JCET
The Joint Center for
Earth Systems Technology

Fifth Annual Report
for
Cooperative Agreement NNX15AT34A

Twenty-fifth Annual Report
for the
Joint Center for Earth Systems Technology

Submitted August 3, 2020

Message from the Directors

This volume is the fifth in the most recent, five-year renewal period 2015-2020, and it is the twenty-fifth annual report describing the scientific accomplishments and status of the Joint Center for Earth Systems Technology (JCET) at the University of Maryland, Baltimore County (UMBC). This report satisfies the annual report requirement for Cooperative Agreement NNX15AT34A.

JCET was established in 1995 to promote close collaboration between scientists at UMBC and the NASA Goddard Space Flight Center (GSFC) in areas of common interest related to developing new technologies for environmental remote sensing and conducting multidisciplinary research on advanced concepts for observing Earth and planetary atmospheres, the solid Earth and planets, and the hydrosphere, using ground stations, aircraft, and space-based platforms. JCET also serves as a means to increase the effectiveness of university research and teaching resulting from the collaboration and provides a venue to train personnel for research in relevant Earth science and technology areas. The NASA Earth Sciences Division funds and collaborates with UMBC through the JCET administration, located at the BWTech Research Park at UMBC. JCET, administered through the Office of the Vice President for Research, has offices in the Physics building, the Sondheim building, and the Technology Research Center on the UMBC campus and at GSFC, Bldg 22. Most of JCET scientists work in offices at Goddard, and a substantial number also reside on campus at UMBC, contributing to research and education of graduate and undergraduate students. Of course, at the moment, due to the COVID-19 pandemic, all JCET faculty and students are working remotely.

In this fifth year of the five-year cooperative agreement period, there are 53 JCET faculty members who conduct their research among nine branches at Goddard, and who collaborate and teach in six departments at UMBC and advise more than 154 graduate students at UMBC. JCET faculty are supported by tasks from Goddard within the Cooperative Agreement and by independent grant funding from federal and state agencies, as well as private industry. State funding supports teaching in UMBC departments, proposal writing and bridge support when a JCET scientist's research funding falls short.

JCET is unique compared to other Cooperative Agreements of its kind at GSFC for its advocacy and inclusion of teaching and student mentorship as an integral part of its faculty's activities. JCET faculty affiliate with departments and teach, advise undergraduate/graduate students, and collaborate with faculty in UMBC's academic departments. Prominent in this collaboration within this reporting period include the departments of Physics, Geography & Environmental Systems, Chemistry, Mathematics & Statistics, Chemical, Biochemical & Environmental Engineering, Computer Science & Electrical Engineering, and the Office of Undergraduate Education. JCET Associate Director for Academics coordinates the activities among the academic departments at UMBC, the JCET research faculty, and students. Through a competitive process, JCET selected two Graduate Fellows this year and supports their stipend, tuition, health care and travel to one professional conference. Each semester, graduate students participate in a weekly seminar series organized by JCET. In the Fall semester, the seminars are given by the students on their research topics while Spring semesters are reserved for exploration of Earth-science related topic. In Spring 2020, the graduate students explored Artificial Intelligence (AI) and Machine learning techniques with applications to Earth Science research, led by incoming JCET Associate Director for Academics, Prof. Zhibo Zhang, and JCET faculty members Drs. Chenxi Wang and Daniel Miller, and Drs. Aryya Gangopadhyay and Jianwu Wang from the Department of Information Systems.

JCET faculty members serve on University-wide committees, such as the Sustainability Committee, the Faculty Advisory Committee for Interdisciplinary Activities, Research and Creative Achievement, and the Faculty Senate. JCET hosts the monthly Telescope Open House events at the UMBC Observatory. According to the recent QS World University Rankings 2020, UMBC is one of the top 500 universities in

the world overall and among the best of the best in a key measure of faculty scholarship, due in no small part to the contributions from JCET faculty.

The Technical Volume of this report comprises tasks that are aligned with GSFC research areas. The task summaries present brief accounts of group members' accomplishments, provided by the respective principal investigators supported through a JCET task that was active during the period from October 1, 2019 to September 30, 2020. Each report includes a description of the Research task, accomplishments for the reporting period, and plans for next year. Following the Technical Volume is supporting material that includes academic affiliations, courses taught, publications, biographies, and a list of abbreviations and acronyms.

JCET continues to be a vibrant research organization, contributing to the Earth science mission at NASA Goddard Space Flight Center, as well as research and education of the next generation of Earth science researchers at UMBC and the nation. For example, this project year saw the launch and first light for the HARP CubeSat – UMBC's first NASA satellite! JCET looks forward to its continued collaboration in important NASA research areas in the coming year.

Belay Demoz, Science Director
Margo Young, Administrative Director
Zhibo Zhang, Associate Director for Academics

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I. Technical Volume: JCET Tasks

Task Number: 101
GSFC Sponsor: Hanisco, T.
UMBC PI: St. Clair, Jason
UMBC Project Number: 00010736

Summary
Airborne in situ measurements of formaldehyde are used, in conjunction with other measurements from aircraft payloads, to better understand the photochemistry of the atmosphere. New instruments are developed to provide formaldehyde measurements from numerous aircraft platforms with different environmental and measurement requirements. The formaldehyde data can be used to improve retrievals of formaldehyde and isoprene (by proxy) from satellites. As a part of a suite of measurements, analysis of field data advances our understanding of atmospheric photochemistry and its effect on air quality and climate.

Accomplishments
The FIREX-AQ aircraft campaign, studying biomass burning emissions in the United States, took place during the summer of 2019. Final data processing for NO2 data from the CANOE (Compact Airborne Nitrogen diOxide Experiment) instrument (St. Clair as instrument PI) was completed. CANOE NO2 data compares favorably with two established NOAA NO2 measurements also aboard the DC-8 aircraft during FIREX. St. Clair led the preparation of the CANOE NO2 and CAFE (Compact Airborne Formaldehyde Experiment) instruments and supported the preparation of the ROZE (Rapid OZone Experiment) instrument for the Dynamics and Chemistry of the Summer Stratosphere (DCOTSS) EVS-3 project. The pandemic has delayed test flights until fall 2020 at the earliest, and science flights until 2021. St. Clair is a co-Investigator on the project and instrument lead on CANOE and CAFE. In January 2020, St. Clair traveled to Fairbanks, AK to make ground-based in situ HCHO measurements alongside aerosol observations in collaboration with faculty at U. Alaska Fairbanks and Georgia Tech. The measurements were a pilot study investigating the role of hydroxymethane sulfonate in the formation of sulfur aerosols in wintertime Fairbanks, where high aerosol loading is a reoccurring air quality problem. The pilot study results were promising and the PIs (St. Clair from UMBC) each submitted collaborative NSF proposals to participate in the Alaskan Pollution And Chemical Analysis (ALPACA) field campaign in 2021. St. Clair deployed a commercial HCHO monitor to the Maryland Department of Environment (MDE) monitoring site in Essex, MD where it was installed alongside MDE air quality monitors for Sept.- Oct. 2019. The data will be used to further understand the positive correlation between HCHO and organic aerosol (OA) and what affects the correlation slope. The work follows a paper by Liao using in situ OA and HCHO correlations to convert satellite HCHO data products into a global, space-based OA data product. Professor Beth Kautzman (Towson U.) and an undergraduate student maintained the instrument during the measurements and will collaborate on data analysis. Development of the next generation in situ HCHO instrument has begun in late spring 2020 and will continue through 2021, with St. Clair leading the effort with contributions from Andrew Swanson (614, USRA), Cam Brann (614, JCET), Steve Bailey (550), and Tom Hanisco (614). The instrument will replace the aging ISAF instrument with an improved architecture that includes a laser system developed at GSFC by Demetrios Poulios (554) and Paul Stysley (554). St. Clair started analysis using ATom in situ HCHO data along with GMI model output to analyze the global atmospheric distribution of HCHO in the remote background troposphere. Data analysis will continue this

summer and fall in collaboration with Qing Liang (614) and other members of the in situ lab and 614 modeling groups.

Plans for Next Year
Test flights and science deployment for the DCOTSS EVS-3 will happen in the next year, pandemic-permitting, with St. Clair leading the effort for the CAFE HCHO and CANOE NO2 instrument and supporting the ROZE O3 instrument. St. Clair will support test flights and science deployment of the ISAF HCHO instrument for the Asian Summer Monsoon Chemical and Climate Impact Project (ACCLIP) WB-57 project in Houston, TX and Naha, Japan. If funded and the pandemic allows, St. Clair will participate in the ALPACA campaign in wintertime 2021 Fairbanks, AK to better understand sulfur aerosol formation in very cold climates. St. Clair will finish managing design and assembly of the next generation ISAF, and will commission and characterize the instrument in lab. If the new instrument is ready, it will fly on the WB-57 (ACCLIP) or ER-2 (DCOTSS) in summer 2021. The collaboration with Towson studying organic aerosol â€“ HCHO relationships will continue, with data analysis starting once MDE data for HCHO measurement periods become available. The manuscript for the ATom in situ and GMI model study of the global distribution of HCHO in the remote background troposphere will be completed and submitted. An instrument paper for the CANOE (Compact Airborne Nitrogen diOxide Experiment) NO2 instrument, using data from the FIREX-AQ campaign for instrument validation, will be submitted.

Task Number: 102
GSFC Sponsor: Hanisco, T.
UMBC PI: Wolfe, Glenn
UMBC Project Number: 00010737

Summary
This task is entails collection and analysis of in situ airborne observations of trace gases, including formaldehyde (HCHO), carbon dioxide (CO2), and methane (CH4). Formaldehyde is a ubiquitous product of hydrocarbon oxidation and is observable from space-borne sensors. It is valuable for quantifying hydrocarbon emission source strength, and it is also a key participant in radical cycling throughout the lower atmosphere. CO2 and CH4 are greenhouse gases. Work on this topic centers on developing an airborne system to directly measure surface-atmosphere exchange (fluxes) of these gases. Data from this work will constrain both high-level satellite products and biophysical model algorithms used in carbon-climate models.

Accomplishments
This task primarily entails collection and analysis of in situ airborne observations of trace gases. This year, activity on this task has mostly centered on collaborative development of new proposals and analysis of existing data. Particular activities have included 1) working with a graduate student at NC A and T State University to constrain primary HCHO emissions using observations from the WINTER mission; 2) development of two airborne science proposals for NSF, one of which was funded (GOTHAAM, which will explore air pollution in the NY and Long Island Sound region); 3) scoping of another mission concept for the upcoming Earth Venture Suborbital call, focused on reactive nitrogen exchange in agricultural and forest ecosystems; 4) optimization of our ISAF formaldehyde instrument for deployment on the WB-57 as part of the joint NASA/NSF ACCLIP mission, which will (eventually)

explore outflow of pollution in the Asian Monsoon; and 5) providing assistance with the installation of a Pandora spectrometer near BWI airport for examining the effect of COVID 19 on airport-related pollution. In addition, Wolfe released a new version of his 0-D box model F0AM, which continues to be widely used by the international atmospheric chemistry community.

Plans for Next Year
If GSFC access restrictions soften, Wolfe will finish preparations for ACCLIP. It remains unclear when this mission will fly. He will also continue development of the aforementioned nitrogen-focused mission concept. And, he may be involved in an upcoming NOAA mission to study urban air quality (AEROMMA), but plans for this remain tentative. F0AM development and user support will continue.

Task Number: 103
GSFC Sponsor: Meyer, David
UMBC PI: Shie, Chung-Lin
UMBC Project Number: 00010738

Summary
As Project Scientist of Goddard Earth Sciences Data and Information Services Center (GES DISC) since January 2013, Shie provides scientific advice and suggestions with an objective to properly and effectively engage the data products/services distributed at GES DISC with the current or/and the in-development science research applications performed internally (GES DISC) or externally (science communities outside GES DISC). He also works closely with the GES DISC Manager (Kempler) and the GES DISC/User Working Group (UWG) Chair (Eric Fetzer at JPL), coordinating interactions/meetings between GES DISC and its UWG aiming to bridge together the user community, the data providers, and GES DISC (as the data distributor and the service provider), for improving the current user and data services and developing new services, as well as creating opportunity in collaborative works. Shie actively participates in Focus Groups within GES DISC, as well as collaborates in research projects (involving data and science) internally or externally (data or science communities outside GES DISC), and participates in Working Groups (WG) (involving data) mainly hosted either by ESDIS or ESIP.

Accomplishments
Dr. Shie has currently served as Scientist of Goddard Earth Sciences (GES) Data and Information Services Center (DISC). His two primary duties for this Task at GES DISC, aiming to help improving the overall data services, are: 1) offering and sharing scientific advises/suggestions with visions and insights, mostly via either exchanging emails/writings or participating various (routine or specific) meetings or activities held at GES DISC, 2) helping Dr. J. Wei (Lead Scientist at GES DISC) and Dr. Meyer (Manager at GES DISC) initiating interactions and coordinating activities between GES DISC and its User Working Group (UWG), such as organizing routine UWG meetings, i.e., the 2-hr telecon meetings and the 1.5-day face-to-face (F2F) meetings. There was one GES DISC UWG 2-hr pre-F2F telecon held on Aug 27, 2019. An annual 1.5-day F2F UWG Meeting was held on Sep 23-24, 2019. Valuable and useful recommendations suggested by the UWG members and the follow-up actions planned and conducted by GES DISC that genuinely help improving overall or

specific user services have been the main outcomes from such meetings. There were two more 2-hr quarterly telecons held on Mar 20, 2020 and Jun 30, 2020, respectively. The next pre-F2F telecon and face-to-face (tentatively) meeting are scheduled for Sep 8, 2020 and Oct 6-8, 2020, respectively. During recent years, Dr. Shie has initiated and performed Ensemble analyses on four major and unique metrics by integrating and inter-comparing the respective results. Three metrics being first examined in recent years are 1) the daily, routine operational distributions metrics: tracking number of distinct,registered users and distributed data files (granules), and size of distributed data volume of individual and overall data products and services; 2) the user publication metrics: collecting info of journal papers authored by users who used Giovanni and downloaded data for their scientific studies; 3) the Bugzilla user assistant ticket metrics: collecting info from those tickets containing users questions, needs and feedback. The fourth metrics newly conducted this year is 4) the GES DISC website metrics: monitoring usersâ€™ online accessing info and studying their search behaviors and potential needs via utilizing the Google analytic tool. Such a sequel of information mining approach and exercise has genuinely helped us better understand our user various needs and improve our overall data services. Dr. Shie cochaired an e-Lightning session targeting Metrics in the AGU 2019 Fall Meeting, Dec. 9-13, 2019, San Francisco, CA, in which Dr. Shie also presented an ensemble analysis of metrics. Dr. Shie has also actively joined external Working Groups (WGs), organized either by EOSDIS or ESIP, engaging external interactions and collaborations tackling on crucial subjects such as Data Quality, Earth Science Data Analytics and Disasters, etc. Through playing an active role in the EOSDIS Data Quality Working Group, Dr. Shie has coauthored four peer-reviewed technical articles published in 2019 by NASA ESDIS Standard Office (ESO), plus one more article published in 2019 by ESIP via Figshare. These five articles aim to ensure and better address the data quality matters by providing proper recommendations and guidelines to data producers and distributors. Dr. Shie also coauthored a peer-reviewed book chapter introducing NASA global satellite and model data products and services to tropical cyclone research community. Besides the aforementioned tasks or research on Data and Science, such as data quality, user multiple metrics, and data list (an advanced data service addressing user data discovery), Dr. Shie has also collaborated and coauthored a scientific peer-reviewed journal paper on evaporation from the Southern Ocean estimated using AIRS satellite data, published by JGR in Dec 2019. Dr. Shie (as a Co-I via a collaborative affiliation with Code 612) has also worked on a lately awarded proposal by the NASA PMM Program. The objective of this 3-yr project (May 2019-May 2022) aims to use GPM products in an optimal estimation Lagrangian framework to quantify moisture transport in Arctic cyclones. More details can be found in the Task 181 Report (UMBC Project: JCET0181).

Plans for Next Year

Dr. Shie may continue serving as Scientist at GES DISC (0.75 or 0.5 FTE). He may still help Drs. Wei and Meyer in the UWG task but will spend more of his time focusing on his Data and Science research (i.e., user multiple metrics, user tickets, data list, data quality, etc.), and exploring a machine learning approach on ensemble metrics analysis. Dr. Shie will also continue collaborative scientific works in the 3-yr PMM project (0.05 or 0.1 FTE; Task 181).

Task Number: 107
GSFC Sponsor: Neumann, T.
UMBC PI: Casasanto, Valerie

UMBC Project Number: 00010742

Summary
ICESat2 (Ice, Cloud, and land Elevation Satellite) is a satellite mission to be launched in late 2017 and will use precision lasers to measure the height of the Earth from Space and provide a 3D view of the EarthÕs elevation, specifically to monitor changing ice sheets and land surfaces. To communicate the important science of the mission, an Education and Public Outreach (EPO) program is underway through Task 107. The goals of the EPO efforts are to engage the general public in the mission and communicate its benefits, and to inspire, engage, and educate youth to pursue Science, Technology, Engineering and Math (STEM) careers. The unique aspects of the ICESat2 mission will be communicated to the public and to the youth, through a wide array of programs and initiatives. Casasanto is leading a team of four to develop and implement the missionÕs EPO and communications efforts.

Accomplishments
Casasanto led the communications and outreach efforts for the mission including mission website, hands-on products, and team communication products. Casasanto and team created and updated several hands-on activities for students including 16 Years of Ice Loss from Greenland And Antarctica: A Comparison Activity, and Sea Ice Towers,â€ posted on the ICESat-2 website. Casasanto and team presented hands-on activities to a variety of school groups including local Girl scouts and Brownies visiting the Goddard Space Flight Center. Casasanto presented a paper on the ICESat-2 module of the HoloGLOBE augmented reality app and Chaired the Hands-on Education and Outreach Session of the International Astronautical Congress (IAC) in Washington, D.C., October 21-25, 2019. Casasanto participated in the following outreach events (both in person and virtual): William T. Pecora Memorial Remote Sensing Symposium (Pecora 21) STEAM event in Baltimore, Maryland, October 6 â€“ 11, Earth to Sky Workshop, October 23, Capitol Hill Maker Faire, July 24, 2020 In June 2020, several summer interns were brought in to work on a variety of projects: 1) Produce the Android version of an ICESat-2 ground tracks app, 2) Use of ICESat-2 data to determine sea ice morphology relative to wildlife populations and to develop outreach products, 3) Comparison of ICESat-2 Tree Height Data to the GLOBE Tree Height Citizen Science Data. Interns are being actively mentored, and they are now completing their summer projects with expected results by mid-August.

Plans for Next Year
Casasanto will continue to lead the ICESat-2 mission outreach and communications team. She will implement the ICESat-2 presence at a variety of remote events including the AGU Fall meeting, Earth Day, and Capitol Hill Maker Faire. She will implement several of the outreach projects developed by her GSFC summer interns. Casasanto and team will also implement new data sets from the ICESat-2 mission on the HoloGLOBE app.

Task Number: 108
GSFC Sponsor: Lyapustin, A.
UMBC PI: Wang, Yujie
UMBC Project Number: 00010743

Summary

The main objective of Dr. Wang's research consists of four areas: 1) Operational performance of the Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm; 2) Adapting the MAIAC algorithm to different satellite sensors such as GLI, VIIRS, EPIC etc.; 3) Conducting MODIS/VIIRS calibration-validation analysis for surface reflectance products; and 4) Provide support for MAIAC data users. The MAIAC is a newly developed atmospheric algorithm which uses a time series approach and an image-based rather than pixel-based processing system to perform simultaneous retrievals of atmospheric aerosols and surface spectral bi-directional reflectance (BRF)/albedo without empirical assumptions. The contemporary paradigm of atmospheric correction algorithms developed for instruments such as MODIS and AVHRR are pixel based and depend on only single-orbit data. It produces a single measurement for every pixel characterized by two main unknowns, AOT and BRF. This raises a fundamental concern: the remote sensing problem cannot be solved without either a priori assumptions or ancillary data. These priori constraints are approximate, and limit the accuracy and/or applicability of the current operational aerosol/atmospheric correction algorithms. On the contrary, The MAIAC algorithm is an algorithm for simultaneous retrieval of the aerosol optical thickness and surface bidirectional reflectance from MODIS. It uses the time series of gridded geolocated and calibrated L1B MODIS measurements, and an image-based rather than pixel-based processing. If we take into account the facts that the surface changes much slower than measurement frequency and the AOT varies over rather large scale, the number of measurements will be more than the number of unknowns, which becomes a solvable problem. The new algorithm is generic and works over vegetated regions of the Earth as well as over bright deserts. The aerosol retrievals are performed at high 1 km resolution, which is a highly requested product in different science and application disciplines, such as Air Quality/Urban Pollution. MAIAC has an advanced cloud mask (CM) and an internal dynamic land-water-snow classification that helps the algorithm to flexibly choose a processing path in changing conditions.

Accomplishments

During the past year, Dr. Wang had developed a code to generate MAIAC daily global 0.05-degree Climate Modeling Grid (CMG) surface reflectance and Aerosol Optical Depth (AOD) data for MODIS. This code ingests daily MAIAC products and aggregate them into uniformed CMG grid. This product includes MODIS daily averaged AOD, AOD at satellite overpass time, band 1-12 surface reflectance in both instance measurement and angular normalized form, cloud fraction and QA information. The code has been delivered to MODAPS for testing. This CMG data will be part of official MAIAC data suite in C6.1. Dr. Wang also did a thorough analysis on Terra MODIS blue and deep blue band striping issue due to polarization difference between sensor mirror sides. These stripes show mostly at high latitude locations and create bias in downstream AOD and surface reflectance products. Dr. Wang developed an empirical correction model to reduce the striping. Results show that the model can decrease the magnitude of AOD striping by about 50-100 percent. Collaborating with Dr. Lyapustin, Dr. Wang continued to improve MAIAC algorithm for MODIS C6.1 code. The new version improved AOD retrieval for both land and water surface, added 250m resolution daily surface reflectance process for red and NIR bands, also improved injection height algorithm. In next two months, this code will be delivered to MODAPS for testing and production.

Plans for Next Year

In the coming year, Dr. Wang will continue to work on MAIAC algorithm improvements. A global MAIAC dataset will be created using the new C6.1 code. Based on that, Dr. Wang will

analyze the global NDVI dynamics at different latitude. Dr. Wang will also work on a new geostationary version of MAIAC code, which will be used on Himawari AHI data and GOES-R ABI data to generate geostationary version of MAIAC data suite. In addition, Dr. Wang will develop version 3 MAIAC code for EPIC process. This code will be part of DSCOVR processing chain.

