Japan Geoscience Union Meeting 2013
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DEVELOPMENT OF AVOBE GROUND BIOMASS ESTIMATION ALGORITHM FOR GCOM-C1/SGLI BASED ON MULTI-ANGLE OBSERVATION DATA

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

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

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

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

Keywords: Second Generation Global Imager (SGLI), Multi-angular observation, Forest canopy, Biomass Estimation

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Snow grain size retrieved with ground and satellite-based remote sensing at SIGMA-A on northwestern Greenland ice sheet

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Snow grain size is one of the most important physical parameters which represent the qualitative snow surface condition. A metamorphosis of snow grains such as sintering or melting causes a snow grain growth, thus the estimation of snow grain size is useful for detecting signs of snowmelt. Snow grain size can be remotely sensed from the near-infrared albedo or reflectance. Furthermore, the vertical information of snow grain size also can be estimated using the wavelength dependence of the photon penetration depth. The snow grain size derived from the shorter wavelength contains the information on a deeper snow layer than those from the longer wavelength. To validate the remote sensing of snow grain size and its vertical profile, snow grain sizes retrieved with ground and satellite-based remote sensing using different spectral channels at 865, 1240 and 1640 nm were compared with in-situ measurements at the SIGMA-A site (78^{o}03'N, 67^{o}38'W, 1,490 m a.s.l.) on northwestern Greenland ice sheet during June 26 to July 16, 2012.

The ground-based remote sensing are from spectral albedos measured with a spectrometer, while the satellite-based remote sensing are from reflectances at the top of the atmosphere by Terra/Aqua MODIS. The snow grain sizes retrieved from both the ground and satellite-based method were consistent well for the same spectral channels with the root mean square differences of less than 0.1 mm. This result implies that the algorithms for snow grain size retrieval were reasonable each other. In-situ measured snow grain size was defined as the width of the narrow portion of broken crystals. On July 4 and 5, melt forms with the radius of 0.5 mm beneath surface hoar of 0.15 mm were measured with snow pit work. The snow grain radii derived from the 1640, 1240 and 865 nm channels were 0.1, 0.25 and 0.6 mm, respectively, which agreed with the in-situ measured profile of snow grain size. During July 6 to 9, the top 10 cm snow layer was mainly composed of melt forms around 0.50 mm. The remotely sensed snow grain radii were 0.1, 0.6 and 1.1 mm for the 1640, 1240 and 865 nm channels, respectively. The overestimation at 865 nm might be result from the reduction in the snow reflectance by the ice layers observed in near snow surface. The underestimations at 1640 nm were also reported in previous studies when the grain size was large. The size derived from the 1640 nm channel would be affected by the microstructures on snow crystal surface as well as the grain size itself due to the smaller penetration depth for large snow grains. After the rainfall event from July 10 to 13, the extreme melt was detected as the increase of the MODIS-derived snow grain radii up to 0.4, 1.0 and 1.3 mm for the 1640, 1240 and 865 nm channels, respectively.

Keywords: snow grain size, remote sensing, MODIS, Greenland

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Satellite observation of marine ecosystem and ocean biogeochemistry

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The oceans absorb approximately 25-30% of anthropogenic carbon dioxide released into the atmosphere. While physics, as represented by temperature and wind speed etc., contribute to carbon flux between the atmosphere and the ocean, marine biota also plays a significant role via photosynthesis on fixation and export of the carbon within the surface ocean and from the surface to the deep ocean, respectively. Especially, the photosynthesis requiring the carbon dioxide in its process can even accelerate the ocean absorption of the carbon dioxide. An ability of the carbon fixation and the export is dependent on photosynthesizing microbe, or phytoplankton. While a large-sized phytoplankton such as diatom fixes and exports the carbon faster than other phytoplankton, cocolithophore even releases the carbon dioxide during its calcium fixation, reducing a net amount of its carbon fixation. Therefore, variability in marine ecosystem structure would, at least partly, explain spatial or temporal anomaly of the carbon flux within the ocean. Currently, the ocean colour remote sensing is only a practical means to observe marine biological and biogeochemical variables with considerable frequency for the large-scale oceans. Under the JAXA GCOM-C project, we have been developing novel algorithms to observe the marine ecosystem structure (especially phytoplankton community structure) and other biogeochemical variables. In this presentation we show these observed by satellite as well as a comparison with the state-of-the-art marine ecosystem model.

Keywords: Biogeochemistry, Ocean Ecosystems, Satellite observation, Ocean color

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Wildfire monitoring utilizing multiple satellites

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Wildfire is not only one of the severe cause of forest degradation, but also ineligible source of GHGs. It emits CO2 as much as 1/4 to 1/2 of GHG emission by fuel combustion. For certain portion of wildfire are ignited by human, wildfire is important in terms of human controllable climate change as well as natural disaster. Although wildfire burns several km^2 in maximum in Japan, some wildfire ignited by a lightning burn more than $1000km^2$ (corresponds to one half of entire Tokyo) in Boreal forest. Because it is difficult to fight against strong intensity, it is important to extinguish wildfire in early stage or monitoring precise location. To achieve such sophisticated fire suppression, a wildfire monitoring system to detect small wildfire utilizing multiple satellites from micro satellite to large satellites. Also, a wildfire alert system to push needed wildfire information to firefighter is indispensable for social implementation for efficient wildfire suppression. Therefore, author developed wildfire detection algorithms for coming satellites including UNIFORM/VOL, GCOM-C1/SGLI and ALOS2/CIRC. an as well as improved wildfire detection algorithm for existing sensors MODIS and Terra/ASTER. Utilizing these algorithms, author also implemented wildfire alert system for peat-land fire in Indonesia. This technology will be used in Southern part of Africa in near future.

