetn Goals, indictor framework, Earth observation

GPM SLH latent heating retrievals with a study on extratropical precipitation systems

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Diabatic heating associated with convection plays essential roles in energy budget in the global atmosphere, driving large-scale circulation, and intensifying various kinds of storms. Dual-frequency Precipitation Radar on board the Global Precipitation Measurement core satellite (GPM DPR) has expanded our ability to consider such convective latent heating in the extratropical regions, in addition to tropical regions where we have estimated the latent heating with the Tropical Rainfall Measuring Mission Precipitation Radar (TRMM PR) observations (TRMM Spectral Latent Heating algorithm; Shige et al. 2004, 2007, etc.). In order to construct an algorithm to retrieve the convective latent heating in the extratropics, we examined the relationship between the precipitation and latent heating in extratropical environments, utilizing GPM DPR data with the aid of cloud-resolving numerical model simulations, contrasting it with tropical precipitation.

For the SLH retrieval algorithm in the tropics, we simulated the TOGA-COARE precipitation with the Goddard Cumulus Ensemble Model, from which we made three spectral look-up tables (LUT) of latent heating profiles for convective, shallow stratiform rain, and deep stratiform rain. Utilizing TRMM PR rain profiles as well as GPM Ku-band Precipitation Radar (KuPR) rain profiles with these tables, we retrieved the latent heating associated with precipitation in tropical and subtropical regions.

Extratropical precipitation consists of systems very different from the tropics. The most dominant system there is the extratropical cyclone and associated frontal systems. The largest difference may reside in the stratiform precipitation. While deep stratiform precipitation is associated with deep convection in the tropics almost without exception, in the extratropics, large-scale ascent associated with frontal systems can result in deep stratiform precipitation from the large-scale condensation. The deep stratiform cloud base in the tropics is, therefore, almost fixed at the freezing level, but it does not necessarily correspond to the freezing level in the extratropics.

As a strategy to obtain adequate LUTs for extratropical systems, with a collaboration of the JMA numerical weather forecast group, we collected forecast run outputs for extratropical systems with the JMA Local Forecast Model (LFM). With these data, we analyzed the simulated precipitation and latent heating for extratropical systems, to produce LUTs for GPM KuPR.

To this end, we had to overcome several hurdles: (1) To obtain consistent LFM and KuPR precipitation flux, (2) to attain consistent convective/stratiform separation, (3) to obtain adequate cloud-base and freezing level relationships, (4) to detect cloud base adequately from the GPM KuPR, and (5) to handle multi-layer precipitations. After solving these problems, we obtained convective precipitation tables looked up with precipitation top heights, and stratiform precipitation tables looked up with cloud-base precipitation intensities. Results from applications of GPM KuPR data to these latent heating LUTs also will be discussed.

GOES-16 Advanced Baseline Imager (ABI) On-Orbit Performance

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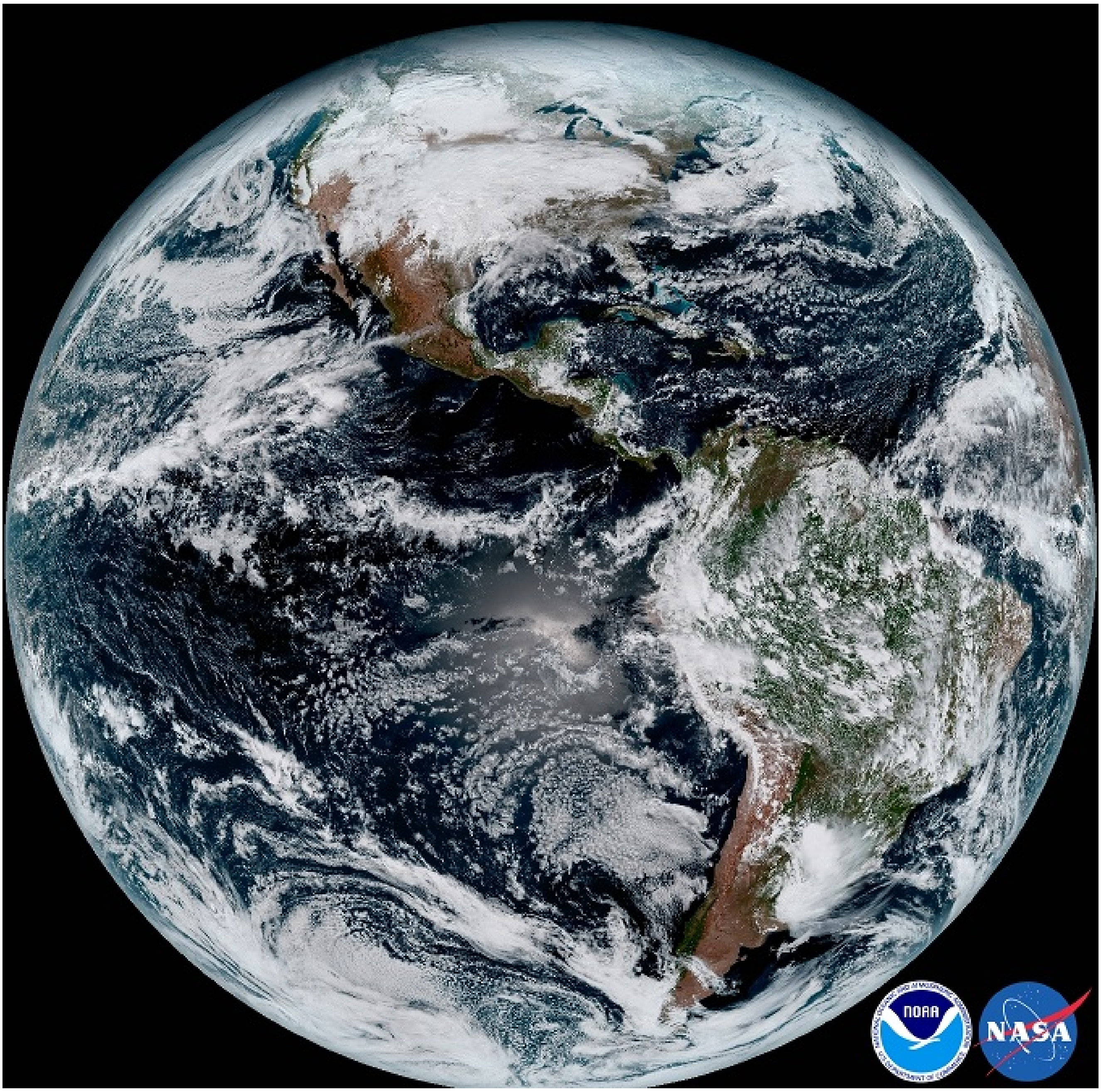
1. Harris Corporation

The GOES-16 Advanced Baseline Imager (ABI) is the first of the United States' next-generation geostationary imagers for weather and environmental monitoring. The design and capabilities are the same as Himawari-8 and -9, but with some differences in the spectral bands. With three times the spectral bands, four times the resolution, and five times the image collection rate, the GOES-16 ABI will significantly improve the quality and frequency of existing data products and provide many new weather and environmental products. It is currently undergoing post launch testing and is scheduled to become operational in November 2017.

The ABI post-launch test campaign takes place from January to June 2017. These tests verify compliance with requirements as well as thoroughly characterize the performance of the instrument, including long-term performance trending. This presentation provides measured, quantitative performance results showing the very high quality of ABI's imagery, including SNR and NEdT, MTF, line-of-sight stability, navigation and registration, and calibration stability. Although the post-launch testing will not be complete, all of these critical performance aspects will have been measured and trended. Understanding the quality of this imagery is the first step in assessing the quality of the many ABI-based L2+ data products.

Keywords: weather, satellite, geostationary, ABI, GOES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Five years Global Water Cycle Observation by the Global Change Observation Mission - Water (GCOM-W)

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The Global Change Observation Mission (GCOM) is consists of two medium sized satellites to provide comprehensive information of the Essential Climate Variables (ECV) of atmosphere, ocean, land, cryosphere, and ecosystem. The GCOM-W (Water) or "SHIZUKU" satellite that is carrying the Advanced Microwave Scanning Radiometer 2 (AMSR2), which was launched from JAXA Tanegashima Space Center on May 18, 2012 (JST); and GCOM-C (Climate) satellite that will carry the Second Generation Global Imager (SGLI) and is scheduled to be launched in Japanese Fiscal Year of 2017.

AMSR2 on board the GCOM-W satellite is multi-frequency, total-power microwave radiometer system with dual polarization channels for all frequency bands, and 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, and completed its operation in December 2015. Basic concept of AMSR2 is almost identical to that of AMSR-E. AMSR2 standard products, including brightness temperature and eight geophysical parameters that related to water cycle, have been introduced to many operational and science applications quickly. AMSR2 standard products are available from the GCOM-W1 Data Providing Service (https://gcom-w1.jaxa.jp/). The latest version of AMSR2 products is Ver. 2.0 (as of February 2017) that was released in March 2015, and JAXA is planning to release new Version 3 standard products for several geophysical parameters, including sea surface temperature and sea surface wind speed, which do not satisfy required standard accuracies in Ver.2, in March 2017. With release of Ver.3 standard products, all AMSR2 standard products satisfy required standard accuracy and achieve mission success criteria of the GCOM-W mission.

AMSR2 products are used in various operational and research fields, including weather forecast, typhoon analysis, global rainfall map, ocean monitoring, fisheries, sea ice extent monitoring and maritime navigation in polar regions. At the meeting, we will highlight major topics of achievements done by the GCOM-W mission in five years.