Task Number: 109
GSFC Sponsor: Hanisco, Tom
UMBC PI: Abuhassan, Nader
UMBC Project Number: 00010744

Summary
The goals of this task include 1) to develop, improve and maintain a network of the Pandora spectrometer systems, 2) to determine levels of ozone and nitrogen dioxide, their altitude profiles, and validate the results in comparison with in-situ instrumentation, 3) to demonstrate the capability of the Pandora Spectrometer to support ground base and aircraft campaigns, as well as satellite validation activities, 4) to deploy Pandora systems at permanent sites in order to develop long-term records, 5) to present results at national and international meetings.

Accomplishments
Our efforts culminated by the official launch of Pandonia Global Network (PGN), a collaborative work funded by NASA and ESA with the objective of establishing long-term, fixed Pandora-monitoring locations focused on providing near-realtime high quality observations of total column and vertically resolved concentrations of a wide range of trace gases. A major joint objective is to support the validation and verification of more than a dozen low-earth orbit and geostationary orbit-based UV-visible sensors, most notably Sentinel 5P, TEMPO and Sentinel 4.

Plans for Next Year
Training of national and international scientists, engineers, and students Support PGN efforts in coordinating and implementing network standards regarding common algorithms and data processing, instrument operating routines, QA/QC, real-time data processing, and data archiving Assist engineers and technicians in future deployments. Recently the PGN and Pandora Spectrometer System have been selected to support Southeastern Asiaâ€™s efforts in the validation of the recently lunched South Korean Satellite GEMS. The UN Clean Air Commission will provide necessary funds to support local scientists, with an official declaration scheduled for early September.

Task Number: 110
GSFC Sponsor: Del Castillo, C.
UMBC PI: Turpie, Kevin
UMBC Project Number: 00010745

Summary
Turpie performs scientific evaluation of ocean color remote sensing measurements using the Visible Infrared Imaging Radiometer Suite (VIIRS) as a member of the NASA Science Team,

which is part of the Suomi National Polar-orbiting Partnership (NPP) mission. This involves the role of Ocean Color Science Co-Investigator for evaluating data quality, supporting calibration efforts, and providing a liaison with NOAA to support research to operations transfer. Efforts require the analysis of remote sensing data products or models and documenting findings through reports to the government and publication in the peer-reviewed literature.

Accomplishments
Dr. Turpie continued his role as ocean discipline co-lead, working with project management and engaging in planning of science team meetings and discussions regarding the senior review process. The discussions focused on how to incorporate JPSS VIIRS data product generation and research into the processing infrastructure for MODIS and NPP VIIRS. Dr. Turpie was engaged on various issues that arose regarding VIIRS calibration, specifically for ocean color applications. This culminated into the co-authorship of a SPIE conference paper regarding augmentations and innovations in the instrument calibration for ocean color. This included the use of lunar observation by NPP VIIRS to correct for spurious drift in the solar calibration observation time series. It was conjectured that the drift could be traced to a small mismatch between the band centers for the VIIRS instrument and those of the Solar Diffuser Stability Monitor (SDSM) channels. Dr. Turpie met with Amir Ibrahim to discuss development of top-of-atmosphere spectra that can be used to expand the analysis of calibration drift stemming from gradual changes in out-of-band response. Dr. Turpie organized semi-regular meetings between the ocean calibration team and the VIIRS Calibration Science Team (VCST). He continued the discussion regarding the effects of spectral drift in the SDSM on the calibration time series, and comparing methods of using observations of the Moon to reduce the effect. This on-going exchange involved the instrument contractor team and VCST, which highlighted the uncertainty in the VIIRS solar calibration trending generated by uncertainty in knowledge of the SDSM behavior and the need of the lunar trending to offset of trend bias in the solar calibration trending.

Plans for Next Year
As an ocean discipline lead for the new VIIRS/MODIS science team, Dr. Turpie will be organizing activities at the science team meeting for 2020, which will likely be remote. He will also likely present results from the air-LUSI effort at the VIIRS/MODIS science team meeting. Dr. Turpie still intends to publish results from his analysis of L3 standard deviation trends noted last year, which show how the data quality changes with instrument responsivity loss over time. This information should provide insight regarding the sensitivity of ocean color algorithms that would help quantify uncertainty. Dr. Turpie plans to work with Dr. Ibrahim to publish the predicted effects of out-of-band drift in calibration to observations of the ocean by NPP VIIRS.

Task Number: 111
GSFC Sponsor: Krotkov, N.
UMBC PI: Evans, Keith
UMBC Project Number: 00010746

Summary
The goal of the NASA/Goddard Sulfur Dioxide Monitoring web site is to create and maintain

long-term SO2 cross-satellite climate data records that started with Nimbus7-TOMS UV SO2 measurements in 1978 and presently continuing with AIRS, Aura/OMI and NPP/OMPS SO2 data. 34 regions of the world are monitored and displayed on a daily basis. The web site will be developed into the Òpublic faceÓ of the volcanic disasters project that will be more useful for near-real time users from different agencies, the general public and for aviation safety. Evans participates in NASAÕs Earth Science Data Systems Working Group which focuses on the exploration and development of recommendations derived from pertinent community insights of NASA's heterogeneous and distributed Earth science data systems.

Accomplishments
The web site currently includes generation of daily OMI and OMPS SO2 images for volcanic regions. Automatic data image upload is no longer possible due to security. This has to be done manually everyday now using the RSA Tokens. Updated the web site to display weekly SO2 outflows and/or eruptions. Created a brand new web site for nitrogen dioxide using OMI data images for over 300 cities around the world. Added upgrades to magnify regional images and color coded the cities based on the difference in the daily NO2 from the 5-year average baseline. Can see changes in NO2, which is related to pollution, due to shutdowns prompted by COVID-19.

Plans for Next Year
Maintain the functionality and add enhancements to the SO2 and the NO2 web sites as needed. SO2 trajectory modeling capability may be added to the NASA SO2 site. Extending long-term monitoring of sulfur dioxide with new satellite instruments as they become available. Add AIRS SO2 maps when SO2 can be measured from AIRS.

Task Number: 115
GSFC Sponsor: Marshak, A.
UMBC PI: Varnai, Tamas
UMBC Project Number: 00010750

Summary
The ultimate goal of this work is to help better understand and characterize the role atmospheric aerosols and aerosol-cloud interactions play in our climate. The research focuses on two main areas. First, it examines the systematic changes in aerosol properties that occur near clouds. This includes characterizing the way these changes vary with season, location, and scene properties, and understanding their causes and estimating their radiative impacts. This first area also includes examining the abundance and radiative impact of undetected cloud droplets that occur outside the clouds identified in satellite images, and exploring the benefits of observing aerosols from multiple view directions. Second, the research investigates the uncertainties 3D radiative processes cause in satellite retrievals of cloud properties and aerosol properties near clouds. This involves combining data from several satellites with radiation simulations, and developing a method that enables satellite data interpretation algorithms to consider the impact of 3D radiative processes.

Accomplishments
Varnai and team continued their research in three main areas. First, they examined systematic cloud-related changes in spaceborne aerosol observations. They work on this topic because

several studies found that aerosol properties are systematically different in the vicinity of clouds. The work includes the analysis of co-located MODIS and CALIOP observations and MERRA-2 reanalysis data. This year the team expanded their dataset and further analyzed data on clouds, aerosols, and meteorological conditions such as humidity or wind. For example, the analysis previously limited to maritime areas has been expanded to continental areas, revealing that near-cloud aerosol changes are even stronger over land than over ocean. The detailed analysis also provided insights into the impact of scene parameters and indicated, for example, that aerosol changes are systematically stronger near thicker clouds. The team also made improvements to their algorithm for removing the impact of cloud-scattered sunlight from MODIS near-cloud aerosol observations. In the next three months, the team will further improve this algorithm and will continue analyzing near-cloud aerosol behaviors. In a second research area, the team analyzed airborne observations taken by the Cloud Absorption Radiometer (CAR) instrument over the South Atlantic Ocean. They found that CAR data can help in validating satellite measurements of the amount of smoke floating above marine stratocumulus clouds. They also found that the three-dimensional nature of radiative processes caused only minor uncertainties in CAR measurements of above-cloud aerosol optical depths. In a third research area, the team continued analyzing images of Earth taken by the DSCOVR spacecraft from a location four times farther than the Moon. They examined sun glints that appear in DSCOVR images due to specular reflection from ice platelets that float inside clouds at a nearly perfect horizontal orientation. This year they examined the wavelength-dependence of glint effects and found that it is shaped predominantly by the absorption and scattering of sunlight by the air above ice clouds. The team also examined the seasonal dependence of glint effects in DSCOVR images and found strong but opposite annual cycles over land and ocean; the differences could be traced to differences in the extent and characteristics of deep convection and anvil clouds.

Plans for Next Year
The team plans to continue research near-cloud aerosol properties. They plan to estimate the impact of various processes contributing to the changes in aerosol properties that occur near clouds (for example aerosols swelling in the humid air). They also plan to further expand their method for improving the accuracy of satellite measurements of near-cloud aerosols, for example by enabling it to work well at a range of spatial resolutions. The team also plans to start developing a method that will enable satellite measurements of cloud optical depth and cloud droplet size to consider the three-dimensional nature of radiative processes. Finally, the team plans to expand the capabilities of their publicly available online simulator of three-dimensional radiative processes.

Task Number: 116
GSFC Sponsor: Butler, J.
UMBC PI: Turpie, Kevin
UMBC Project Number: 00010751

Summary
Turpie participates in the review, analysis, and ocean color science impact assessment of test data from Visible Infrared Imaging Radiometer Suite (VIIRS) instruments, as part of the greater Joint Polar Satellite System (JPSS). His support as an ocean color subject matter expert includes the following: (1) supporting VIIRS ambient and thermal vacuum test data reviews

either at GSFC or at Raytheon El Segundo, (2) reviewing Raytheon VIIRS test plans and technical memos particularly those on spectral and radiometric calibration and characterization, (3) assessing the impacts to science of J1 VIIRS instrument performance as reflected in the instrument ambient and thermal vacuum test results and level 1 requirements.

Accomplishments
SDSM spectral response data were finally acquired during this period and examined. The information supported the hypothesis that significant differences on the order of 1-3 nm existed between the SDSM channels and the corresponding bands of the VIIRS instrument. Dr. Turpie presented updates regarding the air-LUSI mission, which has the objective to characterize the Moon as an absolute calibration reference. He opened discussions with the Ocean Biology Processing Group (OBPG) calibration team to consider what instrument characterization uncertainties would affect lunar calibration accuracy. Understanding such effects could help better plan prelaunch characterization for future missions, such as PACE or SBG.

Plans for Next Year
Dr. Turpie will be working with the OBPG in the on-going calibration of J1 VIIRS onboard the recently launched JPSS-1 satellite. He will continue to assess quality new data from the J1 VIIRS instrument in the event of anomalous behavior. This will include the quantification of striping and other imagery artifacts and characteristics of the calibration data. So far, the instrument is performing quite well and stably, as compared to NPP VIIRS. Dr. Turpie will liaise between the NASA VIIRS Calibration Science Team (VCST) and the VIIRS ocean calibration team. He will also continue to interact with NOAA colleagues in order to facilitate research to operations technologies transfer.

Task Number: 117
GSFC Sponsor: Wu, D.
UMBC PI: Lee, Jae
UMBC Project Number: 00010752

Summary
This task is focused primarily on supporting Total and Spectral Solar Irradiance Sensor-1 (TSIS-1) mission, which will be launched to International Space Station, in late 2017. This task includes reviewing the missionÕs calibration/validation and management plans in collaboration with Laboratory for Atmospheric and Space Physics (LASP). This task also focused on Sun-Earth related research, by analysis from multi-sensor spaced based terrestrial observations of physical variables and atmospheric tracers in conjunction with the solar irradiance observations to develop appropriate Sun-Climate system model. For this research, Lee will investigate characteristics of both total and spectral solar irradiance, both with the inter-validation perspective and also with the identification of biases potentially caused by irradiance sensor degradation from the SORCE (Solar Radiation and Climate Experiment), TCTE (TIM Calibration Transfer Experiment), and upcoming TSIS-1. The primary science objective is to keep developing and exploring the solar impact on EarthÕs climate using a variety of existing terrestrial and solar satellite observations and model results.

Accomplishments
The primary accomplishments during this period are focused on the proper data acquisition and validation of Total Solar Irradiance (TSI)and Spectral Solar Irradiance from Total and Spectral Solar Irradiance Sensor (TSIS-1) mission. Lee supported number of mission reviews, including TSIS-1 monthly and annual operational reviews, mission status reviews, and TSIS/TSI workshop. Lee continue to contribute to TSIS communication and outreach program, including maintenance of Sun-Climate website and media program for TSIS-1. While continuing to support monthly telecom meetings with Laboratory of Atmospheric and Space Physics/ University of Colorado(LASP/UC) for TSIS-1, Lee is also working as a TSIS-2 science team member. For TSIS-2 mission, which will be launched in 2023 on a free-flyer, Lee is supporting staff meeting, operational meeting, instrument suite meeting, tag-up meeting with LASP for an assessment of science risk analysis, mission requirement, and data management plan. For science, Lee published one paper on nighttime ozone variation as a first author, and additional 3 papers as a co-author on diverse topics on Earth Science and Heliophysics. In February 2020, Lee was awarded NASA Special Act Beyond The Call Of Duty from GSFC/613 for leadership in successful Climate and Radiation Lab. Seminar organizer. Lee was an organizer of the Sun-Climate Symposium in January 2020 (Tucsan, AZ) and a chair and of two sessions, entitled Solar Influence on the Atmosphere and Climate and Recent/Space-Era Solar Cycle Timescales. These sessions were devoted to the measured or modeled solar radiations and the response of the Earth's climate to solar variability over the last four solar cycles. The Symposium was very successful with presentations and discussions from nearly 100 domestic and international attendees.

Plans for Next Year
Lee will continue to support for successful operation of TSIS-1, and to review the TSIS-1 data quality, to describe characteristics of the data and algorithms used to produce all data levels of total and spectral solar irradiance. Lee also will continue to support TSIS-2 mission development with mission planning and scientific risk analysis. Lee will continue to work on comparison of solar irradiance data from multi-sensor observations with diverse solar proxies to get a solid mechanism on how solar activity can impact solar irradiance. Lee will work on Solar Tides of the upper mesosphere that how middle atmosphere dynamics are impacted by diurnal solar forcing. Lee is a co-chair of session at AGU 2020 fall virtual meeting in December 2020, entitled Sunset of SORCE, Sunrise of TSIS: Sun-Climate Changes Over Two Solar Cycles. This session solicits contributions on solar variability measurements, causes, and models and their connections to Earth climate studies, as the 11-year solar cycle is now heading into new cycle 25.

Task Number: 119
GSFC Sponsor: Welton, E.
UMBC PI: Lewis, Jasper
UMBC Project Number: 00010754

Summary
This research is focused on the development of cloud and boundary layer detection algorithms for the Micropulse Lidar Network (MPLNET). These retrieval algorithms are applied to a global network of elastic backscatter lidars in order to produce long-term climatologies showing diurnal, seasonal, and annual trends. In particular, boundary layer retrievals are used to quantify and understand spatiotemporal gradients in the Baltimore-Washington DC urban

corridor. A regionally dense network of micropulse lidars, along with aircraft-, ship-, and satellite-deployed lidar systems, are used for comparison with modeled mixed layer heights in order to reduce errors in estimates of urban pollutant emissions and air quality modeling

Accomplishments
A method to distinguish cloud thermodynamic phase from polarized Micro Pulse Lidar measurements has been developed and the manuscript describing the process is under review. Results from a multiyear comparison with the CALIPSO satellite show reasonable agreement with respect to the fraction of supercooled liquid-water from a midlatitude location. A two-year study of cirrus cloud radiative effects at the Fairbanks, AK MPLNET site has also concluded. This marks the final part of a three-part study exploring cirrus cloud radiative effects in tropical, midlatitude, and polar regions. The results are largely consistent with the initial hypothesis of a meridional gradient in forcing going from warming in the tropics to mostly cooling at the poles. However, the sign of forcing at the poles was shown to be more uncertain due to (1) a lack of daylight during winter, which leads to summer months dominating the results, and (2) regional weather variability in the subarctic. Similar findings have recently been demonstrated from the Aqua MODIS sensor.

Plans for Next Year
Dr. Lewis is a member of the EarthCARE Validation Team. The EarthCARE mission (expected to launch in 2022) will provide global observations of cloud and aerosol profiles, horizontal distributions of aerosol and cloud fields, and collocated measurements of long-wave and short-wave radiation. Over the course of the next year, Dr. Lewis will aid in the development of Level 3 MPLNET products for statistical comparisons with EarthCARE measurements. He will design strategies to compare aerosol and cloud retrievals, precipitation occurrences, and cirrus cloud radiative effects. A NASA proposal has recently been submitted to the Earth Science U.S. Participating Investigator program in support of this work.

Task Number: 120
GSFC Sponsor: Chin, M.
UMBC PI: Bian, Huisheng
UMBC Project Number: 00010755

Summary
Atmospheric aerosol and gas tracers affect air quality and climate. To pursue scientific objectives of improving atmospheric aerosol simulation and understanding their impact, Huisheng Bian contributes to several scientific studies and assessments: (1) leading AeroCom III nitrate experiment to assess driving reasons for uncertainty in multi-model nitrate simulations; (2) participating other 4 international assessments for atmospheric aerosol and its impact on atmospheric pollution and dynamic fields; (3) supporting the ATom field campaign by providing GEOS-5 forecast chemical fields; (4) improving chemical lateral boundary conditions for the National Air Quality Forecasting Capability (NAQFC) operated within NOAA; (5) Assisting the study of connection between East Asian air pollution and monsoon system; (6) Assisting the study of the role of surface wind and vegetation cover in multi-decadal variations of dust emission in the Sahara and Sahel; and (7) Proposing new studies about aerosol and its impact and 4 of them have been funded by NASA agency.

Accomplishments
Atmospheric aerosol and gas tracers affect air quality and climate. To pursue scientific objectives of improving atmospheric aerosol simulation and understanding their impact, Huisheng Bian contributes to NASA ROSES projects via task 120. Specifically, she is as a co-I currently supported by two NASA projects via this task. One project is to study aerosol-cloud-radiation interactions in a changing climate and the other is to investigate how mid-latitude cyclones impact on trans-Pacific transport of aerosol and CO using GEOS GOCART simulation, satellite measurements, and ATom aircraft data. To fulfill the tasks proposed by the first project, Huisheng Bian gave big efforts evaluate and improve the GEOS GOCART aerosol simulation. With the improved model, she obtained the model results constrined under various interactions among aerosol, cloud, and radiation. The results are under analyzed. She has also conducted a series GEOS simulations and provided the aerosol, cloud, and meteorological fields to support various AeroCom experiments. In addition, Huisheng Bian lead an effort by integrating AeroCom model results and the NASA aircraft measurement of Atmospheric Topography Mission (ATom) measurements for aerosol and cloud study. To fulfill the tasks proposed by the second project, Huisheng Bian worked closely with Hongbin Yu (NASA) and Qian Tan (Bay Area Environmental Research Institude) to investigate the evolution and transport of total aerosol, as well dust plumes, by anticlockwise cyclic flows. She conducted the GEOS GOCART model runs and assisted the study of tracing the model aerosol change along satellite tracks of CALIPSO.

Plans for Next Year
Huisheng Bian will continue working on various AeroCom multimodel assessments for atmospheric aerosol and cloud fields. She will start to involve in a new NASA AURA project to investigate decadal trends and interannual variability of aerosols in the upper troposphere-lower stratosphere. She will continuously contribute to the study of trans-Pacific pollution by providing model results and involved in scientific analyses.

Task Number: 126
GSFC Sponsor: Duncan, Bryan
UMBC PI: Prados, Ana
UMBC Project Number: 00010761

Summary
Managed and coordinated NASAÕs Applied Remote Sensing Training Program. ARSET offers satellite remote sensing training that builds the skills to integrate NASA Earth Science data into agencyÕs decision-making activities. Trainings were offered in air quality, climate, disaster, health, land, water resources, and wildfire management. Through online and in person training, ARSET has reached nearly 12,500 participants from 152 countries and 2800 organizations worldwide since 2009. In FY17 ARSET reached 4315 participants from 132 countries and more than 1900 organizations.

Accomplishments
Between October 2019 and July 2020 Ana Prados directed the Applied Remote Sensing Training (ARSET) program. She managed a team of 15 scientists, students, and support staff at four NASA centers; and supervised the execution of 11 remote sensing webinars and one in-person training. ARSET has grown into an internationally recognized program known for

exceptional quality in remote sensing training in English and Spanish. ARSET engaged 15,000+ participants from 120+ countries and 5000+ organizations. There were over twice as many participants as the same time period a year ago. This included a webinar series on air quality improvements due to the COVID-19 pandemic. In August and September 2020, there are planned webinars on monitoring heat waves, water budgets, and coastal ecosystems. Selwyn Hudson-Odoi provided outreach and webinar coordination for the program, contributing to the surge in participation. David Barbato edited and translated educational materials into Spanish. This dual language capability has greatly enhanced use of remote sensing across Spanish speaking countries, which account for about one third of total participation.

Plans for Next Year
Ana Prados will direct the development of 14 online courses on air quality, disasters, land, and water resources applications of NASA remote sensing. These include courses on the United Nations Sustainable Development Goals, and new webinars on remote sensing for fire applications and satellite derived population datasets. In response to participant survey data and the current pandemic, she will develop online courses in health, disaster risk assessment, and agricultural applications. Through funding from the U.S Department of State, she will also direct the development of remote sensing webinars for stakeholders in Bhutan. Ana will continue serving on the GES DISC and the LACE User Working groups at NASA GSFC.

Task Number: 127
GSFC Sponsor: Colarco, P.
UMBC PI: Rocha Lima, Adriana
UMBC Project Number: 00010762

Summary
A more comprehensive description of the optical properties of dust and volcanic ashes is needed to better represent aerosols in global models. To assess that, this project aims to incorporate measurements of optical and microphysical properties of mineral dust and volcanic ash into a new optical module of the GEOS-5 model. The new optical module is in development, and it will be tested under different scenarios to evaluate the importance of the variability of the optical and microphysical properties of dust for prediction of dust lifecycle, global mass distributions, and ultimately radiative forcing.