Keywords: Satellite, Wildfire, Disaster, International Collaboration, Social Impremention

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Monitoring of agrometeorological information in major grain belts using global satellite data

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The JAXA Satellite Monitoring of Agrometeorological Information (JASMAI) is a monitoring system of major grain belts with global satellite products, which provides information on soil moisture, solar radiation, surface temperature, and snow cover at 62 countries and regions in near real-time. In this presentation, more detail will be introduced.

Keywords: satellite observation, drought

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Retrieval of effective particle radius of clouds using MTSAT-2 and Fengyun-2E satellite data

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Aerosols, the tiny particles suspended in the atmosphere, can exert an important impact on radiative forcing and cloud-precipitation system of the earth. It is known that an increase in aerosols causes an increase in number density of cloud droplets but a decrease in cloud droplet size for given liquid water content. Furthermore, recent studies have shown that a marked increase of absorbing aerosols in South Asia has altered the characteristic of Asian monsoon. Therefore, it is important to obtain observational data of cloud particle properties such as an effective radius toward the deeper understanding of aerosol-cloud-climate interactions.

In this study, a method is proposed which retrieve effective particle radius of optically thick water clouds using hourly observation by geostationary meteorological satellites, Multi-functional Transport Satellite-2 (MTSAT-2) and Fengyun-2E (FY-2E). The use of ”the geostationary satellite” has a merit that it provides globally high temporal resolution, typically one or half hour, rather than the observation by polar orbital satellites such as the Advanced Very High Resolution Radiometer (AVHRR) boarded on the NOAA polar platforms or the MODerate resolution Imaging Spectrometer (MODIS) boarded on the Terra polar platforms whose observation interval is approximately once or twice a day.

Our retrieval method basically follows Kaufman and Nakajima (1993) in which the cloud effective particle radius is estimated from the cloud reflectance at 3.7 um band using NOAA/AVHRR instruments. At first, the retrieval developed for NOAA/AVHRR is directly adapted to MTSAT-2 and FY-2E data and the cloud effective radius is calculated. The results show confliction between effective radius values retrieved from MTSAT-2 and from FY-2E. In order to obtain harmonic results, several modifications and improvements are added to the original method and the more accurate algorithm is established. A good correlation is achieved between the retrieved values from two different satellites after careful consideration of response functions of each imager and scattering properties of water clouds. The validity of cloud effective radius obtained by this procedure is confirmed by comparing the results with those obtained by the MODIS cloud products.

The newly developed method is applied to obtain the distributions of the cloud effective particle radius over South Asian region for 2012. Well known characteristics, such that the cloud effective particle radius is smaller in continental clouds than in maritime clouds, are confirmed from FY-2E observations. It is also suggested that the cloud effective particle radius over the Indian subcontinent becomes larger and that over Arabian Sea becomes smaller during summer monsoon season.

The method also allows high temporal resolution and global scale observations of the effective radius compared to the conventional observations using polar orbital satellites.

Keywords: Satellite observations, Geostationary meteorological satellite, Effective particle radius of clouds, Aerosol indirect effects

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Evaluation of cloud radiative forcing simulated by the NICAM with A-Train

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Global satellite observation provides valuable information not only to the retrievals of physical quantities relevant to aerosol and clouds but also to the evaluation of these simulated by GCMs and cloud resolving models. We discuss synergetic use of A-Train satellite observations to evaluate cloud and precipitation fields simulated by a global cloud-resolving model (GCRM). Our previous efforts were made in evaluating cloud microphysical quantities by comparing simulated satellite signals against observation. However, for the context of climate prediction, it is crucial to understand the differences in terms of the radiation energy budget. In this presentation, effective ways to evaluate the relationships between vertical profiles of active sensors and TOA cloud radiative forcing are discussed.

The outputs from the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) are run through a satellite signal simulator (Joint Simulator for Satellite Sensors) to simulate CloudSAT/CALIPSO/CERES data. This study uses a merged dataset for CloudSat and CALIPSO, and CERES SSF level2 is co-located to the grid. A simple CloudSat cloud-type scheme is applied to the observed and simulated merged dataset. Then, the cloud radiative forcing will be evaluated for each cloud type.

Keywords: global cloud-resolving model, A-Train, cloud radiative forcing, satellite data simulator

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Low cloud distributions around anticyclone observed by the CALIPSO satellite in the mid-latitude ocean

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Cloud cover is important to analyze the future climate change because variations of cloud cover largely affect the global radiation budget. Low cloud thickness is sometimes a few hundred meters so that most of global climate model cannot simulate correct features of low cloud with their poor vertical resolution. Therefore many previous studies have prospected the factor which controls the variation of low cloud cover. Wood and Bretherton (2006) reported that a strength of inversion above a marine boundary layer strongly governed seasonal variations of low cloud cover. This is because the strong inversion tends to catch water vapor from the sea surface, and then to make thick low cloud under the inversion.

