JCET
The Joint Center for
Earth Systems Technology

Fourth Annual Report
for
Cooperative Agreement NNX15AT34A

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

Submitted August 1, 2019

Message from the Directors

This volume is the fourth in the most recent, five-year renewal period 2015-2020, and it is the twenty-fourth 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.

In this fourth 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. 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 contribute 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 2019, the graduate students explored Data Assimilation, led by JCET faculty member Andy Tangborn and Animikh Biswas from the Department of Mathematics and Statistics.

JCET faculty members serve on University-wide committees, such as the Sustainability Committee, the Faculty Advisory Committee for Interdisciplinary Activities and the Faculty Senate. JCET hosts the monthly Telescope Openhouse 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, 2018 to September 30, 2019. 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. JCET looks forward to its continued collaboration in the coming year.

Belay Demoz, Director
Susan Hoban, Associate Director for Academics
Margo Young, Associate Director

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Tasks & Grants

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
St. Clair continued analysis of convective influence on HCHO in the remote mid and upper troposphere, using data collected from the Atmospheric Tomography (ATom) EVS-2 aircraft campaign. The work was presented at the 2018 Fall AGU meeting and the 2019 American Meteorological Society meeting. The instrument paper for CAFE (Compact Airborne Formaldehyde Experiment) formaldehyde instrument was submitted to Atmospheric Measurement Techniques and is currently available as a discussion paper here. The paper will be accepted before the end of the fiscal year. The FIREX-AQ aircraft campaign will study biomass burning emissions in the United States during the summer of 2019. St. Clair traveled to Palmdale, CA in June to install three NASA Goddard in situ instruments onto the NASA DC-8 aircraft and will return to Palmdale in July with Reem Hannun (JCET) for test flights as well as NASA SARP (Student Airborne Research Program) flights. The Goddard instruments will measure HCHO, O3, and NO2. St. Clair submitted a proposal as PI to the NASA Rapid Response ROSES call, requesting funding to deploy the CAFE HCHO instrument to Romania in September 2019 for aircraft-based validation of the Trop-OMI HCHO data product, and is awaiting a response. In July 2019, St. Clair, Jin Liao (USRA), and a high school intern will deploy a commercial HCHO monitor to the Howard University Beltsville monitoring site where it will be installed alongside Maryland Department of Environment air quality monitors. 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.

Plans for Next Year
An instrument paper for the CANOE (Compact Airborne Nitrogen diOxide Experiment) NO2 instrument, using data from the ATom and FIREX-AQ campaigns for instrument intercomparison, will be submitted. A draft of the ATom HCHO convective influence paper will also be completed. St. Clair is a co-I on the successful EVS-3 proposal, Dynamics and Chemistry of the Summer Stratosphere (DCOTSS). DCOTSS test flights will occur in the spring of 2020 and science flights will start in summer 2020. The Goddard contribution to the DCOTSS ER-2 aircraft payload will be CAFE (HCHO) and CANOE (NO2) and St. Clair will be leading the effort with both instruments. Preparation for the campaign and deployment will consume much of next year.

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. Wolfe recently completed a project to estimate the global distribution of hydroxyl radical (the "detergent" of the atmosphere) from a combination of satellite and airborne observations. This work was published in PNAS and has been presented at the Fall 2018 AGU Meeting and the Spring 2019 ACS Mid-Atlantic Regional Meeting. Wolfe recently received a NOAA grant to continue this work. Wolfe has also continued development of the Framework for 0-D Atmospheric Modeling (F0AM), a community tool for simulation of atmospheric chemistry. Specific achievements include moving the code to a public repository (github), addition of new features, and providing ample community support via the user forum. Wolfe was also responsible for preparing NASA's In Situ Airborne Formaldehyde (ISAF) instrument for an upcoming deployment on the FIREX-AQ field mission.

Plans for Next Year
Wolfe's activities in the coming year will include analysis of observations from the 2019 FIREX-AQ mission, assistance with upcoming 2020 deployments, continued development of F0AM (hopefully include a new version release), and comparison of remote environment HCHO retrievals in support of the aforementioned NOAA award.

