ICWG-2
POSTER ABSTRACTS

Bedka, Sarah. *New Methods for Improving the Characterization of Cloud Properties and Vertical Structure from Satellite Imager Data*

Sarah Bedka, W. L. Smith Jr., P. Minnis, S. Sun-Mack, R. Palikonda

The SATellite ClOud and Radiative Property retrieval System (SatCORPS) employs a set of algorithms designed at NASA Langley Research Center to retrieve daytime and nighttime cloud properties from passive satellite observations. The methods are similar to those developed for application to MODIS and VIIRS data for the CERES (Clouds and the Earth's Radiant Energy System) program. They have been adapted for application to current and historical Geostationary satellite data including GOES, Himawari-8 and MSG, and are widely used in weather and climate applications and studies. While the retrieval methods are well suited to identify the geographic location of clouds and cloud top information at high spatial and temporal resolution, obtaining accurate estimates of cloud layering, geometric thickness and cloud ceiling have proven difficult. During the daytime, satellite solar reflectance measurements provide some information about vertical dimension, since they can be related to a wide range of cloud optical thicknesses. Assessment of cloud vertical structure at night is problematic since only infrared data are available, and optical thickness sensitivity is limited to thinner clouds. The challenge is in developing methods that best exploit the information contained in the satellite radiances to improve cloud vertical structure characterizations over the entire diurnal cycle. This paper describes progress in developing and applying new techniques that employ artificial neural network approaches to estimate cloud geometric thickness, multilayer cloud occurrence and properties, and nighttime optically thick cloud properties from satellite imager data. The training datasets in the initial methods employ CloudSat/CALIPSO data matched with nadir observations and retrievals from MODIS. Here, we test the methods for off-nadir use based on co-located Geostationary satellite data with CloudSat and CALIPSO, and report progress in refining the methods for more general use.

Daniels, Jaime. *Error Characterization and Validation of Atmospheric Motion Vectors Derived from the GOES-16 Advanced Baseline Imager (ABI)*

Jaime Daniels ,Andrew Bailey, Wayne Bresky, Americo Allegrino, Steve Wanzong, Chris Velden

Following the successful launch of the GOES-16 satellite on November 19, 2016, and subsequent Post-Launch Test (PLT) period, the ABI Level 1B products were declared provisionally operational on June 1, 2017. Throughout this PLT period, intense effort was and continues to be dedicated to validating and characterizing the performance and quality of the GOES-16 Derived Motion Winds (DMW) product. Heights assigned to derived winds are achieved through judicious use of pixel level cloud-top height products produced upstream of the winds algorithm. This means that the quality of the winds product is very much dependent on the quality of the cloud-top height product. As a result, we developed a number of validation and deep-dive analysis tools that enable close inspection, analysis, and characterization of the quality of the derived winds. More specifically, we developed a stand-alone tool that permits deep-dive analysis of individual DMWs on a case by case basis. Another tool was developed that allows for interrogation of the DMW vs. Rawinsonde (RAOB) match verification database to identify outliers in quality. The combination of these tools and others has been and continues to be critical to understanding and characterizing errors associated with the derived winds. This poster will highlight the use of these tools for some specific cases.

Frey, Richard. *The MODIS-VIIRS Cloud Mask (MVCM)*

Richard Frey, Steve Ackerman, Robert Holz, Steve Dutcher

As MODIS instruments on the Terra and Aqua platforms near the end of their useful lifetimes, concerns about continuing the time series of derived atmospheric science data products into the future has surfaced. A NASA effort to extend MODIS "climate data records" into the future using VIIRS instrumentation has begun. Included in that effort are cloud products, beginning with cloud detection. A cloud mask has been developed that continues the use of a "fuzzy logic" approach, named the MODIS-VIIRS Cloud Mask (MVCM). It is designed to bring continuity in cloud detection for MODIS, SNPP and NOAA-20 (J1) VIIRS, and the several planned VIIRS instruments beyond these. The algorithm uses only those spectral bands that are common to both MODIS and VIIRS instruments. The poster will detail similarities and differences from the current MODIS cloud mask (MOD35) and show comparisons of MVCM results to both MOD35 (Aqua) and CALIOP lidar. These comparisons illustrate that overall, the MVCM is very close to the quality of MOD35; however, it also points out regions on the globe where more work is needed. In particular, clear vs. cloudy discrimination in certain nighttime and polar scenes are impacted by the absence of atmospheric absorbing channels on the VIIRS.