Most of previous studies have focused on the subtropical west coastal ocean where low cloud is dominant all year around. In contrast, the analysis of low cloud in the mid-latitude ocean is still not sufficient partly because it is difficult to observe low cloud with a satellite due to high cloud cover. Moreover in the mid-latitude ocean, it is necessary to analyze shorter time scales than in the subtropical ocean due to prevailing moving cyclones and anticyclones. On such a time scale, we need to consider many factors such as a large scale descending motion, warm or cold advections near the sea surface, and ocean surface wind speed in addition to the strength of inversion. Therefore this study first investigated horizontal distributions of the inversion strength above marine boundary layer and moving cyclones and anticyclones in the mid-latitude ocean with every six hours reanalysis data. As a result, it was found that the inversion above marine boundary layer became strong around anticyclones and on the other hand weak around cyclones in the mid-latitude ocean.

Norris and Iacobellis (2005) reported that low clouds over the mid-latitude ocean had a particular distribution around cyclones and anticyclones as well as inversion strength. However in this report, the accuracy of height information is rough because the cloud top height is retrieved from the infrared brightness temperature observed by satellites. And the analysis region is limited in the northern Pacific region which has many ship passages because this study uses ship observations in order to distinguish low cloud types.

Low cloud height above the marine boundary layer is important to analyze low cloud cover variations because low cloud height affects a convective structure within the marine boundary layer. Therefore this study utilized the CALIPSO satellite which can observe vertical distributions of cloud fractions, and analyzed vertical structure of low cloud around cyclone and anticyclone in detail. As the result it was found the correspondence that low cloud height became low where a large scale descending motion was strong in the mid-latitude ocean. Another result is that low cloud around anticyclones in the northern Pacific ocean has somewhat different distributions from that in the southern Pacific ocean because in the northern Pacific ocean the structure of marine boundary layer may be affected by a strong subtropical anticyclone in summer and by a strong cold air from the Asian continent in winter. On that day we will present the result how do the difference of the factors, inversion strength, a large scale descending, warm or cold advection over the sea surface, affect low cloud cover and the visible optical thickness of low cloud respectively.

Instead of the CALIPSO vertical feature mask (VFM), we utilize new cloud mask data which are developed in Hagihara et al. (2010). This new cloud mask data overcome the problem which the CALIPSO VFM may mistake aerosol or noise for cloud, and as the result improve overestimation of low cloud cover (Rossow and Zhang., 2010). This work was supported by JSPS KAKENHI Grant number 22340133.

Keywords: low cloud, mid latitude, CALIPSO, anticyclone, inversion, marine boundary layer

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Aerosol algorithm of GOSAT/TANSO-CAI

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GOSAT (Greenhouse gases Observing SATellite) is an Earth observing satellite, launched in January 2009. The satellite equips two sensors, TANSO-FTS (Thermal And Near-infrared Sensor for carbon Observations ? Fourier Transform Spectrometer) and TANSO-CAI (Thermal And Near-infrared Sensor for carbon Observations ? Cloud and Aerosol Imager). TANSO-FTS is a primary sensor of the satellite devoted to measuring concentrations of greenhouse gasses such as carbon dioxide and methane. On the other had, TANSO-CAI is a secondary sensor and the purpose of this is to detect clouds and aerosols with four bands, 380 nm, 674 nm, 870 nm, and 1600 nm, from near ultraviolet to near infrared. The precision of retrieval of greenhouse gases gets lower, when an area is contaminated with clouds or aerosols but greenhouse gases are retrieved without any consideration for clouds or aerosols. Aerosol retrieval is also important for understanding the direct and indirect influence of aerosols on climate as assessed by the IPCC-AR4.

In this study, we have developed an aerosol remote sensing algorithm to implement for operational process. Over the ocean area, two-channel method (Higurashi and Nakajima; 1999, 2000) is implemented. Both of Aerosol Optical Thickness (AOT) and Angstrom Exponent (AE) are retrieved by use of 674 nm and 870 nm. Over the land area, we uses a modified Kaufman (MK) method, which is a modified version of Kaufman method (Kaufman et al., 1997) and retrieved AOT with use of 380 nm. It is difficult to estimate the ground reflectance with use of minimum reflectance (MR) method because of the observation frequency is not enough for TANSO-CAI case. In MK method, we use NDVI, which is calculated by MR of 674 nm and 870 nm, and the MR of 674 nm to estimate the reflectance of 380 nm. The relationships between NDVI, MR of 674 nm and 380 nm are determined empirically.

It is thought that the values of retrieved AOT are influenced by the assumptions of characteristics of aerosol particle, such as mode radius and standard deviation of particle size distribution function, single scattering albedo (SSA) and aerosol layer height. These parameters are fixed in the current version of operational algorithm. We performed sensitivity tests to study such assumptions do not cause a significant error for retrieval other than the assumption of SSA. Mode radius and standard deviation of particle size distribution function do not produce large errors even if they are fixed in the algorithm. However, SSA is thought to be the reason of large error if they are far from real value. We have calculated correlation coefficient between AOT of CAI and AOT of AERONET(AErosol ROBotic NETwork) in condition that both SSA is fixed and SSA is from averaged value of AERONETS. The result shows that correlation coefficients are improved in some sites, but in some other sites, correlation coefficients are not improved. We need to investigate this result further.