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 served as project scientist of Goddard Earth Sciences (GES) Data and Information Services Center (DISC). His two primary duties for this Task (#103) 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 1-hr telecon meetings and the 1.5-day face-to-face meetings. There was one GES DISC UWG telecom meeting held on April 2, 2019. An annual 1.5-day face-to-face UWG Meeting was held on Sep 25-26, 2018. Useful recommendations suggested by the UWG members and the respective actions planned by GES DISC that would eventually help further improving overall or specific user services have been the crucial outcomes from those meetings. The next telecon and face-to-face meeting will be held on Aug 27, 2019 and Sep 23-23, 2019, respectively. Dr. Shie has recently performed an “Ensemble” metrics analysis/study by integrating and inter-comparing results from three unique and crucial metrics of data usages, i.e., 1) the daily/routine operational distributions metrics, i.e., tracking number of distinct users and distributed data files/granules, and size of distributed data volume for individual and overall data products and services, 2) the user publication records, i.e., collecting info of journal papers authored by users who have used Giovanni (a powerful in-house visualization tool) and downloaded data for their scientific studies, and 3) information collected based on the Bugzilla user assistant tickets that GES DISC have constantly received from our users mainly seeking helps or contributing feedback. Dr. Shie has named such an approach as “Information Mining”, as well as genuinely treasured and believed that it should help and lead to a comprehensive understanding of the essential and inseparable relations between “Data & Science”, i.e., “No data, no science; and vice versa”. Dr. Shie (as a convener) has also involved in a new session proposal focusing on the Metrics matters that has recently been accepted for the upcoming AGU 2019 Fall Meeting, Dec. 9-13, 2019, San Francisco, CA. Dr. Shie has also actively participated external Working Groups (WGs), organized either by EOSDIS or ESIP, intending to engage additional 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 five peer-reviewed technical articles being submitted to the NASA ESDIS Standard Office (ESO). They have been published, accepted or still in review (see additional info in References via “Digital Measures”). These five technical reports generally aim to ensure or/and better address the data quality matters by providing proper recommendation/guidelines to data producers and distributors. As a versatile research scientist with broad interests, Dr. Shie, besides performing

research on “Data & Science” such as data quality, user metrics, and “data list” (an extended data service for user’s data discovery), has also “voluntarily” collaborated in scientific studies on 1) the evaporation (weather or climate related) features in the polar regions, 2) the renowned butterfly effects in Lorenz models (this latter collaboration, however, ended around Feb 2019). The resultant productions (i.e., articles or conference presentations) can be found in References via “Digital Measures”. Dr. Shie (as a Co-I via a collaborative affiliation with Code 612) has very recently started working on a newly awarded proposal by the NASA PMM Program. The objective of this 3-yr proposal/project (2019-2021) aims to use GPM products in an optimal estimation Lagrangian framework to quantify moisture transport in Arctic cyclones. More details can be found in Dr. Shie’s “Task 181” Report.

Plans for Next Year
Dr. Shie may continue serving as project scientist at GES DISC (0.75 FTE). He may still help Dr. Wei and Dr. Meyer in the UWG task but will spend most of his time focusing on continuing his “Data & Science” research (i.e., user metrics, user tickets, data list, data quality, etc.), as well as exploring a possible “Machine Learning” approach on “Information Mining”. Dr. Shie will also continue collaborative scientific works involving the lately funded PMM project (0.05 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 Earth’s 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 mission’s EPO and communications efforts.

Accomplishments
Casasanto and team completed follow-on activities to the ICESat-2 launch, September 15, 2018. The “Trees Around the Globe” Campaign https://www.globe.gov/web/trees-around-the-globe/overview, kicked off in September 2018, with hundreds of students and teachers participating world-wide. The campaign includes webinars for participants to interact and learn about taking tree height measurements. To date, 11 webinars have been held. The GLOBE/ICESat-2 Citizen science app https://observer.globe.gov/do-globe-observer/trees was released in March 2019. To date, 7,000 tree height measurements globally have been taken through the app since its release. An ICESat-2 ground tracks app was initiated by the Project Scientist and Casasanto assisted in kicking it off. Several public outreach events took place in Washington, D.C. in 2018 and 2019 including a booth at AGU, NASA Earth Day, Awesome

Con, and the Capitol Hill Maker Faire. We plan to have an ice booth at the NASA Apollo 50th Anniversary events on the Mall (July 18-20), and a 1-year anniversary party for the ICESat-2 launch in September.

Plans for Next Year
Casasanto will implement ICESat-2's presence at several public events including Earth Day and the NOVA Maker Faire. She will present a paper and Co-Chair a hands-on session at the International Astronautical Federation meeting in Washington D.C. in October. Casasanto will assist in implementing the ICESat-2 ground tracks app. Casasanto will form new collaborations with polar researchers to craft new outreach programs to underserved audiences. Casasanto and team will 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

Collaborating with Dr. Lyapustin, Dr. Wang has made good progress on MODIS Collection 6.1 MAIAC algorithm development. We have added 250m resolution data process to create 250m surface reflectance in current MAIAC data product suite. We also plan to solve the discontinuity issues in current MAIAC AOD product by introducing weight function in AOD models. Dr. Wang has developed a new algorithm to generate composite daily MAIAC products (including Surface Reflectance, AOD, Water Vapor, Cloud Fraction and Vegetation index) in 0.05 degree CMG grid. This code will be running in MODIS Collection 6.1 process. Together with Dr. Lyapustin, we also developed new version of MAIAC algorithm for geostationary satellites Himawari 8 AHI sensor and GOES ABI sensor. We have introduced new scheme to characterize SRC more effectively, preliminary results have showed good performance. Dr. Wang also developed a new algorithm to process high resolution WorldView 2 data to support ABoVE (the Arctic Boreal Vulnerability Experiment). This algorithm uses NASA Center for Climate Simulation (NCCS) Advanced Data Analytics Platform (ADAPT) to create Enhanced Very-High Resolution (EVHR) Products for NASA's Earth Science Investigators. Dr. Wang has delivered the algorithm to operational team for further testing. Dr. Wang performed validation of MAIAC injection height product. Dr. Wang compared MAIAC injection height with collocated MISR and Calipso injection height products and found that MAIAC injection height agrees with MISR/Calipso injection height within 500 meters.