Accomplishments
During this period we have performed simulations of dust aerosol distributions using the NASA Goddard Earth Observing System (GEOS) model using an apportionment technique that allows us to select and analyze individual regions in the globe. The apportionment technique consists of model simulations with tagged regions in which emissions, deposition, transport, and aerosol optical depth (AOD) for a given predefined region can be tracked. This allows us to examine individual dust sources and their contribution to the overall global budget. In this study, fourteen regions were mapped and analyzed over the period of four years. The results of these simulations are being evaluated and they will be part of a collaborative study that compares the results from the GEOS simulations with other global models.

Plans for Next Year
A collaborative paper summarizing the results above is being written, and we expect the results will be published by next year.

Task Number: 130
GSFC Sponsor: Middleton, E.
UMBC PI: Huemmrich, Fred
UMBC Project Number: 00010765

Summary
This task supports development of methods for using optical and thermal data to describe vegetation physiological condition and relating that information to ecosystem processes, such as productivity. This work is directed in three areas: the collection and analysis of field measurements; science support for the Earth Exploring 1 satellite mission; and support for the development of the Hyperspectral Infrared Imager (HyspIRI).

Accomplishments
This task supports development of methods for using optical and thermal data to describe vegetation physiological condition and relating that information to ecosystem processes, such as productivity. This work is directed in multiple areas: the collection and analysis of field measurements along with support for development of the Structure and Function of Ecosystems (SAFE), Concurrent Artificially-intelligent Spectrometry and Adaptive Lidar System (CASALS), Plankton, Aerosol, Cloud and ocean Ecosystem (PACE), and Surface Biology and Geology (SBG) missions. Dr. Huemmrich was a participant in the SBG workshop webinars as well as being a member of the SBG working groups on Applications and Algorithms. Dr. Huemmrich is also supporting the development of the SAFE mission concept. SAFE will make both high spatial multi-angle measurements to derive forest canopy structure and hyperspectral or superspectral reflectance measurements to derive vegetation functional characteristics, such as pigment concentrations. He has tested SAFE measurement concepts using high spatial resolution hyperspectral imagery measured from Goddard's LiDAR, Hyperspectral and Thermal Imager suite observing forests at multiple times of the day as well as examining diurnal patterns of ecosystem productivity. He worked on the science traceability matrix for SAFE. Dr. Huemmrich is a member of the PACE Science and Applications Team (SAT), representing the only terrestrial ecologist in the PACE SAT. He made a presentation on the potential uses of PACE data for monitoring terrestrial ecosystem processes in the PACE SAT virtual workshop, provided slides and graphics for the PACE web site, and is working with one of the PACE applications teams. Dr. Huemmrich is also a member of the CASALS science team where his role is to support studies of the use of hyperspectral imagery combined with lidar descriptions of canopy structure to describe vegetation function.

Plans for Next Year
Support SAFE efforts to develop an Earth Venture proposal. Support PACE, CASALS, and SBG development activities.

Task Number: 131
GSFC Sponsor: Huffman, G.
UMBC PI: Mehta, Amita
UMBC Project Number: 00010766

Summary
This task is designed to conduct capacity building activities for NASA Applied Remote Sensing Training (ARSET) program and focuses on developing training material and conducting on-line and in-person trainings in using NASA remote sensing data for water resources and disasters (extreme precipitation, flooding, hurricanes) management. The trainings include overview presentations of NASA data products, data access web-tools, data applications, and demonstrations of computer-based case studies to facilitate NASA data usage by water resources and disasters management stakeholders.

Accomplishments
Mehta developed and conducted several multi-session webinars for NASA Applied Remote Sensing Training (ARSET) program. Mehta co-led a webinar on â€˜River Basin Delineation Based on NASA Digital Elevation Dataâ€™ on 26 November 2019. This webinar introduced the digital elevation data from Shuttle Radar Topography Mission and the use of Hydrological data and maps based on SHuttle Elevation Derivatives at multiple Scales (HydroSHEDS) for identifying river basin area. Mehta conducted an advanced level webinar on Applications of GPM IMERG Reanalysis for Assessing Extreme Dry and Wet Periods, with multi-hour sessions on 28 and 30 January, and 4 February 2019. This webinar introduced techniques of identifying floods and drought conditions based on precipitation anomalies and Standardized Precipitation Index based on IMERG precipitation data. In addition, Mehta contributed a session on availability of soil moisture from the Land Data Assimilation System in a webinar on â€˜Satellite Remote Sensing for Agricultural Applicationsâ€™ (26 April 2020). On 25 June, Mehta led a webinar on Groundwater Monitoring using Observations from the NASA Gravity Recovery and Climate Experiment (GRACE) Missions. Mehta is leading a webinar on Using Earth Observations to Monitor Water Budgets for River Basin Management II on 21 and 28 July, and 4 August 2020. This webinar focuses on GIS analysis of water budget components obtained from GPM precipitation, MODIS evapotranspiration, GRACE terrestrial water storage, and Global Land Data Assimilation System â€“ Catchment model to understand dry and wet season water budget differences over Limpopo River Basin. Presentations and recordings of all the webinars can be found on the ARSET website. During 2019, ARSET water resources and disasters team, in which Mehta is one of the lead instructors, trained more than 5000 participants from more than 100 countries. The ARSET program completed 10 years of training in 2019 and Mehta received a commendation For Leading Outstanding Water and Disaster Trainings & For Being the First ARSET Water Trainer. Mehta will conduct one more webinar in September-October focusing on Extreme Heat Disaster Risk Assessment.

Plans for Next Year
Mehta will be involved in multiple ARSET webinars in FY21. The topics will include applications of remote sensing for 1) Reservoir Management, ii) Monitoring Coastal Water Quality, iii) Monitoring Fire-related Disasters, and iv) Monitoring Evapotranspiration and Agriculture.

Task Number: 132
GSFC Sponsor: Gleason, J.
UMBC PI: Strow, Larabee
UMBC Project Number: 00010767

Summary
UMBC supports NASA GSFC in the following areas: (1) performance evaluation of the J1 CrIS instrument during observatory level and early on-orbit instrument activation, (2) pre-launch performance evaluation of the J2 CrIS instrument, and (3) review/analysis support of the development of the J3 and J4 CrIS instruments. These activities are conducted at Exelis and at UMBC and include participation in meetings and telecons, analysis of instrument performance data, and documentation review in an effort to ensure the CrIS instruments are meeting or will meet their performance requirements.

Accomplishments
UMBC supports the NASA GSFC JPSS Project for performance evaluation of the JPSS CrIS instrument, including pre-launch testing, in-orbit instrument activation, and long-term calibration issues. Long term measurements of the SNPP CrIS neon lamp (spectral calibration) stability we performed this years showing real drifts, but just below the 1 ppm level over 7 years, which can be corrected in software in the future. Most of our efforts this year involved pre-flight TVAC testing of the third CrIS instrument, the JPSS-2 model. We participated fully in TVAC spectral testing, performing independent analyses of the spectral response for the 27 different CrIS detectors. These were done in near real-time in order to ensure that CrIS met performance specifications before testing was finished. We established the aligment of the CrIS Michelson interferometer relative to the three focal planes and have generated the calibration parameters that are needed to correct the CrIS radiances to a fixed frequency scale after launch. These tests use measurements of gas cell spectra (CO2, CH4, and CO) that were designed by UMBC. The J2 instrument results, and testing procedures, were executed almost flawlessly by Harris, results in extremely accurate transmittance spectra of these gases in the infrared. We have now established that small deviations between observed and computed spectra are essentially the same from data taken with SNPP, J01, and now J02.

Plans for Next Year
The final analysis of the J02 TVAC data will be completed and written up for distribution or for a journal article. We plan to study the gas cell spectra in more detail now that we see the the transmittance fit residuals are likely due to liens in the gas spectroscopy, and not due to the instrument. It is possible, especially for CO2, that this may improve some understanding of CO2 line-mixing that is very important for the CrIS RTA and Level 2 retrievals, especially in the stratosphere. We also expect to be doing JPSS J03 TVAC testing in the next year, preliminary testing has already started.

Task Number: 133
GSFC Sponsor: Kirschbaum, D.
UMBC PI: Mehta, Amita
UMBC Project Number: 00010768

Summary
This task involves development of training modules and holding quarterly webinars describing

sensor characteristics, data products, and potential applications of the Global Precipitation Measurement (GPM) mission that was launched in February 2014.

Accomplishments
Mehta, in coordination with the GPM Applications Team, organized and conducted a webinar on Overview and Applications of Integrated Multi-Satellite Retrievals for GPM (IMERG) Long-Term precipitation Data Products on 16 October 2019. The long-term IMERG combines TRMM and GPM precipitation records and extends data from June 2000 to present. This data product will be very useful for applications in monitoring floods, landslides, agriculture, and public health.

Plans for Next Year
This task is currently extended through December 2020. In consultation with the GPM Applications Team, Mehta will conduct one more training on IMERG data usage.

Task Number: 134
GSFC Sponsor: Braun, S.
UMBC PI: Olson, William
UMBC Project Number: 00010769

Summary
The main emphasis of the research is on the calibration of satellite passive microwave and infrared estimates of precipitation and latent heating using coincident, high-resolution estimates from spaceborne radar as a reference. Spaceborne radar methods for estimating precipitation/latent heating vertical structure are being developed and tested for applications to 14 GHz radar (Tropical Rainfall Measuring Mission; TRMM) and 14 + 36 GHz radar (Global Precipitation Measurement mission; GPM) in conjunction with passive microwave radiometer multi-frequency observations. The GPM combined radar-radiometer algorithm (CORRA) is continually upgraded and tested against ground-based radar estimates of precipitation.

Accomplishments
Prior to and during the reporting period, the GPM Combined Radar-Radiometer (CORRA) precipitation algorithm was adapted to utilize Ka channel radar data that had been shifted from inner swath to outer swath observations in May, 2018. Only a slight trend of increasing precipitation rates from inner to outer swath radar footprints was seen in the new observing mode. This trend was attributed to assumptions concerning the effects of attenuation through the ground clutter between the lowest observable radar targets and the earthâ€™s surface. Post-May-2018 CORRA estimates were subsequently delivered to the GPM radiometer team for the purpose of calibrating their passive microwave based GPM precipitation retrieval algorithm. Currently, the overall low bias of CORRA estimates relative to ground radar observations is being investigated, and bias mitigation based on adjustments of assumed precipitation particle size distribution parameters and other factors are being evaluated by Dr. Olson and Dr. Mircea Grecu.

Plans for Next Year
Dr. Olson, in collaboration with Dr. Grecu, Dr. Stephen Munchak, and Dr. Sarah Ringerud, will continue to investigate the low precipitation bias issue and mitigation strategies. In

addition, at high latitudes, diminished signal of precipitation in GPM radar observations will require an alternative, radiometer-only based estimation method, to be developed by Dr. Munchak and the team of investigators. Dr. Olson also plans to study the effects of assumed ice precipitation particle density on CORRA estimates of snow rate.

Task Number: 141
GSFC Sponsor: Gleason, J.
UMBC PI: Strow, Larabee
UMBC Project Number: 00010864

Summary
The University of Maryland Baltimore County (UMBC) Atmospheric Spectroscopy Laboratory (ASL) and the University of Wisconsin (UW) Space Science and Engineering Center (SSEC) support NASA climate research by providing a climate quality Level 1B (geolocation and calibration) algorithm and long-term measurement record for CrIS. The related objectives of the work have been to: 1. Create software that produces climate quality CrIS Level 1B data to continue EOS-like data records, and provide this software and associated documentation to the appropriate NASA data processing groups. 2. Provide samples of CrIS Level 1B data for the Suomi-NPP science team in advance of production for validation by the science team. 3. Provide a) long-term monitoring and validation of the CrIS Level 1B data record and b) long-term maintenance and refinement of the Level 1B software. 4. Provide a CrIS radiative transfer algorithm and code for use by the L1b and L2 NPP Science Teams. Details of this effort are outlined in the proposals by Larrabee Strow titled, "NASA CrIS Level 1B and VIIRS Level 1 Algorithm and Software Development" dated August 1, 2014 and in "CrIS RTA Development" dated January 30, 2015.

Accomplishments
Development and deployment of climate-level CrIS Level 1 data sets for NASA Continuity Products for distribution by the NASA GSFC DIS continued this year. The CrIS V3 Level 1b code development was completed, and includes polarization corrections, and a new product the geo-references the VIIRS visible imagery to the CrIS field-of-view. In addition, the V3 Level 1B radiances have been corrected for both earth-motion Doppler shifts, and spacecraft Doppler shifts. Various improvements to the CrIS L1b Q/A have also been made. Our new Level 1 product called the Climate Hyperspectral InfraRed Product (CHIRP) that converts AIRS, CrIS, and IASI to a common spectral spectral response function has been largely completed and is now undergoing integration at the Sounding SIPS at NASA JPL in preparation for deployment at the GSFC DIS. CHIRP will provide a 35+ year record of infrared hyperspectral radiances that can be used directly for trending as well as for Level 2 retrievals. Calibration offsets between these instruments are included that provide long-term stability at the 0.03K/decade level or better. In addition, a new radiative transfer algorithm (RTA) was created using the CHIRP spectral response format and has been made available to the community. At present the NASA AIRS Project and the NASA S-NPP Science Team are considering using CHIRP radiances for multi-instrument Level 2 retrieval products.

Plans for Next Year
The new CrIS L1b V3 radiance product will be extensively validated along with the first version of the CHIRP radiance product. We expect to improve radiance offsets caused by the

SNPP mid-wave shutdown in the March-July 2019 time frame. Examination of the stability of SNPP Cris and J1 CrIS will begin using a new approach we have developed. This approach first converts the radiance time record, for clear ocean scenes, into radiance anomalies that are used as input to an optimal estimation retrieval of CO2 concentration anomalies that are extremely well known using in-situ measurements. Application of this approach to the AIRS L1c record has established that a large number of channels on AIRS are stable to 0.03K per decade or better. This provides confidence for long-term climate trends that are derived from these hyperspectral sensors.

Task Number: 148
GSFC Sponsor: Szabo, Adam
UMBC PI: Herman, Jay
UMBC Project Number: 00011511

Summary
As Instrument Scientist for EPIC satellite instrument on board the DSCOVR (Deep Space Climate Observatory) satellite, the researcher will lead the effort to characterize the optical performance of the EPIC instrument including stray light determination, laboratory and in-flight calibration, and provide initial algorithms for retrieving ozone, aerosol index, and surface reflectivity. The researcher will assist and manage the transformation of the initial algorithm development to the ROSES-supported science team.

Accomplishments
I wrote two 1st author papers and two co-author papers. One if the 1st author papers is published and the second is under review. I helped the PI make key decisions for the DSCOVR satellite project and prepared large portions of the project review for NASA Headquarters. I have worked on the comparison of DSCOVR data with data from other satellites related to Earth's energy balance.

Plans for Next Year
I will continue to advise the PI on the DSCOVR project on key issues and will publish a paper on the diurnal variation of cloud cover using DSCOVR data.

Task Number: 150
GSFC Sponsor: Kuang, Weijia
UMBC PI: Tangborn, Andy
UMBC Project Number: 00011724

Summary
developing, testing and validating hybrid algorithms for ensemble Kalman filter used in geomagnetic data assimilation, and on observation and model biases estimation. He will also work on assimilation and analysis modules for MoSST_DAS, the GSFC geomagnetic data assimilation system.

Accomplishments
We have completed the development of a geomagnetic ensemble Kalman filter (EnKF) for

studying the changes to the Earth's geomagnetic field. We have used this for both improving the knowledge of processes within the core of the Earth and forecasting future changes to the magnetic field. This system was used as a candidate model for the International Geomagnetic Reference Field (IGRF) 2020, which predicts changes to the geomagnetic field out to 2025. In addition, this work will be featured on the NASA portal in coming weeks.

Plans for Next Year
We plan to continue work on improving the data assimilation system, particularly in regards to the multivariate assimilation of the geomagnetic field so as to improve estimates of the velocity field within the core of the Earth. Publication of this work is expected later in 2020.

Task Number: 153
GSFC Sponsor: Tucker, Compton
UMBC PI: Shuman, Christopher
UMBC Project Number: 00011762

Summary
The activity is an effort to reanalyze all remaining tropical glacier areas using Landsat 8 and commercial high-resolution imagery. An ancillary goal of the task is to use high resolution DEMs to assess glacier area changes for selected high elevation ice masses with changes in climate variables extracted from the MERRA-2 reanalysis product.

Accomplishments
This project is essentially complete except for the write-up and related visualization needed to compile the results for all tropical ice area (some now barren). Along with the country-by-country summaries of ice area changes that exist for all tropical ice areas except for two complicated cordillera of Peru, some of these analyses have been adapted to support a paper focused on ice core data acquired by a researcher at Ohio State (paper now being revised for resubmission). Further, besides the Landsat-based hyperwall content showing obvious losses of ice remnants in Papua, New Guinea, and two locations in Peru (two of these can now be updated), four additional hyperwalls for other tropical glacier locations in northern South America have been created and are being used for internal presentations and potentially for virtual learning presentations. The underlying paper is prepared for publication and an abstract and virtual presentation on the overall project are being discussed for Fall AGU 2020.

Plans for Next Year
Fine tuning the results from two major cordillera of Peru mentioned above (Blanca and Vilcanota) may extend into the next reporting year but organizing the many ice areas into a coherent publication with all the necessary supporting Landsat imagery information will also take some additional time. The supporting climate reanalysis data, derived from MERRA-2, will also need to be worked into the final effort. And given their powerful visual impact, one or more existing hyperwall stories will be updated with recent imagery. This activity is also leading to experimentation with commercial high-resolution imagery from Digital Globe (now MAXAR Technologies) and Planet (was Planet Labs) but to date, these imagery sources have proven difficult to work with and are much more temporally constrained than the â€˜Landsat Storiesâ€™ that have been assembled, in some cases back to 1972. These images do offer the prospect of better understanding debris-covered outlet glaciers that cannot be assessed with the

current Landsat-based technique. This element is ongoing.

Task Number: 155
GSFC Sponsor: Hanisco, T.
UMBC PI: Hannun, Reem
UMBC Project Number: 00012077

Summary
This task involves the observation and analysis of trace atmospheric gases Ð including carbon dioxide (CO2), methane (CH4), and formaldehyde (HCHO) Ð from airborne platforms. In situ, high frequency measurements of CO2 and CH4 , both greenhouse gases, enable direct quantification of their surface-atmosphere exchange (fluxes). These observations will provide a useful dataset to constrain carbon-climate model algorithms as well as carbon data products from satellite. In situ measurements of HCHO, a key tracer of atmospheric oxidation chemistry, will also help constrain satellite retrievals and aid our general understanding of atmospheric photochemistry.

Accomplishments
During FY2020, Hannun completed a manuscript entitled Spatial Heterogeneity in CO2 and CH4 flux: Insights from Airborne Eddy Covariance Measurements over the Mid-Atlantic Region. The paper resolves CO2 and CH4 vertical fluxes measured during the Carbon Airborne Flux Experiment (CARAFE) campaign (FY2017) over various land cover and land use types. Additionally, we compare results with AmeriFlux tower measurements from sites located beneath the flight tracks to show that tower fluxes do not fully represent carbon cycle dynamics at the regional level. In addition, Hannun finalized ozone (O3) data collected from the Rapid Ozone Experiment (ROZE), a new high-precision, fast instrument using a cavity enhanced absorption technique. ROZE was successfully deployed for the first time during the Fire Influence on Regional to Global Environments Experiment - Air Quality (FIREX-AQ) campaign (FY2019) aboard the NASA DC-8 aircraft. The O3 data were validated against a well-established chemiluminescence instrument also aboard the DC-8. The instrument performance was further demonstrated via eddy covariance calculations of O3 vertical fluxes, which require precise measurements and a fast instrument response time. Hannun submitted a manuscript in May 2020 detailing the instrument design and performance entitled A Cavity-Enhanced UV Absorption Instrument for High Precision, Fast Time Response Ozone Measurements.

Plans for Next Year
In FY2020, Hannun will continue using eddy covariance analysis to determine an upper limit on CH2O deposition over the open ocean (from prior ATOM campaigns). Work on the data analysis is currently underway and will be finalized in the next fiscal year. Additionally, Hannun will collaborate with atmospheric chemistry modelers to implement a more accurate CH2O deposition scheme into existing chemistry modules. Hannun has also begin instrument preparation for the Dynamics and Chemistry of the Summer Stratosphere (DCOTSS) campaign, scheduled to take place in Fall 2020/Summer 2021 aboard the NASA ER-2 high altitude aircraft. The ROZE instrument has already undergone a series of successful tests in a thermal vacuum chamber that showed no loss of performance under low pressure/low temperature conditions. DCOTSS will study the impact of summertime convection on

stratospheric composition over North America, and flights will be based out of Salina, KS. Hannun will also participate in the Asian Summer Monsoon Chemical and Climate Impact Project (ACCLIP), a joint NSF/NASA campaign, to study the impacts of gas and aerosol emissions in convection to the stratosphere over Asia. The NASA WB-57 aircraft will deploy from Okinawa, Japan during late summer 2021.

Task Number: 156
GSFC Sponsor: Santanello, J
UMBC PI: Caicedo, Vanessa
UMBC Project Number: 00012344

Summary
The determination of mixing layer height as derived from lidars, microwave radiometers, satellites and other instrumentation as needed. A strong collaboration with the MPLnet group to bring together results from ongoing NOAA/ASOS network, EPA and university collaborators as well as integrate NASA tropospheric chemistry studies.

Accomplishments
The development of a common aerosol backscatter retrieval methodology for planetary boundary layer and cloud heights for heterogeneous ground-based remote sensing networks was accomplished. The algorithm was developed in support of the U.S. EPA ceilometer operational network and publication of this algorithm was accepted for publication in the Journal of Atmospheric and Oceanic Technology (JTECH). Further, a collection of remote sensing systems was used to study coastal boundary layer dynamical processes in relation to air quality. The results from this work give insights into the impact of the Chesapeake Bay breeze on the vertical distribution of ozone over marine sites. Results from both projects were recently presented at the 2019 AGU conference and 2020 AMS conference. The publication for the common algorithm is expected to be finalized in mid-August. Results for the bay-breeze study are currently under preparation for publication with plans for submission in August-September 2020 timeline.

Plans for Next Year
Continued tested for the operational implementation of a common retrieval algorithm for mixing layer heights will be pursued and are expected to be fully operational by June 2021. Additionally, strong collaborations with the NASA Micro Pulse Lidar (MPL) Network will combine efforts operational mechanisms of ground-based aerosol remote sensing networks including the U.S. EPA Ceilometer network efforts. These works will be presented in the 2021 American Meteorological Society (AMS) and 2020 American Geophysical Union conference.