We further discuss a use of the 1600-nm channel as a reference band of Kaufman method to estimate the ground reflectance at 680 nm to retrieve AOT at 680 nm.

Keywords: aerosol, remote sensing, GOSAT, TANSO-CAI

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Development of generalized satellite remote sensing algorithm for aerosol properties.

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In late years, high accurate multiple-wavelength, multiple-angle observation data have been obtained by grand-based spectral radiometers and multi wavelength imager sensors on board the satellite. Associated with the situation, the optimized multi-parameter remote sensing method by Bayesian theory has become popularly used(Turchin and Nozik, 1969; Rodgers, 2000; Dubovik *et al*., 2000). With the progress of computing technology, this method has being combined with radiation transfer calculation numerically solved each time in iteration for solution search, without using LUT (Look Up Table), as shown by successful examples of a flexible and accurate remote sensing (Dubovik *et al*., 2011).

We are developing a new Bayesian type inversion method, which combine the MAP method (Maximum a posteriori method) in Rodgers (2000) with the Phillips-Twomey method (Phillips, 1962; Twomey, 1963) as a smoothing constraint for the state vector.

Defining a radiance (measurement) vector at TOA by L and a geophysical (state) parameter or vector determining radiance by u, we express the observation as follows: $L = f(u) + e$, where e is the error caused by several error sources (observation error, modeling error in radiance and error in numerical calculation), and f is the forward operator to model the observation. L and u are defined in the target region determined by spatial and temporal dimensions, (x, y, t). Then, the cost function (E) is expressed as the sum of those of MAP method and of Phillips-Twomey method:

$$E = (L - f)^T S_e^{-1} (L - f) + (u - u_a)^T S_e^{-1} (u - u_a) + \mathrm{SUM}_k [\, w_k \, |A_k + D_k \, u \,|^2]$$

where, T is the transposed matrix, S_e and S_a are the covariance matrix for the observation operator, respectively. u_a is a priori (climatic) value. A_k indicates boundary condition in a certain region. D_k is a quadratic differential operator for structural valuables. w_k is a factor chosen to give appropriate relative weighting to the constraints. To minimize the cost function, we used a Newton method, and the solution may be obtained by several iterations. In our algorithm, L is the radiance observed by satellite and u is the aerosol properties: as of now, the aerosol optical depth (AOT) of fine particles, sea salt particles and dust particles, and the soot fraction in fine particles.

We conducted numerical tests for the retrieval of aerosol properties for GOSAT CAI imager data, to test this algorithm. In this test, we used the simulated radiance data observed by a satellite (5 by 5 grid) using a radiation transfer calculation model, Rstar code (Nakajima and Tanaka, 1986, 1988) assuming wavelengths of 380, 674, 870 and 1600 [nm], atmospheric condition of the US standard atmosphere, fine particle AOTs as 0.2, sea salt particle AOTs as 0.0 and dust particle AOTs as 0.1 for all grids.

For the test, we set to our algorithm each initial and a priori value, (0.001, 0.1) for fine particles and (0.001, 0.5) for dust particles, respectively. We gave the value corresponding to 10% error in measurements for S_e, and the value assuming that a priori AOT has |0.1| differences for S_a.

We calculated the difference between simulated true values and retrieval values of AOT; dAOT= [(retrieval value) - (true value)]/(true value). The result of the experiment shows the algorithm could retrieve AOT of fine and dust particles, and dAOT of fine and dust particles are about -0.15 and +0.07 under the present condition of test experiment, and it was confirmed that our new algorithm works and can derive AOT with a certain accuracy. We will test several other conditions by numerical test, and discuss the information content of several parameter needed for retrieval (e.g. S_e, S_a, w) and the boundary condition and errors included in the retrieval algorithm.

Keywords: Satellite remote sensing, Aerosol

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Development of a radiative flux evaluation program with a 3D Monte Carlo radiative transfer code

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In this study, we have developed a 3D Monte-Carlo radiative transfer code that can treat a broadband solar flux calculation, also implemented with k-distribution parameters of Sekiguchi and Nakajima (2008). We used this code for generating the radiative flux profile and heating rate profile in the atmosphere including broken clouds. In order to construct 3D extinction coefficient fields, we tried following three methods:, 1) stochastic clouds generated by randomized extinction coefficient distribution and regularly-distributed tiled clouds, 2) numerical simulations by a non-hydrostatic model with bin cloud microphysics model and 3) Minimum cloud Information Deviation Profiling Method (MIDPM).

The second construction of 3D cloud systems was performed by numerical simulation of Californian summer stratus clouds using a non-hydrostatic atmospheric model with a bin-type cloud microphysics model based on the JMA NHM model (Iguchi et al., 2008; Sato et al., 2009, 2012). The numerical simulations were conducted on horizontal (vertical) grid with a spacing of 100m (20m) and 300m (20m) in a domain of 30 km,30 km,1.5 km with a horizontally periodic lateral boundary condition. Two different cell systems were simulated depending on the cloud condensation nuclei (CCN) concentration. In the case of level scale resolution 100m, a regional averaged cloud optical thickness, <COT>, and standard deviation, standard deviation of COT, are 3.0 and 4.3 for pristine case and 8.5 and 7.4 for polluted case.