Since designed mission life of the GCOM-W satellite is five years and will be achieve in May 2017, we have started discussion of possible follow-on mission with various user communities as well as expansion of application of AMSR2 and follow-on data in new fields.

Keywords: satellite remote sensing, water cycle, microwave radiometer

Development of CloudSat/CALIPSO- and EarthCARE-algorithms for studies of cloud macroscale- and microphysical properties

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This work improved on cloud mask, cloud particle type and cloud microphysics algorithms that can be applied to CloudSat-CALIPSO and EarthCARE satellites. We first revised the cloud mask algorithm designed for CALIPSO lidar developed by Hagihara et al., to increase the detectability of cloud bottom regions in CALIPSO lidar observations. Algorithm for cloud particle type (cloud phase and orientation of ice particles) developed by Yoshida et al., is also refined. Introducing the new function, cloud particle phase near cloud bottom is better characterized by the revised algorithm. Retrieval algorithm for ice cloud microphysics is also carried out to extend the one developed by Sato and Okamoto with modified look up tables for ice particles. That for water cloud microphysics was newly implemented.
The refinements were achieved by using the new type of ground-based lidar, Multiple-Field of View Multiple Scattering Polarization lidar (MFMSPL) with cloud radar. MFMSPL was designed to measure enhanced backscattering and depolarization ratio comparable to space-borne lidar. The system consists of five sets of parallel and perpendicular channels with different zenith angles. We first evaluated our former cloud mask scheme. It was applied to the data obtained by the MFMSPL and it was found that the cloud mask scheme underestimated cloud top portions. New cloud mask scheme showed improvement in the detectability of cloud top portions. Co-located 95GHz cloud radar and MFMSPL with the new cloud mask scheme showed good agreement at the cloud top altitude. The cloud mask scheme also has a function to identify fully attenuated pixels where lidar and cloud radar signals are totally attenuated.
Our former cloud particle type algorithm was evaluated by the observed attenuated backscattering coefficient and depolarization ratio by off-beam channels of MFMSPL. Extinction-depolarization ratio diagram is created based on the observed data. The analyses of MFMSPL show that large depolarization ratio with small attenuation can be caused by water clouds. The features have not observed in the CALIPSO lidar data since our former cloud mask scheme did not detect cloud bottom portions in the analysis of CALIPSO lidar data and such features are found in the regions newly detected by the improved cloud mask algorithm. The new feature is implemented in the refined cloud particle type algorithm to better discriminate ice and water where lidar signals are largely attenuated and depolarization ratio increased.
We report the results of global analyses of cloud fraction, ice/water fraction and ice/water microphysics by using CloudSat and CALIPSO. We also discuss possible extension of the algorithms for cloud profiling radar (CPR) and high spectral resolution lidar (ATLID) on EarthCARE.

Keywords: cloud, radar, lidar

Global water cloud microphysics from active sensor synergy toward the EarthCARE mission

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Retrieval of global water cloud microphysics from space-borne lidar and cloud radar is on focus. Issues exists in how quantitatively multiple scattering effects from vertically inhomogeneous cloud layers are estimated for microphysical inversion, and in the reliability of low-level cloud detection in this connection. In our previous studies, A prototype of the microphysics retrieval algorithm combining the lidar attenuated backscattering coefficient, depolarization ratio and Cloud radar observables were developed for particle sizing and cloud particle-drizzle mass ratio estimates. There, the lidar returns from inhomogeneous clouds were simulated by combining look-up-tables of the parallel and perpendicular components for homogeneous profiles according to their contribution to the total path to reflect inhomogeneity effects. In this study, improvements were made in that area to replace the former approach by a numerically effective and flexible physical model that traces the exact Monte Carlo simulations, and to further meet the technical requirements for global retrieval. Preliminary results from CloudSat/CALIPSO data analysis showed the effectiveness of the synergy algorithm in tracking the vertical variation of cloud properties. Global analysis of water cloud microphysics will be further carried out together with a refined low-level cloud detection scheme.

Keywords: space-borne lidar/radar, cloud

Ice crystal number concentration estimates from lidar-radar satellite remote sensing

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Recent assessments from the climate research community clearly highlight the emergency to reach a better understanding of aerosol-cloud interactions in order to improve current radiative forcing estimates. Satellite observations are ideal to fulfill this task due to their high temporal and spatial coverage, but their operational products are not always suited to answer these questions. Indeed, while the number concentration of cloud droplets (CDNC) and ice crystals (ICNC) are often considered as some of the most important parameters to quantify aerosol-cloud interactions, they are not yet optimally retrieved from satellite remote sensing. Despite recent efforts to estimate the CDNC, there exists to date no space-borne operational product of the ICNC.

As a first step to fill this gap, this study presents results from a preliminary product of the ICNC obtained from combined CALIPSO/CloudSat observations. The operational liDAR-raDAR (DARDAR) product is used as a basis for these estimations. Climatologies corresponding to the overall A-Train period have been analyzed and show an overall agreement with theoretical expectations. Furthermore, the accuracy of these ICNC retrievals has been rigorously estimated through comparisons with in situ measurements from recent airborne campaigns. Good agreements are found for ice clouds colder than about -40°C, where homogeneous nucleation processes dominate. Limitations have nevertheless been observed due to misrepresentations of the amount of small ice particules (i.e., sizes smaller than 100 microns) in existing parameterizations of the particule size distribution. Subsequently, preliminary applications of this novel dataset to evaluated global climate model predictions and observe aerosol-cloud interactions have been made and will be presented.

Keywords: ice clouds, satellite, retrievals, model evaluation, aerosol-cloud interactions

Ice particle morphology and microphysical properties of transparent cirrus clouds inferred from CALIOP–IIR measurements

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Microphysical properties and ice particle morphology of cirrus clouds are important for estimating the radiative forcing associated with these clouds. Many satellite measurements allow us to estimate the cloud optical thickness (COT) and cloud-particle effective radius (CER) of cirrus clouds over the globe via multiple retrieval methods such as the bi-spectral method using visible and near-infrared cloud reflectivities, the split-window method using thermal infrared brightness temperatures and the unconstrained method using lidar signals. However, comparisons among these retrievals exhibit discrepancies in some cases due to particular error sources for each method. In addition, methods to infer ice particle morphology of clouds from satellite measurements are quite limited. To tackle these current problems, we develop an optimal estimation based algorithm to infer cirrus COT, CER, plate fraction including horizontally oriented plates (HOPs) and the degree of surface roughness from the Cloud Aerosol Lidar with Orthogonal Polarization (CALIOP) and the Infrared Imaging Radiometer (IIR) on the Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) platform. A simple but realistic ice particle model is used, and the bulk optical properties are computed using state-of-the-art light-scattering computational capabilities. A rigorous estimation of the uncertainties related to the surface properties, atmospheric gases and cloud heterogeneity is performed. A one-month global analysis for April 2007 with a focus on HOPs shows that the HOP fraction has significant temperature dependence and therefore latitudinal variation. Ice particles containing many HOPs have small lidar ratio due to strong backscattering. The lidar ratio of cirrus clouds has a negative correlation with the temperature where the cloud temperature is warmer than −40℃, for which the median HOP fraction is larger than 0.01%.

Keywords: Cloud properties, Satellite remote sensing, Oriented ice crystals

The retrieval of ice-cloud properties from Himawari-8/AHI

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Himawari-8 satellite was successfully launched in October 2014, which carry a multi-spectral sensor of Advanced Himawari Imager (AHI). The AHI cloud products were developed by employing the cloud algorithm of the GCOM-C satellite program, which included cloud mask, thermodynamic phase, cloud optical, microphysical properties and cloud types. Some of the cloud products (e.g. cloud optical thickness and cloud types) are archived in JAXA homepage (http://www.eorc.jaxa.jp/ptree/).
Cloud products from remote sensing instrument is applicable in climate change study, numerical weather prediction, meteorological disaster, as well as atmospheric study. In this study, ice cloud optical and microphysical properties are simulated from RSTAR radiative transfer code by using various ice particle scattering models. Scattering property of the Voronoi ice particle scattering model is investigated for developing the AHI ice cloud products. Furthermore, optical and microphysical properties of the ice clouds are retrieved from Himawari-8/AHI satellite measurements. Finally, retrieval results from Himawari-8/AHI are compared to MODIS-C6 cloud property products for validation of the AHI cloud products.

Keywords: Ice cloud, Remote sensing, Ice particle scattering property

Validation of Himawari-8 and MODIS observed water cloud microphysical and optical properties using ground-based observation data

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Along with the development of remote sensing technology, cloud remote sensing from the space has become a very powerful tool to gather information related to clouds, including cloud optical and microphysical characteristics, by covering sufficiently large areas. Those data are being implemented to cope/understand several issues related to climate change and hydrological cycle phenomena. Due to such broad implications, quality check of such space-observed cloud properties takes a very high priority. Such quality check can be fundamentally done by using ground-truth data; however, retrieval of cloud properties from ground-based observation data itself is a challenging task, which has also limited validation of cloud products made from observations by several sensors onboard several satellites. Taking this difficulty into account, we developed a cloud retrieval method by implementing spectral transmittances of near-infrared wavelengths observed by zenith-looking sky radiometer of SKYNET (http://atmos2.cr.chiba-u.jp). The retrieval accuracy has been quantified and cloud products from sky radiometer along with surface-observed global flux data of four SKYNET sites (Chiba, Fukuejima, Hedomisaki, and Miyakojima) of nearly one year period have been used to validate water cloud properties observed by the Himawari-8, a Japanese geostationary satellite, and the MODIS sensor onboard the TERRA and AQUA earth observation satellites. The temporal variation of cloud optical thickness (COD) from three independent instruments (Sky radiometer, MODIS, Himawari-8) is consistent, though they differ in magnitude. Generally speaking, COD from MODIS is found to be underestimated followed by Himawari 8 and sky radiometer. The underestimation of COD from satellite observations could be further justified by CODs estimated from the global flux data by assuming the fixed value of effective radius (Re). On the other hand, Re from MODIS is found to be overestimated followed by Himawari-8 and sky radiometer. The overestimation of Re from satellite observations is consistent with prior studies. Data of long-term observation are being analyzed to quantify the error ranges of MODIS and Himawari-8 observed cloud properties (particularly COD) with respect to surface-based sky radiometer and global flux data. Similar analyses to validate ice cloud properties observed from satellites will be performed in the near future.