Li, Yue. *Infrared Cloud Phase and Height Continuity Products between MODIS and VIIRS*

Yue Li, Andrew Heidinger, Steven Platnick, Robert Holz, Steve Ackerman, Kerry Meyer

The MODAWG project aims to develop retrieval products from VIIRS that demonstrate continuity with the current NASA MODIS data. The MODAWG IR cloud type/phase and height algorithms are based on those run in the Clouds from AVHRR Extended (CLAVR-x) NOAA processing system. The height algorithm is also employed as NOAA's operational retrieval algorithm for the VIIRS sensor. In this study, comparisons are carried out to assess the cloud phase and height products from MODAWG-VIIRS, MODAWG-MODIS, and NASA MODIS Collection 6.1. For the evaluation purpose, the NASA CALIPSO/CALIOP datasets are utilized. It is concluded that both MODAWG-VIIRS and MODAWG-MODIS produce high quality IR cloud phase and height products. Additionally, research is being conducted to improve consistency between the two MODAWG products and preliminary results prove to be promising.

Menzel, W. Paul. *Hemispheric Cloud and Moisture Exchanges seen in HIRS Measurements*

W. Paul Menzel, Eva Borbas, Richard Frey, Bryan Baum, Geoff Cureton, and Nick Bearson

This poster presents the cloud and moisture parameter data records derived from HIRS (High-resolution Infrared Radiation Sounder) and Moderate resolution Imaging Spectro-radiometer (MODIS) measurements. Cloud top pressure (CTP) and effective emissivity (εf, cloud emissivity multiplied by cloud fraction) are derived using the 15-µm spectral bands in the CO_2 absorption band and implementing the CO_2 slicing technique. High, mid, and low clouds are separated into thin, thick, and opaque categories; the approach is robust for high semi-transparent clouds but weak for low clouds with little thermal contrast from clear sky radiances. HIRS Total Precipitable Water (TPW) are from statistical regressions of geographically seasonally distributed radiosonde, ozonesonde, and ECMWF ReAnalysis data. The AVHRR based PATMOS-x is used to characterize HIRS sub-pixel cloud cover. TPW and high cloud detection hemispheric trends (since 1980 for HIRS and since 2002 for MODIS) are presented.

Nelson, Ethan. *Upper Tropospheric Cloud Properties and Their Variability with the El Nino Southern Oscillation*

Ethan Nelson, Paul Menzel, Richard Frey

The El Nino Southern Oscillation (ENSO) is a large source of climate variability worldwide, both locally in the Pacific Ocean region and globally through teleconnections. Here we explore these features using High Resolution Infrared Radiation Sounder (HIRS) data that has been reprocessed to provide multi-decadal observations from the same polar-orbiting satellite sensor family. Spatial regressions are performed between the ENSO 3.4 index based on sea surface temperature and monthly mean afternoon high cloud information from HIRS on seven different satellites over a nearly continuous 32-year time period. Strong, negative regression slopes are found between the 3.4 index and high cloud top pressure through portions of the Eastern Pacific ITCZ and the Eastern Asian continent regions, while positive slopes are found over the Maritime Continent, Central South America, and Southern end of Africa. Regression slopes between the 3.4 index and high cloud frequency are opposite in sign and spatially more uniform. These results demonstrate the usefulness of and motivate further climate system analysis by long-term, inter-calibrated instrument climate records from space.

Palikonda, Rabindra. *Global GEOsat Cloud and Surface Temperature Datasets for Climate Monitoring and Nowcasting Applications from the NASA LaRC SatCORPS*

R. Palikonda, William L. Smith Jr., P. Minnis, Sarah Bedka, Gang Hong, Kris Bedka, Ben Scarino, Chris Yost, Qing Z. Trepte, Douglas A. Spangenberg

Geostationary satellite (GEOSat) imager radiances are valuable for remote sensing of many different physical parameters that can be used for a variety of weather, aviation, and energy applications. At NASA Langley, the Satellite ClOud and Radiation Property retrieval System (SatCORPS) has been developed for application to meteorological satellite data to provide cloud and surface parameters for the Clouds and the Earth's Radiant Energy System (CERES) program. The system is currently processing a constellation of GEOsat data in two modes. The first mode applies frozen algorithm versions to all 2nd and 3rd generation GEOsat's coinciding with the CERES data record (March 2000 - current) for trend detection and other climate applications. These retrieved properties form a GEOsat climate data record (CDR) complementary to the CERES polar orbiting cloud data set. The second mode is processing current data for nowcasting and other near-real time (NRT) applications. The algorithms in this mode are continuously evolving and updated routinely with the goal of achieving improved accuracies rather than time continuity. All data are processed hourly at 4-km resolution (8-km in CDR mode) between 60°N and 60°S. In the NRT mode, the bounds are extended for selected areas, such as Alaska where data is analyzed, at higher temporal resolution, for viewing angles up to 82.5° or latitude 75°N at a maximum. A rigorous calibration protocol has been developed to ensure accuracy and satellite inter-consistency as much as possible. A cloud masking procedure is applied to identify clear and cloudy pixels. For cloudy pixels, the cloud phase, optical depth, top height, base height, particle effective size, and in some cases, cloud layering is provided. The NRT dataset also contains an overshooting top product that provides the locations of severe