In the MIDPM method, we first constructed a library of the pair of observed parameters from CLOUDSAT/CPR and collocated AQUA/MODIS imager products at the footprint of CPR along the CLOUDSAT orbit, i.e. the profile of effective radar reflectivity factor, dBZe(z), spectral MSI radiances, cloud optical thickness (COT), effective particle radius (RE) and cloud top temperature (Tc) for a case of summer stratus cloud off California coast on July 2, 2007. We then selected a best matched radar reflectivity factor profile from the library for each of off nadir pixels of MODIS where CPR profile is not available, by minimizing the deviation between library MODIS parameters and those at the pixel.

Using these constructed 3D cloud systems, we calculated the radiation field by our Monte-Carlo radiative transfer code at wavelengths of 0.5, 1.6 and 2.1 microns. We compared a reflectivity of 3D with plane parallel and a reflectivity of 3D with IPA. Independent Pixel Approximation (IPA) is an approximation calculated as plane parallel

each pixel for radiation. In the case of wavelength 0.5 microns, as expected, all the discrepancy between 3D cloud and equivalent IPA cloud cases are smaller than the discrepancy between 3D cloud and equivalent plane parallel cloud cases. At a maximum the reflectivity difference for the IPA cloud cases for NHM+ACB model and MODSI/CPR result reaches a value up to 0.040, whereas plane parallel show a large reflectivity difference as 0.010. Each values convert to incident radiative flux then the values are 30Wm-2 and 10Wm-2 respectively. We made sure of the high resolution reduce the accuracy of the difference between the 3D clouds case and IPA clouds case. Then we validate the evidence for tiled clouds we found the relativity of solar zenith angles and the relativity solar azimuth angles for the difference between 3D clouds and IPA clouds. For relativity of solar zenith angles the difference is thickness of stratum. For the relativity solar azimuth angles the difference is amount of cloud. We should calculate the radiation field in many cases of clouds both the realistic clouds case as MODIS/CPR and tiled clouds and so on.

Keywords: Monte Carlo, radiative transfer, radiative flux, 3D cloud, satellite observation, model

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Dual Ka-band radar field campaign for GPM/DPR algorithm development

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Dual Ka-band radar system is developed by the JAXA for the GPM/DPR algorithm development. The dual Ka-radar system which consists of two identical Ka-band radars can measure both the specific attenuation and the equivalent radar reflectivity at Ka-band. Those parameters are important particularly for snow measurement. Using the dual Ka-radar system along with other instruments, such as a polarimetric precipitation radar, a wind-profiler radar, ground-based precipitation measurement systems, the uncertainties of the parameters in the DPR algorithm can be reduced. The verification of improvement of rain retrieval with the DPR algorithm is also included as an objective. Observations using the dual Ka-radar system were performed in Okinawa Island, in Tsukuba, over the slope of Mt. Fuji, in Nagaoka, and in Sapporo, from 2011 to 2013. Through those experiments the main results are the *k-Ze* relationships on various precipitation types. The feasibility of total attenuation in melting layer has been studied. Different *k-Ze* relationships have been obtained in snow observations. The vertical variations of rainfall are also analyzed for the DPR algorithm development.

Keywords: GPM/DPR, Ground Validation, Ka-band Radar, k-Z relationship

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Estimation of errors due to aerosol scattering on the remote sensing of the lower tropospheric ozone with measurement of

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abstract

Estimation of errors due to aerosol scattering on the remote sensing of the lower tropospheric ozone with measurement of solar UV-Vis. backscattered spectra from space

The lower tropospheric ozone is a major photochemical oxidant affecting human health and vegetation. In recent years, the long-range transport of the tropospheric ozone from the Asian Continent affects air quality in Japan and other wide areas. Remote sensing from a satellite is effective to observe such extensive/transboundary air pollution. However, it has been quite difficult to measure the lower tropospheric ozone from the satellite.

We have proposed that it can be evaluated with simultaneous measurement of solar backscattering spectra in the ultraviolet(UV) and visible(Vis) regions. Because the atmospheric Rayleigh scattering cross-section is much larger in UV than that in Vis, lower tropospheric light path length of the solar scattered radiation observed from space is significantly different in these two wavelength regions. This difference in the light path changes ozone column amount along it in the lower troposphere, and enables us to evaluate the lower tropospheric ozone mount.

The accuracy/precision in this evaluation depends on the accuracy/precision both in the ozone column measurement from UV/Vis solar backscattered spectra and in the model calculation of the light path length in these wavelength region. In this study, we estimate errors in the mode calculation of the light path length with a simulation of

UV/Vis solar backscattered spectra measurement. The scattering by atmospheric aerosols is one of most significant factors influencing the light path length of the solar scattered radiation because the quantification of its vertical profile is quite difficult because it is highly variable temporary and spatially. Variation of the light path length with model profiles of aerosol extinction coefficient based on a lidar measurement is calculated with SCIATRAN (Rozanov et al., 2005) to estimate errors due to the difference between the ”true” aerosol profile and the ”assumed” profile.