Keywords: Cloud, Satellite, SKYNET, Sky radiometer

Accomplishments from 3-years of Global Precipitation Measurement (GPM) Data: NASA’ s Perspective

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Precipitation is a key source of freshwater; therefore, the observation of global patterns of rain and snow and their intensity is important for science, society, and understanding our planet in a changing climate. In 2014, NASA and the Japan Aerospace Exploration Agency (JAXA) launched the Global Precipitation Measurement (GPM) Core Observatory (GPM-CO) spacecraft. The GPM-CO carries the most advanced precipitation sensors currently in space including a Dual-frequency Precipitation Radar (DPR) provided by JAXA measuring the three-dimensional structures of precipitation and a well-calibrated, multi-frequency passive microwave imaging radiometer (GPM Microwave Imager –GMI) providing wide-swath precipitation data. The GPM-CO was designed to measure rain rates from 0.2-110.0 mm h^{-1} and to detect moderate to intense snow events. The GPM-CO is a key part of the GPM mission, which is defined to encompass multi-satellite unified precipitation estimates. The GPM-CO serves as a reference for unifying data from a constellation of about 10 (in 2016) partner satellites (see Fig. 1) to provide next-generation, merged precipitation estimates globally and with high temporal (0.5 to 3.0 hours) and spatial (5 to 15 km) resolutions. Through improved measurements of rain and snow, precipitation data from GPM provides new information such as: details of precipitation structure and intensity; observations of hurricanes and typhoons as they transition from the tropics to mid-latitudes; data to advance near-real-time hazard assessment for floods, landslides and droughts; inputs to improve weather and climate models; and insights into agricultural productivity, famine, and public health. Since launch, GPM teams have calibrated satellite instruments, refined precipitation retrieval algorithms, expanded science investigations, and processed and disseminated precipitation data for a range of applications.

The GPM-CO spacecraft is an advanced successor to the Tropical Rainfall Measuring Mission (TRMM), with additional channels on both the DPR and GMI with capabilities to sense light rain and falling snow (Hou et al., 2014, Hou et al., 2008). The GPM-CO was launched at 18:37 UTC 27 February 2014 and operates in a non-sun-synchronous orbit with an inclination angle of 65° (Fig. 2). The prime mission lifetime (instrument design life) is 2 months for checkout and 3 years for operations, but operations could last 15-24 years according to fuel projections in November 2016 (see Appendix E for fuel charts) assuming the instruments/spacecraft systems (e.g., batteries) do not fail and fuel requirements do not increase. The inclined orbit allows the GPM-CO to sample precipitation across all hours of the day from the Tropics to the Arctic and Antarctic Circles. GPM expands TRMM’ s reach not only in terms of global coverage, but also through more sophisticated satellite instrumentation, systematic inter-calibration of datasets from other microwave radiometers, refined merged precipitation data sets, reduced latency for delivering data products, simplified data access, expanded global ground-validation efforts, and integrated user applications. Because of the application focus of GPM, the public release of precipitation products is required in NRT (1-5 hours after the observations are downlinked to the ground stations).

Accomplishments of the Prime Mission lifetime (March 2014-May 2017) can be categorized into four topics: Instrument calibration, Improvements in the Retrieval Algorithm, Progress toward the Scientific Objectives of the GPM mission, and Meeting the GPM Level 1 Mission Requirements. These accomplishments and future activities will be presented.

Keywords: Earth, Satellite, Precipitation, GPM

Three-year results of the Global Precipitation Measurement (GPM) mission in Japan

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The Global Precipitation Measurement (GPM) mission is an international collaboration to achieve highly accurate and highly frequent global precipitation observations. 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, launched on February 2014, carries the Dual-frequency Precipitation Radar (DPR) by the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT). 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. The Japan Meteorological Agency (JMA) started the DPR assimilation in the meso-scale Numerical Weather Prediction (NWP) system on March 24 2016. This was regarded as the world ‘s first “operational” assimilation of spaceborne radar data in the NWP system of meteorological agencies.
JAXA also develops the Global Satellite Mapping of Precipitation (GSMaP), as national product to distribute hourly and 0.1-degree horizontal resolution rainfall map. The GSMaP near-real-time version (GSMaP_NRT) product is available 4-hour after observation through the “JAXA Global Rainfall Watch” web site (http://sharaku.eorc.jaxa.jp/GSMaP) since 2008. The GSMaP_NRT product gives higher priority to data latency than accuracy, and has been used by various users for various purposes, such as rainfall monitoring, flood alert and warning, drought monitoring, crop yield forecast, and agricultural insurance. There is, however, a requirement for shortening of data latency time from GSMaP users. To reduce data latency, JAXA has developed the GSMaP real-time version (GSMaP_NOW) product for observation area of the geostationary satellite Himawari-8 operated by the Japan Meteorological Agency (JMA). GSMaP_NOW product was released to public in November 2, 2015 through the “JAXA Real-time Rainfall Watch” web site (http://sharaku.eorc.jaxa.jp/GSMaP_NOW/).
All GPM standard products and the GPM-GSMaP product have been released to the public since September 2014 as Version 03. The GPM products can be downloaded via the internet through the JAXA G-Portal (https://www.gportal.jaxa.jp). The DPR, the GMI, and the DPR-GMI combined algorithms will be updated in April 2017 and the latent heating product will be released in June 2017 as Version 04.
New calibration factors will be applied for both Ku and Ka-band radars. As its results, values of Z factor will increase, but estimated value of rain intensity does not necessarily increase. Also calibration factors of TRMM/PR will be re-examined to have consistency between DPR/Ku. Furthermore, the GPM-GSMaP algorithms were updated and the GPM-GSMaP Version 04 products have been provided since Jan. 2017.

Keywords: GPM, Satellite Remote Sensing, Precipitation

DSD database for the GPM/DPR precipitation retrieval algorithm

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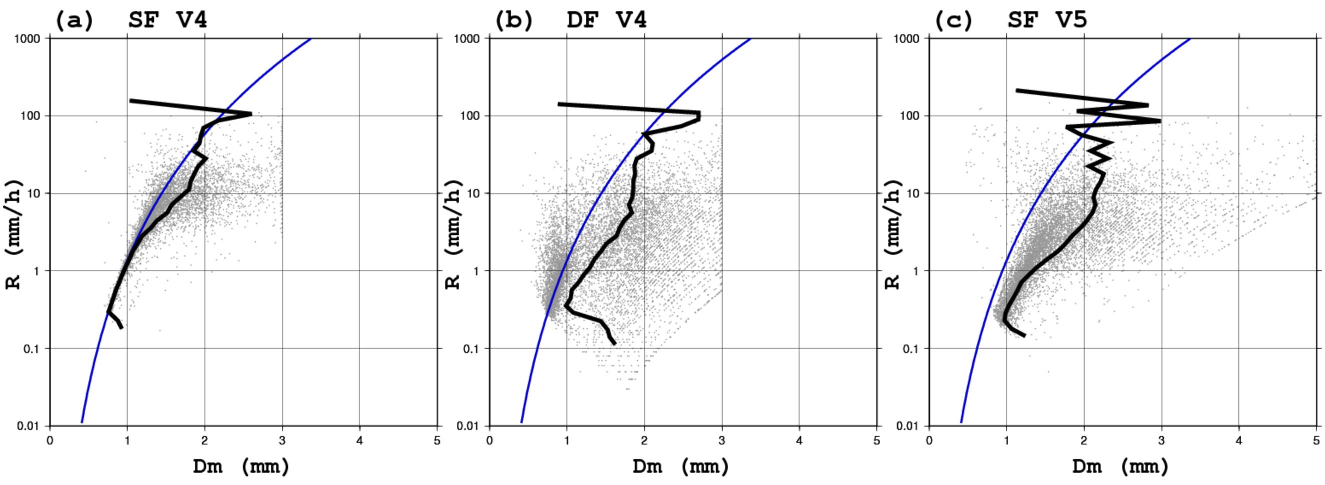
Rain Drop Size Distribution (DSD) has been and is being measured with disdrometers at many stations in the world. Parameterization of DSD is necessary for retrieving rain rates (R) from radar measurements. The relation between radar reflectivity factor (Z) and R (Z-R relation) is an example of DSD parameterization.
In the precipitation retrieval algorithm of the Dual-frequency Precipitation Radar (DPR) of the Global Precipitation Measurement (GPM) mission core satellite, the relation between the mass-weighted mean drop size (D_m) and R (R-D_m relation) is used. As both R and D_m are independent of radar frequency, R-D_m relation is useful in the dual-frequency algorithm and it may be extended for other radar measurements.
The standard R-D_m relation in the DPR algorithm was derived from Z-R relation which Kozu et al. (2009) proposed based on precipitation measurements in Tropics. It may not be appropriate and need to be modified for mid- and high-latitude precipitation within the DPR coverage.
In the DPR algorithm, at each pixel, R-D_m relation is modified by the Surface Reference Technique (SRT), while the SRT does not work well for light precipitation. However, dual-frequency measurements make it possible to adjust R-D_m relation for light precipitation.
The figure shows estimates of R and D_m for over-land convective precipitation cases by single-frequency (SF) algorithm (Fig. a) and dual-frequency (DF) algorithm (Fig. b) in the version-4 DPR algorithm. For weak precipitation, SF algorithm mostly follows the standard R-D_m relation, but DF algorithm gives larger D_m estimates.
Based on DF estimates, optical R-D_m relations are calculated for seasons and regions. They are summarized as DSD database. The new R-D_m relations are used for SF algorithm in the version-5 DPR algorithm (Fig. c). As a result, SF and DF algorithms give closer D_m for weak precipitation. As the next step, the DSD database needs to be validated and improved with ground-based measurements.