convective weather, and two aircraft icing products; one, that identify the airframe icing potential and altitude range due to super-cooled liquid water encounters, and another that identifies the location of dangerous levels of high ice water content (HIWC). New methods are available for estimating the cloud ice and liquid water path simultaneously for a given pixel. Surface skin temperature, clear-sky reflectance, and, over marine areas, aerosol optical depth are estimated for clear pixels. Top-of-atmosphere and surface shortwave and longwave radiative fluxes are also currently available. The cloud data are used for climate monitoring and are being assimilated into numerical weather prediction models. The overshooting top and icing products are being evaluated for operational use in a number of weather forecast offices. This paper describes the dataset, current applications, and availability.

Park, Ki-Hong. *Retrieval of Cloud Amount from Himawari-8 observation using Machine Learning*

Ki-Hong Park, Hwan-Woo Lee, Geun-Hyeok Ryu, Eun-Ha Sohn, and Jae-Dong Jang

Korea Meteorological Administration (KMA) has established a plan to automate synoptic observation of Cloud Amount (CA), instead of the naked-eye observation. Thus, National Meteorological Satellite Center (NMSC) of KMA developed CA retrieval model using Himawari-8 observation. To retrieve CA that is determined from 0 to 10 (0~100%), we used Random Forest (RF) which is one of the machine learning. For training the RF model, Target value is calibrated CA of ground at the 22 points in the South Korea during daytime for 2016. As a predictors and input for this model, 48 variables exploiting the brightness temperature difference (BTD) of IR channels from Himawari-8 were used and considered for the 9×9 pixels (18×18 km2) area to reflect ground observation characteristics. In addition, the accuracy of estimating the CA range from 1 to 9 was improved through sequential system of individual RF models generated by classification learning because of the high frequency of 0% or 100% CA. Details will be given at the conference. As a result of validation from September to December 2015, averaged bias, RMSE and correlation is –0.05, 1.58 and 91%, respectively. Proportion correct ±0 (PC±0) that means the percentile of no difference between observer and model CA is 43.9% and PC±2 is 89.3%. Also, model`s PC±2 in the range of 1 to 9 has increased 20.1% (29.9% → 50.0%) compared to COMS CA for January 2017 in the test. Finally, this product will be used to operationally enter CA code for meteorological message from 1st August 2018. In the future, we will try to apply the GeoKompSat-2A data that will release from 2019.

Reed, Bonnie. *JPSS Enterprise Algorithms Migration to CSPP*

The term, "Enterprise Algorithm" is used to describe an algorithm that uses the same scientific methodology and software base to create the same classification of product from differing input data (satellite, in-situ or ancillary). The Joint Polar Satellite System (JPSS) program has been transitioning to an enterprise approach using enterprise algorithms for the production of their level-2 data products - which include cloud, aerosol, land, ocean, and atmospheric parameters. Currently, the next generation of both polar (S-NPP and NOAA-20) and geostationary (GOES-16 and GOES-17) satellites are in orbit and as data from these satellites are processed on the ground, the enterprise methodology allows for one product algorithm to be used for both satellite streams. In addition to implementing the enterprise algorithms within the ground system, the JPSS program is working with the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin (UW) to migrate the enterprise algorithms to the Community Satellite Processing Package (CSPP) which supports the Direct Broadcast (DB) meteorological and environmental satellite community through the packaging and distribution of free open source science software. It is expected that by the end of December 2018, CIMSS will have the capability to provide these enterprise algorithms via CSPP. This talk will describe the algorithms that are currently available within CSPP and provide the migration plan for the remaining algorithms included in the CSPP software suite.