Plans for Next Year
In the coming year, Dr. Wang will continue work on MAIAC algorithm improvements. The new version of MAIAC algorithm will be used in MODIS collection 6.1 processing. The improved MAIAC code will be adapted to VIIRS sensor, first version of operational MAIAC VIIRS code will be delivered. Dr. Wang will further improve the MAIAC algorithm for Himawari 8/9 AHI sensor. The algorithm developed for WorldView2 data will also be improved. Dr. Wang will adapt MAIAC algorithm to Landsat 8/Sentinel 2 sensors. MAIAC products at 30m resolution will serve as a bridge between 1km standard MAIAC MODIS products and high resolution MAIAC products such as WorldView2. Dr. Wang will continue to provide user support of MAIAC data for the user community.

Task Number: 109
GSFC Sponsor: Swap, Robert
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
The Pandora team has been heavily involved in deploying and evaluating the Pandora instruments operations in the field while providing any necessary support to scientists and operators from NASA and other national and international institutions. The team has been

involved in multiple field campaigns, training courses and made sure to monitor "in real time" the instruments stability and the data quality.

Plans for Next Year
The Pandora team will continue to support NASA's activities in deploying, monitoring and maintaining Pandora ground base instruments within the PGN network (Pandonia Global network). Provide support for any necessary hardware and software updates including lab and field calibrations

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 for the Suomi National Polar-orbiting Partnership (NPP) NASA Science Team. Dr. Turpie collaborated in the evaluation of solar and lunar calibration trending of changes in the responsivity of the VIIRS instrument. He continued to give input regarding calibration of the VIIRS instruments using the solar diffuser and the Moon. He also provided a methodology to select lunar correction to the solar calibration trending using hypothesis testing. 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 Solar Diffuser Stability Monitor (SDSM) on the calibration time series, identify data that would help understand the scale of 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. Turpie made a new attempt to acquire SDSM spectral response data from VCST, which were received by the ocean team and analysis was begun. Dr. Turpie also has been contributing to the GSFC Chesapeake Bay Working Group, including attendance of monthly meetings, including updates on the Surface Biology and Geology (SBG) mission concept study, and provided presentations at the Chesapeake Bay Working Group remote sensing data end-user workshop in August 2018 and the American Water Resources Association (AWRA) conference in November 2018.

Plans for Next Year
Dr. Turpie will review sensor characterization documents for VIIRS. As an ocean discipline

lead for the new VIIRS/MODIS science team, Dr. Turpie will be organizing activities at the science team meeting in October, 2018. He will also likely present results from the air-LUSI effort at the VIIRS/MODIS science team meeting.

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 "public face" 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 NASA's 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 pages for security reasons. Added images to monitor two new volcanic regions, South Sandwich Islands and Andaman Island. Also added a new set of images and scripts to display SO2 image data from TROPOMI. Updated the web pages for large volcanic eruptions, e.g., Sierra Nevada in the Galapagos and Kilauea in Hawaii.

Plans for Next Year
SO2 trajectory modeling capability will 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

Várnai and team continued researching systematic cloud-related changes in spaceborne aerosol observations. They work on this topic because several studies found systematic changes in clear-sky observations near clouds, and also because a substantial portion of all clear areas lie within a few kilometers from clouds. This year the team expanded their dataset to include additional data such as the MAIAC (Multi-Angle Implementation of Atmospheric Correction) product, which provides information not only on aerosols and cloud cover, but also on humidity. In addition to analyzing the expanded dataset, the team also analyzed the performance of their algorithm for removing the impact of cloud-scattered sunlight from MODIS near-cloud aerosol observations. This task included the analysis of co-located data from MODIS and the CALIOP lidar (whose clear-sky observations are not affected by cloud-scattered sunlight). In the next three months the team will continue the analysis and explore the benefits of various statistical measures for capturing key aspects of cloud influences on aerosol data. The team also published their study on using airborne multiangle measurements for characterizing the properties and radiative impacts of wildfire smoke. The study combined observations by the Cloud Absorption Radiometer (CAR) with radiative simulations, and addressed three main issues: (i) What are the radiative properties (optical depth and absorptivity) of smoke particles; (ii) What is the angular distribution of smoke-reflected sunlight that satellites would observe? (iii) Over what range of scene characteristics can we use CAR data to help the analysis of broadband satellite observations of solar reflection from smoke? The results indicate that (i) the observed smoke plume was quite thick and moderately absorbing; (ii) the smoke greatly changed the angular distribution of solar reflection from the region, and (iii) CAR data can help the interpretation of satellite observations over a wide range of conditions. The team also continued analyzing images of our planet that were 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 horizontal orientation. This year they published the analysis of glints over oceans and examined the differences between sun glints caused by clouds and the ocean surface. They found that cloud glints are ubiquitous, small, and bright. The team also used a statistical analysis of glint observations to test the upcoming new version of DSCOVR data products and identified subtle problems that the DSCOVR team then fixed ahead of the planned public release of the new data products. Finally, the team created and released the sole publicly available online simulator of three-dimensional (3D) radiative processes. The simulator makes it easy to perform simple 3D simulations of sunlight moving through the atmosphere; it can be used, for example, in exploring new ideas, testing 3D radiative effects of inhomogeneous cloud structures, or doing class projects. The simulator is publicly available at i3rcsimulator.umbc.edu.