Keywords: GPM, DPR, drop size distribution



Improving Physically Based Retrievals of Rain and Snow over Land Surfaces for the GPM Constellation

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The joint NASA/JAXA Global Precipitation Measurement Mission (GPM) offers an unprecedented opportunity for development of highly accurate global rain and snowfall observation. Utilizing the GPM core satellite as a transfer standard, physically based Bayesian retrievals are applied consistently across a constellation of passive microwave radiometers for increased observations in both time and space. The use of a physically based retrieval scheme also allows for connection of the retrieval to models and physical processes, integrating them in valuable ways for the study of the processes themselves and more general Earth system science.

While the utility of the Bayesian retrieval has been well demonstrated over ocean surfaces, the relatively high surface emissivity in the microwave region over land and snow-covered areas makes the distinguishing of the precipitation signal more difficult. As the emission signals at lower frequency are extremely difficult to differentiate from the emissive land background, the scattering signal is the primary indicator of precipitation in this case, and the higher frequency channels more heavily weighted. Two crucial areas for such retrievals are therefore identified for improvement: accurate representation of scattering radiative transfer in the high frequency channels of the retrieval *a priori* database, and accurate identification of the surface characteristics for database indexing.

Early versions of GPM constellation retrievals model ice particles in the *a priori* database as spheres. Comparisons of radiative transfer results suggest that spherical particles do not correctly reproduce observed scattering in the high frequency channels, and that non-spherical particle radiative transfer is required for multispectral agreement. In order for the Bayesian retrieval scheme to choose the correct precipitation profiles, the radiative transfer must be accurate. For this work the full retrieval database is recomputed using non-spherical particles and the retrieval results compared.

Land surfaces in the current GPM constellation retrievals are classified statically, using a climatology of self-similar retrieved emissivities. Such a classification does not account for dynamic surface changes such as dramatic soil moisture shifts due to rainfall that have a large dielectric effect. For this work alternative classification using dynamically assessed land surface characteristics of soil moisture and vegetation is tested within the retrieval algorithm and compared to retrievals using the static classification.

Sensitivity to both the scattering radiative transfer and the dynamic definition of surface type will be demonstrated in the context of the full retrieval algorithm and a path forward suggested for improved performance.

Keywords: precipitation, remote sensing, passive microwave retrieval

Recent progress in Global Satellite Mapping of Precipitation (GSMaP) product

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The Global Precipitation Measurement (GPM) mission is an international collaboration to achieve highly accurate and highly frequent global precipitation observations. As one of Japanese GPM products, Global Satellite Mapping of Precipitation (GSMaP) product has been provided by Japan Aerospace Exploration Agency (JAXA) to distribute hourly global precipitation map with 0.1x0.1 deg. lat/lon grid. The GSMaP products are composed of “standard product”, “near-real-time product”, “real-time product”, and “reanalysis product”. The standard products are processed 3 days after observation, and the near-real-time products are processed 4 hours after observation. In addition, the real-time version, GSMaP_NOW has been provided by the JAXA over the geostationary satellite “Himawari-8” region since Nov. 2015.
Recently, the GSMaP algorithms were majorly updated on September 2014 and January 2017.
Major improvements on September 2014 are following. 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 areas; 3) Update of database, including rainfall detection over land and land surface emission database; 4) Development of microwave sounder algorithm over the land; and 5) Development of gauge-calibrated GSMaP algorithm. In addition to those improvements in the algorithms, a number of input passive microwave imagers and/or sounders was increased using the GMI and the GPM Constellation Satellites.
Major improvements on January 2017 are following. 1) Improvement of the GSMaP algorithm using GPM/DPR observations as its database; 2) Implementation of a snowfall estimation method in the GMI & SSMIS data, based upon Liu and Seto (2013) and Sims and Liu (2015) and a screening method using NOAA multisensor snow/ice cover maps in all sensors; 3) Improvement of the gauge-correction method in both near-real-time and standard products; 4) Improvement of the orographic rain correction method; 5) Improvement of a weak rain detection method over the ocean by considering cloud liquid water.
The current paper describes overviews of the GSMaP products and recent progress of the GSMaP product.

Keywords: Precipitation, Satellite, Remote Sensing

Development of the GEO-KOMPSAT-2A AMI rainfall rate algorithm

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A rainfall rate algorithm has been developed for the Advanced Meteorological Imager (AMI) onboard the GEO-KOMPSAT-2A (GK-2A), the second Korea’s geostationary satellite, scheduled to be launched in early 2018. The AMI rainfall rate algorithm uses the a-priori information including the microwave rainfall data from the low-earth orbiting satellites and infrared (IR) brightness temperatures from geostationary satellites. The algorithm may better perform with a variety of a-priori information describing all possible precipitating systems. In addition, separation of physically different precipitating systems likely to improve the accuracy of retrieval process. However, it has been well known that such the separation can be hardly achieved based on the measurements of cloud top temperatures. This algorithm tries to utilize the radiative characteristics observed differently for different wavelengths in IR spectral regions. The characteristics include the different emissivity as a function of wavelength and cloud thickness. Using the brightness temperature differences (BTDs) between IR channels the algorithm discriminates three types of precipitating clouds: shallow, not-shallow-tall and not-shallow-taller types. The separation of three types of precipitating clouds may help the accuracy of rainfall estimates for each type of clouds. In addition to the separation of cloud types in the databases, the algorithm also uses databases classified by latitudinal bands. The bands are separated with four latitudinal zones. The separation of database based on latitudes may have an effect of distinguishing the cloud types that can occur regionally. The a-priori databases are thus classified with 12 different categories. Once the a-priori databases are constructed, the algorithm inverts the AMI IR brightness temperatures to the surface rainfall rate based on a Bayesian approach. The Bayesian approach has advantages on using multi-channel brightness temperatures simultaneously and utilizing the probability of rainfall reserved in the a-priori databases. As a proxy for the AMI this algorithm first tests the Advanced Himawari Imager (AHI) data. Retrieval results and the status and plan of the algorithm development will be introduced.

Keywords: GK-2A, AMI, Rainfall rate algorithm

Studies on future spaceborne precipitation measuring mission

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Dual frequency precipitation radar (DPR) onboard the core satellite of the Global Precipitation Measurement (GPM) has been demonstrated its feasibilities for three years. In the scientific viewpoint, GPM/DPR is contributing to provide precipitation structures globally including snowfall over 90 % of global coverage, almost 20 years of accumulation of accurate global rainfall (mainly tropics to sub-tropics) since the observation by the precipitation radar (PR) onboard the Tropical Rainfall Measuring Mission (TRMM) satellite, and hourly global precipitation map (such as GSMaP) by combining not only the sensors onboard the GPM/core satellite but also the satellites that equip microwave radiometer. The societal importance of the space based precipitation observation has changed since the launch of the TRMM. The TRMM mission is rather a process-study mission to reveal the three dimensional heating profiles of the precipitation systems especially for the tropical rainfall systems. Success of the TRMM in terms of the accurate precipitation measurement and long-term observation period, provision of the accurate precipitation map was added for the TRMM’ s roll. Global precipitation maps such as GSMaP which is one of major purposes of GPM provide hourly 0.1 degree in latitude/longitude data and utilized for the flood forecasting/warning system, agricultural applications and so on. On the technological aspect, the success of the GPM/DPR has shown maturities of its technology such active phased array system using slotted waveguide antenna, solid state power amplifier and so on. In addition, recent studies on the pulse compression technology and the TRMM end of mission experiment (Takahashi et al., 2016) indicate the further advances of the spaceborne precipitation radar are possible with current technology.
Based on achievements of TRMM and GPM, science targets of the future precipitation mission have been discussed among the GPM science community.
One of the science targets is cloud-precipitation processes. Since the cloud and precipitation interaction is important process of the precipitation formation. Both the cloud and precipitation observation is also very helpful to evaluate the cloud physical processes of the numerical climate models. The societal contribution target will be to improve GSMaP both on the accuracy and data latency.
For these purposes, three types of missions are considered: 1)small radar constellation satellites to upgrade the GSMaP product by replace the passive microwave estimation by radar estimation (radar constellation), 2) development of the DPR type radar with better sensitivity and the wider swath observation based on the advances on the solid state power amplifier and the wide swath operation of the TRMM EOM experiment (DPR2), and 3) radar observation of precipitation from geostationary satellite (GPR).
Feasibility studies for these missions have started on the key elements such as precipitation estimation accuracy for radar constellation satellite, feasibility study on the pulse compression technology for wide swath operation of DPR2, and feasibility of the large antenna design and the clutter mitigation for GPR. Time scale of these missions are different; DPR2 is almost ready to move the development phase, the development of small radar for the radar constellation needs the feasibility of small antenna system through bread board model (BBM) development, and several fundamental technologies such as deployable large size antenna are needed to demonstrate in orbit for GPR.