Task Number: 157
GSFC Sponsor: Ferrell, Trena
UMBC PI: Shuman, Christopher
UMBC Project Number: 00012523

Summary
The NASA Earth Science Education Collaborative project is working with WGBH to help

review the K-12 learning resources that WGBH is producing for NASA SMD. As part of WGBHÕs process, they are identifying media (e.g., video clips, animations, visualizations) that could support learning related to science concepts in the Next Generation Science Standards. Dr. Shuman and Dr. LeGrande are reviewing these unfinished education products as Subject Matter Experts (SMEs) before WGBH goes too far along the production pathway (editing videos, creating the learning resources). The goal is to ensure the basic media pieces are scientifically accurate and appropriate for the learning concepts identified.

Accomplishments
Among many in-person and remote presentations for multiple venues, both on and off the GSFC campus, one of the more memorable ones was creating a nearly 50-year time series for the Park Rangers at Glacier Bay National Park that was updated in the fall of 2019. These Landsat mosaics show ice losses and landscape changes park-wide using from the first melt season in 1972 to the most recent one in 2019. This visually powerful PowerPoint set also includes six inset maps of areas of distinct cryospheric change within the Park area. Although invited by the Interpretative Division Staff at the Park at the Park to come to Glacier Bay and to explain the imagery details in the 47-year time series there, the COVID-19 crisis canceled this invitational travel and essentially all cruise ship visitors to this scenic area. This content was presented at the Fall AGU meeting in early December 2019 and I continue to support my Earth To Sky colleagues at Glacier Bay and also nearby Mendenhall Glacier (a separate 47 year Landsat time series was created for this major outlet from the Juneau Ice Field). A secondary activity in late 2019-early 2020, enabled through SME collaborators at GISS, was supporting a New York City school teacher for Polar Trec, Sarah Slack. She was deployed on the Nathaniel B. Palmer offshore of the Pine Island and Thwaites Glaciers and this required imagery monitoring as well as updating Landsat-based time series for these major West Antarctic, outlet glaciers. These images have been very useful at outreach events and as part of distance-learning talks when contacted for climate change speakers. A recent calving from Pine Island Glacier also made for a number of media mentions at the time the Palmer was in the Weddell Sea. In addition, there have been substantial imagery and altimetry illustrations created in support of Global Learning and Observations to Benefit the Environment (GLOBE) Program. Educational summaries of Trees in the News, such as at Joshua Tree National Park, and also imagery visualizations of local and distant tree canopies have been created with imagery and ICESat-2 data available from OpenAltimetry.org.

Plans for Next Year
A Landsat imagery series created to highlight an unusual melt event impacting East Greenland (a related paper is in review) shows a meltwater polynya sampled during an Oceans Melting Greenland flight. This image series are being prepared for use as a hyperwall and some of the same material will also be presented at the Fall AGU Meeting (abstract not yet submitted). Ideally, this will be a short paper with the support of a collaborator who specializes on Helheim Glacier. Additional creation of virtual content for use at outreach events will continue as cryospheric changes unfold around Antarctica and Greenland.

Task Number: 158
GSFC Sponsor: Heymsfield, G
UMBC PI: Guimond, Stephen
UMBC Project Number: 00012524

Summary
Research focus is on the analysis of data sets from NASA and NOAA field campaigns with emphasis on hurricanes to address questions such as the role of convection on intensification. Various algorithms developed and applied to data sets.

Accomplishments
Published a fundamental paper in the Journal of the Atmospheric Sciences entitled, The Dynamics of Vortex Rossby Waves and Secondary Eyewall Development in Hurricane Matthew (2016): New Insights from Radar Measurements. I developed a new mathematical framework that enables the first observational quantification of vortex Rossby waves in the hurricane secondary eyewall formation process. Ground-based and airborne radar data were used to perform the analysis. The airborne radar data comes from the NASA/GSFC HIWRAP instrument including 3D wind retrievals performed with my 3DVAR method. I validated the winds with collocated dropsonde data, which showed very good error statistics. This paper is also featured in the June issue of BAMS under the heading of Papers of Note. I also submitted a proposal to the NASA Weather and Atmospheric Dynamics"call as PI and the score was Very Good, although the proposal was not selected. I attended and presented a slide at the NASA Planetary Boundary Layer (PBL) workshop. I participated as mission scientist in the 2020 field phase of the NASA IMPACTS experiment. I am currently working on science and analysis of IMPACTS data as well as numerical simulations of a case study.

Plans for Next Year
I plan to work more heavily on IMPACTS airborne radar data and numerical simulations. We just got some initial level 1 data and I will be working to analyze the data and understand the context with numerical simulations. The numerical simulations will be done at turbulence scales with grid spacing less than 100 meters. These simulations and data analysis will serve as the backbone for the radar data analysis and will provide answers to NASA science questions on winter storms.

Task Number: 159
GSFC Sponsor: Yang, Yuekui
UMBC PI: Zhai, Pengwang
UMBC Project Number: 00012578

Summary
This task provides radiative transfer supports for the Earth Polychromatic Imaging Camera EPIC) onboard the Deep Space Climate Observatory (DSCOVR) mission, which acquires the EarthÕs images from the L1 point. We will develop a radiative transfer package which simulate what EPIC measures for a variety of different cloud scene for major EPIC channels. The radiative transfer package will be used to simulate radiance field exiting at the top of the atmosphere, which will be in turn used to design cloud retrieval algorithms for EPIC. We expect all work to be done iteratively and collaboratively, with the additional goal of publishing all results and findings.

Accomplishments
We have provided support for simulating the response of the Earth Polychromatic Imaging

Camera EPIC) onboard the Deep Space Climate Observatory (DSCOVR) mission for both cloud and ocean scenes.

Plans for Next Year
This task has been terminated by the NASA sponsor.

Task Number: 161
GSFC Sponsor: Merkowitz, Stephen
UMBC PI: Pavlis, Erricos
UMBC Project Number: 00012580

Summary
The purpose of this activity is to maintain the JCET/GSFC Analysis and Combination Center of the ILRS by: (a) maintaining a state-of-the-art Satellite Laser Ranging (SLR) data analysis capability for the primary geodetic satellites to support the IERS and ITRS contributed products of the ILRS, (b) generating weekly, daily and annual analysis products to be submitted to the IERS/ITRF as required by the ILRS, (c) generating quality check (QC) reports for SLR data in support of the ILRS Rapid Response service and Quality Control Board, (d) generating weekly and daily combination ILRS products, (e) developing the infrastructure required to combine SLR products with those from other space geodetic techniques (e.g. VLBI, GPS, DORIS), (f) executing studies for future geodetic SLR missions (including the tracking of future GNSS targets) and (g) generating and evaluating optimized geodetic network designs using simulations based on future system parameters.

Accomplishments
Throughout the reporting period we carried out the daily and weekly analysis of SLR data and the combination of products from the ILRS network, and we delivered analysis and combination products to the ILRS archives. We additionally supported the ILRS Central Bureau operations and the ILRS Network of stations, performing the required validation and qualification tests. We organized on Oct. 1 an 1-day ILRS ASC fall meeting at the Paris Observatory, attended by 25 colleagues. We participated in the GGOS-IERS Unified Analysis Workshop in Paris, October 2-4, 2019, and the IERS JournÃ©es meeting, October 7-10, also in Paris, France. We participated in the 69th IERS Directing Board meeting (Dec. 8) and the Fall AGU meeting (Dec. 8-13). The COVID-19 pandemic forced a cancellation/postponement or conversion to virtual all meetings large and small after mid-March 2020. On March 25 we attended the annual ILRS Governing Board meeting that was held virtually as a teleconference. EGU2020 sessions were also scheduled virtually and we attended the sessions we had submitted presentations as the time-difference allowed it. On May 11, 2020 we organized and chaired the ILRS ASC spring meeting that was done as a virtual teleconference, attended by 25 ILRS associates. This meeting laid the plan for the upcoming reprocessing of all of the SLR data since 1983 (REPRO2020), for the generation of the official ILRS contribution to the development of the next ITRF2020 model, with a delivery date of mid-February 2021. We successfully completed a 4-year guest editorship task for the Journal of Geodesy, culminating with the publishing of the November 2019 issue as the Special Issue on Satellite Laser Ranging. The issue comprises 20 articles and the preface. Our international collaboration since 1996 with the Italian groups at the Rome University La Sapienza and the University of Salento (which led to the launch of the LARES mission in 2012) continues with

the finalization of the LARES-2 follow-on mission this spring, funded by the Italian Space Agency (ASI) and under construction now in Italy. A free launch from ESA is now scheduled for late 2020. We completed a number of simulations for the characterization of the minimum requirements of the onboard oscillator for the proposed NASA mission GEOCON. By the end of this reporting period we will have generated more simulations on the contribution of such a mission in the determination and monitoring of the ITRF.

Plans for Next Year
The near-term plans for our SLR work are the finalization of the a priori error model based on the results from the Station Systematic Error Model Pilot Projectâ€"SSEM PP, its implementation in the REPRO2020 and the transition to a routine service-like process by this coming winter. By the end of summer 2020 we will complete the final reanalysis of all SLR data, from 1983 and up to present, using the latest measurement models and the newly adopted geophysical models. We will also complete the final report on the GEOCON mission simulations.

Task Number: 138
GSFC Sponsor: Wolff, David
UMBC PI: Tokay, Ali
UMBC Project Number: 00010773

Summary
The theme of the study is to improve the precipitation measurements under the umbrella of the NASAÕs Precipitation Measurement Mission. The investigator takes four major avenues in improving precipitation measurements. First, the collocated measurements of disdrometers, profilers, and scanning radars have been employed to diagnose the measurement accuracy and error bars of each measurement. Second, the variability of raindrop size distribution and rain parameters has been investigated within the radar pixel and satellite field of view. Third, the efforts have been made in determining precipitation microphysics in rain, mixed precipitation, and snow. Four, the steps have been take to evaluate the existing operational rainfall products that can be used to validate the satellite precipitation products.

Accomplishments
This task requires the data processing for in-situ precipitation measuring devices. The investigator processed all available 2DVD and PARSIVEL2 disdrometer data from NASA Wallops Flight Facility for January 15 to February 28, 2020 coinciding the IMPACT field campaign. The Pluvio database from Marquette, Michigan is further analyzed including wind and temperature corrections.

Plans for Next Year
The investigator is currently working on the Particle Imaging Package data analysis. The methodology will be provided through a peer-reviewed journal paper and/or white paper.

Task Number: 169
GSFC Sponsor: Yu, Hongbin
UMBC PI: Zhang, Zhibo

UMBC Project Number: JCET0169

Summary
A JCET faculty to participate in a TASNPP proposal (PI: Hongbin Yu) on the dust variability and radiative effects. This faculty will advise his/her PhD student to calculate with a radiative transfer model the dust radiative effect on solar and terrestrial radiation by using satellite-based dust 3-D distribution and observationally constrained dust optical properties.

Accomplishments
Mineral dust aerosol has significant long wave thermal infrared (LW) direct radiative effect (DRE) due to its large size. However, unlike the well-agreed cooling effect of the shortwave solar (SW) DRE of dust aerosol, the LW DRE remains uncertain because of the poor understanding of the LW radiative properties, especially the optical depth. The objective of this project is to fill this gap by developing an infrared based dust aerosol retrieval algorithm. This year, based on the observations of Infrared Imaging Radiometer (IIR) and the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) onboard CALIPSO, we developed a preliminary algorithm for dust aerosol optical depth (AOD) retrieval using the brightness temperature difference(dBT) between clear-sky and dust-laden scenarios based on Lookup-Table (LUT) method. In contrast to thermal infrared hyperspectral observations with coarse spatial resolution carries sub-grid cloud contaminations, this method takes advantage of the accurate cloud-free dust vertical distribution provided by CALIOP. With the pre-calculated dust models by particle size distributions and refractive indices of dust samples from world-wide deserts, we can further retrieve the dust particle size based on the split-window signatures of BT provided by three IIR bands centered at 8.5,10.8 and 12 Î¼m. The pixel-to-pixel comparison will be applied to the retrieved thermal infrared dust AOD with that from AIRS and IASI observations. The retrieved dust particle size will be compared with the AERONET observations and the measurements during the Fennec campaign.

Plans for Next Year
1) Further improve the IIR-based dust retrieval algorithm 2) Using the IIR-based dust retrieval algorithm to derive multiple year climatology of dust over dust outflow regions 3) Compare the infrared and visible dust aerosol optical depth

Task Number: 170
GSFC Sponsor: Yu, Hongbin
UMBC PI: Song, Qianqian
UMBC Project Number: JCET0170

Summary
A PhD student at JCET is to participate in a TASNPP proposal (PI: Hongbin Yu) on the dust variability and radiative effects. The PhD student will calculate with a radiative transfer model the dust radiative effect on solar and terrestrial radiation by using satellite-based dust 3-D distribution and observationally constrained dust optical properties.

Accomplishments
1) Based on the method developed by the PI Dr. Hongbin Yu, we derived a decadal (2006-2017) global-scale 3-D dust optical thickness climatology from the CALIOP satellite

observations. 2) Similarly, we have also developed a 2-D dust optical thickness climatology based on MODIS observations. 3) We are investigating the seasonal to inter-annual variability of dust aerosol based on the derived dust climatology. 4) A journal paper is being prepared to publish the results.

Plans for Next Year
1) We will compare the dust simulations in the global climate models with our dust climatology. 2) We will also investigate the dust direct radiative effects based on the derived dust climatology.

Task Number: 172
GSFC Sponsor: Franz, Bryan
UMBC PI: Martins, J. Vanderlei
UMBC Project Number: JCET0172

Summary
JCET/UMBC will support NASA GSFC in the following areas: (1) development of algorithms for Level-0 to Level-1A/B/C processing of data from the HARP2 instrument that is expected to fly on the PACE mission, and delivery of protoype software; (2) development and delivery of Level-0 to Level-1A/B/C prototype software and data from AirHARP/HARP, to be used as prelaunch proxy for HARP2 by the PACE Science Data Segment (SDS); (3) guidance on implementation and testing of AirHARP/HARP/HARP2 processing capabilities within the SDS; (4) expertise in algorithm development and validation for polarimetery science for the PACE mission. These activities will be conducted at GSFC and UMBC and will include participation in regular meetings, telecons, science team meetings, presentation in conferences, publications, data analysis and documentation.

Accomplishments
In this reporting period we have made substantial progress in the development of the HARP2 payload for the NASA PACE mission. Our design concept went through many levels of discussion and formal reviews with the PACE project. The last of these reviews was the PACE Mission PDR, where a summary and status of the HARP2 instrument was presented in front of the review board and approved without substantial questioning. The UMBC team has completed the full design of the HARP2 instrument and have basically fabricated all the essential components. The detail design of the optical coatings for the prism has been completed. The first batch of flight prisms were sent for coating and will soon be validated for its science performance. All mechanical parts are currently in house and are undergoing cleaning and thermo-vacuum baking for decontamination and cleanness, prior to final assembly. The first prototypes of the digital electronics board has been manufactured and successfully tested in the lab. A copy of this first prototype has been delivered to Goddard for testing in a flatsat configuration. The flight versions of the power system, and the digital FPGA boards are currently being fabricated. The UMBC team is starting to assemble the first prototype detector for testing in the final configuration. All HARP2 elements in the mechanical, optical, thermal and electronics sides are being completed for the final integration and testing of the full system during the next reporting period.

Plans for Next Year
For the next year, the team plans to complete all components of the HARP2 instrument and perform a battery of environmental and functional tests at UMBC and Goddard. We also expect to perform full calibration and characterization of the system, culminating with its delivery to Goddard for integration to the PACE spacecraft.

Task Number: 173
GSFC Sponsor: Levy, Robert
UMBC PI: Remer, Lorraine
UMBC Project Number: JCET0173

Summary
Developing, validating and providing science-quality aerosol retrievals from geostationary sensors, while also ensuring product consistency with existing retrievals from low earth orbiting sensors. Analyzing multiple data sets to look for trends and patterns of fires and smoke in India and other regions. Synthesizing and managing projects, providing high level scientific input, strategic planning and help towards decision-making. Involving synthesis of literature review, data analysis, mentoring less-experienced team members, a variety of leadership responsibilities and writing/publishing papers.

Accomplishments
Under this task I support the NASA Dark Target aerosol team under the leadership of Robert Levy, devoting 0.17 FTE of my time. The team is actively engaged in adapting their traditional MODIS aerosol retrieval algorithm to new sensors. During the reporting period we had two papers published on this topic. The first paper, led by Dr. Virginia Sawyer, is a comprehensive evaluation of the Dark Target algorithm now applied to the VIIRS instrument on the Suomi-NPP mission. The VIIRS algorithm has just been released as an operational product by NASA and reprocessing completed from the beginning of the mission. Therefore this paper analyzes a stable 7 year time series of retrieved products, validates against AERONET and compares with similar time series from Terra MODIS and Aqua MODIS. The second paper is the first analysis of the algorithm applied to the Advanced Himarari Imager (AH)) on board the geostationary Himarari satellite. This the first time the Dark Target algorithm has been adapted to a geostationary sensor, and the new geometry surprised us with unexpected artifacts. Dr. Pawan Gupta led the analysis and paper authorship. Currently I am leading the writing effort of a manuscript that we will submit to a special issue of the journal Remote Sensing before the due date of 01 August 2020. This will be a substantial review paper focusing on the Dark Target aerosol algorithm. The objectives are to use a retrospective of the three decade history of the Dark Target algorithm to illustrate how an algorithm is developed and maintained, to provide an annotated list of references, to show the impact of the algorithm on advancing science and applications, to critically examine the concept of continuity with an evolving algorithm applied to aging sensors, and to preview the future. I am the lead author in a list of 18 co-authors.

Plans for Next Year
We will continue to adapt the Dark Target algorithm to other sensors, evaluate the results and describe different aspect of the adaptation in papers. At the same time we are working towards making improvements to the algorithm. The end goal is a unified global grid of aerosol retrievals at moderate spatial and temporal resolution consisting of the same algorithm applied

to different sensors. We anticipate next year to publish the retrospective paper that I am leading, a paper describing the moderate resolution global grid that will form the basis of the global system of aerosol products that we envision, and at least one paper addressing improvement to the retrieval either dust over ocean, or missing retrieval opportunities in east Asia.

Task Number: 176
GSFC Sponsor: Kuang, Weijia
UMBC PI: Tyler, Robert
UMBC Project Number: JCET0176

Summary
This task supports the development and use for scientific research of numerical software for estimating the tidal response of fluids. This includes the theoretical and algorithmic development, coding, testing, validation, documentation, and example applications, as well as usage to tackle scientific problems of interest. The numerical models developed include the fluid tidal response as well as the electromagnetic tidal response. The research results will be used with both the Earth and other planetary bodies.

Accomplishments
In this year, I completed and released for public distribution a software package I developed for calculating the tidal response of planetary fluids (Tidal Response Of Planetary Fluids (TROPF). I completed publication of a paper on the tidal response of Jupiterâ€™s atmosphere (Tyler, R. H. (2019), and a paper on the tidal response of Enceladusâ€™ ocean (Tyler, R. H. (2020). I have further worked on the tidal response of planetary fluids as well as the electromagnetic response of ocean tides, with development toward remote magnetometric sensing of ocean flow by satellite magnetometers.

Plans for Next Year
In the coming year, I will work toward estimating the tidal response of the Titan ocean, as well as the tidal response of the Saturnian atmosphere. I will continue to develop magnetometric remote sensing methodology for sensing ocean flow and heat content remotely using magnetometers.

Task Number: 178
GSFC Sponsor: Middleton, E.
UMBC PI: Campbell, Petya
UMBC Project Number: JCET0178

Summary
SCERIN: These activities involve the coordination and support for the South Central and Eastern European Network (SCERIN, http://www.fao.org/gtos/gofc-gold/networks.html). Supported activities include: i) coordinating, facilitating and organizing the activities and collaborative work of SCERIN; ii) conducting and participating in international workshops and meetings; and iii) contributing/facilitating SCERIN Training and Capacity Building initiatives to facilitate the development and use of interoperable remote sensing methods,

technologies and products in the region. Activities include the comparison/evaluation/advancement of measurement and analysis techniques from ground-based, aircraft, and satellite-borne instruments for a variety of ecosystem types and conditions, writing and presenting results at scientific and professional meetings and support of LCLUC and GOFC-GOLD program activities. Surface Biology and Geology (SBG): The SBG activities support the Designated Observable mission defined in the 2017 Decadal Survey for imaging spectroscopy and multispectral imaging thermal measurements, with GSFC as a partner Center with the lead Center, JPL. This task provides support to participate in the Research and Application Working Groups, the Architectural Design activities, and the Workshop planning and support activities. Activities also include the advancement of measurement and analysis techniques from ground-based, aircraft, and satellite-borne instruments for a variety of ecosystem types and conditions; modeling of ecosystem function and radiative transfer; writing and presenting results; and support of SBG programmatic activities. This task also supports the collection and analysis of field measurements for calibration/validation, aimed at the development and testing of algorithms applicable to SBG and other NASA-supported missions. A focus will be given to activities related to plant functional types and physiology, and supports research to justify missions currently under development.

Accomplishments

The work includes two components: 1) SCERIN and 2) SBG. 1) SCERIN: The task includes the coordination and support for the South Central and Eastern European Network (SCERIN). The activities include: i) coordinating, facilitating and organizing the activities and collaborative work of SCERIN; ii) conducting and participating in international workshops and meetings; and iii) contributing/facilitating SCERIN Training and Capacity Building initiatives to facilitate the development and use of interoperable remote sensing methods, technologies and products in the region. SCERIN Accomplishments during the reporting period include, advancing the organization of the SCERIN-8 capacity building workshop, planned for June 2020 and postponed due to COVID19 for 2021. The workshop will be conducted jointly with MedRIN, and in coordination with the Trans-Atlantic Training (TAT) initiative. 2) Surface Biology and Geology (SBG): The SBG activities support the Designated Observable mission defined in the 2017 Decadal Survey for imaging spectroscopy and multispectral imaging thermal measurements, with GSFC as a partner Center with the lead Center, JPL. This task provides support to participate in the Research and Application Working Groups, the Architectural Design activities, and the Workshop planning and support activities. Task 178 supports the collection and analysis of field measurements for product calibration and validation, aimed at the development and testing of algorithms applicable to SBG and other NASA-supported missions. A focus will be given to activities related to plant functional types and physiology, and supports research to justify missions currently under development. Task activities include the advancement of measurement and analysis techniques from ground-based, aircraft, and satellite-borne instruments for a variety of ecosystem types and conditions; modeling of ecosystem function and radiative transfer; writing and presenting results; and support of SBG programmatic activities. SBG accomplishments include: i) collection and analysis of field measurements for product calibration and validation, aimed at the development and testing of algorithms applicable to SBG and other NASA-supported missions; ii) participated in the SBG Research and Application Working Groups, the Architectural Design activities, and the Workshops planning and support activities; iii) implementation of radiative transfer model for estimation of

vegetation traits based on VSWIR satellite spectra.