Plans for Next Year

The team plans to continue research on near-cloud aerosol properties and processes. As part of this effort, they plan to further expand and analyze their dataset of aerosol, cloud, and

atmospheric properties. During this analysis, they plan to estimate the microphysical and radiative impact of various processes contributing to the observed behaviors (for example aerosol swelling in the humid air near clouds), and to expand and further test their method for improving the accuracy of satellite measurements of near-cloud aerosols. The team also plans to combine the analysis of DSCOVR images with simulations, with the goal of characterizing the ice crystals that cause sun glint in DSCOVR observations. Finally, the team plans to expand the capabilities of the recently released 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
Dr. Turpie worked to assured that the proper characterization tables for the JPSS1 VIIRS instrument were being used by the Ocean Biology Processing Group (OBPG), which generates and publicly distributes ocean color data products for NASA. JPSS-1 VIIRS is on board the recently launched JPSS-1 satellite, which was launched this past year. He worked with the OBPG in the on-going calibration of the newer VIIRS instrument and identifying anomalies and their causes.

Plans for Next Year
Turpie will continue working with the OBPG in the on-going calibration of J1 VIIRS onboard the recently launched JPSS-1 satellite. Turpie will continue to assess quality new data from the J1 VIIRS instrument. This will include the quantification of striping and other imagery artifacts and characteristics of the calibration data. 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 mission's 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 Earth's 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 annual operational review and mission requirement review. Lee also contributed to mission communication and outreach program, including development of Sun-Climate website and Awesome-Con event for TSIS-1. While continuing to support weekly staff meetings and monthly telecom for TSIS-1, Lee is also working as a TSIS-2 science team member. For science, Lee awarded Piers J. Sellers Award for Interdisciplinary Science from Director of Sciences and Exploration Directorate/GSFC, Mark Clampin, at the 12th Annual New Year's NASA/GSFC poster party. Her poster "Is There a Time Lag between Total Solar Irradiance and Sunspot Area?" explores two fundamental quantities in Heliophysics and Earth Science: the solar magnetic field emergence and total solar energy input to Earth. To examine the relationship between the two, she showed SDO solar disc images, ground observations of Sunspot area, and three different satellite measured total solar irradiance data from SORCE, TCTE, and newly launched TSIS-1. Lee was also received a group achievement award for TSIS-1, from NASA Administrator for successful launch of TSIS-1 and deployment to ISS.

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 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 is an organizer of the Sun-Climate Symposium 2020 and the chair of session, entitled Solar Influence on the Atmosphere and Climate. The Symposium will be held in January 2020 at Tucsan, AZ. This session will be devoted to the measured or modeled response of the Earth's atmosphere and climate to solar variability over the last few solar cycles.

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
An automated procedure for detecting the presence of drizzle and light precipitation from volume depolarization ratio measurements was developed and is being incorporated into NASA MPLNET operational processing. Once completed, previously published methods to determine the rain rate and rain droplet size can be made standard products within the network. A study using a cloud dataset from the South Pole to verify neutrino detection has been completed and the results are being summarized for publication.

Plans for Next Year
A feature mask product will be developed from MPLNET detections of aerosols, clouds, and precipitation. A procedure to incorporate data from ceilometers and non-MPL systems within MPLNET will be developed as a step toward meeting the requirements for the Global Atmospheric Watch (GAW) Aerosol Lidar Observation Network, GALION.

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. Huisheng Bian, together with Christina Williamson (NOAA) and Mian Chin (NASA), proposed an AeroCom-ATom aircraft experiment. This is an aerosol study joined by AeroCom aerosol modeling community and the aircraft measurement of Atmospheric Topography Mission (ATom), a NASA-funded Earth Venture-suborbital project. As a first step of this study, she led a sea salt study using GEOS GOCART aerosol model, ATom measurements, as well as other satellite and ground station measurements. This is the first-time comprehensive evaluation of the GEOS GOCART sea salt simulation over global oceans by investigating its emission, removals, vertical distribution, size distribution, and optical thickness. She has submitted a manuscript to ACP, which is currently under review. She, as a co-I, has currently been supported by two NASA projects via JCET task 120. To fulfill the tasks proposed by the projects, she gave big efforts to evaluate and improve the GEOS GOCART aerosol simulation. With the improved model, she produced the required aerosol, cloud, and meteorological fields and contribute them to more AeroCom experiments together with Mian Chin: AeroCom control experiment, In-situ measurement comparison experiment, UTLS aerosol experiments, and Volcanic ACI experiment. She also investigated how mid-latitude cyclones impact on trans-Pacific transport of aerosol and CO using GEOS GOCART simulation, satellite measurements, and ATom aircraft data. She 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 traced the model aerosol change along satellite tracks of CALIPSO and CATS.