Keywords: Remote Sensing

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Lower troposphere ozone derivation by remote sensing : earth surface albedo presumption in airplane observation

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abstract

The lower tropospheric ozone is a major photochemical oxidant affecting human health and vegetation. In recent years,the long-range transport of the tropospheric ozone from the Asian Continent affects air quality in Japan and other wide areas. Remote sensing from a satellite is effective to observe such extensive/transboundary air pollution. However, it has been quite difficult to measure the lower tropospheric ozone from the satellite.

We have proposed that it can be evaluated with simultaneous measurement of solar backscattering spectra in the ultraviolet(UV) and visible(Vis) regions. Because the atmospheric Rayleigh scattering cross-section is much larger in UV than that in Vis, lower tropospheric light path length of the solar scattered radiation observed from space is significantly different in these two wavelength regions. This difference in the light path changes ozone column amount along it in the lower troposphere, and enables us to evaluate the lower tropospheric ozone amount.

We carried out aircraft experiments to validate this method over Tsukuba on 10th and 13rd September 2012. UV and Vis backscatter spectra were measured with two Maya2000pro (Ocean Optics) spectrometers at two altitudes 2500 ft (760 m) and 25000 ft (7600 m). Simultaneously, ozone profile was measured with ozone monitors on-board the aircraft, with ozonesonde launched near Tsukuba, and the tropopheric ozone lidar. Because aerosol scattering may significantly affect the evaluation of the lower tropospheric ozone amount, in situ aerosol observation with the CRDS, PSAP, and PASS instruments and the lidar observation were carried out in the Meteorological Research Institute. In this study, surface scattering spectra, which significantly affects both the evaluation of ozone column amount from the measured spectra and the light path length. In this study, we estimate the surface scattering spectra from the solar back scattering spectra at 2500 ft level, considering the influence of aerosol scattering and absorption.

Keywords: lower troposphere ozone, remote sensing, earth surface albedo

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Lithosphere-Atmosphere-Ionosphere Observation by Small Satellite Constellation

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Current status of the ELMOS small satellite constellation will be presented.

Keywords: Small Satellite Constellation, Lithosphere, Atmosphere, Ionosphere, GPS occultation, Numerical Weather Prediction

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Doppler wind lidar measurement from space

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Wind profile is fundamental in many atmospheric phenomena. About 1,300 weather stations launch radiosondes to obtain profiles of pressure, wind, temperature, and humidity. Most of the weather stations are on land, while the stations on the sea are very sparse. Spaceborne infrared and visible imagers and microwave scatterometers can make wind measurement only at a specific altitude. Weather prediction and scientific people expect the realization of a global observation system for three-dimensional wind measurements. The spaceborne Doppler lidar is one of the candidate sensors for the global wind measurements. The working group on Japanese spaceborne Doppler Lidar has been established to realize for wind measurements from space. In this presentation, we describe wind measurement with the Japanese spaceborne Doppler Lidar and the activities and goals of this working group.

Keywords: wind measurement, spaceborne lidar, Doppler lidar, global climate model, weather prediction

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Production of Global Satellite Mapping of Precipitation and Evolution for the Global Precipitation Measurement Mission

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Japanese Global Rainfall Map algorithm has been developed based on heritages of the Global Satellite Mapping for Precipitation (GSMaP) project, which was sponsored by the Japan Science and Technology Agency (JST) under the Core Research for Evolutional Science and Technology (CREST) framework between 2002 and 2007. The GSMaP project utilized accomplishments of observations by the Precipitation Radar (PR) onboard the Tropical Rainfall Measuring Mission (TRMM), and produce high-resolution and high-frequent global rainfall map based on multi-satellite passive microwave radiometer observations with information from the Geostationary InfraRed (IR) instruments. Output product of GSMaP algorithm is 0.1-degree grid for horizontal resolution and 1-hour for temporal resolution. The GSMaP near-real-time version product (GSMaP_NRT) has been in operation at JAXA since October 2008 in near-real-time basis, and browse images and binary data available at JAXA GSMaP web site (http://sharaku.eorc.jaxa.jp/GSMaP/). Altough the itinial GSMaP algorithm used passive microwave imagers only, SSMIS instruments onboard DMSP F16 and F17 has been introduced to GSMaP_NRT since 14 June 2010, in response to decrease of number of available passive microwave imagers. In addition, microwave sounders, AMSU-A/MHS instruments onboard NOAA-19 and MetOp-A has been introduced to the system since 1 August 2011.

With the objective of neccessity of continuous and log-term rainfall data set, GSMaP Reanalysis version (GSMaP_MVK V5.222) was produced and released recently. Reanalysis version is available for the period from March 2000 to November 2010, and will be updated in future. GSMaP_MVK product differs sligtly from the GSMaP_NRT product in terms of input data and algorithms. GSMaP_MVK uses all available microwave imager, microwave imager/sounder, and sounder data as inputs, since its processing is not in near-real-time basis. In addition, a full version of the algorithm (morphing and Kalman filtering by forward and backward processes) are used. GSMaP_MVK is available to registered users via JAXA GSMaP web site, as well as GSMaP_NRT. Users of GSMaP product extends broad user community, such as flood alert and weather services, and data utilization demonstrations are underway in several Asian and African countries.