Keywords: precipitation observation mission, radar

Evaluation of potential benefits of outer-loop iteration for all-sky microwave imager radiance assimilation at JMA's global NWP system

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In numerical weather prediction (NWP), assimilation of cloud and precipitation affected radiance is essential to obtain accurate initial fields in cloudy areas. Cloud and precipitation phenomena have non-linear behaviors in their formation and dissipation. To consider such non-linearity in an incremental four dimensional variational (4D-Var) data assimilation, outer-loop iteration is necessary for re-computation of departures from the observations and updates of trajectory in minimizations of the 4D-Var.
The impacts on tropical cyclone prediction from all-sky microwave imager radiance assimilation using JMA’ s global NWP system were presented at the last conference in 2016. The system used in the experiment had no use of the outer-loop iteration as same configuration of JMA’ s operational global NWP system. In this research, we investigated impacts of the outer-loop iteration for the all-sky microwave imager radiance assimilation. Three data assimilation experiments were performed to compare with a control run whose configuration was same to current operational JMA’ s global NWP system: all-sky microwave imager radiance assimilation experiment (EXP1), outer-loop introduced experiment (EXP2), and their combined experiment (EXP3). The EXP1 results indicate the positive impacts on tropical cyclone’ s track and intensity predictions from the all-sky assimilation by improving analyses in the cloudy areas which are meteorologically sensitive and where no useful information is obtained from current clear-sky assimilation. The EXP2 results demonstrated large positive impacts from the outer-loop introduction on analysis and forecast accuracy of geopotential height, tropospheric temperature, humidity, and wind fields.
The comparison between the EXP1 and EXP3 which can indicate the impact of the outer-loop iteration on the all-sky radiance assimilation reveals that the introduction of outer-loop iteration increased assimilated existing humidity sensitive observations (e.g., microwave humidity sounder radiances) and improved the analysis accuracy. However, the gains from the all-sky assimilation for the forecast skill were similar. One possible reason of this result is a discrepancy of cloud and precipitation representation between inner and outer model in the 4D-Var system. To get further benefits from the outer-loop iteration in the all-sky assimilation, a consistent cloud and precipitation representation between the models would be necessary.
The details of the latest experiment results and the issues are discussed in the conference.

Assimilation of Satellite Soil Moisture Contents and Clear-sky Radiance in Operational Local NWP System at JMA

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The Japan Meteorological Agency (JMA) operates the Local NWP system constructed with the high-resolution Local Forecast Model (LFM) and Local Analysis. LFM and Local Analysis are run hourly and various types of the latest observation are assimilated.
JMA started to assimilate the satellite observation of clear-sky radiance (CSR) and soil moisture content (SMC) in the Local NWP system in January 2017. The assimilated radiance data are CSR observation from Himwari-8 AHI, GPM GMI, GCOM-W AMSR2, Metop-A/B AMUS-A/MHS and DMSP SSMIS. And the assimilated SMCs are those of L2-products from GCOM-W AMSR2 and Metop-A/B ASCAT. These SMC are assimilated after variable transformation using cumulative distribution function (CDF) matching method. The CDF matching method fits the probability density function (PDF) of observation to the PDF of model variables. This pre-conditioning by CDF matching helps to minimize the cost function because the innovation of SMC becomes Gaussian after the CDF matching. However, it is known that the observation bias of satellite fluctuate over time. To remove adaptively such bias of the secular changes, the variational bias correction method is adopted in the Local Analysis. As a result, both the CSR and SMC can be assimilated as unbiased observation and the forecast accuracy of atmosphere and surface is improved. The impact of these satellite data assimilation will be presented.

Application of aggregated non-spherical ice-phase particle modeling to assimilation of GPM radiance observations in meso-scale NWP

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Variations in the distributions of ice-phase cloud and precipitation particles are important indicators of dynamical and physical processes in atmosphere, but at the same time, the representation of these particle types and the underlying processes in numerical weather prediction model forecasts are often subject to substantial errors. Since ice-phase cloud/precipitation can have a significant impact on upwelling microwave radiances at the higher microwave frequencies (85 –183 GHz) through the scattering process, assimilation of satellite microwave observations into model-supported analyses has the potential to correct for model errors. Crucial to the assimilation of these observations are forward radiative models that can be used to simulate higher-frequency microwave radiances based on forecast earth/atmosphere states. In this work we present the development and improvements in forward modeling of using aggregated non-spherical ice-phase particles to calculate microwave single-scattering properties with particle size distribution descriptions based of field campaign studies. Experiments are carried out using NASA Unified Weather Research Forecast ensemble data assimilation system. All-sky radiance observations from NASA/JAXA Global Precipitation Measurement (GPM) mission Microwave Imager (GMI) are assimilated into high-resolution model forecasts. The impact of both the input data and the forward modeling on first-guess radiance departures and analyzed/forecast fields are investigated in case studies of mid-latitude snowstorm and warm season convective storm overland.

Keywords: satellite observations, precipitation, data assimilation

Model Parameter Estimation Using Ensemble Data Assimilation: A Case with the Nonhydrostatic Icosahedral Atmospheric Model NICAM and the Global Satellite Mapping of Precipitation Data (GSMaP)

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This study aims to improve precipitation forecasts from numerical weather prediction (NWP) models through effective use of satellite-derived precipitation data. Kotsuki et al. (2017, JGR-A) successfully improved the precipitation forecasts by assimilating the Japan Aerospace eXploration Agency (JAXA)'s Global Satellite Mapping of Precipitation (GSMaP) data into the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) at 112-km horizontal resolution. Kotsuki et al. mitigated the non-Gaussianity of the precipitation variables by the Gaussian transform method for observed and forecasted precipitation using the previous 30-day precipitation data.
This study extends the previous study by Kotsuki et al. and explores an online estimation of model parameters using ensemble data assimilation. We choose two globally-uniform parameters, one is the cloud-to-rain auto-conversion parameter of the Berry's scheme for large scale condensation and the other is the relative humidity threshold of the Arakawa-Schubert cumulus parameterization scheme. We perform the online-estimation of the two model parameters with an ensemble transform Kalman filter by assimilating the GSMaP precipitation data. The estimated parameters improve the analyzed and forecasted mixing ratio in the lower troposphere. Therefore, the parameter estimation would be a useful technique to improve the NWP models and their forecasts. This presentation will include the most recent progress up to the time of the meeting.

Keywords: Data Assimilation, GSMaP precipitation, NICAM, LETKF, Parameter Estimation

Assimilation of cloudy infrared radiances of the geostationary Himawari-8 imager

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We introduce the current status of experiment of assimilating cloud-affected infrared observation from a geostationary satellite, Hiamawari-8, into JMA global numerical weather prediction model.
Infrared observation data from geostationary satellites such as Himawari-8 are contributing to improving analysis and forecast accuracy in numerical weather prediction.
However, cloud-affected observation data are rarely used in the practical assimilation system due to the nonlinearity physical process in clouds, complex and non-Gaussian statistics and so on.
Assimilation of cloud-affected observation data is crucial for improving the accuracy of analyses and forecasts in numerical weather prediction(NWP).
The radiance data to be assimilated were created by averaging pixels from the original radiances (ASR, or All Sky Radiance), which was developped at Meteorological Satellite Center (MSC) in 2016.
In this study, we assimilated infrared radiances by assuming a single layer cloud ("simple cloud"), in which cloud effect in radiative transfer is calculated simply by using the cloud-top pressure and an effective fraction of cloud.
The results of the experiments so far showed that even with this simple treatment, appropriately selected data offer valuable information not available from cloud-free observations.

Keywords: satellite observation, Himawari-8, data assimilation, numerical weather prediction, cloudy observation

Eight Years of GOSAT Operation in Space and New Science from GOSAT-2

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Greenhouse Gases Observing Satellite (GOSAT) and its successor, GOSAT-2, are Japanese earth observing satellites for greenhouse gases (GHG) measurements from space. Both satellite projects are joint efforts among Ministry of the Environment (MOE), Japan Aerospace Exploration Agency (JAXA), and National Institute for Environmental Studies (NIES).
GOSAT was launched in January 2009 and has been operated for more than eight years. It has a Fourier transform spectrometer (FTS) for the measurements of columnar abundances of carbon dioxide (CO2) and methane and a UV-VIS-NIR-SWIR imager (CAI) for cloud and aerosol detection. Its data are being used in various scientific researches related to climate change and atmospheric pollution monitoring such as monitoring of whole-atmosphere monthly mean carbon dioxide concentration, evaluation of inventories for anthropogenic emissions of CO2 and methane, and PM2.5 mapping in asian urban regions.
GOSAT-2 will be launched in FY2018. GOSAT-2 instruments (FTS-2 and CAI-2) will be modified or improved based on the experiences of GOSAT instruments. FTS-2 will have the extended spectral coverage for carbon monoxide measurement and the intelligent pointing capability to avoid cloud contamination. CAI-2 will have multiple UV bands for more precise land aerosol monitoring and the forward/backward viewing capability to avoid sun glint over oceans. GOSAT-2's spacecraft, instruments, and ground data processing systems are currently being manufactured.
In this presentation, several scientific achievements based on GOSAT's eight-year GHG data and new science expected from GOSAT-2 will highlighted.