Plans for Next Year
Huisheng Bian will continue working on various AeroCom multimodel assessments for atmospheric aerosol and cloud fields. Particularly, she will lead an effort by integrating AeroCom model results and ATom measurements for aerosol and cloud study. She will continuously contribute to the study of trans-Pacific pollution by providing model results and involved in scientific analyses.

Task Number: 121
GSFC Sponsor: Oreopoulos, L.
UMBC PI: Yuan, Tianle
UMBC Project Number: 00010756

Summary
This task entails analysis of climate data records and model simulation data to find useful patterns of information. Specifically, we are researching clouds' behavior under changing climatic conditions and seeking to identify cloud feedback patterns. It also involves probing dust activity under changing climate conditions.

Accomplishments
Present our research at major conferences. Published a preprint at arXiv on dust variability and how to explain the variability.

Plans for Next Year
We plan to get the dust variability work published this year

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

Summary
Managed and coordinated NASA's Applied Remote Sensing Training Program. ARSET offers satellite remote sensing training that builds the skills to integrate NASA Earth Science data into agency's 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 2018 and July 2019 Ana Prados provided overall program management for the Applied Remote Sensing Training (ARSET) program across four NASA centers. ARSET is funded by NASA's Applied Sciences Program. She managed a team of 15 scientists, students, and support staff; and supervised the execution of 9 remote sensing webinars and two in-person trainings. In total, these activities engaged 7,000+ participants from 110+ countries and 3000+ organizations. The two in-person trainings were conducted in India in collaboration with the Indian Space Research Organisation (ISRO), and covered topics in air quality and flood applications. In August and September 2019, there are planned webinars on disaster risk assessment and use of Synthetic Aperture radar (SAR). Selwyn Hudson-Odoi conduced outreach and training coordination for the program. David Barbato edited training materials and conducted translations into Spanish.

Plans for Next Year
About 14 online and in-person trainings will be conducted in air quality, disasters, land, and water resources applications of NASA remote sensing. There will be a continuation of trainings on the UN Sustainable Development Goals, and new online webinars on remote sensing for agricultural applications. In response to participant survey data, we will also continue to cover topics in disaster risk assessment. Webinars will incorporate more training modules on access to and data analysis with Google Earth Engine, and advanced topics in SAR. Finally, there will be 2-3 training modules dedicated to MODIS to VIIRS transition.

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 global apportioned dust simulations using the GEOS model to investigate dust contribution from different regions of the globe. The goal for the next months is to calculate the radiative forcing for the different regions and different particle size bins.

Plans for Next Year
For the next year, we plan to have these results shared and intercompared with other models and we expect to collaborate on the confection of a publication with the findings from this study.

Task Number: 129
GSFC Sponsor: Middleton, E.
UMBC PI: Turpie, Kevin
UMBC Project Number: 00010764

Summary
Dr. Kevin Turpie leads research efforts related to the development and evaluation of coastal and in-land water aquatic remote sensing data products and applications for the Hyperspectral and Infrared Imager (HyspIRI). He functions as the founding chair of the HyspIRI Aquatic Studies Group (ASG), directing the dialogue of ASG members and other members of the coastal and in-land aquatic remote sensing community to identify and lay the groundwork for development of aquatic data products for HyspIRI and related missions. This work leverages community collaboration, scientific literature, and analysis and be documented in reports submitted to project management and through peer review publications.

Accomplishments
Dr. Kevin Turpie participated in the final HyspIRI Science Workshop in August, in Washington, D.C. He presented ideas regarding the development of a capability for remote sensing of coastal / inland water ecosystems from space focused on selected, representative sites around the globe. Dr. Turpie engaged in the last HyspIRI Steering Committee meetings and participated in the final teleconferences of the Science Study Group (SSG). He also presented an update on community activities of the Aquatic Study Group (ASG). He hosted a Town Hall on the Future of Coastal and Inland Aquatic Remote Sensing at the bi-annual Ocean Optics meeting, this year in Dubrovnik, Croatia. He provided input into the final report for the HyspIRI mission concept study, which was formally closed 30 September 2018. Dr. Turpie was appointed a member of the Research and Applications Team of the Surface Biology and Geology (SBG) mission concept study and also became the primary co-chair of the SBG Calibration and Validation Working Group. He played a significant role in the Applications Working Group and Algorithms Working Group, including pulling in input from

the aquatic remote sensing community via the ASG. Plans for Next Year Dr. Turpie will continue to function as lead Research Topic editor for the open access journal Frontiers in Marine Sciences. Turpie will publish material from his two white papers on coastal and inland remote sensing in the Frontiers in Marine Sciences Research Topic.

Plans for Next Year
Dr. Turpie will continue attending meetings of the SBG working groups, including working more closely with the Modeling Working Group regarding Observation System Simulation Experiments (OSSE). He will work with the SBG Cal/Val working group to begin expanding on validation for SBG and development of the SBG Cal/Val concept plan. He will continue to lead the ASG to provide input and recommendations from the community and host a Town Hall at the next Ocean Sciences Meeting.