Plans for Next Year
1) SCERIN: During the coming year I will coordinate to the ongoing activities of SCERIN, facilitate network research projects and publications, and will organize the forthcoming joint SCERIN and MEDRIN (Mediterranean Research Information network) capacity building workshop and activities. The joint workshop is to be conducted in June 2021. The joint activities and collaborative discussions will be finalized during the fall of 2020 and spring of 2021. Currently, I am coordinating the organization of a Virtual seminar on RS from the ISS for the SCERIN network members. 2) SBG: During the forthcoming year I will participate in the SBG Research and Application Working Groups, the Workshop planning and support activities, and will contribute to the SBG Space-based Imaging Spectroscopy and Thermal pathfindER (SISTER) study, working with spectral time series to advance the development of algorithms for analysis of terrestrial vegetation function and spectral and biophysical traits.

Task Number: 179
GSFC Sponsor: Del Castillo, C.
UMBC PI: Turpie, Kevin
UMBC Project Number: JCET0179

Summary
Participate in architecture discussions to provide prioritized input regarding the needs of the coastal and inland aquatic remote sensing community, identify potential data products to support science and applications, and inform the mission study regarding the effect of different requirement and architecture options on related science and application objectives and data quality. Lead the Cal/Val working group and member participating in the Objectives and Performance working group. Head a community of practice (CoP) for the coastal and inland aquatic remote sensing community. Disseminate appropriate and relevant information regarding NASA SBG mission development and draw input from the community for consideration by NASA. Engage in discussions and collaborations, as appropriate, with other international groups with common interests. This includes participating with groups such as the Committee on Earth Observation Satellites (CEOS) and the Group on Earth Observations (GEO) and their initiatives (e.g., Blue Earth, Aquatic Watch, GEOGLOWS, and GEO Wetlands).

Accomplishments
Dr. Turpie continued his leadership role in the concept development for Surface Biology and Geology (SBG) mission. He co-led the SBG Calibration and Validation Working Group and the Research and Application Team and Steering Committee. He participating in weekly meetings of the project leadership, the steering committee, and working groups and development meetings at JPL, ARC, and NASA HQ. At NASA HQ, he presented development of mission calibration and validation capabilities. He also provided consultation services during mission design sessions. Dr. Turpie provided a detailed analysis of the effects of differing revisit times on temporal sampling, better informing the project the actual benefits of partnering with international missions. Dr. Turpie continued to with the Aquatic Studies Group (ASG), a community of practice for aquatic remote sensing of coastal and inland waters. This included developing and hosting an SBG Town Hall at the 2020 Ocean Science

Meeting (OSM) in San Diego, California, USA on 17 Feb 2020, titled "The NASA Surface Biology and Geology (SBG) mission and observation of coastal and inland waters from space." The objective of the meeting was to provide the community with an overview of SBG activities and objectives and to collect and organize input from the community. He also continued to work with the ASG to gather community input and coordinate activities where useful. Dr. Turpie also planned and moderated a science session on aquatic remote sensing innovations at the meeting titled â€œFrom catchments to open ocean: advances in remote sensing for monitoring water quality, food security, ecosystems and change.â€ This session included a number of new technology and methods for observing aquatic environments. Dr. Turpie presented two talks at a meeting on international collaboration between SBG and European partners. The first was regarding areas of potential areas of calibration and validation and the second was regarding areas of common interest in remote sensing of coastal and inland waters. Dr. Turpie developed an interface control document to describe the expected interactions between the Cal/Val Working Group and the other Research and Applications Working Groups. Dr. Turpie was instrumental in the development of an approach to scoring calibration infrastructure as supported by different candidate architectures. He worked with other working groups and architecture team members to develop guidelines for a baseline calibration infrastructure. Dr. Turpie developed and hosted a Cal/Val Webinar series where members of the Cal/Val community could present potential Cal/Val resources that could be used in the development of the SBG mission. He also has opened a number of discussions with potential domestic and international partners.

Plans for Next Year
Dr. Turpie will continue to lead the Aquatic Studies Group (ASG). He will be involved in the SBG pathfinder project, which was established to mature algorithms and Cal/Val capabilities over the next five years, in preparation for the flight of the SBG satellite. He will continue to support the Cal-Val Working Group Webinar series. Dr. Turpie will participate in the development of the project final report and the preparation for the SBG Mission Concept Review (MCR).

Task Number: 180
GSFC Sponsor: Levy, Robert
UMBC PI: Shi, Yingxi
UMBC Project Number: JCET0180

Summary
Aims to improve our understanding of the global aerosol system, in regards to their changing distributions in time and space, their composition, and their impacts to EarthÕs radiation and air quality. Focusing on enhancing the capabilities of the current single-sensor aerosol retrieval algorithm to make fuller use of available space-based instrumentation and computational techniques. Specific instrumentation goals include refinement to improve algorithm performance; combining complementary sensors (VIIRS/OMPS) and new techniques such to enable retrieval of new data products such as aerosol absorption; and making use of the new generation of geostationary platforms to enable rapid temporally-resolved aerosol monitoring using advanced algorithms. This understanding includes validation and scientific analysis of aerosol products in tandem with ground, airborne, and field observations, and model outputs.

Accomplishments
Dr. Shi worked on three major projects during Oct1, 2019 to Sept 30, 2020 time period. Project 1 regarding Dark Target (DT) algorithm improvement and products validation and analyses. Dr. Shi investigated the validation procedures that are generated for comparing low earth orbit satellite data against ground truth and its applicability to geostationary view. The validation procedure then is modified and applied on geostationary satellite products. DT products on all available sensors including MODIS Terra and Aqua, VIIRS, ABI-E, ABI-W, and AHI during FIREX and CAMPEX period are validated and analyzed against ground truth. Research has been done on DT products on eMAS vs. MODIS, VIIRS, and ABI DT products and AERONET stationary and mobile observations during FIREX period. The ability of satellite data capture and represent the smoke plume in both spatial and temporal dimensions are investigated against high resolution eMAS data. Dr. Shi also finished her paper regarding understand satelliteâ€™s ability of capture the pollution events over Beijing region by increasing the DT product data coverage over China during wintertime and compare its retrievability against ground truth. Project 2 is using OMPS and VIIRS combined reflectance level2 products to generate an iterating system that retrieves aerosol absorbing properties along with aerosol vertical distribution and aerosol optical depth. Dr. Shi used combined OMPS and VIIRS reflectance as they are from the same sensor and retrieved AOD and absorption using least square function to match the TOA reflectance from precalculated aerosol models. Dr. Shi then applied sensitivity study to evaluate the impact of changing refractive index on DT algorithm aerosol model selection. Dr. Shi then applied OMPS UV algorithm retrieved absorption value to VIIRS DT algorithm over a case study in order to improve the pre-determined aerosol model for the selected smoke. Project 3 is on capturing the atmospheric deposition, specifically dust deposition and its impact on ocean ecosystem. Dr. Shi applied various statistical methods to relate dust deposition patterns over mid to high latitude North Pacific Ocean to the ocean biology records. Dr. Shi also generated the atmospheric dust transport patterns for the current June 23 to July 4th 2020 dust storm that is across the Atlantic ocean to Pacific ocean. Dr. Shi attended AGU 2019 and AMS 2020 and presented her research at these conferences. She also published three co-authored papers during this time period.

Plans for Next Year
Dr. Shi will write a ROSES NIP proposal. For project 1, Dr. Shi will continue work on validating, analyzing and improving DT products specifically understanding the sampling differences between different sensors. Improving DT products on applying algorithm to global extend for extreme aerosol loading case. Publish a paper regarding FIREX campaign. Dr. Shi will finish the OMPS VIIRS project with a paper. She will continue to search for dust deposition to ocean and its relationship with ocean biology and write a paper about dust transport.

Task Number: 181
GSFC Sponsor: McParland, Linnette
UMBC PI: Shie, Chung-Lin
UMBC Project Number: JCET0181

Summary

"Use of GPM observations in an Optimal Estimation Lagrangian Framework (OELaF) to quantify moisture transport in Arctic Cyclones" the specific objectives are: 1. Generate Arctic cyclone tracks between 2003-2020 using a well developed cyclone tracker and MERRA-2 sea level pressures. 2. Investigate Arctic cyclone moisture budgets using our OELaF approach to produce a balanced moisture transport along cyclone tracks identified in Objective 1. a. Utilize the lagrangian framework to create a timeseries of moisture transport (q) along cyclone trajectories with data from MERRA-2 reanalysis. b. Run Polar WRF simulations to create a database of balanced relationships between observed surface E, P and (e-c) (derived from MERRA-2; see section 1.2.3.i) which will be used to update the MERRA-2 reanalysis moisture variables. c. Use an optimization procedure to incorporate observed E (AIRS) and P (GPM) in the q time-series derived in Objective 2a to adjust the MERRA-2 q, E and P at each timestep along the cyclone trajectories. Output: The OELaF will provide balanced, adjusted estimates of q, E and P along cyclone tracks. 3. Assessment/Validation of output from OELaF a. Use coincident in-situ observations of precipitation associated with Arctic cyclones (from 1) to assess the accuracy/realisticness of the balanced, adjusted estimates of q, E and P (from 2). i. 100+ Ice Mass Balance (IMB) buoys (2003-2020) ii. Extensive P measurements from the Multidisiplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) year-long (2019-2020) campaign 4. Use output from OELaF to do precipitation and moisture studies on strong cyclones in the Arctic Ocean. a. Gain insight and improve our understanding of P events associated with cyclones and changes in a rapidly changing New Arctic climate system by performing a series of annual, seasonal and regional analyses on: i. Arctic cyclone moisture source and sink regions for the Arctic Ocean ii. Arctic cyclone precipitation behavior iii. Arctic cyclones precipitation and sea ice

Accomplishments

This Task is relatively a new project funded by the NASA PMM Program. The objective of this 3-yr proposal (May 2019-May 2022) aims to use GPM products in an optimal estimation Lagrangian framework to quantify moisture transport in Arctic cyclones and further understand the evaporation (E) and precipitation (P) features. As a Co-I (0.05 FTE), Dr. Shie has utilized his expertise and knowledge in air-sea surface turbulent fluxes over global open seas, and global water and energy cycle to assist the proposal PI (Dr. L. McPartland) and the team in analyzing and accessing the evaporation and precipitation products. Dr. Shie, also a long-term modeler experienced in cloud modeling and tropical cyclone/hurricane simulations using the WRF model, will also assist Dr. M. Grecu (the other Co-I) in producing and assessing the OELaF outputs. As an experienced data producer and distributor, Dr. Shie will lead the effort on data archive and distribution as needed, expectedly during the later stage of this project. Dr. Shie has worked with the team on this project since April 2019 (around one month before official funding arrived in May 2019). We identified one strong 5-day (Dec 4-8, 2014) winter cyclone system and used it as the prototype case study to examine moisture transport in Arctic cyclone. Per performing analysis on this storm data, we have confirmed a few known features, as well as gained further preliminary insights. Applying the research findings, Dr. Shie has so far coauthored two conference presentations (one oral and one poster) in the 2019 PMM Science Team Meeting (Nov 2109); one oral (virtual) presentation at the 2020 EGU Virtual Meeting (May 2020). A related journal paper writing is currently in preparation and draft.

Plans for Next Year

Dr. Shie will continue actively playing his Co-I role (0.05 or 0.1 FTE) in this project such as,

performing science research/data analysis; organizing group meetings; co-authoring journal and conference papers.

Task Number: 182
GSFC Sponsor: Platnick, S.
UMBC PI: Wang, Chenxi
UMBC Project Number: JCET0182

Summary
Develop and evaluate optimal estimation (OE) and Machine Learning (ML) algorithms to advance retrieval of cloud optical properties from MODIS, VIIRS, sounders, and similarly capable airborne observations. Research efforts include infrared OE algorithms for simultaneous retreivals of ice cloud-top properties (pressure, temperature), optical thickness, effective particle and thermodynmaic phase as well as ML algoirthms for cloud classification problems (e.g., masking, thermodynamic phase, multilayer cloud scenes). The task includes validation of retrieved products and comparison with other remote sensing products. Additional efforts will include the use of solar reflectance and microwave channels that provide unique information content relative to NASA imager observations alone.

Accomplishments
1. A novel machine learning based cloud mask/phase algorithm was developed. We trained two Random Forest (RF) machine-learning models for cloud mask and cloud thermodynamic phase detection using spectral observations from VIIRS on Suomi NPP (SNPP). A research article was published on Atmospheric Measurement Techniques (doi:10.5194/amt-13-2257-2020). 2. An improved Infrared based Optimal Estimation ice cloud retrieval algorithm was developed and tested for the next version of MODIS (Collection 7) cloud product. For a long time, many existing operational cloud retrieval algorithms (e.g., MODIS) are relying on daytime solar reflectance, resulting in a lack of nighttime cloud record and incomplete cloud climatology. Consistent IR observations in both daytime and nighttime allow us to build a comprehensive cloud climatology and understand the full cloud diurnal cycle. Different from previous IR-based cloud retrieval algorithms, the present algorithm is based on a fast and accurate radiative transfer model (RTM). Cloud optical thickness (COT), cloud effective radius (CER), and cloud-top height (CTH) will be retrieved simultaneously from thermal IR observations. A unique feature of this retrieval algorithm is that we fully consider how ice cloud optical properties change with the change of ice crystal shape. This is the first time that a retrieval algorithm provides pixel-level uncertainties from measurements, ancillary datasets, and assumptions in ice crystal habits. The algorithm has matured to the point that it is now being proposed as a substitute for the current MODIS Collection 6 cloud-top pressure 1km dataset. Meanwhile, the two papers will be the theoretical basis for the MODIS next collection IR cloud retrievals. 3. A research proposal titled Developing Passive Satellite Cloud Remote Sensing Algorithms using Collocated Observations, Numerical Simulation and Deep Learning" was submitted to NASA ROSES NNH19ZDA001N-ACCESS: Advancing Collaborative Connections for Earth System Science. 4. We plan to submit a paper about a new infrared and microwave joint ice cloud retrieval in September.

Plans for Next Year
1. We plan to submit a research proposal to NASA ROSES Terra-Aqua-SNPP late this year. 2.

We plan to test and finalize the Infrared based Optimal Estimation (IROE) ice cloud retrieval algorithm for operational. 3. We will organize an AGU session on applying ML and AI to atmospheric sciences. The session title is A019. Application of Machine Learning and Artificial Intelligence in Observing and Modeling, and Analyzing Our Atmosphere.

Task Number: 183
GSFC Sponsor: Yang, Yuekui
UMBC PI: Zhou, Yaping
UMBC Project Number: JCET0183

Summary
Focus on cloud and aerosol analysis using data from a variety of NASA satellite observations, including those from DSCOVR (Deep Space Climate Observatory), MODIS (Moderate resolution Imaging Spectroradiometer) and others. Conduct studies on the signature of clouds and aerosols over different surface types at different wavelengths to improve the satellite retrievals. Validation of these products is also part of the task. The ultimate goals are to use these improved products to improve our understanding of global cloud and aerosol properties.

Accomplishments
Dr. Zhou was involved in three main projects during this report period. One project is to evaluate the cloud products including cloud mask, cloud pressure height and cloud optical thickness from the Earth Polychromatic Imaging Camera (EPIC) onboard the Deep Space Climate Observatory (DSCOVR). This project is funded by DSCOVR science team funding and led by Dr. Yuekui Yang at Goddard. An initial evaluation of the products using the collocated cloud retrievals from other sensors show that the EPIC CM performs very well in general, but a large discrepancy is found in the cloud mask over the snow- or ice-covered surfaces, where the EPIC algorithm significantly underestimates cloud fraction, especially over ice and snow-covered Antarctic (Yang et al., 2019). Due to lack of Infrared channels, EPIC relies on two oxygen absorption band pair ratios in A-band (764 nm, 780 nm) and B-band (688 nm, 680 nm) for cloud detection over the snow and ice surfaces. Dr. Zhou has designed a new dynamic threshold for the oxygen band ratios as a function of surface elevation and zenith angle. The new scheme achieves significant improvements over the existing algorithm. The results are published in an AMT journal (Zhou et al. 2020a) In a separate project, Dr. Zhou has been working on dust detection and dust aerosol optical properties retrievals with the MODIS Dark Target (DT) aerosol team led by Dr. Robert Levy of NASA Goddard for several years. The DT aerosol retrievals are used widely in the community. However, over the ocean, the DT algorithm is known to contain scattering-angle-dependent biases in its retrievals of Aerosol Optical Thickness (AOD), Angstrom Exponent (AE) and Fine Mode Fraction (FMF) for dust aerosols. These long-standing retrieval biases are due to non-spherical nature of the dust particles not treated properly in the existing retrieval algorithm. Dr. Zhou has addressed the problem by first detecting dusty pixels and then apply a non-spherical dust models for those identified dusty pixels. The implementation of the new dust detection and dust model has improved the retrieval of AOD, FMF, AE. During this period of time, Dr. Zhou has improved the dust detection algorithm which had been the most difficult part of this project and completed two manuscripts that separately document the dust detection (Zhou et al. 2020b) and non-spherical dust model (Zhou et al. 2020c). In addition, Dr. Zhou participated a project that is led by another JCET scientist Dr.

Chenxi Wang in applying machine-learning technique for cloud detection and cloud thermodynamic phase identification. That part of work has led to a publication in AMT (Wang et al. 2020).

Plans for Next Year
For the EPIC project, Dr. Zhou is currently working on solving cloud mask biases in the sun glint regions and a manuscript on new methodology and improvement will be prepared before the next EPIC science team meeting in October. She will conduct another round of validation with several updates in the operational EPIC cloud algorithm in the coming year. For the Dark Target related project, Dr. Zhou will evaluate the operational implementation of dust detection and retrieval in MODIS and VIIRS. She will also be working to improve the cloud mask in the aerosol retrieval.

Task Number: 184
GSFC Sponsor: Lyapustin, A.
UMBC PI: Go, Sujung
UMBC Project Number: JCET0184

Summary
Development of the cloud detection, aerosol retrieval and atmospheric correction algorithms for the geostationary imagers (ABI, AHI), as well as for the hyperspectral polar-orbiting or geostationary instruments. Algorithm prototyping and testing, as well as aerosol and surface reflectance product analysis and validation.

Accomplishments
I work on PACE OCI aerosol algorithm development. This year (March 1, 2020 - September 30, 2020), I have created subset for the project, and attended relative science team meeting to discuss further development of the algorithm.

Plans for Next Year
Next year, I would adjust MAIAC algorithm to TROPOMI instrument as a proxy for OCI and will write a paper for the key findings.

Task Number: 186
GSFC Sponsor: Sauber-Rosenberg , J.
UMBC PI: Han, Shin-Chan
UMBC Project Number: JCET0186

Summary
Test how varied observational strategies for gravimetric systems will improve the results for the science and user needs of the Earth Surface and Interior community. Prticularly new tectonic and earthquake signals that are beyond the present GRACEÕs sensitivity, Quantify the pros and cons of different types (microwave, laser, gravity gradient tensor) of satellite measurements, characterize the measurement error and other geophysical signal aliasing effects on our global gravity inversion, and assess the effects of different orbit configurations (inclination and altitude) and satellite system (number of satellites, accelerometer vs drag-free,

and cost) in order to develop the optimal cases of satellite mission scenarios for solid Earth applications.

Accomplishments
This is a new task, started in January 2020. The numerical modelling code of computing gravitational perturbation by earthquakes was revised. The recent event in Peru in 2019 was examined with a finite fault and global CMT solutions. New GRACE Follow-On Laser Ranging Interferometer (LRI) data were analyzed.

Plans for Next Year
The code and modelling algorithm will be finalized. The earthquake correction models will be produced for GRACE and GRACE-FO. A manuscript on these technical development will be prepared. This work will be used for ESI OSSIE simulation for future NASAâ€™s Mass Change mission.

Task Number: 187
GSFC Sponsor: Meyer, Kerry
UMBC PI: Miller, Daniel
UMBC Project Number: JCET0187

Summary
Develop algorithms and forward modeling simulators in support of cloud optical/microphysical property retrievals from satellite sensors and missions including EOS MODIS, SNPP/JPSS VIIRS, and the NASA Decadal Survey mission ACCP, in addition to similarly capable airborne sensors. Research efforts include 1D and 3D radiative transfer calculations (including shortwave intensity, polarimetry) using large eddy simulation (LES) cloud fields that enable assessments of the information content of a variety of observational approaches; development of techniques for cloud optical thickness and effective particle size retrieval inversions, including machine learning algorithms; and analysis of NASA airborne field campaign observations.

Accomplishments
This task supports the forward modeling and simulation efforts of the MODIS/VIIRS Cloud Retrieval Group (CRG) and their development of new cloud retrieval products. As part of these activities I have presented on planned activities at the MODIS science team meeting in the fall. I also attended the AGU Fall Meeting and presented associated polarimetric cloud remote sensing research. Additionally, I published a paper in Atmospheric Measurement Techniques on my previous work developing a neural network-based cloud microphysics retrieval algorithm. This neural network retrieved cloud microphysical properties from multi-spectral and multi-angular polarimetric observations obtained by the Research Scanning Polarimeter instrument.

Plans for Next Year
Current and pending work supporting CRG development has focused on the analysis and feasibility of developing a multiangle correction factor for biased cloud effective radius retrievals. This study has been completed for 1-D radiative transfer at coarse resolution observations (similar to MODIS resolution) and is planned to be continued at higher spatial

resolutions and for simulated observations using a 3-D radiative transfer modeling. It is expected that this study might lead to publication and potentially future applications on data obtained by multiangle. Additional future activities and projects include a sensitivity study addressing scattering angle sensitivities within our new gridded level-3 product produced by our group. I also intend to implement a new vector radiative transfer algorithm for possible use in future forward modeling studies.

Task Number: 189
GSFC Sponsor: Gleason, James
UMBC PI: Gambacorta, Antonia
UMBC Project Number: JCET0189

Summary
Continuing retrievals of temperature, water vapor and trace gases from the AIRS instrument on EOS Aqua. Studies of new instrument and observing architectures for improving NOAA weather forecasts. Development of new retrievals combining measurements from infrared and ultra-violet/visible instruments. Development of new and/or improved data products from satellite infrared spectral data.