The development of GSMaP algorithm was originally started for the Global Precipitation Measurement (GPM) mission, which is successor and extend mission of the TRMM. The GPM Core Observatory, which is a U.S-Japan joint mission, is scheduled to be launched in early 2014, and new version of GSMaP product is one of GPM products produced in JAXA. New version will include several updates of microwave imager and sounder algorithms and databases, and introduction of rain-gauge correction. As JAXA GPM product, we will provide 0.1-degree grid and hourly product for standard and near-realtime processing. Outputs will include hourly rainfall, gauge-calibrated hourly rainfall, and several quality information (satellite information flag, time information flag, and gauge quality information) over global areas from 60S to 60N. In addition, monthly rainfall product in 0.1-degree grid will be provided as JAXA GPM product.

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

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Gauge Adjusted Global Satellite Mapping of Precipitation (GSMaP_Gauge)

Tomoo Ushio[1*], Satoru Yoshida[1], Shoichi Shige[3], Kazumasa Aonashi[4], Takuji Kubota[2], Misako Kachi[2], Riko Oki[2]

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Precipitation is one of the most important parameters on the earth system, and the global distribution of precipitation and its change are essential data for modeling the water cycle, maintaining the ecosystem environment, agricultural production, improvements of the weather forecast precision, flood warning and so on. The GSMaP_MVK is a product of surface rainfall rate with 0.1 degree and 1 hour resolution on a global basis using the data from microwave radiometers on low earth orbit and infrared radiometers on geostationary orbit, and has been widely used through internet. However, some validation results from the hydrological madel show that the GSMaP_MVK sometimes underestimates the surface rainfall rate. In this presentation, the GSMaP_Gauge which is a gauge adjusted product to the GSMaP_MVK for climatological studies are introduced, focusing particularly on structure and performance of the algorithm and some initial evaluation tests. Additionally, the concept and theoretical basis of the near real time product of the GSMaP_Gauge named as GSMaP_Gauge_NRT is introduced.

Keywords: Precipitation, Satellite, GPM

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Semi-diurnal variation of precipitation over the tropics analyzed from TRMM 3G68 data

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Diurnal variation of deep convection and/or rainfall over the tropics has been studied using satellite data and/or surface data. Many numerical models have still deficiency in representation of this diurnal variation. While semi-diurnal variation of rainfall was reported in the global cloud system resolving model (Nonhydrostatic ICosohedral Atmospheric Model; NICAM) by Tomita et al. (2005) and Yasunaga et al. (2011) for aqua-planet experiment. Miura et al. (2007) simulated the realistic structure of a Madden-Julian Oscillation (MJO) event that occurred during December 2006 using the NICAM with land-sea contrast. Some areas over the tropics show semi-diurnal variation of rainfall in the 3.5 km grid hindcasting experiment of this NICAM MJO simulation. Here, we studied the semi-diurnal variation of rainfall using microwave (TMI) and radar (PR) observations from TRMM and infrared observations from geostationary satellite.

Harmonic analysis is applied for the 14 years TRMM 3G68 TMI data of December over the tropics. Amplitude of diurnal variation is larger over the southern Africa, Madagascar, Amazon and maritime continent. Semi-diurnal variation over the southern Africa, Amazon and western Pacific indicate larger amplitude. Semi-diurnal variation over the southern Africa and Amazon is characterized as primary peak in the afternoon and secondary peak in the morning from TMI and PR. PR observation indicates that afternoon peak is mostly consist of convective rain and morning peak is mostly consists of stratiform rain over both area. Infrared observation indicates that afternoon peak coincides with large number of deep convective cloud that is rapidly increasing stage of size, while morning peak coincides with re-enhanced size of deep cloud. This cloud configuration suggests that afternoon peak corresponds to developing stage of convective cloud and morning peak corresponds to re-enhanced anvil cloud.

Keywords: TRMM, precipitation, semi-diurnal variation, NICAM

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Study of tropospheric tomography for water vapor distribution with Neural Network

Akimitsu Hiroki[1*], Katsumi Hattori[1], Shinji Hirooka[1]

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Many meteorological disasters such as flood and landslides with torrential rain have been reported, and the mechanism of the precipitation system has been studied. Grasp of the situation of the precipitation with the portable radar is important, and a practical use study is investigated in Meteorological Research Institute or Osaka University. However, in the developing countries such as Indonesia and the Philippines, the observation with the radars have difficulty in realization under the present conditions at the point of cost and the maintenance. The water vapor tomography using a GPS and/or broadband satellite is thought to be effective as a situation of the precipitation monitoring system for the radars in the above-mentioned countries. When the development of a rain cloud bringing the damage of a heavy rain and the thunderstorm happens, there is an inflow of the water vapor from the neighborhood. It is thought that the measurement with the GPS elucidates the meteorological important flow and distribution of water vapor. Therefore, in this study, we develop water vapor tomography, the three-dimensional water vapor distribution, from GPS data and AMeDAS observation data using algorithm of residual minimization learning neural network (RMTNN). The numerical simulation demonstrate three-dimensional water vapor distribution can be estimated from GPS data. The details will be shown at our presentation.