Task Number: 129
GSFC Sponsor: Middleton, E.
UMBC PI: Turpie, Kevin
UMBC Project Number: 00010764

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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
Dr. Huemmrich provides support for NASA Surface Biology and Geology (SBG) mission development activities. He lead the production of a report on the existing and projected program of record that could address SBG directed science questions. He took part in the SBG workshop, presenting both a poster and an invited talk. He is a member of the SBG working group on Applications. Dr. Huemmrich is also supporting the development of the Structure and Function of Ecosystems (SAFE) mission concept. SAFE will make both high spatial multi-angle measurements to derive forest canopy structure and hyperspectral 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. He has also worked on the science traceability matrix for SAFE.

Plans for Next Year
Support SAFE 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 and an in-person trainings for NASA Applied Remote Sensing Training (ARSET) program. Mehta, in collaboration an ARSET colleague from JPL, provided a 2-day in-person training titled 'Satellite Remote Sensing of Flood Monitoring and Management' in India (November 18-19). This training was hosted by the Indian Institute for Remote Sensing, and focused on monitoring intensity, duration, and spatial extent of floods using GPM precipitation, Sentinel 1 - Synthetic Aperture Radar backscatter, Terra and Aqua MODIS optical reflectance, Shuttle Radar Topography Mission terrain, and web-based flood detection tools. Participants learned to analyze floods using the remote sensing data in open sources geospatial Information System before, during and after the events to facilitate decision making for preparedness, response, and relief activities. During her visit to India, Mehta was invited to give a seminar at the Indian Institute of Technology –New Delhi, about the ARSET program and about the availability and applications of NASA remote sensing data for water resources and disasters management (November 22). Mehta also gave a presentation in the World Bank hydrology group in New Delhi about applications of remote sensing observations (November 21). Mehta led a webinar titled 'Using Earth Observations to Monitor Water Budgets for River Basin Management' (March 13, 20, 27, & April 3). This webinar demonstrated how Global Land Data Assimilation data, including precipitation, evapotranspiration, and run off, can be used to estimate surface water balance for better water resources management. The webinar showed how to analyze inter-annual variations in water budget over i) Potomac River Basin that is a major source of drinking water for expanding urban areas of Washington DC, Maryland, and Virginia, and 2) Parana River Basin, a trans-boundary river passing through Brazil, Paraguay, and Argentina. In addition, Mehta co-led an advance webinar on 'Integrating Remote Sensing into a Water Quality Monitoring Program' (June 5,12,19). This webinar included i) step-by-step instruction and demonstration of Landsat-8 image processing using SeaDAS, NASA Ocean Color data processing system, 2) monitoring chlorophyll concentration in in-land lakes, 3) comparing in situ and remote sensing–based water quality parameters in lakes and coastal areas, and 4) information about developing algorithm to estimate water quality parameters from optical remote sensing images. All the training materials are available from (https://arset.gsfc.nasa.gov). These trainings were attended by 1000+ end-users from 100+ countries. Details can be found in ARSET annual report available from https://arset.gsfc.nasa.gov/sites/default/files/users/2018-ARSET-Annual-Report.pdf. Mehta presented a webinar in the Fourth Gregory G. Leptoukh Online Giovanni Workshop,"Enhancing Knowledge with Giovanni" (July 10) about how ARSET uses Giovanni, data analysis and visualization web-tool for water resources and disasters monitoring. Mehta was a coauthor on a peer-reviewed paper titled 'Impact of the ARSET Program on Use of Remote-Sensing Data (Prados et al., 2019, ISPRS Int. J. Geo-Inf. 2019, 8(6), 261; https://doi.org/10.3390/ijgi8060261) based on evaluation of ARSET training impact.

Plans for Next Year

Mehta will continue to develop and conduct trainings for ARSET. Mehta will offer two multi-

hour sessions on ‘Earth Observations for Disaster Risk Assessment & Resilience’ in August/September 2019. Mehta will participate in an in-person training on water resources management using NASA earth science data. This training will be hosted by UNESCO at Centro Internacional de Hidroinformática in Paraguay in December 2019. In addition, webinars covering 1) disaster risk reduction for earthquakes, landslides, and volcanoes, 2) application of remote sensing for agricultural management (e.g. crop monitoring, irrigation planning), 3) Applications of Visible Infrared Imaging Radiometer Suite (VIIRS) for water quality and flood monitoring, among others, will be developed and offered during FY2020.

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 NASA GSFC for performance evaluation of the SNPP and J1-4 CrIS instruments for pre-launch testing, in-orbit instrument activation, and long-term calibration. Monitoring of the J1 CrIS continued after it's activation in Jan. 2018. We have concentrated on understanding radiometric liens for NOAA20, especially differences among the 9 detectors (FOVs) on each of the three focal planes. These differences can be significant for NWP assimilation since NWP centers (NASA GMAO, NCEP, ECMWF, etc.) do not track detector ID when performing dynamic bias correction. We can make these differences available to centers if desired. We have also developed a dynamic correction for some of the NOAA20 longwave detectors (mostly FOV 5 and 6) where the radiances have a slight "bleed in" of the window channel radiances (due to imperfect non-linearity corrections). These corrections are quite simple to implement. The SNPP Cris mid-wave infrared (MWIR) electronics failed in March 2019. This removed all channels from ~1200 to 1750 cm-1 inoperable, which contains all mid- and upper-tropospheric water vapor channels. Unfortunately, NOAA did not attempt to restart SNPP CrIS for 3 months! CrIS SNPP was restarted on June 24 and the MWIR was swtiched to the side-2 electronics. The main difference between side-1 and side-2 "electronics" was a different Neon lamp used for spectral calibration. We re-calibrated the new Neon lamp over several days, and we hope NOAA implements this in the operational system in the next few weeks. The SNPP CrIS thermal environment is also slightly different. A possible consequence of this is our measurement of some spatial shifts in all three bands of SNPP CrIS that result in spectral shifts that vary over the nine FOVs on each focal plane. We have also quantified these shifts and supplied them to NOAA. NASA SNPP reprocessing (continuity products at the NASA DIS) can likely use the appropriate new SNPP calibration soon after June 24 turn-on.