Sawyer, Virginia. *Cloud Fraction in the Dark Target product for MODIS and VIIRS*

Virginia Sawyer, Robert Levy, Shana Mattoo, Geoff Cureton, Yingxi Shi

The Dark Target algorithm for MODIS relies on cloud masking for its retrieval of aerosol optical depth (AOD), so its data product includes datasets of cloud distance and cloud fraction alongside datasets dealing more directly with aerosol. Because the VIIRS Dark Target retrieval (VNPAERDT) currently in development is intended to extend the MODIS data record beyond the end of the Terra and Aqua missions, making it possible to construct a multidecadal climate data record, its algorithm follows MODIS as closely as possible while still following a consistent convention with other VIIRS products. One important difference stems from the fact that the MODIS Dark Target product has a spatial resolution of 10km at nadir, while VNPAERDT is at 6km. The resolution of the cloud mask affects sampling for the level-2 AOD retrieval, which in turn causes a discrepancy in cloud fraction and AOD in the level-3 gridded averages. Comparing both retrievals to the MODIS 3km Dark Target product, which uses the same algorithm at an even finer spatial resolution, distinguishes this sampling effect from other potential sources of disagreement.

Spezzi, Loredana. *Performance of the Optimal Cloud Analysis (OCA) algorithm on MODIS measurements*

Loredana Spezzi, Philip Watts, John Jackson

The Optimal Cloud Analysis (OCA) algorithm derives two-layer cloud properties from concurrent visible, near-IR, and IR observations [Watts et al. 2011]. OCA is currently used at EUMETSAT to derive operational cloud products (cloud top pressure and microphysical properties) from MSG/SEVIRI observations, and is the baseline cloud retrieval algorithm for the next generation of EUMETSAT imagers: MTG/FCI and EPS-SG/METimage.

The EPS-SG/METimage case represents the first application of OCA to low-Earth orbit imaging measurements and, as such, requires additional testing and refinements. It also offers the opportunity to test the impact of new channels not available on SEVIRI. In this context, this poster presents the first results of the application of OCA to MODIS data, chosen as proxy for METimage.

Stegmann, Patrick. *Future Development of the Scattering Properties of the Community Radiative Transfer Model*

Patrick Stegmann, Benjamin Johnson

This presentation is giving an overview of the ongoing work to improve the scattering properties used in the Community Radiative Transfer Model (CRTM) maintained by the Joint Center for Satellite Data Assimilation, including hydrometeors and aerosols. For the assimilation of satellite data under all-sky conditions, the CRTM includes the Advanced Doubling-Adding Method (ADA) and Successive Order of Interaction (SOI) radiative transfer solvers. These solvers allow to consider cloud and aerosol layers in the setup of an atmospheric column for which measured radiometric quantities are to be determined. Light scattering properties of cloud layers are pre-computed off-line and loaded by the solvers as binary file Look-Up Tables (LUTs) during a solver run to maximize computational speed of the CRTM. However, the ongoing development of the CRTM itself and problems with the existing LUTs require a several changes in the existing database. Existing LUTs contain scalar scattering properties that have been produced early in the development of the CRTM. As such, the lack of existing documentation on how these scattering properties have been produced also provides a strong motivation to look deeper into the existing LUTs. Recent efforts have been made by Yi et al. (2016) and Stegmann et al. (2018) to include MODIS Collection 6 ice scattering properties in the CRTM LUTs and assess the possibility of a variable-density bicontinuous random medium model for the snow and graupel properties. Recent developments in considering polarimetric observations in the CRTM require the provision not only of the phase function, but the full phase matrix in the LUTs. For aerosol scatterers, recent advances in modeling aerosol optical properties are to be included in the CRTM. These include novel refractive index spectra for mineral dust by Stegmann and Yang (2017), that are physically consistent and enable both a distinction of the source region and the particle size, as well as fractal models for soot and biomass burning aerosols.

Trepte, Qing. *Evaluation of Cloud Detection Biases in Geostationary Satellites using CALIPSO Data*

Qing Trepte, Patrick Minnis, Christopher R. Yost, William Smith Jr., Rabi Palikonda, Sarah Bedka

With the launch of a new generation of Geostationary satellites (GEO) such as Himawari and GOES-16, cloud detection using satellite imager data has been greatly enhanced with increased spectral bands, and higher temporal and spatial resolutions. A concern for all geostationary sensors, however, are changes in instrument sensitivity and algorithm performance at different viewing and solar zenith angles. CALIPSO lidar observations provide a valuable reference for assessing these impacts as the satellite flies in the A-Train sun-synchronous orbit and crosses a wide range of GEO viewing angles each day.

This paper will present the cloud mask results using the imager data from Himawari (AHI) and GOES-16 (ABI). The detection algorithms have been adapted from the Cloud and Earth's Radiant Energy System (CERES) MODIS Edition 4 cloud mask, and adjusted and tuned to geo-satellites. They are used operationally for the CERES Time and Space Averaging (TISA) gridded cloud products and for near-real-time retrievals for weather and nowcasting applications. Examples of Himawari nighttime cloud mask over ocean and GOES-16 daytime cloud detection over CONUS will be shown.