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Cloud observation by next generation Earth observing satellites

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The use of some polar orbital satellites GCOM and EarthCARE for observing clouds is suggested in this paper. Since clouds exert an important influence on the planets water and energy balances and processes, more observations and understanding life-cycle of these particles are required. Adding to some passive sensors, the CloudSat and the CALIPSO present a new epoch in cloud observation with the purpose of revealing the particle transition. It is expected that the combined use of polar orbital passive/active sensors and geostationary satellites reveal details of cloud evolution process using multi-spectral capability and the vertical observation capability of active/passive sensors. In this paper, we would like to introduce recent progresses of cloud observations from satellites, to show multi-sensor views of cloud droplet growth process and comparison results between observations and models.

Keywords: Atmospheric observation, Earth observing satellite, cloud properties

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Satellite Image Analysis for Channels covering East Asia Region and Hidden Periodicities for Time Series Data

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Image analysis and time series analysis for MTSAT-2 images covering East Asia region of channels (IR1 and IR3) are discussed. The new time series data derived from fractal analysis of the time series images illustrated in 600x462 pixels from 2009 to 2010 are generated and power spectra for the ratio of cloud covers, water vapor, and space packing exponents with periodic peaks are calculated by using Fourier transform and periodicities of peaks in autocorrelation function are analyzed.

Caotic behaviors of orbits for their time series data restructured with three dimensional space of states are observed. The branch points of the system, the points of intersections where the amplitude of the fluctuations in four moving average curves become smaller at the same time, are evaluated with the time interval related to the periodic peaks. The features of the branch points and between the ratio of cloud cover or the ratio of water vapor and the space packing exponent are described.

Correlations between time series data of hourly air temperature from 1991 to 2010 observed at Kobe station and Niigata station are discussed.

For time series data of hourly air temperature in 1996, 2000, 2009, and 2010, power spectra with periodic peaks are calculated by using Fourier transform, respectively. A first peak of power spectra is determined and time intervals between nearest neighbor peaks are evaluated. As a result, hidden periodicities are observed. In addition, the features of power spectra for the ratio of cloud covers and space packing exponents by image analysis and time series analysis for MTSAT-2 images covering East Asia region of channels IR1 in 2009 and 2010 are described and similarities between the hidden preiodicities for time series data of hourly air temperature are suggested.

Keywords: MTSAT-2 images, Time Series Analysis, Fourier transform, continuous wavelet transform, hidden periodicities

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Terrestrial Water Storage in Northeastern Asia with GRACE satellite

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Monthly measurements of time-variable gravity from the GRACE (Gravity Recovery and Climate Experiment) satellite mission was used to investigate the temporal change of Terrestrial Water Storage (TWS) in the arid regions of Northeastern Asia, during the period of April, 2004 to December, 2010. The study area was a square between 40 degree N and 50 degree N, and between 90 degree E and 115 degree E, which includes most of Mongolia and a part of northern China.

The results show that decreasing trend of TWS was observed in mountainous areas and in Inner Mongolia, while TWS is fairly constant in the central area of Mongolia. These findings are consistent with the reported decrease of glaciers [Kadota et al., 2011] and the depletion of groundwater level in Inner Mongolia during the last several decades [Kitawaki, et al., 2010]. TWS observed in the central Mongolia does not contradict with hydrological characteristics of the region with dry climate, where precipitation almost equals evaporation [Kaihotsu et al., 2004], and groundwater level hardly shows noticeable change without excessive human influence.

Autocorrelation between TWS from GRACE and the surface soil moisture from the microwave remote sensing of AMSR-E (Advanced Microwave Scanning Radiometer for Earth Observation System) [Fujii, et al., 2009] was investigated, where the latter was processed with the same filters used with GRACE. It was found that there is a higher correlation in the dry regions, which indicates that there is a possibility that TWS variations in dry regions depend mainly on that of the surface soil moisture. On the other hand, the soil moisture is well-correlated with TWS at 3 month earlier in the mountainous regions. This suggest linkage between snow and soil moisture in the region.

These results indicate the potential of GRACE to provide information on hydrological change, such as soil moisture, groundwater storage, glacier, etc, in the arid and semi-arid regions, even though variations of TWS are relativity smaller in the regions.

Keywords: arid region, Mongolia, Hydrological change, climate change, AMSR-E

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Land-cover change detection in Siberia using Landsat

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Siberia is well known one of the most vulnerable ares for climate change. As a result of climatic change, large areas have undergone land cover change (e.g., ecological succession after forest fire and permafrost degradation), and the change affects ecological functions. It is important to monitor the process of the land cover change for understanding the role of terrestrial ecosystems in the carbon and water cycles, the frequency of natural disasters, and the impact of ecosystem services. Land cover map is used as the basis for ecosystem management, conservation and restoration activities. Therefore, timely and accurate land cover map is needed at the regional scale. In order to produce land cover map, remote sensing is a very useful tool for repetitive sampling over large areas. A method to produce the land cover map based on high temporal frequency sensors, such as MODIS and SPOT VGT, has already been established. However, the spatial resolution of 1 km limits the performance of land cover map. The land cover maps includes a potential source of error because of the heterogeneity of the landscape at the subpixel scale. According to a comparative study, the pixel-level classification accuracy is not high, ranging between 50 and 58%. Medium spatial resolution sensors, such as Landsat TM/ETM+, allows the direct comparison of the field plot with a 30 m image pixel. The objectives of this study is to produce accurate land cover map using Landsat, and to better understand the relation between climate change and land cover change.

Keywords: land cover change, climate change, Siberia, Landsat