Accomplishments
My activity during this past quarter was mainly focused on two areas. First, I conducted a spectral sensitivity analysis in the infrared domain to support the NASA Global Modeling Atmospheric Office (GMAO). Specifically, the target of this effort was to support the data assimilation of the Cross-track InfraRed Sounder (CrIS) at GMAO, with a particular attention to water vapor sensitive channels in the 1200-1600 cm-1 band. Figure 1, 2 and 3 describe a sensitivity study of selected water vapor sounding channels to atmospheric and surface temperature in addition to interfering trace gas species, also active in this band, i.e. nitrous oxide (N2O) and methane (CH4). Channel selection techniques are employed to perform radiance data thinning and essentially serve two purposes. They expedite computation and help mitigate ill-conditioning due to interference of trace gases whose abundances are unknown and radiative transfer properties still largely uncertain. A second focus of this past quarterly has been my involvement with the GSFC Earth Planetary Boundary Layer (PBL) Study Task Group. I have performed an extensive research on current sounding capability in the lower reaches of the troposphere from the use of microwave and infrared hyperspectral sounder. I am currently collaborating on an Observational Simulation and Sensitivity Experiment (OSSE) whose goal is to demonstrate the current capability of PBL sounding from conventional microwave and infrared sounders. Both activities will support the draft of a white paper on PBL remotely sensed capability expected to be published by the end of 2020 by the PBL Decadal Survey Incubation team.

Plans for Next Year
This task is has ended as of 7/20//20

Task Number: 190
GSFC Sponsor: Utz, Stephanie
UMBC PI: Mehta, Amita

UMBC Project Number: JCET0190

Summary

Gathering and comparing existing in situ data sets with remote sensing-based water quality parameters in coastal and inland waters. Participation and contribution to NASA activities relevant to water quality, including preparing and presenting at the Idaho Water Quality Workshop.

Accomplishments

Mehta focused on collecting and processing multi-year Level-1 data from Landsat-OLI, Sentinel 2 A/B-MSI, Sentinel 3 A/B-OLCI, Aqua-MODIS, and ISS-HICO for the Chesapeake Bay. Mehta developed a procedure for bulk-processing of the Level-1 data to obtain water-leaving, and top-of-atmosphere reflectances, and Chlorophyll-a concentration from these sensors using SeaDAS/OCSSW software from NASA Ocean Biology Group. Mehta also analyzed in situ water quality data for the Chesapeake Bay obtained from the Maryland Department of the Environment. The remote sensing and the in situ data will be used by the project team to develop an Artificial Intelligence /Machine Learning algorithm to predict remote sensing based algal bloom and Fecal Coliform concentration in the Bay to assist Shellfish aquaculture activities in the region.

Plans for Next Year

Mehta will continue to process the Level-1 data for the algorithm development. In addition, Mehta will analyze ~20 years of IMERG precipitation, NLDAS runoff, and MODIS land cover data in Chesapeake Bay watershed along with the in situ data to examine how these parameters affect turbidity and algal bloom in the Bay. Mehta will participate in writing a report based on this project.

II. Supplemental Information

A. Departmental Affiliations

Chemistry	Information Systems	Geography & Environmental Systems	Mathematics & Statistics	Physics
St. Claire, J. Wolfe, G.	*Wang, J.	Campbell, P. Huemmrich, K. Mehta, A. Remer, L. Shuman, C. Tokay, A. Turpie, K.	Tangborn, A.	Delgado, R. DeSouza-Machado, S. *Demoz, B. Guimond, S. *Martins, V. Olson, W. Remer, L. Varnai, T. *Zhai, P. *Zhang, Z.

* Tenured or Tenure-track Faculty

B. Courses Taught

Fall 2019	Spring 2020
GES 311: Weather & Climate, **Tokay** (3 credits) PHYS 335: Physics and Chemistry of the Atmosphere, **Delgado/de Souza-Machado** (3 credits)	PHYS 622: Atmospheric Physics II, **Demoz** (3 credits) PHYS 640: Computational Physics, **Várnai** (3 credits) PHYS 650: Special Topic: Application of Artificial Intelligence to Earth Sciences, **Zhang, Wang, Miller** (1 credit)

C. Reported Publications

Archer, C. L., Wu, S., Vasel-Be-Hagh, A., Brodie, J. F., **Delgado, R.**, **St Pe, A.**, Oncley, S., Semmer, S. (2019). The VERTEX field campaign: observations of near-ground effects of wind turbine wakes. *JOURNAL OF TURBULENCE, 20*(1), 64-92. doi.org/10.1080/14685248.2019.1572161

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Campbell,, P. K. E., Huemmrich, K. F., Middleton, E. M., Ward, L. A., Julitta, T., Daughtry, Craig S. T., Burkart, A., Russ, A. L., Kustas, W. P. (2019). Diurnal and Seasonal Variations in Chlorophyll Fluorescence Associated with Photosynthesis at Leaf and Canopy Scales. *REMOTE SENSING, 11*(5).

Ciufolini, I., Matzner, R., Paolozzi, A., **Pavlis, E. C.**, Sindoni, G., Ries, J., Gurzadyan, V., Koenig, R. (2019). Satellite Laser-Ranging as a Probe of Fundamental Physics. *arXiv preprint arXiv:1907.00395*.

Ciufolini, I., Paolozzi, A., **Pavlis, E. C**., Sindoni, G., Ries, J., Matzner, R., Koenig, R., Paris, C., Gurzadyan, V., Penrose, R. (2019). An Improved Test of the General Relativistic Effect of Frame-Dragging Using the LARES and LAGEOS Satellites. *Eur. Phys. J. C/Springer*.

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Davis, G. D., **Caicedo, V., Demoz, B. B., Delgado, R.** (2020). Cloud Climatology over Baltimore. *100th American Meteorological Society Annual Meeting*.

De Souza-Machado, **S. G., Strow**, **L. L., Motteler**, H., Hannon, S. (2020). kCARTA : A fast pseudo line-by-line radiative transfer algorithm with analytic Jacobians, fluxes, Non-Local Thermodynamic Equilibrium and scattering for the infrared. *AMT, 13*, 323-339. https://doi.org/10.5194/amt-13-323-2020

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D. Proposals & Status

PI (JCET)	Proposal Title	Funding Agency	Status
Baker, Barry	Development of a machine learning emulator for CAM-CMAQ to improve wildfire smoke forecasts	National Oceanic and Atmospheric Administration	Awarded
Wang, Chenxi	Developing an Advanced Algorithm to Retrieve Cloud Water Path using Combined Passive Infrared and Microwave Observations	NASA Goddard Space Flight Center	Awarded
Yuan, Tianle	Impact of aerosol-cloud interactions on the intensity of deep convection and lightning as viewed by CloudSat/CALIPSO	National Aeronautics and Space Administration	Awarded
Zhang, Zhibo	Using IIR, CALIOP and Other Satellite Observations to Better Understand the Thermal Infrared Optical Depth and Radiative Effects of Dust Aerosols	National Aeronautics and Space Administration	Awarded
Baker, Barry	Advance FV3-CAM to improve wildfire detection, prediction and dust prediction	National Oceanic and Atmospheric Administration	Submitted
Baker, Barry	Mechanistic development of the NOAA Emissions and eXchange Unified System (NEXUS) and coupling to atmospheric aerosol and composition models	George Mason University	Submitted
Bian, Huisheng	Atmospheric organic nitrate aerosols: Implementation, uncertainties, and impacts on terrestrial ecosystem in the NASA Earth System Model	National Aeronautics and Space Administration	Submitted
Bian, Huisheng	Capturing ecosystem-atmospheric chemistry feedbacks between ozone, aerosols, and vegetation: impacts on air quality and crop yields in a changing climate	USRA - Universities Space Research Association	Submitted
Campbell, Petya	Diurnal Course of Vegetation Reflectance Indices (VI): Physically based Modeling Analysis and Implication for Near Polar Satellite Data	NASA Goddard Space Flight Center	Submitted
Campbell, Petya	Training the New Generation of Machine Learning Approaches for Monitoring the Dynamics of Terrestrial Ecosystem Function	NASA Goddard Space Flight Center	Submitted
Delgado, Ruben	Cohort 4: Financial Assistance to Establish Four NOAA Cooperative Science Centers at Minority Serving Institutions	Research Foundation of The City University of New York	Submitted

Delgado, Ruben	UMBC Characterization of Lidar Remote Sensing Aerosol Backscatter Profiles and Atmospheric Dynamics in the Plume labeling and Untangling using Multi-Feature Embedding Network (PLUMENet)	Intelligent Automation, Inc.	Submitted
Demoz, Belay	CISESS: UMBC-Howard University Support of NOAA's Commitment to the Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN)	University of Maryland, College Park	Submitted
Demoz, Belay	Diagnosing and constraining the contribution of land-atmosphere feedbacks to terrestrial aridity	National Aeronautics and Space Administration	Submitted
Demoz, Belay	NOAA Cooperative Science Center in Atmospheric Sciences and Meteorology at Howard University	Howard University	Submitted
Demoz, Belay	Student Airborne Science Activation for MSIs(SaSa)	USRA - Universities Space Research Association	Submitted
Guimond, Stephen	The dynamics of turbulent buoyant plumes	Los Alamos National Laboratory operated by Triad National Security, LLC	Submitted
Herman, Jay	Tropospheric Emissions, Monitoring of Pollution (TEMPO)	Smithsonian Astrophysical Observatory	Submitted
Huemmrich, Karl	Integrating ISS, satellite and ground data to characterize biodiversity changes across forest biomes	National Aeronautics and Space Administration	Submitted
Lewis, Jasper	EarthCARE Cal/Val Using the NASA Micro Pulse Lidar Network (MPLNET)	National Aeronautics and Space Administration	Submitted
Martins, Jose	Development of Components for an Advanced SWIR Imaging Polarimeter Towards the A&CCP Mission and Beyond	National Aeronautics and Space Administration	Submitted
Mehta, Amita	Water quality monitoring in rivers and floodplains through the integration of sediment yield and transport models in the NASA Land Information System	University of Maryland, College Park	Submitted
Rocha Lima, Adriana	Identifying and investigating the sensitivities of dust emissions to key input parameters in a physically-based dust mobilization scheme in GEOS	National Aeronautics and Space Administration	Submitted

St. Clair, Jason	Collaborative Research: Investigating Formation of Sulfur Aerosols in Fairbanks, Alaska	National Science Foundation	Submitted
Strow, L	AIRS Radiative Transfer Algorithm	NASA Goddard Space Flight Center	Submitted
Strow, L	JSTAR SDR CrIS: UMBC Support to JPSS CrIS Cal/Val and NUCAPS	University of Maryland, College Park	Submitted
Tangborn, Andrew	Assimilation of planetary boundary layer height measurements to improve subseasonal climate prediction	National Oceanic and Atmospheric Administration	Submitted
Tangborn, Andrew	Development of PBL assimilation approaches for improved NWP applications using NASA modeling and observational assets	National Aeronautics and Space Administration	Submitted
Tangborn, Andrew	Observation operators for satellite microwave sensors to improve the representation of convective storms by NU-WRF	Jet Propulsion Laboratory - Operated by CalTech	Submitted
Turpie, Kevin	Assessing Ecosystem Response to Glacier-Ocean System Dynamics	National Aeronautics and Space Administration	Submitted
Turpie, Kevin	Assessment of Geophysical Oceanographic Forcing on Outlet Glaciers and the Downstream Marine Ecological Response	National Aeronautics and Space Administration	Submitted
Turpie, Kevin	Remote Sensing Assessment of Light Stress, Hyperthermia, and Hypoxia in the Florida Big Bend Seagrass Ecosystem.	Florida Fish and Wildlife Research Institute	Submitted
Tyler, Robert	Long-term maintenance of liquid oceans by self-tuned tidal resonance	NASA Goddard Space Flight Center	Submitted
Wang, Yujie	Adapting MODIS MAIAC Algorithm to Geostationary Sensors	Bay Area Environmental Research Institute	Submitted
Wolfe, Glenn	Collaborative Research: Boreal Organic Reactivity, Emissions, Aerosols and Depositions Study (Boreads)	University of Wisconsin-Madison	Submitted
Wolfe, Glenn	Collaborative Research: Greater NY Oxidant, Trace gas, Halogen, and Aerosol Airborne Mission (GOTHAAM)	National Science Foundation	Submitted
Xu, Xiaoguang	Participation in European's Sentinel-4 and Sentinel-5 Mission: Aerosol Layer Height Algorithm	University of Iowa	Submitted

	Development and Improvement		
Yuan, Tianle	Building a Customizable Deep Learning Workflow for Efficient Large-scale Data Exploration and Discovery: Demonstration for Fire-Induced Smoke Plumes	National Aeronautics and Space Administration	Submitted
Yuan, Tianle	Linkages between cumulus convection and deep convective cloud systems across scales in global simulations	National Aeronautics and Space Administration	Submitted
Zhai, Pengwang	A hyperspectral retrieval scheme for Surface Biology and Geology Designated Observable in optically complex waters	Science Systems and Applications, Inc.	Submitted
Zhai, Pengwang	Fusion of active and passive remote sensing for global ocean biology research	Science Systems and Applications, Inc.	Submitted
Zhou, Yaping	Characterizing Life Cycle of Extreme Precipitation Events and Their Controlling Mechanisms from Observations, GCM and Reanalysis data	National Aeronautics and Space Administration	Submitted
Delgado, Ruben	HU CARES: Hampton University Center for Atmospheric Research and Education	Hampton University	Not Funded
Remer, Lorraine	Aerosol effects on the evolution of cloud development and organization on fine temporal scales	National Aeronautics and Space Administration	Not Funded
Zhai, Pengwang	A Joint Retrieval Algorithm for Multi-Angle Polarimeters Over Costal Waters	National Aeronautics and Space Administration	Not Funded

E. Biographies

Nader Abuhassan, Associate Research Engineer
Ph D, University of Pierre and Marie Curie (1995)

Dr. Abuhassan participated in the design and development of multiple world recognized sensors such as the Cimel sun photometers, Solar Viewing Interferometer and the Pandora Spectrometer. He participated in multiple national and international satellite validation and ground based instruments inter comparison campaigns. For the past four years he was heavily involved in the NASA's DISCOVER_AQ project " Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality" where he managed to deploy and maintain up 15 Pandora spectrometers for each of the 4 field campaigns. Dr. Abuhassan's research is focused on designing and developing new sensors in support of the atmospheric chemistry research activities. He is highly interested in providing new tools to help scientists develop new methods to better understand the atmosphere composition, its dynamics and air-surface interactions.

Bian, Huisheng, Senior Research Scientist
Ph D, University of California Irvine (2001)

From 1988 to 1995, Bian worked in Chinese Meteorological Academy as an assistant researcher, where her research interest was regional air quality modeling. Her Ph.D. work focused on improving, validating, and applying UCI global chemistry transport model for tropospheric ozone simulation, as well as on developing a module (Fast-J2) to accurately simulate stratospheric photolysis in global chemistry models. Upon graduation, Dr. Bian became interested in atmospheric aerosols, their distribution and their photolytic and heterogeneous impacts on tropospheric chemistry. Her current major research interest involves improving and applying multiple CTMs to the atmospheric chemistry studies and providing mission planning and mission support.

Roberto Borda, Assistant Research Scientist
Ph D, University of Buenos Aires (2001)

Dr. Roberto Fernandez Borda is interested in scientific instrumental design and experimental physics. Since his Master thesis, he was involved in the design of scientific instrumentation like HRXS (part of the payload of SAC-B, Conae Argentina) and HASTA telescope (International agreement between the Max Planck Institute, Germany and IAFE, Argentina). Dr Borda has strong background in different instrument design areas like optics, digital electronics, sensors and real time software. He came to the United States, as National Research Council Post-Doctoral Fellow, to work with Dr. Mario H Acuna at GSFC NASA in 2002. In 2006, He became Associated Researcher at JCET-UMBC. Dr Borda, as member of the research group of Dr Vanderlei Martins at JCET-UMBC, was involved in many instrumental projects for avionics applications (Cloud Scanner, Rainbow camera, PACS VNIR) and for satellite applications (HARP)and also he was part of many field campaigns (Milagro, Vocals, Podex). Dr. Borda has been awarded for his performance as instrumental designer two times: The first time by the Laboratory of Atmospheres, Climate & Radiation branch, GSFC NASA (2007) and the second time by Climate & Radiation Branch, GSFC NASA (2009).

Vanessa Caicedo, Post-doctoral Research Associate
Ph D, University of Houston (2017)

Dr. Caicedo obtained a Ph.D. in Atmospheric Sciences from the University of Houston where her research was based upon the retrieval of the planetary boundary layer height, coastal boundary layer evolution and climatology, and the evaluation of observed and simulated boundary layer dynamics in urban-coastal environments using remote sensing observations. Dr. Caicedo joined the Atmospheric Lidar Group at UMBC/JCET in 2017 to work on planetary boundary layer height retrieval methodology using lidars, boundary layer meteorology, air quality and atmospheric chemistry. Recent work includes an extensive comparison of planetary boundary layer height retrieval algorithms, coastal planetary boundary layer climatology of the Houston-Galveston area using long-term ceilometer data, unique 3-dimensional spatial and temporal case study integrating multiple in-situ data sets, airborne and ground-based remote sensing instrumentation with a numerical model simulation using WRF-Chem, and analysis of PBL and ozone relationships in coastal environments.

Petya Campbell, Research Associate Professor
Ph D, University of New Hampshire (2000)

Dr. Campbell is an experienced scientist, forest engineer and ecologist by training. She has conducted numerous field campaigns, in the US and abroad, collecting: vegetation traits, spectral and biophysical data for the analysis of satellite and airborne acquisitions. Her research focus is on Remote Sensing for Natural Resources, specifically spectral analyses for assessment of vegetation condition, ecosystem monitoring and forest damage detection using reflectance and fluorescence measurements. Dr. Campbell has taught undergraduate and graduate courses in remote sensing, has mentored students and served on graduate student committees. Dr. Campbell's research focus is on spectral analysis for the assessment of vegetation function and damage detection. Dr. Campbell has experience collecting and analyzing vegetation reflectance and fluorescence measurements, ecosystem gas exchange parameters, as well as measuring other associated biophysical characteristics. She works with spectroscopy data collected in the laboratory, on the field, from aircraft, and from satellite for a variety of vegetation canopies (forests and crops, C3 and C4 vegetation).

Sergio de Souza-Machado, Research Associate Professor
Ph D, University of Maryland (1996)

Having obtained a Ph.D. in Plasma Physics, Dr. DeSouza-Machado joined the Atmospheric Spectroscopy Laboratory at UMBC to work on radiative transfer, spectroscopy, retrievals and climate studies. He has written a state-of-the-art line-by-line code and KCARTA, a clear/cloudy sky radiative transfer code for the (Earth atmosphere) thermal infrared region which is the Reference Forward model for NASA's AIRS instrument. His research interests include dust and volcanic ash detection and retrievals, trace gas, cloud and atmospheric geophysical retrievals, and climate studies of extremes and evolution of probability functions. In addition he performs teaching duties on campus. Dr. DeSouza-Machado's current interests in Atmospheric Physics include updating spectroscopy and radiative transfer calculations used by kCARTA, flux calculations in the longwave, and dust/volcanic ash detection and atmospheric. loading/height retrievals. He also does retrievals for broader target species, notably trace gas and geophysical retrievals under clear and cloudy conditions. In addition he uses 16+ years of hyperspectral AIRS data for climate studies Dr. DeSouza-Machado also pursues some interest in Plasma Physics, notably MHD simulations and kinetic theory

Ruben Delgado, Assistant Research Professor
Ph D, University of Puerto Rico (2011)

Dr. Delgado, holds a doctoral degree in Chemistry, and is experienced in remote sensing technology for air quality, wind energy, and meteorology applications. His interest and experience in active and passive remote sensing measurements has allowed him to participate in numerous field campaigns with NASA, NOAA, NSF and DOE. Dr. Delgado has mentored undergraduate and graduate students from diverse majors (Math, Physics, Chemical Engineering, Mechanical Engineering, Geography and Environmental Systems) in atmospheric and remote sensing topics, and serves on graduate committees. Dr. Delgado research interests focus in atmospheric chemistry and physics, and laser remote sensing technology. Elastic, Raman, and Doppler wind lidar measurements are integrated with satellite retrievals, ground based concentration measurements of gases and aerosols (TEOM, BAM, filters), and numerical weather prediction models to reach a thorough understanding of the coupling of chemistry and dynamics in air-land-marine interactions.

Belay Demoz, Professor and Director
Ph D, University of Nevada-Reno, Desert Research Institute (1992)

Dr. Demoz has over 20 years of research experience in private industry, government, and Academia. He has chaired the Committee for Atmospheric LIDAR Application Studies (CLAS) for the American Meteorological Society; is a member of the Atmospheric Observation Panel for Climate (AOPC) Working Group on GRUAN (WG-GRUAN); and has served in Editorial Boards of Journals and Magazine. He has organized national and international conferences, experiments, and workshops. He is a Professor in Physics and the current Director of the (JCET). Dr. Demoz's research interest covers the broad area of atmospheric observations with a particular emphasis in lidar, radar and Microwave radiometer and their applications in mesoscale observations, climate observation and network design. He is mainly interested in integrating the multiple instruments and their physics in understanding atmospheric dynamics to improve now casting and climate.

Antonia Gambacorta, Associate Research Scientist
Ph D, UMBC (2008)
Antonia earned her PhD (2008) and MS (2004) in Atmospheric Physics from the University of Maryland Baltimore County and her Laurea Degree (2001) in Applied Physics (Summa cum Laude) from the University Aldo Moro of Bari, Italy. She has 20 years of experience in active and passive remote sensing methods for the retrieval of atmospheric temperature and constituents. She currently serves as Research Scientist in Aerospace Technology for Atmospheric Measurements, at the NASA Goddard Space Center, in the Climate and Radiation Laboratory.

Stephen Guimond, Assistant Research Professor
Ph D, Florida State University (2010)

Guimond is interested in remote sensing with a focus on airborne Doppler radar including designing algorithms for computing geophysical variables such as winds, latent heat and precipitation. Geophysical fluid dynamics with a focus on hurricanes, convection, turbulence and computational methods.

Reem Hannun, Post-doctoral Research Associate
Ph D, Harvard University (2017)

Hannun has been at NASA/GSFC and UMBC/JCET since March 2017. Her research interests include atmospheric oxidation chemistry and the surface-atmosphere exchange of greenhouse gases. Prior to arriving at NASA, held a Climate and Energy Policy internship with the American Physical Society.