Cloud fraction biases compared to CALIPSO Version 4 data products will be described for different viewing angles, cloud types (ice/water), cloud optical depth, and surface backgrounds. Regional and zonal cloud amount comparisons among GEO cloud mask, CERES MODIS Ed4 and CALIPSO Vertical Feature Mask will also be presented.

Wang, Chenxi. *A new machine learning based cloud phase discrimination algorithm designed for passive infrared satellite sensors*

Chenxi Wang, Steven E. Platnick, Kerry Meyer

Clouds play critical roles in the Earth's energy budget due to their large coverage and strong radiative effect. Among various important cloud properties, cloud thermodynamic phase is a critical one to link cloud microphysical properties with cloud optical and radiative properties. In this study, we developed a novel cloud thermodynamic phase algorithm based on a Random Forest (RF) classifier. The training (75%) and validation (25%) datasets are generated using a 3-year coincidental MODIS (onboard both Aqua and Terra) and CATS (onboard the ISS) observations. The "true" cloud thermodynamic phases are provided by a lidar on CATS and inputs are solely from MODIS thermal infrared (IR) observations and surface temperature from reanalysis. An independent 1-year cloud phase dataset from CALIPSO/CloudSat is also used for validation purpose. Our preliminary results show that the RF-based phase algorithm performs much better than current MODIS MOD06 IR Phase 1km product. In the near future, we intend to apply a similar RF-based phase algorithm to daytime clouds with a more complete spectral information (e.g., using IR and shortwave observations).

Weisz, Elisabeth. *Generating Sounder Products at Imager Spatial and Temporal Resolution*

Elisabeth Weisz, W. P. Menzel, E. Borbas, B. A. Baum

Hyperspectral sounder measurements (e.g., from CrIS) are sampled at relatively coarse spatial resolution (~14 km) but can be combined with the imager (i.e., VIIRS) infrared (IR) window band measurements to construct any spectral band at imager spatial resolution (750-1000 m). The fusion approach (Cross et al. 2013, Weisz et al. 2017) was developed and tested using MODIS and AIRS, where MODIS already takes 4.3 and 15-micron carbon dioxide and 6.7-micron water vapor band measurements for assessing the fusion bands. Rather than going through the process of constructing radiances, the direct fusion of sounder products with imager radiances also shows promise for all imager/sounder pairs, including GEO/LEO imager/sounder pairings. With this approach, it is possible to improve continuity in derived products (e.g., cloud properties, clear sky temperature and moisture layers, and atmospheric stability) over the generations of weather satellite sensors, and continue applications that require IR absorption bands. In this paper we describe application of the fusion method to connect LEO sounder radiances and products (from CrIS) to LEO imager radiances (from VIIRS) as well as to GEO imager radiances (from ABI) to create high spatial (horizontal and vertical) resolution depictions of atmospheric changes.

Yang, Yiseok. *Validation of the new cloud optical and microphysical properties retrieval algorithm for the South Korea stationary satellite (GK-2A).*

Yiseok Isaac Yang, Seong Soo Yum, and Junshik Um.

Recent extreme weather event, such as a heat dome in northern hemisphere, that might be attribute to climate changes is a serious social issue. Many studies showed that better understanding of interactions between cloud and aerosol can improve our knowledge on how climate may change. It has been proven that remote sensing of clouds and aerosols using satellite platforms is an effective method to quantify the impacts of clouds and aerosols on the earth energy budget. The Geo-KOMPSAT-2A (Geostationary Korea Multi-Purpose Satellite-2A, GK-2A) will be launched in the end of 2018. The development of GK-2A cloud properties retrieval algorithms will be completed before the launch. In this study, the GK-2A cloud optical and microphysical properties algorithm that retrieves daytime cloud optical thickness (COT), cloud effective radius (CER), cloud liquid water path (LWP), and ice water path (IWP) is explained and the algorithm's structure is also introduced. An optimal estimation (OE) approach is employed that requires appropriate a-priori values and measurement error information to retrieve COT and CER. LWP and IWP are then calculated using the empirical relationships between COT/CER and cloud water path that were determined previously. To validate the retrieved cloud properties, GK-2A cloud products are compared with those of other operational satellites. To compare the results with other algorithms that use cloud reflectance at visible and near-IR channels as input data, MODIS MYD06 cloud products are selected as reference value. For the validation with cloud products that are based on microwave measurements, COT(2B-TAU)/CER(2C-ICE) data retrieved from CloudSat cloud profiling radar (W-band, 94 GHz) are used, whereas the AMSR-2 Level-3 cloud liquid water data are selected for the cloud water path validation. Details on the development, status, and results of validation tests will be presented at the meeting.