GOSAT-2 science plan and recent progress in sensor development for CO_2 monitoring over mega-cities from space

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Greenhouse gases Observing Satellite (GOSAT) was launched on January 23, 2009, and it has provided worldwide scientists with high quality observational data for more than 7 years. The primary purpose of the mission is to reduce the posterior error in inversion analysis of CO_2 source/sink strengths by about 50% in some sub-continental scales (several thousand kilometers square). As have already showed by previous studies (e.g., Takagi et al., 2011), the original purpose has been accomplished on a project basis. Based on these successful results, its successor, GOSAT-2 has been designed and developed to be launched in FY2018. At the same time, the science team of the project started discussion on its scientific objectives to be summarized as "Science Plan". Most important obligation for the project to the scientific community is the continuity of the observational data connecting from GOSAT project with the same or, hopefully better quality. The improvement of signal-to-noise ratio (SNR) of TANSO-2 Fourier transform spectrometer/GOSAT-2 ensures the continuity, and furthermore observable regions could be expanded toward higher latitudes and the region size of inversion analyses is expected to be able to be smaller. Its scientific objectives can be classified into four categories for CO_2; 1) fusion of bottom-up and top-down approaches in budget analyses, 2)up grading of prediction performances of land-ecosystem models and coupling to the inversion models, 3)improvement of detectability of hotspots, and 4)contribution to REDD+ by providing the relevant community with desired data. As for CH_4, 1)detection of changes in emissions from wetlands attributing to global warming, 2)watching the gas leaks from pipelines, 3)monitoring the emission from agricultural sources, and 4)investigations on the long-term trend of increasing rate of atmospheric concentration. Recently, satellite sensors of which instantaneous field of view (IFOV) is narrow enough to resolve emission sources in mega-cities have been developed (e.g., CLAIRE/GHGsat). However, their calibration accuracies are not necessarily better than preexisting sensors. One possible way to apply these sensors to monitor small emissions with useful accuracy is combining the sensors with well calibrated sensors such as GOSAT-2 on radiance or higher product level basis. In this point of view, GOSAT-2 sensors are expected to keep the highest performance of accuracy.

Keywords: GOSAT-2, science plan, mega-city

GHG Observations of GOSAT/TANSO-FTS TIR band: data quality and scientific findings

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The Greenhouse Gases Observing Satellite (GOSAT) has continued its observations of greenhouse gases (GHG) such as CO_2 and CH_4 for almost 8 years since its launch on 23 January 2009. The Thermal and Near Infrared Sensor for Carbon Observation (TANSO)–Fourier Transform Spectrometer (FTS) on board GOSAT consists of three bands in the short-wave infrared (SWIR) region and one band in the thermal infrared (TIR) region (Kuze et al., 2009). From the TANSO-FTS TIR spectra, CO_2 and CH_4 concentrations are retrieved in several atmospheric layers; the latest TIR Level 2 (L2) retrieval product is version 1 (V1) (Saitoh et al., 2016).

We have evaluated the bias in the CO_2 concentrations of the TIR V1 L2 CO_2 product of the GOSAT/TANSO-FTS based on comparisons with data from the Continuous CO_2 Measuring Equipment (CME) in the Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL) project (Machida et al., 2008) in the upper troposphere and lower stratosphere (UTLS), the middle troposphere (MT), and the lower troposphere (LT) for the 3 years from 2010 to 2012. Here, we used the CME data obtained during the level flights over a wide area and the ascent and descent flights over several airports for the comparisons in the UTLS region and the ML and LT regions, respectively. Furthermore, we examined the validity of the bias assessment over limited areas over the airports by comparing TIR CO_2 data globally with CO_2 data simulated by the Nonhydrostatic ICosahedral Atmospheric Model (NICAM)-based transport model (TM) (Niwa et al., 2011). The comparison results in the UTLS region showed that TIR CO_2 data had larger negative biases in spring and summer (>2 ppm) than in fall and winter in the northern low and middle latitudes (Saitoh et al. 2016), and the biases became larger over time. This is because TIR UT CO_2 data were constrained by the a priori data whose growth rates were ˜1.4 ppm/yr from 2010 to 2012, which was less than the growth rates based on CME data (˜2.1 ppm/yr). However, TIR UT CO_2 data displayed seasonal variations that were more similar to the CME data than to the a priori data. The amplitudes of the seasonal variations were comparable, except at the northern middle latitudes. In the ML and LT regions (736–287 hPa), TIR CO_2 data had negative biases against CME CO_2 data in the latitude range between 40°S and 60°N in all seasons. They had the largest negative biases in retrieval layers 5–6 (541–398 hPa), which mainly came from the retrieval at the CO_2 10-μm absorption band (930–990 cm^{-1}). Comparisons between NICAM-TM CO_2 data and bias-corrected TIR CO_2 data to which the bias-correction values evaluated over the airports were applied showed that the median values of their differences were closer to zero, which demonstrates the validity of the bias-correction values; we conclude that the bias-correction values defined the comparisons in limited areas over airports can be applicable to TIR CO_2 data in areas other than the airport locations.

We compared TIR V1 L2 CH_4 data with data obtained over Minamitorishima by a C-130H cargo aircraft (Tuboi et al., 2013; Niwa et al., 2014) and with data obtained in a wide latitude range during the HIAPER Pole-to-Pole Observation (HIPPO) aircraft campaign (Wofsy et al., 2011). The comparison results showed that TIR CH_4 data agreed with the aircraft CH_4 data to within ˜1% in the MT and LT regions in the northern middle latitudes in spring, fall and winter, although they had negative biases of 1.2–1.5% in the MT region in summer. TIR CH_4 data in the MT regions agreed with HIPPO CH_4 data to within 1% in low latitudes and in the southern middle latitudes, which is consistent with the results of Zou et al. (2016) and Olsen et al. (2017).

Philippines TCCON Installation: Towards Quantifying Atmospheric Carbon in Southeast Asia

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The Total Carbon Column Observing Network (TCCON) is dedicated to the precise measurements of greenhouse gases such as CO_2 and CH_4. TCCON measurements have been and are currently used extensively and globally for satellite validation, for comparison with atmospheric chemistry models and to study atmosphere-biosphere exchanges of carbon. With the global effort to cap greenhouse gas emissions, TCCON has taken on a vital role in validating satellite-based greenhouse gas data from past, current and future missions like Japanese GOSAT and GOSAT-2, NASA's OCO-2 and OCO-3, Chinese TanSat, and others. The lack of reliable validation data for the satellite-based greenhouse gas observing missions in the tropical regions is a common limitation in global carbon-cycle modeling studies that have a tropical component. The international CO_2 modeling community has specified a requirement for "expansion of the CO_2 observation network within the tropics" to reduce uncertainties in regional estimates of CO_2 sources and sinks using atmospheric transport models. A TCCON site in the western tropical Pacific is a logical next step in obtaining additional knowledge that would greatly contribute to the understanding of the Earth's atmosphere and better constraining a major tropical region experiencing tremendous economic and population growth.
An assessment for possible sites in the Philippines where TCCON FTS should be installed were performed and we decided to install it at Burgos site (the substation of Energy Development Corporation Burgos Wind Farm Project), Ilocos Norte, Philippines (18.5326° N, 120.6496° E). We characterized a performance of the newly constructed TCCON instrument intended for deployment to the Philippines and made initial measurements at the NIES compound in Japan. After development in Japan, we deployed TCCON FTS at Burgos site in Dec. 2016 and conducted installation/set up of instruments until Mar. 2017. Then we could get the first light measurements in Philippines. Here, we will present the whole picture of the Philippines TCCON project.

Keywords: Carbon-cycle, Greenhouse Gas, Total Carbon Column Observing Network, Satellite Validation

Natural and anthropogenic contributions to long-term variations of SO_2, NO_2, CO and aerosol over East China

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East China has been experiencing significant air pollution during the past decades. Long-term variations of air pollutants over East China are affected by increasing energy consumption, government pollution regulation, new technologies, economic conditions, human activities and a number of natural factors such as global warming, long-term variations in precipitation, monsoon strength etc. Quantifying the impacts of natural oscillations and anthropogenic activities on the long-term variations of air pollutants is critical for guiding emission control measures. In this study, satellite-retrieved and MOZART-4-simulated SO_2, NO_2, CO and total column aerosol mass concentration (AMC) data are used to investigate the impacts of natural factors and human activities on long-term variations of these air pollutants over East China. The Kolmogorov–Zurbenko (KZ) filter is used to extract long-term trends from both observed and simulated air pollutant data. Results show that SO_2 concentrations decreased from 2007 to 2014, with natural and anthropogenic factors contributing 37.4% and 62.6% to this decrease, respectively. NO_2 concentrations increased significantly during 2000–2014; anthropogenic activities contribute 79.5% to this variation, while natural factors only account for 20.5%. CO concentrations decreased slowly from 2003 to 2009, with contributions of natural and anthropogenic factors of 19% and 81%, respectively. Since 2006, AMC decreased slightly, with natural factors accounting for 43% of the total variation, while human activities account for 57%.