Christopher Hepplewhite, Associate Research Scientist
Ph D, University of Oxford

Dr. Hepplewhite is an experienced atmospheric physicist, remote sensing instrument scientist and developer. He has 20 years in the academic environment and supported teaching and research at undergraduate and graduate level. Dr. Hepplewhite has worked on remote sensing instrument teams in the U.K. with ESA and NASA, including ship-borne infra-red radiometry, solar occultation radiometry, Mars Orbiter, Saturn Cassini, and NASA EOS missions. This has included all phases of mission life-cycle, including design, development, calibration, test, operation and data analysis. Dr. Hepplewhite has supported project management, aerospace industry, systems engineering and project science lead. He has worked in atmospheric physics and chemistry and meteorology and has a keen interest in climate dynamics. Dr. Hepplewhite is currently involved in supporting research to quantify and improve the inter-calibration of space-based hyper-spectral infra-red observations of the Earth using data from weather satellite sensors. These include NASA EOS Terra AIRS, Suomi-NPP CRIS and ESA Metop IASI sensors.

Dr. Hepplewhite has interest in observation of climate change signals from space based sensors and the underlying physical processes. An understanding of the nature and morphology of climate change processes is essential when looking for signals in the observations and differentiating sensor artifacts.

Jay Herman, Senior Research Scientist
Ph D, Pennsylvania State University (1965)

Dr. Herman has had wide experience in a number of diverse fields. Early in his career at Goddard Space Flight Center (1965-1970) he worked in the fields of ionospheric and plasma physics and planetary atmospheres. Starting in 1970, he developed a theoretical model of the earth's atmosphere that included extensive chemistry analysis to estimate the effects of accumulating chlorine on the ozone layer. This led to an interest in satellite instruments measuring ozone (Total Ozone Mapping Spectrometer, TOMS). Dr. Herman devised a corrected calibration method that led to the capability of the TOMS instrument successfully producing long-term ozone trends. As part of this effort, he became the Principle Investigator to the joint US-Russian Meteor-3 TOMS project. Dr. Herman worked on distribution of aerosols as detected by the TOMS instrument and published the first papers on the motions of dust, smoke, and volcanic ash over the entire earth. He also developed an analysis of cloud amount and the long-term trends of cloud amount. This data was used to estimate the amount of ultra-violet radiation reaching the earth's surface and discussions of potential health effects. In 1998, Dr. Herman became the Project Scientist of the Triana spacecraft project, now known as DSCOVR, which was just launched (February 2015) to the Lagrange-1 point to measure ozone, aerosols, cloud properties, and vegetation. Starting in 2006, Dr. Herman began the development of a new ground-based instrument, Pandora, capable of accurately measuring ozone and other trace gases in the atmosphere. The Pandora instrument is now mature and being deployed widely in the US and other countries. Dr. Herman started work at UMBC in 2009 where he continued the work on DSCOVR as EPIC instrument scientist and the Pandora spectrometer system project. Dr. Herman has 160 peer reviewed scientific journal publications.

Fred Huemmrich, Research Associate Professor
Ph D, University of Maryland (1995)

Dr. Huemmrich has a life-long interest in understanding the natural world. This interest, coupled with his training in physics has lead him to work on remote sensing of ecosystems. He has performed fieldwork in a variety of different ecosystems, including working on NASA field studies in grasslands and boreal forests. Dr. Huemmrich's research focuses on the use of remote sensing to describe biophysical characteristics of terrestrial ecosystems and to utilize that information to improve understanding and modeling of ecosystem processes. He is interested in developing approaches that lead to global observations from satellite based sensors.

Magdalena Kuzmicz-Cieslak, Faculty Research Assistant
Ph D, A. Mickiewicz University (1997)

Dr. Kuzmicz-Cieslak's main research task supports the investigation of mean sea-level monitoring using operational satellite data and SLR. Satellite laser ranging (SLR) refers to a global network of observation stations measures the round trip time of flight of ultrashort pulses of light to satellites equipped with retroreflectors. This provides instantaneous range measurements of millimeter level precision which can be accumulated to provide accurate measurement of orbits and a host of important scientific data. Furthermore, she is further contributing to investigation of the improved analysis of SLR data with GEODYN II and in combination with other data to obtain a set of normal equations that will yield the

Terrestrial Reference Frame. Dr. Kuzmicz-Cieslak is specifically focusing on the reanalysis of all SLR data from 1976 to the present with the inclusion of the atmospheric modeling. This research assists with building more precise models of the gravitational field of the Earth. Currently, Dr. Kuzmicz-Cieslak, and her research group, is working on the expansion of the Very Long baseline Interferometry (VLBI) simulation package using NASA's supercomputer. This will enable scientists to carry out several large scale simulations and to combine various algorithms and produce a TRF that satisfies the accuracy requirements of the Global Geodetic Observing System (GGOS) program.

Jae Nyung Lee, Assistant Research Scientist
Ph D, Stony Brook University (2008)

Jae N. Lee is working with on TSIS (Total Solar Irradiance Sensor) due for launch on JPSS Free Flyer in 2017. She is also working on the climate responses to solar forcing in different time scales by integrating satellite measurements and model simulations. She worked at JPL as a NASA postdoc fellow. During her postdoc, she worked on dynamics and transport in the middle atmosphere and variability in cloud and aerosol caused by natural and anthropogenic forcings. Dr. Lee's research interests include observation of total and spectral solar irradiance, analysis of solar irradiance variability, and its impact on earth's climate. She uses numerical models of the sun and earth's atmosphere as well as remote sensing observations to investigate solar activities, climate variability and their interconnections. Besides this, she also finds that remote sensing of cloud and aerosol is an important problem to addressing the climate change from both the natural and anthropogenic forcings.

Jasper Lewis, Assistant Research Scientist
Ph D, Hampton University (2010)

Dr. Jasper Lewis is an assistant research scientist in the Joint Center for Earth System Technology at UMBC. Previously, he performed ground-based and aircraft lidar measurements to observe air quality from NASA Langley Research Center. Currently, he conducts research at the NASA Goddard Space Flight Center as a member of the Micropulse Lidar Network (MPLNET) team. Dr. Lewis' research interests include remote sensing of cirrus clouds and the planetary boundary layer.

Vanderlei Martins, Associate Professor
PhD, University of Sao Paulo

Dr. Martins is an Experimental Physicist by training specializing in the development of instrumentation and algorithms for the measurement of the properties of aerosol and cloud properties via remote sensing from ground, aircraft, and space as well as in situ and laboratory measurements. He has designed, built and integrated several instruments for multiple NASA aircrafts including the ER-2, P3, DC8 and Langley B200, and has participated in numerous aircraft and ground based field campaigns. Dr. Martins is a tenured Professor in the Physics Department at UMBC and has mentored several students from undergraduate to the PhD level. Dr. Martins is particularly interested in the effect of natural and anthropogenic aerosol particles on cloud microphysical and thermodynamic properties as well and in the radiative properties of aerosol and cloud particles from UV to thermal infrared. In particular Dr. Martins and his group has developed methods for measuring the spectral the refractive index of aerosols from the UV to SWIR, in situ instrumentation for measuring the angular dependence of the particle scattering matrix for clouds and aerosols, remote sensing imagers for the vertical profile of cloud droplet sizes, and multi-angle imaging polarimeters for airborne and space applications. He is also working with NASA GSFC on the development of remote sensing instrumentation for next generation of Earth Science satellites required by the National Academy of Sciences Decadal Survey on Earth Science Missions.

Amita Mehta, Research Assistant Professor
Ph D, Florida State University

Dr. Mehta's interest and expertise are in satellite remote sensing of geophysical parameters and their analysis to understand climate and its variability. Dr. Mehta has extensive experience in a variety of topics including retrievals of clouds, rain, and radiative fluxes from satellite measurements, use of cloud resolving models, use of a hierarchy of radiative transfer 102 models, statistical analyses of in situ and remote sensing observations, and climate model outputs to understand climate variability. Dr. Mehta is a member of NASA Atmospheric Remote Sensing Training group and conducts online and in-person trainings of NASA remote sensing data utilization for water resources and disaster management. Dr. Mehta's research interests include satellite remote sensing of geophysical parameters and their analysis to understand weather and climate variability from storm-scale to global scale. In addition, Dr. Mehta's is interested in analysis of global climate change model data to understand climate impacts on regional and global water cycle.

Howard Motteler, Retired Faculty
Ph D, University of Maryland

Dr. Motteler has worked in radio and television and as an academic support and systems programmer at the University of Puget Sound and Purdue University. He was an associate professor of computer science in the UMBC CSEE department and then a research associate professor at JCET. He retired from that position but later returned to JCET as a research associate scientist. Dr. Motteler's research interests are in the areas of scientific computation and applications, including instrument modeling and calibration, passive infrared and microwave sounding, atmospheric radiative transfer calculations, and parallel and distributed processing.

Bill Olson, Research Associate Professor
Ph D, University of Wisconsin (1987)

Dr. Olson studied physics and astronomy as an undergraduate, and became interested in planetary atmospheres research with encouragement from Prof. Peter Gierasch and Prof. Warren Knapp at Cornell University. He continued these studies as a graduate student at Univ. of Wisconsin under the advisement of Prof. James Weinman, using satellite microwave remote sensing to diagnose precipitation and latent heating in convective storms. This led to collaborations with Dr. William Raymond in an effort to assimilate precipitation/heating in numerical weather prediction forecasts. Since joining NASA in 1994, he has continued these studies using data from the Tropical Rainfall Measuring Mission and Global Precipitation Measurement mission satellites. He leads a team that continues to develop a method for estimating precipitation profiles and latent heating from a combination of radar and passive microwave radiometer observations from the TRMM and GPM satellites. Currently, he is also developing a gridded analysis for the global water and energy cycles based upon a variational assimilation approach. His main professional focus is in radar and passive microwave measurement of precipitation and latent heating, but his research interests go beyond remote sensing. Some of his side interests include cloud physics, diagnosis of latent heating and generation of available potential energy in convective systems, stratocumulus modeling, the earth's energy and water cycles, and data assimilation.

Erricos C. Pavlis, Research Professor
Ph D, Ohio State University (1983)

Dr. Pavlis is a major contributor to the Global Geodetic Observing System, and has over 130 referred publications in the field.

Ana Prados, Research Assistant Professor
Ph D, University of Maryland

Dr. Prados has 12 years experience in the application of satellite remote sensing to air pollution monitoring. She currently manages the NASA Applied Remote Sensing Training Program, where she develops courses worldwide on the application of satellite imagery to environmental decision-making activities related to climate change, water resources, disaster, land, and air quality management. She has 10 years of environmental policy experience working with local governments on the implementation of local and regional climate and air pollution initiatives. She has also coordinated multiple workshops for federal agencies on how to assess the benefit of Earth Science information and improve stakeholder collaboration. Dr. Prados is interested in environmental policy-making in the context of water resources management and climate change, air quality policy, program/project evaluation, and communicating scientific information to the public.

Lorraine Remer, Research Professor
Ph D, University of California, Davis (1991)

Lorraine Remer spent 21 years at the NASA Goddard Space Flight Center involved in the remote sensing of aerosol and the use of remote sensing data for the study of aerosols in climate processes, how aerosol particles affect clouds, aerosol transport and particulate air pollution. Her first position at Goddard in 1991 was in the role of a support scientist, employed by Science Systems and Applications, Inc. (SSAI), where she contributed to the development of the MODIS aerosol algorithms. In 1998 Dr, Remer joined the Federal civil service, and in 2012 she left NASA to become a part of JCET-UMBC. Currently she is working on aerosol remote sensing for the MODIS, VIIRS and PACE missions. She also contributes to measuring aerosols from ground-based and air-borne sensors Dr. Remer has served on a variety of national and international panels. She has co-edited a textbook, Aerosol Remote Sensing, and is currently an editor of the Journal of the Atmospheric Sciences. Dr. Remer was named a 'highly cited' scientist in geosciences by Thomson-Reuters for the time period 2002 - 2012, and recently was elected as Fellow of the American Geophysical Union. Dr. Remer's research interests include remote sensing of aerosol and the use of remote sensing data for the study of aerosols in climate processes, how aerosol particles affect clouds, aerosol transport and particulate air pollution. She is also interested in atmospheric correction for ocean and land remote sensing.

Adriana Rocha Lima, Research Assistant Professor
Ph D, UMBC (2015)

Dr. Rocha Lima is a Research Assistant Professor at the Department of Physics at University of Maryland, Baltimore County (UMBC) since 2019. Her specialization is on laboratory measurements of optical and microphysical properties of different types of aerosol particle including mineral dust and volcanic ash. She has been performing simulations of aerosol distributions using the Goddard Earth Observing System Model (GEOS) since 2015. In particular, she is working on the development of apportionment study of dust target sources to investigate the relative importance of individual dust sources in the Middle East and North Africa for the global aerosol budget. Her goal is to understand the physical processes of aerosol particles and their effects in the Earth’s atmosphere. For that, her research focus on the measurements of aerosol optical properties and their representation in the model, aiming to

provide more reliable information about dust aerosol distributions, total mass loading, and dust processes in the Earth's atmosphere.

Chung-lin Shie, Associate Research Scientist
Ph D, Florida State University (1995)

Dr. Shie has been involved and played crucial roles in several projects of diverse interests. He has studied air-sea interaction, as well as developed a series of successively improved global air-sea surface turbulent fluxes datasets (i.e., from GSSTF2b, GSSTF2c to GSSTF3), derived from improved remote sensing data and updated reanalysis data, by using updated algorithms [NASA funded project of MEaSUREs]. Dr. Shie has also investigated the potential influence of SAL dust on intensity of tropical cyclone and hurricane/typhoon using multi-sensors data and modeled simulations (applying the WRF model) [NASA funded projects of EOS; NAMMA; TCSP]. He has also applied the cloud-resolving model (GCE): studying the radiative-convective system (clouds) and its interaction with large-scale environment; producing numerical vertical heating profiles and improving the satellite latent heating profile retrieval [NASA funded projects of NEWS; TRMM]. Dr. Shie, as the project scientist of GES DISC (the data center at Goddard) since January 2013, has recently extended his interests into the "Data Science" field focusing on better understanding the characteristics of the massive and heterogeneous Earth Science data, as well as aiming to further (how to) improve the science data distributions and user services. Dr. Shie has also actively studied the overall metrics of user's data and services usages at GES DISC, which also include special information obtained from the users' "Tickets", i.e., basically users' emails or online feedback mainly asking for helps or questions on the data or/and services they have requested. Information about the user's specific scientific research subjects and applications associated with the data they have requested and used has also been voluntarily provided inside those users' tickets sometimes. Dr. Shie has named such an approach as "Information Mining", as well as genuinely treasured and believed it should help and lead to a comprehensive understanding of the essential and inseparable relations between "Data & Science."

Christopher Shuman, Research Associate Professor
Ph D, Pennsylvania State University (1992)

Dr. Christopher A. Shuman is a Research Scientist within the Cryospheric Sciences Laboratory at NASA Goddard Space Flight Center (GSFC). He has been employed by the University of Maryland, Baltimore County's JCET since 2011. Before joining JCET, he was with UMBC's Goddard Earth Sciences & Technology Center for four years. In 2014, he became affiliated with UMBC's Geography and Environmental Systems Department as an Research Associate Professor. From 2001-2007, Dr. Shuman was a Physical Scientist with the Cryospheric Sciences Branch (now Laboratory) at GSFC, and the Deputy Project Scientist for the Ice, Cloud, and land Elevation Satellite (ICESat) Mission from 2001 to 2005, as well as an Adjunct Research Faculty at the Earth System Science Interdisciplinary Center (ESSIC) at the University of Maryland, College Park. From 1999-2001, Dr. Shuman was an Assistant Research Scientist at ESSIC. From 1996-1998, he was a Visiting Research Fellow with the Universities Space Research Association at GSFC's Oceans and Ice Branch working with Dr. Robert A. Bindschadler. From 1994-1996, he was a National Research Council, Resident Research Associate at GSFC's Oceans and Ice Branch, Greenbelt, MD working with Dr. Robert A. Bindschadler. From 1992-1994, he was a Research Associate at the Earth System Science Center and Department of Geosciences of The Pennsylvania State University, working with Dr. Richard B. Alley. Dr. Shuman received his Ph.D. in Geosciences in 1992 and his M.S. in Geology in 1987 from The Pennsylvania State University, and his B.S. in Geology in 1982 from Moravian College. Currently, Dr. Shuman is primarily working on large

iceberg calving events from Antarctica in collaboration with other researchers at NASA GSFC and abroad. He is also contributing to outreach events on changes to Antarctic ice shelves and glaciers. Additional research on mountain glacier losses in the tropics is ongoing. Previously, he has authored or co-authored research papers on ice elevation changes and glacier mass losses using altimetry in combination with other remote sensing in the Antarctica Peninsula, on the accuracy of the first ICESat mission's data over Antarctica's large subglacial lakes. He has also worked on composite temperature records derived from automatic weather stations (AWS), passive microwave data from SMMR and SSM/I and IR data from AVHRR satellite sensors. In addition, Dr. Shuman has successfully matched those records through stratigraphic correlation with stable isotope temperature proxy profiles in shallow snow layers. He has worked extensively in Greenland (7 deployments) and Antarctica (6 field deployments plus more recent Operation Ice Bridge flights from Punta Arenas, Chile to Antarctica). He began his cryospheric career helping to date the 3054 m long Greenland Ice Sheet Project 2's (GISP2) deep ice core in 1992. He was the longest serving member of the Polar DAAC Advisory Group (PoDAG) and also served on the Center for Remote Sensing of Ice Sheets (CReSIS) advisory board and is still serving on the Executive Committee of the Cryosphere Sciences Section (was Focus Group) of American Geophysical Union.

Jason St. Clair, Research Assistant Professor
Ph D, Harvard University (2007)

Over the last 15 years, Dr. St. Clair has worked on developing and deploying novel instrumentation for the in situ measurement of trace atmospheric compounds, with science goals ranging from quantification of the convective transport of water into the stratosphere to understanding how biogenic emissions can lead to ozone and aerosol formation. Research interests broadly include the chemical evolution of reactive compounds in the atmosphere. Specific subjects of interest include (1) high and low NO oxidation of biogenic compounds and their role in the formation of ozone and secondary organic aerosol, (2) the chemical evolution of forest fire plumes, and (3) the use of common oxidative products such as formaldehyde to trace the influence of polluted environments on more remote parts of the atmosphere.

Larrabee Strow, Research Professor
PhD, University of Maryland

Dr. Strow's research focuses on remote sensing of the earth in the infrared using high spectral resolution satellite instruments. His research interests include molecular spectroscopy, especially spectral line shapes, and radiative transfer, and atmospheric remote sensing. His primary goal is to measure climate trends using NASA, NOAA, European, and Japanese satellites. To that end, Dr. Strow is a Science Team Member on NASA's AQUA AIRS instrument, the NPOESS CrIS and EUMETSAT's IASI suite of instruments, and the Japanese GOSAT greenhouse gas mission. His group provides NASA and NOAA with the radiative transfer algorithms for the retrieval of geophysical variable using AIRS, IASI, and CrIS. Present research topics include measurements of atmospheric CO2 and dust in order to better understand their effects on climate change. He is a Member of the NASA AIRS and NPP (CrIS Sensor) 106 science teams, and a Co-Investigator on EUMETSAT's IASI sounder on the new METOP platform.

Ivy Tan, Post-doctoral Research Associate
Ph D, Yale University (2016)

Dr. Ivy Tan's research encompasses the study of cloud processes and their influence on climate change using a combination of satellite observations and climate models. Her research focuses on the study of

microphysical processes in mixed-phase clouds, with an emphasis on how they impact extratropical cloud feedbacks.

Andrew Tangborn, Research Associate Professor
Ph D, Massachusetts Institute of Technology (1988)

Tangborn joined JCET in 1998, when he also became a member of the technical staff at the Data Assimilation Office at Goddard Space Flight Center. Since 2012 he has been a member of the Planetary Geodynamics Laboratory, where he works on geomagnetic data assimilation. He is also affiliated with the Mathematics Department at UMBC. Dr. Tangborn's research interests include geomagnetic data assimilation, stochastic modeling of climate variability, and radiative transfer modeling.

Ali Tokay, Research Associate Professor
Ph D, University of Illinois at Urbana-Champaign (1993)

Dr. Tokay is an atmospheric scientist and meteorological engineering by training and conducted numerous filed campaigns under the umbrella of NASA's precipitation measurement mission. Dr. Tokay published 40+ peer-reviewed journals and served as an anonymous reviewer for more than 20 different journals and NASA, NSF, and DOE proposals. Dr. Tokay was the co-chair of the 34th AMS radar meteorology conference and co-chair of 2016 European conference on radar meteorology and hydrology. He is the chair of the AMS radar meteorology committee and is also associate editor of the Journal of Applied Meteorology and Climatology and Journal of Atmospheric and Oceanic Technology. Dr. Tokay focuses on precipitation measurements including microphysics, spatial variability, and measurement accuracy. Dr. Tokay was a principal investigator during a series of field campaigns under NASA Tropical Rainfall Measuring Mission. He is a member of NASA Precipitation Science Team.

Robert Tyler, Associate Research Scientist
Ph D, McGill University (1995)

Dr. Tyler's research is primarily in two areas: the elecctrodynamics of Earth's ocean; and the tidal response of planetary fluids. Understanding the electric and magnetic fields of ocean flow is important because the measurements of these fields (locally or remotely from spacecraft) can be used to infer information about the electrical conductivity (and heat content) and flow of the oceans. Understanding the tidal response of fluids is important because tidal heat may maintain liquid water oceans, and also explain observed features of other planetary fluids including atmospheres, magma, and fluid cores.

Kevin Turpie, Research Associate Professor
Ph D, University of Maryland (2012)

Dr. Turpie has over two decades of experience with ocean color remote sensing, where he has been heavily involved in remote sensing models, instrument calibration and mission design, data quality assessment, and uncertainty analysis. His work also has a focus on coastal and inland aquatic remote sensing, where he specializes in hyperspectral remote sensing and applications in wetlands where he has done field campaigns and developed a marsh canopy reflectance model. His work has involved several NASA space borne instruments. In support of his academic work and coastal research, he has also worked with data from Landsat, Hyperspectral Imager for the Coastal Ocean (HICO), the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and the European Space Agency's Compact High Resolution Imaging Spectrometer about the Project for On-Board Autonomy (CHRIS/Proba). He was the Ocean Color Science Principle Investigator and Ocean Discipline Lead on the VIIRS NASA

Science Team, which is part of the Suomi National Polar-orbiting Partnership (Suomi-NPP) mission and led the VIIRS Ocean Science Team, part of the NASA Ocean Ecology Branch. He continues to advise the Joint Polar-orbiting Satellite System (JPSS) project regarding future VIIRS instruments. He is also an appointed member of the Hyperspectral Infrared Imager (HyspIRI) Science Study Group (SSG), where he is applying his combined experience of terrestrial and aquatic problems to help define the future HyspIRI mission. He has expanded this role by becoming the founding chair of the international HyspIRI Aquatic Data Products Working Group (H-ASG). Dr. Turpie has also work with astronomy missions. In 1993, he also worked with Nobel laureate Dr. John Mather on the NASA Cosmic Background Explorer (COBE), where he mapped the distribution of foreground emission lines that marked the location of water and carbon across our galaxy using the interferometric data from the Far Infrared Absolute Spectrophotometer (FIRAS). Dr. Turpie is interested in the use of remote sensing to extract information from the spectral and radiometric properties of aquatic habitats to learn more about conditions in those environments and their corresponding ecosystems. He is interested in studying sensor calibration and behavior, and how these influence remote sensing applications in marine and aquatic remotes sensors. He developed methods for data quality assessment and visualization and has done research in ocean color uncertainty analysis. He is also interested in development of remote sensing models that model the transmission and reflection of light at the air-water interface and how this changes with deep or the presence of emergent vegetation. Dr. Turpie is exploring ways to retrieve information about the conditions in shallow water environment, including coastal marsh ecosystems, through remote sensing. In particular, he is interested in developing methods to assess and record changes in the canopy architectural of coastal marshlands that are caused by climate change and human activities. His research looks to accomplish this through satellite data applications, ground data, and radiative transfer modeling. It is his hope that the result will contribute a methodology to understand, monitor and manage these precious ecological resources.