Plans for Next Year
Pre-launch testing of the third CrIS instrument (JPSS-2) was scheduled for the winter of 2019, but now has been delayed to Sept. 2019. We will be doing intensive analysis of the spectral tests of J2 that will be performed during thermal vacuum testing. We are still hoping to persuade the vendor (Harris) and the JPSS Project Office to NOT perform spectral testing with ammonia, since it provides NO value to the program, but instead introduces risk, in that the ammonia is extremely difficult to remove from the gas cell, and it can interfere with more definitive testing done with carbon dioxide. Moreover, the ammonia testing takes up precious testing time that could be better used on other tasks.

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
In the previous reporting period, the Global Precipitation Measurement (GPM) mission combined radar-radiometer precipitation estimation algorithm was adapted to inputs from the Tropical Rainfall Measuring Mission (TRMM) satellite, but it was later found that the resulting TRMM estimates were low-biased relative to GPM. Dr. Olson demonstrated that this bias could not be explained by the lower sensitivity of the TRMM radar, and afterward, the TRMM spatial resolution enhancement method was found to be wanting and corrected, in collaboration with Dr. Mircea Grecu. Revised TRMM algorithm estimates now exhibit a bias that is consistent with the differences in TRMM and GPM radar sensitivities. It is also anticipated that within the next two months, the GPM precipitation algorithm will be adapted to a Ka radar channel scan shift that was implemented in May, 2018. The shifted data will lead to combined dual-wavelength radar / microwave precipitation estimates over the full radar swath.

Plans for Next Year
Regarding algorithm development, a low bias of precipitation estimates over land surfaces, associated with intense convection, will be investigated in collaboration with Dr. Mircea Grecu. In addition, algorithm modifications to address high latitude low biases due to a lack of radar sensitivity in regimes of very light rain and snow will be studied. In these regimes, it may be possible to use only radiometer data to estimate precipitation profiles. These algorithm improvements will be examined by Dr. Olson in collaboration with Dr. Grecu, Dr. Stephen

Munchak, and Dr. Sarah Ringerud.

Task Number: 136
GSFC Sponsor: Swap, Robert
UMBC PI: Herman, Jay
UMBC Project Number: 00010771

Summary
This task is implemented to 1) develop and improve the Pandora spectrometer system to determine ozone and nitrogen dioxide, their altitude profiles, and validate the results comparing with in-situ instrumentation, 2) correct problems with the Pandora optics to enable retrieval of other trace gases such as formaldehyde and bromine oxide, 4) deploy Pandora at permanent sites to develop long-term records, 5) present results at national and international meetings, and 6) publish results in refereed journals.

Accomplishments
I attended the Pandora portion of the TEMPO (June 2019) meeting in Madison Wisconsin concerning optimal deployment of Pandora Spectrometer instruments for TEMPO validation. I presented work showing the usefulness of Pandoras for determining local air quality. I have published 5 papers on the use of Pandora data as first author or co-author,

Plans for Next Year
Not Funded

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 NASA's 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
As part of the GPM Level-1 requiement, empirical relationships between the size distribution parameters and radar observables were developed through disdrometer observations from GPM field campaigns. These relationships are used for direct validation of GPM dual-frequency radar based DSD estimate. The manuscript is its minor revision stage [Tokay et al. 2019a]. The study was extended to comparison of the NASA's S-band polarimetric radar

(NPOL) derived and 2DVD measured DSD parameters. A key finding of this study is the radar observations that were outside the 2DVD measurements. These observations coincided with low ZH high ZDR and high ZH and low ZDR. The manuscript has been submitted and revised [Tokay et al. 2019b]. The investigator analyzed the PARSIVEL2 disdrometer and PLUVIO weighing bucket gauge observations that were participated International Collaborative Experiment for Pyeongchang 2018 Olympic and Paralympic (ICE-POP). A presentation was given during 4th ICE-POP workshop in South Korea in November 2018.

Plans for Next Year
The investigator will analyze the both WFF and Marquette, Michigan (MQT) rain and snow events, particularly on pluvio, PIP, MRR database.