Keywords: satellite observation, MOZART-4 model, contribution

Description of Advanced Himawari Imager (AHI) Yonsei aerosol retrieval algorithm Version 1

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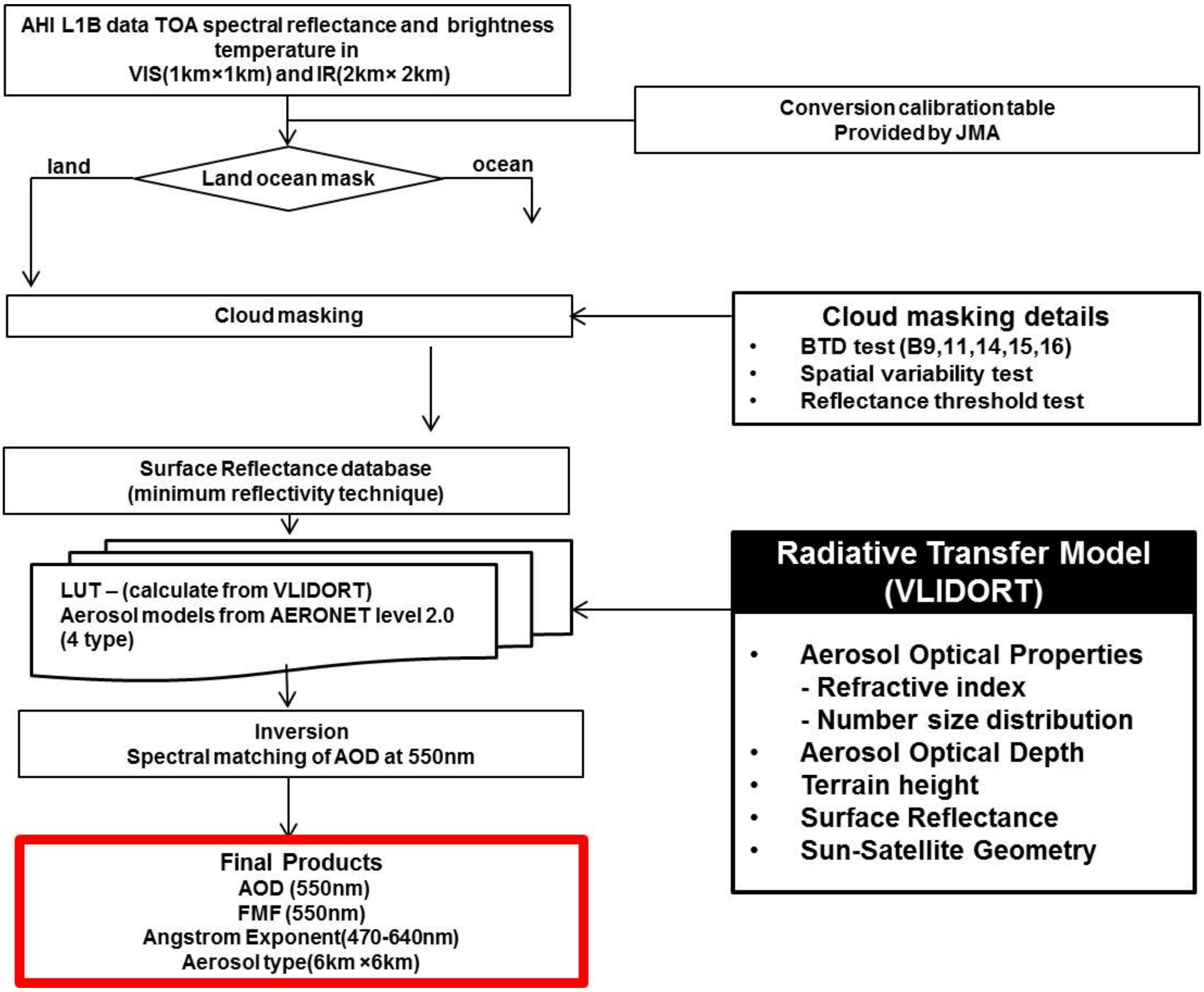
Japan Meteorological Agency (JMA) successfully launched the next-generation geostationary satellite called Himawari-8 in 7 October 2014 and started a formal operation in 7 July 2015. The Advanced Himawari Imager (AHI) sensor having 16 channels (from 0.47 to 13.3 μm) is the next-generation geostationary satellite that observes the full disk every 10 minutes. This study attempts to retrieve the aerosol optical properties (AOPs) based on the spectral matching method, with using three visible and one near infrared channels (470, 510, 640, 860nm). This method requires the preparation of look-up table (LUT) approach based on the radiative transfer modeling. Cloud detection is one of the most important processes for guaranteed quality of AOPs. Since the AHI has several infrared channels, which are very advantageous for cloud detection, clouds can be removed by using brightness temperature difference (BTD) and spatial variability test. The Yonsei Aerosol Retrieval (YAER) algorithm is basically utilized on a dark surface, therefore a bright surface (e.g., desert) should be removed first. Then we consider the characteristics of the reflectance of land and ocean surface using three visible channels. The known surface reflectivity problem in high latitude area can be solved in this algorithm by selecting appropriate channels through improving tests. Based on validation results with the sun-photometer measurement in AErosol Robotic NETwork (AERONET), we confirm that the quality of Aerosol Optical Depth (AOD) from the YAER algorithm is comparable to the product from the Japan Aerospace Exploration Agency (JAXA) retrieval algorithm. Our future update includes a consideration of surface reflectance at ocean BRDF and non-spherical aerosols. This will improve the quality of YAER algorithm more, particularly retrieval for the dust particle over the bright desert surface in East Asia.


AHI L1B data TOA spectral reflectance and brightness temperature in VIS(1km×1km) and IR(2km× 2km)
Conversion calibration table Provided by JMA
land
Land ocean mask
ocean
Cloud masking
Cloud masking details
BTD test (B9,11,14,15,16)
Spatial variability test
Reflectance threshold test
Surface Reflectance database (minimum reflectivity technique)
LUT – (calculate from VLIDORT)
Aerosol models from AERONET level 2.0
(4 type)
Radiative Transfer Model (VLIDORT)
Aerosol Optical Properties
- Refractive index
- Number size distribution
Aerosol Optical Depth
Terrain height
Surface Reflectance
Sun-Satellite Geometry
Inversion
Spectral matching of AOD at 550nm
Final Products
AOD (550nm)
FMF (550nm)
Angstrom Exponent(470-640nm)
Aerosol type(6km ×6km)

Development and acceleration of aerosol remote sensing algorithm and its application to GOSAT/TANSO-CAI data

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Aerosol in the atmosphere is an important atmospheric constituent for determining the earth’s radiation budget, especially perturbation by the human activity, so the accurate aerosol retrievals from satellite is useful. We have developed a satellite remote sensing algorithm to retrieve the aerosol optical properties using multi-wavelength and multi-pixel information of satellite imagers (MWPM). The method simultaneously derives aerosol optical properties, such as aerosol optical thickness (AOT) and single scattering albedo (SSA), by using spatial difference of surface reflectance. Thus, the method is useful for aerosol retrieval over spatially heterogeneous surface like an urban region. We apply an optimal method and spatial smoothness constraint for aerosol properties, and directly combining with the radiation transfer calculation/model (RTM), Rstar (Nakajima and Tanaka, 1986, 1988), numerically solved by each iteration step of the non-linear inverse problem, without using Look Up Table. The merit of direct use of RTM is that: more accurate multiple scattering calculations in more realistic atmospheric conditions are available; it is easy to change retrieval parameters or wavelengths. Therefore, more accurate and flexible retrievals can be expected. However, it has also weak point that it takes a large computation time compared to that with LUT method. To accelerate the calculation time, we replace the RTM with an accelerated RTM solver learned by neural network-based method (Takenaka et al., 2011), EXAM, using Rater code. We apply MWPM with EXAM to GOSAT/TANSO-CAI (CAI) imager data. CAI has four bands, 380, 674, 870 and 1600 nm, and observes in 500 meters resolution for band1, band2 and band3, and 1 km for band4. The retrieved parameters are fine and coarse mode AOTs, SSA and surface reflectance at each wavelength by combining a minimum reflectance method and Fukuda et al. (2013). As a result, the calculation time was shortened from about 10 second to 0.01 second per pixel. And also, the similar retrieval results are obtained compared with MWPM with RTM over Beijing region.

Keywords: Aerosol, Remote sensing

Spectrally Dependent Calibration Requirement for CLARREO IR Instrument

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The infrared (IR) spectrometer of the Climate Absolute Radiance and Reflectivity Observatory (CLARREO) will measure the Top of Atmospheric (TOA) thermal radiance spectra from 200 to 2000 cm^{-1}. It is designed to detect trends of atmospheric temperature, moisture, cloud, and surface properties even in the presence of measurement gaps. Wielicki et al [1] have studied the CLARREO measurement requirements for achieving climate change absolute accuracy in orbit. The goal of this study is to further quantify the spectrally dependent calibration requirement for CLARREO IR instrument. Spectral fingerprinting method is used to evaluate how the calibration error affects our ability to detect the changes that are smaller than the natural variability of temperature and moisture. The temperature, humidity, and surface skin temperature variability and the associated correlation time are derived using Modern Era Retrospective-Analysis for Research and Applications (MERRA) and European Center for Medium-Range Weather Forecasts (ECMWF) reanalysis data. The results are further validated using the climate model simulation results. To detect an accurate trend for a geophysical parameter, the observation system has to be able to separate the natural variability from the climate changes. Therefore, even for a perfect observation system, one has to make long enough observations to minimize the contribution from the natural variability. With the derived natural variability and correlation time as the reference, the calibration requirement for the IR instrument can be deduced based on a spectral fingerprinting method.