Tamas Varnai, Research Associate Professor
Ph D, McGill University (1996)

Dr. Varnai's research aims at improving our ability to measure the properties of clouds and atmospheric aerosols from space, and to use satellite data for better understanding the impact of clouds and aerosols on the solar heating of our planet. He is particularly interested in the way the three-dimensional nature of atmospheric radiative processes affects satellite observations, and in understanding the way atmospheric particle populations change in the vicinity of clouds. His work involves analyzing data from satellite instruments such as MODIS or CALIOP and airborne instruments such as THOR or CAR, and combining the data with theoretical simulations of radiative processes.

Yujie Wang, Associate Research Scientist
Ph D, Boston University (2002)

Dr. Wang is experienced on radiative transfer theory and algorithm development. He also has conducted numerous field campaigns in support of satellite and airborne acquisitions. During 1998-2002, Dr. Wang worked on MODIS Leaf Area Index (LAI) and Fraction of Absorbed Photosynthetically Active Radiation (FPAR) algorithm development and validation. After that, he has been working on a new generation atmospheric correction algorithm --- Multi-Angle Implementation of Atmospheric Correction (MAIAC). Dr. Wang's research interests include radiative transfer theory on vegetation and atmosphere, satellite generated products analysis and validation, and new algorithm development.

Glenn Wolfe, Research Associate Professor
Ph D, University of Washington (2010)

Dr. Wolfe has been at NASA/GSFC and UMBC/JCET since October 2012, where he studies the chemistry of the lower atmosphere using a combination of airborne field observations and detailed numerical modeling. Prior to arriving at NASA, Dr. Wolfe was a NOAA Climate and Global Change Post-doctoral fellow at the University of Wisconsin, Madison, WI. Dr. Wolfe's research interests include atmospheric chemistry, forest-atmosphere interactions and instrument development.

Xiaoguang Xu, Assistant Research Scientist
Ph D, University of Nebraska-Lincoln (2015)

Dr. Xu is an atmospheric scientist studying the aerosol processes that control Earth climate and air quality with global models and remote sensing observations.

Tianle Yuan, Associate Research Scientist
Ph D, University of Maryland, College Park (2008)

Dr. Yuan is an experienced scientist, geophysicist by training. He has conducted several ground breaking analysis on interactions between aerosols and clouds. His interests and experience include Remote Sensing , cloud physics, aerosol and cloud feedbacks, aerosol-cloud-climate interactions. Dr. Yuan has given undergraduate and graduate lectures in remote sensing and statistics. He has mentored students. Dr. Yuan's research interest includes the role of aerosols and clouds in the climate system and their feedback to climate change. He uses the vast amount of satellite data together with other sources of observations to tackle a range of issues. He also employs models with a hierarchy of complexity to model observational results. Dr. Yuan also has an interest in developing novel theories to understand cloud statistics.

Pengwang Zhai, Associate Professor
Ph D, Texas A&M University (2006)

Dr. Zhai's research interests are in light scattering by irregular particles, vector radiative transfer in coupled atmosphere and ocean systems, and remote sensing of aerosols and hydrosols. He is enthusiastic about understanding inherent optical properties of hydraulic algae particles and developing algorithms to monitor and retrieve these particles in our natural environments. In order to extract information from optical signals, the multiple scattering in the turbid media has to be taken care of. One of his main research focuses is to explore accurate and efficient ways to solve the polarized radiative transfer equation. With the help of light scattering and radiative transfer theories, Dr. Zhai strives to develop new and better remote sensing algorithms for aerosols and ocean color using satellite or airborne measurements from multi-directional, multi-wavelength, multi-polarized sensors.

Zhibo Zhang, Associate Professor, JCET Associate Director for Academics
Ph D, Texas A&M University (2008)

Zhibo Zhang received his B.S. from the Nanjing University, China in 2001. He received MS and PhD degree in Atmospheric Sciences in 2004 and 2008, respectively, from the Texas A&M University. Dr. Zhang joined the Goddard Earth Sciences & Technology Center of UMBC in 2009 working onsite in NASA Goddard Space Flight Center. In 2011, Dr. Zhang joined the Physics Department as a tenure-track faculty. He served as the Graduate Program Director of the Atmospheric Physics Program for 5 years from 2014 to 2019 and became Associate Director for Academic of UMBC in 2019. At UMBC, Dr.

Zhang leads the Aerosol, Cloud, Radiation-Observation and Simulation (ACROS) group. His research focuses on observing, understanding and describing the interactions between aerosol, cloud and radiation, and studying the implications of their interactions for global warming, climate change, air quality and weather. Our research is supported by grants and funding from NASA, the Department Of Energy (DOE), NSF, and Joint Center for Earth Systems Technology (JCET) of UMBC.

F. Acronyms

Acronym	Description
ABI	Advanced Baseline Imager
ABoVE	Arctic boreal Vulnerability Experiment
ACA	Above-Cloud Dust Aerosols
ACCLIP	Asian Summer Monsoon Chemical And Climate Impact Project
ACCP	Aerosol, Cloud, Convection And Precipitation
ACD	Aerosol Collection Device
ACE-ENA	The Aerosol And Cloud Experiments In The Eastern North Atlantic
ACS	American Chemical Society
ADAPT	Advanced Data Analytics Platform
ADDA	Amsterdam Discrete Dipole Approximation
AE	Angstrom Exponent
AEROMMA	Atmospheric Emissions And Reactions Observed From Megacities To Marine Areas
AERONET	Aerosol Robotic Network
AEROSE	Aerosols And Ocean Science Expeditions
AGU	American Geophysical Union
AHI	Advanced Himarari Imager
AIRS	Atmospheric Infrared Sounder,
ALPACA	Alaskan Pollution And Chemical Analysis
AMS	American Meteorological Society

AMT	Atmospheric Measurement Techniques
AOD	Aerosol Optical Depth
AOT	Aerosol Optical Thickness
ARM	Atmospheric Radiation Measurement
ARSET	Applied Remote Sensing Training
ASG	Aquatic Studies Group
ASI	Italian Space Agency
ASL	Atmospheric Spectroscopy Laboratory
ASOS	Automated Surface Observing Stations
ATMS	Aerosol Optical Thickness
Atom	Atmospheric Tomography
AVHRR	Advanced Very High-Resolution Radiometer
AVIRIS NG	Airborne Visible Infrared Imaging Spectrometer Next Generation
AWRA	American Water Resources Association
BAMS	Bulletin Of The American Meteorological Society
BARC	Beltsville Agricultural Research Center
BIRA	European Collaborators In Belgium
BRDF	Bidirectional Reflectance Distribution Function
BRF	Bi-Directional Reflectance
BSM	Baker-Schepanski Map
CAFE	Compact Airborne Formaldehyde Experiment
CALIOP	Cloud-Aerosol Lidar With Orthogonal Polarization
CALM	Circumpolar Active Layer Monitoring
CAM-CMAQ	Cloud Allowing Model - Community Multiscale Air Quality

CAMPEX	Cloud-Aerosol-Monsoon Philippines Experiment
CANOE	Compact Airborne Nitrogen Dioxide Experiment
CAR	Cloud Absorption Radiometer
CARAFE	Carbon Airborne Flux Experiment
CARE	Center For Atmospheric Research And Education (Hampton University)
CASALS	Concurrent Artificially Intelligent Spectrometry And Adaptive Lidar System
CBZ	Convergent Boundary Zones
CCCM	CERES-CALIPSO-Cloudsat-MODIS
CCN	Cloud Condensation Nuclei
CCST	California Council On Science And Technology
CER	Cloud Effective Radius
CESSRST	Center For Earth System Sciences And Remote Sensing Technologies
CH4	Methane
CHIRP	Climate Hyperspectral Infrared Product
ChlF	Canopy Chlorophyll Fluorescence
CLAIPSO	Cloud-Aerosol Lidar And Infrared Pathfinder Satellite Observation
CM	Cloud Mask
CMG	Climate Modeling Grid
CMIP6	Coupled Model Intercomparison Project-Phase 6
CO2	Carbon Dioxide
COAWST	Coupled Ocean Atmosphere Wave Sediment Transport Modeling System
COBRA	Combined Radar-Radiometer Algorithm
CORRA	Combined Radar-Radiometer Precipitation Algorithm
COT	Cloud Optical Thickness

CREST	Center Of Remote Sensing Science And Technology
CRG	Cloud Retrieval Group
CRI	Complex Refractive Index
CrIS	Cross-Track Infrared Sounder
CSA	Clear-Sky Dust Aerosols
CTH	Cloud-Top Height
CWP	Cloud Water Path
CYGNSS	Cyclone Global Navigation Satellite System
DCOTSS	Dynamics And Chemistry Of The Summer Stratosphere
DDA	Discrete Dipole Approximation
DEMs	Digital Elevation Models
DIAL	Differential Absorption Lidar
DISC	Data And Information Services Center
DISORT	Discrete Ordinate Radiative Transfer
DOE	Department Of Energy
DORIS	Doppler Orbitography And Radio positioning Integrated By Satellite
DPR	Dual-Frequency Precipitation Radar
DRE	Direct Radiative Effects
DSCOVR:EPIC	Deep Space Climate Observatory: Earth Polychromatic Imaging Camera
DSD	Raindrop Size Distribution
DSS	Decision Support System
DT	Dark Target
DYNAMO	Dynamics Of The Madden-Julian Oscillation
ECMWF	European Center For Medium Range Weather Forecasting

EF	Evaluation Framework
EMP	Enhanced Monitoring Plan
EOS	Earth Observing System
EOSDIS	Earth Observing System Data And Information System
EPA	Environmental Protection Agency (United States)
EPIC	Earth Polychromatic Imaging Camera
EPO	Education And Public Outreach
ER-2	Earth Resources 2
ESA	European Space Agency
ESDIS	Earth Science Data And Information System
ESIP	Earth Science Information Partners
ESM	Earth System Models
ESO	ESDIS Standard Office
ESRL/CSD	Earth System Research Laboratories Chemical Sciences Division
ESRL/GSD	Earth System Research Laboratories Global Systems Division
ESSIC	Earth System Science Interdisciplinary Center
EVHR	Enhanced Very-High Resolution
EVI-1	Earth Venture-Instrument
EVS-3	Earth Venture Suborbital 3
F0AM	Framework For 0-D Atmospheric Modeling
FASDOM	Radiative Transfer Model
FC	Forest Cover
FENGSHA	Dust Emission Scheme
FIREX	Fire Influence On Regional To Global Environments Experiment

FIREX-AQ	Fire Influence On Regional To Global Environments Experiment-Air Quality
FLoX	Fluorescence Box
FMF	Fine Mode Fraction
FORTRAN	Formula Translation Programming Language
FP2	Functional Parallel Programming
FTE	Full Time Equivalent
GAW	Global Atmospheric Watch
GCMs	Gas Chromatography–Mass Spectrometry
GEFS	Global Ensemble Forecast System
GEMS	Global And Regional Earth-System Monitoring Using Satellite And In-Situ Data
GEO-CAPE	Geostationary Coastal And Air Pollution Events
GEOCON	Geotechnical Engineering, Environmental Consulting
GEOS-5	Goddard Earth Observing System Model, Version 5
GEP	Gross Ecosystem Production
GES	Goddard Earth Sciences
GES DISC	Goddard Earth Sciences Data And Information Service Center
GGOS/IERS	Global Geodetic Observing System International Earth Rotation And Reference Systems Service
GIS	Geographic Information System
GLOBE	Global Learning And Observations To Benefit The Environment
GMAO	Global Modeling And Assimilation Office
GMI	Global Modeling Initiative
GNSS	Global Navigation Satellite System
GOES ABI	Geostationary operational Environmental Satellites-R Series Advanced Baseline Imager
GOFC GOLD	Global Observation For Forest And Land Cover Dynamics

GOTHAAM	Airborne Science Proposals
GPM	Global Precipitation Measurement Mission
GPP	Gross Primary Production
GPS	Global Positioning Service
GRACE	Gravity Recovery And Climate Experiment
GSFC	Goddard Space Flight Center
GV	Ground Validation
H5	Hierarchical Data Format 5
HARP	Hyper Angular Rainbow Polarimeter
HARP2	Hyper-Angular Rainbow Polarimeter #2
HBL	Hurricane Boundary Layer
HCHO	Formaldehyde
HIGRAD	High-Resolution Model For Strong Gradient Applications
HiMAT	High Mountain Asia Team
HIPP	Hyper-Angular Image Processing Pipeline
HITRAN	High-Resolution Transmission Molecular Absorption Database
HIWRAP	High-Altitude Imaging Wind And Rain Airborne Profiler
HSRL	High Spectral Resolution Lidar
HyspIRI	Hyperspectral Infrared Imager
IASI	Nadir-Viewing Instrument Recording Infrared Emission
IC	Information Content
ICE-POP	International Collaborative Experiment For PyeongChang 2018 Olympic And Paralympic
ICESat2	Ice, Cloud, And Land Elevation Satellite

IERS	International Earth Rotation And Reference Systems
IFloodS	Iowa Flood Studies
IGRF	International Geomagnetic Reference Field
IIR	Imaging Infrared Radiometer
ILRS	International Laser Ranging Service
IMB	Ice Mass Balance
IMERG	Integrated Multi-Satellite Retrievals For GPM
IMPACT	Field Campaign
IMPACTS	Investigation Of Microphysics And Precipitation For Atlantic Coast-Threatening Snowstorms
INCAS	European Collaborators In Romania
IOP	Intensive Observation Period
IPHEX	Integrated Precipitation And Hydrology Experiment
IR	Infrared
IROE	Infrared Based Optimal Estimation
ISAF	In Situ Airborne Formaldehyde
ISRO	Indian Space Research Organization
ITEX AON	International Tundra Experiment Arctic Observing Network
ITRF	Terrestrial Reference Frame
ITRS	International Earth Rotation And Reference Systems Service
IWP	Ice Water Path
IWRAP	Imaging Wind And Rain Airborne Profiler
JAMC	Journal Of Applied Meteorology And Climatology
JCET	Joint Center For Earth Systems Technology
JGR	Journal Of Geophysical Research

JJA	June, July, August
JPL	Jet Propulsion Lab
JPSS	Joint Polar Satellite System
JQSRT	Journal Of Quantitative Spectroscopy & Radiative Transfer
JTECH	Journal Of Atmospheric And Oceanic Technology
L1B	Level 1 Data Set
LACE	Lunar Atmosphere Composition Experiment
LANL	Los Alamos National Laboratory
LARC	Langley Research Center
LARES	Laser Relativity Satellite
LASP	Laboratory For Atmospheric And Space Physics
LCC	Land Cover Change
LCLU	Land-Cover And Land-Use Change
LES	Large Eddy Simulation
LiDAR	Light Detection And Ranging
LMA	Leaf Mass Per Area
LMOL	Langley Mobile Ozone Lidar
LW dust	Open Modular Dust Collector
LWP	Liquid Water Path
MAIAC	Multi-Angle Implementation Of Atmospheric Correction
MAP	Multi-Angle Polarimeter
MBL	Marine Boundary Layer
MDE	Maryland Department Of Environment
MEDRIN	Mediterranean Research Information Network
MERRA-2	Modern-Era Retrospective Analysis For Research And Application, Version 2

MERRAero	Modern Era Retrospective Analysis For Research And Applications Aerosol Reanalysis
MJO	Madden-Julian Oscillation
ML	Machine Learning
MLH	Mixing-Layer Height
MODAPS	Modis Adaptive Processing System
MODIS	Moderate Resolution Imaging Spectroradiometer
MOSAiC	Multidisciplinary Drifting Observatory For The Study Of Arctic Climate
MoSST_DAS	Geomagnetic Data Assimilation System,
MPL	Micro Pulse Lidar
MPLNET	Micro Pulse Lidar Network
MRR	Micro Rain Radar
MW	Microwave
NAAMES	North Atlantic Aerosols And Marine Ecosystems Study
NAQFC	National Air Quality Forecast Capability
NASA	National Aeronautics Space Administration
NBL	Night-Time Boundary Layer
NCAR	National Center For Atmospheric Research
NCAS-M	NOAA Cooperative Science Center In Atmospheric Sciences And Meteorology
NCCS	NASA Center For Climate Simulation
NCEP	National Center For Environmental Prediction
NDVI	Normalized Difference Vegetation Index
NEON	National Ecological Observatory Network
NGAC	National Global Aerosol Capability
NGGPS	Next Generation Global Prediction System
NIP	New Investigator Program

NIR	Near Infrared Band
NO2	Nitrogen Dioxide
NOAA	National Oceanic And Atmospheric Administration
NPOL	Nasa S-Band Polarimetric Radar
NPP	National Polar-Orbiting Partnership
NSF	National Science Foundation
NUMA	Non-Uniform Memory Access
NWS	National Weather Service
O3	Ozone
OA	Organic Aerosol
OBPG	Ocean Biology Processing Group
OCI	Ocean Color Instrument
OE	Optimal Estimation
OELaF	Optimal Estimation Lagrangian Framework
OLYMPEX	Olympic Mountain Experiment
OMI	Ozone Monitoring Instrument
OMPS	Ozone Mapping And Profiler Suite
ORACLES	Observations Of Aerosols Above Clouds And Their Interactions
OSSE	Observation System Simulation Experiments
OSVW	Ocean Surface Vector Winds
OWLETS	Ozone, Wind, Temperature And Aerosols
PACE	Plankton, Aerosol, Cloud, And Ocean Ecosystem
PAMS	Photochemical Monitoring Assessment Stations
PARSIVEL2	Particle Size Distribution - Second Generation
PBL	Planetary Boundary Layer

PECAN	Plains Elevated Convection At Night
PFT	Plant Functional Types
PGN	Pandonia Global Network
PI	Principal Investigator
PIP	Precipitation Intercomparison Projects
PMM	Precipitation Measurement Missions
PNAS	Proceedings Of The National Academy Of Sciences
PNG	Portable Network Graphics
PSD	Particle Size Distribution
QA/QC	Quality Assurance/Quality Control
RCM	Reginal Climate Model
ROSES	Research Opportunities In Space And Earth Sciences
ROZE	Rapid Ozone Experiment
RSA	RSA SecurID
RSP	Research Scanning Polarimeter
RTA	Radiative Transfer Algorithm
RTM	Radiative Transfer Model
SABOR	Ship-Aircraft Bio-Optical Research Field Campaign
SAFE	Structure And Function Of Ecosystems
SAL	Saharan Air Layer
SAR	Synthetic Aperture Radar
SAT	Science And Applications Team
SBG	Surface Biology And Geology
SCE	Stochastic Collection Equation
SCERIN	South Central And Eastern European Network

SDG	Sustainable Development Goal
SDS	Science Data Segment
SDSM	Solar Diffuser Stability Monitor
SERC	Smithsonian Environmental Research Center
SEVIRI	Spinning Enhanced Visible Infra-Red Imager.
SFMIS	Sustainable Forest Management And Information System
SHEDS	Shuttle Elevation Derivatives At Multiple Scales
SIF	Solar-Induced Fluorescence
SIPS	Science Investigator Processing System
SISTER	Space-Based Imaging Spectroscopy And Thermal Pathfinder
SLR	Satellite Laser Ranging
SMD	Science Mission Directorate
SME	Subject Matter Experts
SNPP	Suomi National Polar-Orbiting Partnership
SO2	Sulfur Dioxide
SORCE	Solar Radiation And Climate Experiment
SPEX	Spectrometer For Planetary Exploration
SPH	Smoothed Particle Hydrodynamics
SSAI	Science Systems And Applications, Incorporated
SSEC	Space Science And Engineering Center
SSG	Science Study Group
STEM	Science, Technology, Engineering And Math
SWAN	Simulating Waves Nearshore
TASNPP	The Science Of Terra, Aqua, And Suomi NPP

TAT	Trans-Atlantic Training
TCTE	Tim Calibration Transfer Experiment
TDR	Doppler Radar
TEMPO	Tropospheric Emissions, Monitoring Of Pollution (TEMPO)
TIR	Thermal Infrared
TOA	Top Of Atmosphere
TOLNet	Tropospheric Ozone Lidar Network
TOMS	Total Ozone Mapping Spectrometer
TPOC	Technical Point Of Contact
TRMM	Tropical Rainfall Measuring Mission
TROFP	Tidal Response Of Planetary Fluids
TROPOMI	Tropospheric Monitoring Instrument
TROPOZ	Tropospheric Ozone Campaign
TSIS-1	Total And Spectral Solar Irradiance Sensor-1
TVAC	Thermal Vacuum Chamber
UFS	Unified Forecast System
UMBC	University Of Maryland, Baltimore County
UMD: CICS	University Of Maryland: Cooperative Institute For Climate & Satellites
UMD-CP	University Of Maryland, College Park
UNESCO	United Nations Educational, Scientific And Cultural Organization
USDA	United States Department Of Agriculture
USRA	Universities Space Research Association
UTC	Coordinated Universal Time
UWG	User Working Group
VCST	VIIRS Calibration Science Team

VIIRS	Visible Infrared Imaging Radiometer Suite
VLBI	Very-Long-Baseline Interferometry
VN	Validation Network
VOCs	Volatile Organic Compounds
VSWIR	Imaging Spectrometer
WB-57	Mid-Wing, Long-Range Aircraft
WFF	Wallops Flight Facility
WGBH	Public Broadcasting Service Member Television Station Boston
WINTER	Emission Mission
WML	Well-Mixed Layer
WRF	Weather Research Forecasting