Keywords: Climate trend detection, remote sensing, satellite instrument intercalibration

Evaluation of ozone profile and tropospheric ozone retrievals from GEMS and OMI spectra

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South Korea is planning to launch the GEMS (Geostationary Environment Monitoring Spectrometer) instrument into the GeoKOMPSAT (Geostationary Korea Multi-Purpose SATellite) platform in 2018 to monitor tropospheric air pollutants on an hourly basis over East Asia. GEMS will measure backscattered UV radiances covering the 300–500 nm wavelength range with a spectral resolution of 0.6 nm. The main objective of this study is to evaluate ozone profiles and stratospheric column ozone amounts retrieved from simulated GEMS measurements. Ozone Monitoring Instrument (OMI) Level 1B radiances, which have the spectral range 270–500 nm at spectral resolution of 0.42–0.63 nm, are used to simulate the GEMS radiances. An optimal
estimation-based ozone profile algorithm is used to retrieve ozone profiles from simulated GEMS radiances. Firstly, we compare the retrieval characteristics (including averaging kernels, degrees of freedom for signal, and retrieval error) derived from the 270–330 nm (OMI) and 300–330 nm (GEMS) wavelength ranges. This comparison shows that the effect of not using measurements below 300 nm on retrieval characteristics in the troposphere is insignificant. However, the stratospheric ozone information in terms of DFS decreases greatly from OMI to GEMS, by a factor of 2. The number of the independent pieces of information available from GEMS measurements is estimated to 3 on average in the stratosphere, with associated retrieval errors of 1% in stratospheric column ozone. The difference between OMI and GEMS retrieval characteristics is apparent
for retrieving ozone layers above 20 km, with a reduction in the sensitivity and an increase in the retrieval errors for GEMS. We further investigate whether GEMS can resolve the stratospheric ozone variation observed from high vertical resolution EOS MLS. The differences in stratospheric ozone profiles between GEMS and MLS are comparable to those between OMI and MLS below 3 hPa (40 km), except with slightly larger biases and larger standard deviations by up to 5 %. At pressure altitudes above 3 hPa, GEMS retrievals show strong influence of a priori and large differences with MLS, which, however, can be sufficiently improved by using better a priori information. The GEMS-MLS differences show negative biases of less than 4% for stratospheric column ozone, with standard deviations of 1–3 %, while OMI retrievals show similar agreements with MLS except for 1% smaller biases at middle and high latitudes. Based on the comparisons, we conclude that GEMS will measure tropospheric ozone and stratospheric ozone columns with accuracy comparable to that of OMI and ozone profiles with slightly worse performance than that of OMI below 3 hPa.

Keywords: Geostationary enviomental satellite, ozone, profile

High-performance clear-sky temperature and humidity information from geostationary imagers and their applications to short-term weather forecasting

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As more and more high-performance imagers are flying in geostationary orbits, there has been growing interest in how to utilize the imager-derived products and how accurate those products are. Although researchers and forecasters have already been provided with very accurate data from the numerical weather prediction (NWP) model or hyperspectral sounders onboard the polar orbiters, both type of data are provided in lower temporal and spatial resolution when compared to that from high-resolution imagers such as the Advance Himawari Imager (AHI) on board Himawari-8 that is operating on orbit or the Advanced Meteorological Imager (AMI) on board Korea’s 2^{nd} generation geostationary satellite, Geo-KOMPSAT-2A, scheduled to launch in 2018. Furthermore, NWP model accuracy decreases in the presence of clouds or in data sparse areas. This study focuses on this aspect, emphasizing the advantage of using high-resolution products, particularly moisture related products, retrieved from the AHI through a couple of case studies and suggests the potential benefits of using those products for short-range severe weather forecasting. Product accuracy is evaluated using radiosonde measurements, NWP model analysis, and Radio-Occultation measurements. Presentation will cover a brief introduction to the retrieval algorithm, which is based on an optimal estimation method with the unified model forecast as the first guess to produce clear-sky vertical profiles of temperature and moisture and other atmospheric parameters such as total precipitable water and instability indices. Algorithm characteristics and validation results will be also presented during the conference.

Keywords: high-performance geostationary imager, temperature and humidity profile retrieval algorithm, short-term weather forecasting, optimal estimation

Constructing an ocean data assimilation product using satellite sea surface temperature

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The Japan Aerospace Exploration Agency (JAXA) operates the several earth observation satellites, and provides satellite sea surface temperature (SST) data. Satellite capability to detect SST data is advancing in recent year. For example, the Himawari-8 which was launched in 2014 is able to detect SST around Japan every 10 minutes. However, a satellite SST dataset includes some missing depending on the type of satellite and sensor, and doesn't provide the vertical ocean data. In this study, we construct a temporally and spatially uniform ocean dataset, using a data assimilation method which combines the satellite SST data and the ocean model data.

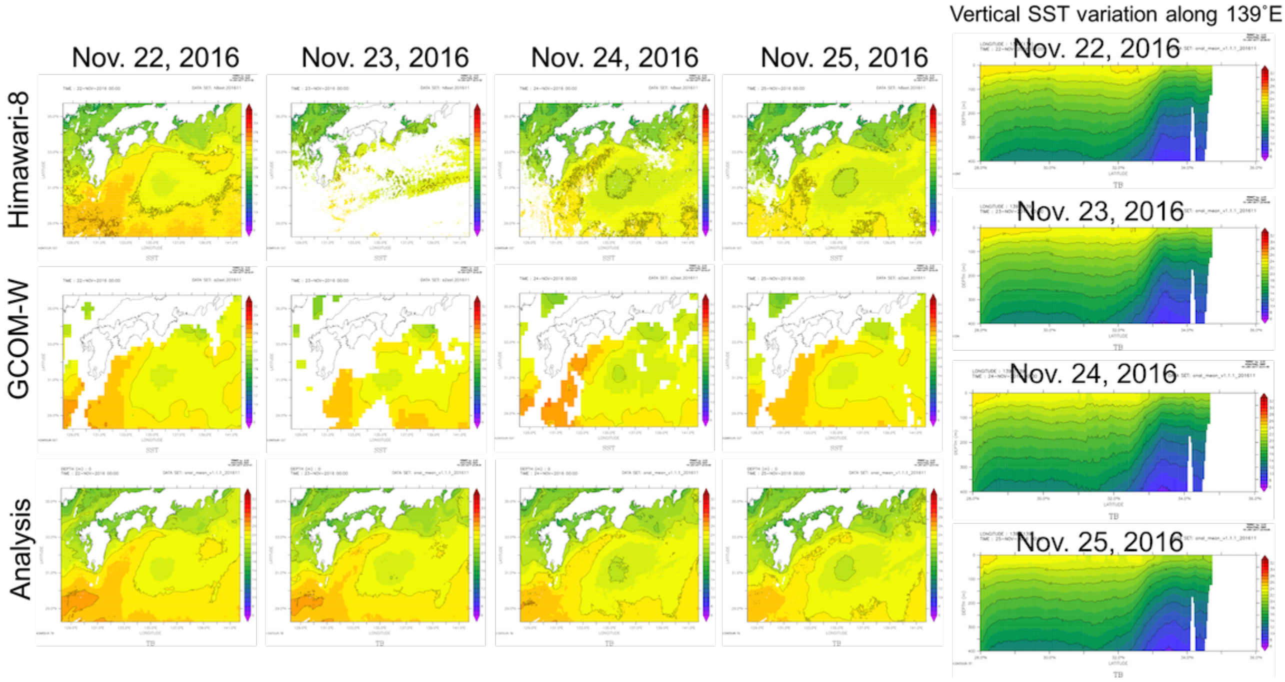
Our target area is south of Japan where the Kuroshio flows. The data assimilation technique and ocean model which we use are the Local Ensemble Transform Kalman Filter (LETKF) and the Stony Brook Parallel Ocean Model (sbPOM). The LETKF is able to represent small scale variations effectively. We assimilated the observation data including in two satellite SST data sets (Himawari-8 and GCOM-W/AMSR2) provided by JAXA. The Himawari-8 data allow spatio-temporally high resolution but could include cloud noise. On the other hand, GCOM-W/AMSR2 provides relatively coarse resolution cloud-free data.

In attached figures, we show the satellite and analysis SST distributions and the vertical temperature distributions represented by analysis data along 139E, from November 22 to November 25, 2016. A cyclone passed south of Japan from November 23 to 24, and it snowed around Tokyo with cool air coming southward. The analysis data reproduce the observed SST drop caused by the weather disturbances and reasonably estimate the SST states in the cloudy area and nearshore region missed by the satellite observation. Also, subsurface isotherms became sparse along 139E, suggesting the mixed layer deepening induced by the cyclone.

We are constructing a web site to operationally provide the information for fishery applications. The contents include 'analysis data', 'forecast data', 'satellite SST', 'sea levels on observation sites', and 'time series at mooring sites off Kochi'. We are updating the information on the website every week.

In the presentation, we will discuss usability of the satellite SST data for data assimilation in detail.

Keywords: Himawari-8, AMSR2, ocean data assimilation, LETKF, sea surface temperature


Vertical SST variation along 139°E
Nov. 22, 2016
Nov. 23, 2016
Nov. 24, 2016
Nov. 25, 2016
Himawari-8
GCOM-W
Analysis

Preliminary results of observing system simulation experiment (OSSE) for future space-based Doppler wind lidar

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1. Meteorological Research Institute, 2. National Institute of Information and Communications Technology, 3. JAXA, 4. FUJITSU FIP Corporation

Space-based Doppler Wind Lidar (DWL) can provide global wind profiles that are significantly beneficial for the numerical weather prediction. The feasibility of DWLs has been investigated using OSSE. Our DWL OSSE features a realistic simulation of Lidar scattering from 3-dimentional, hourly aerosol that is consistent to wind field and created by a full-brown lidar simulator. The aerosol is produced by a global aerosol chemical transport model developed by MRI in which wind field is nudged with pseudo-truth. The pseudo-truth atmospheric field is generated from the Sensitivity Observing System Experiment (SOSE) approach. Simulated line-of-sight wind speeds are assimilated with the four-dimensional variational (4D-Var) scheme based on the operational global data assimilation system at JMA. We have conducted OSSEs for DWL onboard a satellite in a polar and low-inclination orbiting satellite, showing forecast improvement by assimilating DWL with inflated observation errors. The preliminary results from the two measurement strategies will be presented.

Keywords: data assimilation, OSSE, Doppler wind lider (DWL), global numerical weather prediction