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 L1b/L1c products for NASA Continuity Products at the NASA Atmospheres DIS is the subject of this task. This work is done in collaboration with the University of Wisconsin Space Science Engineering Center (SSEC), Joe Taylor, SSEC P.I. In the past year the CrIS V2.1 software was delivered to the JPL Sounder SIPS and subsequently put into production at the GSFC DIS this past Spring. This new version provided support for the JPSS-1 CrIS instrument, as well as the SNPP CriS. Presently a new version is nearing completion that supports the side-2 electronics change that was required for the SNPP CrIS, mainly new instrument line shape calibration to fix spectral changes. Our philosophy was to minimize differences in the CrIS calibration from the pre-shutdown time of March 2019 for continuity rather than use a slightly better calibration that will produce a jump in the record. These differences are mostly at the <0.01K level. Up to now, the CrIS L1b calibration did not include corrections for polarization (which vary with the scan mirror angle). These are small (~0.1-0.2K) and occur mostly in the shortwave region under cold

scene conditions. However, the corrections are based on solid measurements of the polarization that were done during SNPP roll maneuvers. This correction will be part of a new software delivery to the GSFC DIS in the coming months. A new CrIS product is nearly complete that geo-references the VIIRS visible imagery to the CrIS field-of-view, which will provide researchers with much better information on inhomogeneous scenes, especially percentage of cloud fraction. A new product called CHIRP (Climate Hyperspectral InfraRed Product) has started development under this Task, with the aim of combining the AIRS L1c and CrIS L1b/L1c products into a climate-level radiance product with identical spectral characteristics (spectral resolution, line shape, and center frequencies). This product will also adjust the AIRS radiometry to agree with the SNPP (or with J1) CrIS radiometry to remove offsets in the record caused by instrument differences. These adjustments are in the 0.2K range and have been validated using several techniques. A CrIS radiative transfer algorithm has also been developed under this task. This year we improved the water vapor continuum in the shortwave near the important temperature sounding channels using some new work by Hartman et. al. and we are presently switching the RTA parameterization to the HITRAN 2016 database (from the HITRAN 2012 version).

Plans for Next Year
We will implement the new SNPP side-2 electronics calibration algorithm at the NASA DIS, as well as produce a new V3 algorithm for SNPP and J1 that includes polarization corrections and the new VIIRS co-located image product. Corrections to the CrIS L1b data for Doppler shifts are also planned. We also hope to provide the first version of the CHIRP continuity radiance data set and a new CHIRP RTA that matches the CHIRP spectral parameters.

Task Number: 142
GSFC Sponsor: Mohr, Karen
UMBC PI: Nicholls, Stephen
UMBC Project Number: 00010865

Summary
Task 142 funded research falls into three main research project sub-tasks: Projecting potential future precipitation climate properties (total, coverage, and diurnal cycle) change in the Central Andes resulting from land cover and climate changes with a regional climate model (RCM); Determining the capability of space-based infrared (IR)-based atmospheric sounders to detect and characterize the bulk properties (temperature, moisture content, thickness, etc.) of the well-mixed layers over North Africa; Provide RCM data to support the multi-disciplinary research efforts of NASA's High Mountain Asia Team (HiMAT) to determine potential future water resource variability in High Mountain Asia. Work on sub-task 1 provides a glimpse into how future water resources in the Central Andes may change in response regional and global climate drivers. Results from this effort will provide needed information in a data sparse region where political leaders could use it to help guide future water resource policy decisions. Sub-task 2 attempts to fill a data void over the Sahara Desert and its associated well-mixed layer (WML) called the Saharan Air Layer (SAL). The SAL is significant for its impact on the global radiation budget, air quality, regional agriculture, and Atlantic tropical cyclone development. Space-based IR sounder retrievals provide a consistent and reliable means to measure the size, scope and properties of WMLs where in-situ observations are scarce. Finally, sub-task 3 (similar to sub-task 1) focuses on future, regional

water resources, but for a region that is home to over 2 billion people and has a strong dependence on glacial melt water. The multi-disciplinary approach to HiMAT is key to its success and understanding all the pieces that shape this region's climate. Data generated from Task 142 will drive HiMAT glacier and hydrological models and represents the cutting edge of regional climate simulation efforts.

Accomplishments

Summary For FY2019, Task 142 funding was applied to six subtasks: 1) Generate projections and understand how regional precipitation climate (coverage, amounts, seasonal cycle) in the Central Andes may change in response to projected climate change over the 21st Century using a convective system resolving (9-km), regional climate model (RCM) 2) Develop an algorithm to automate the detection of dry, well-mixed layers (WMLs) in North Africa and characterize its properties using observations, models, and satellite data products, which will be used to generate a WML climatology. 3) Investigate the capabilities of NASA's MERRA-2 reanalysis products to characterize Saharan WMLs and replicate observed aerosol profile properties and attributes. 4) Operate and analyze a 15-year (Oct. 1999 – Sept 2014) convective-storm resolving (4-km grid spacing) regional climate model of High Mountain Asia (HMA) to support the efforts of the multi-disciplinary research efforts of NASA's High Mountain Asia Team (HiMAT) to characterize and predict current and future water resources in HMA. 5) Set-up, preparation, and support for the Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) Earth Venture Suborbital-3 project, which will study banded structures within intense wintertime cyclones. 6) Providing modeling analysis and support for Precipitation Measurement Mission (PMM) proposal tasked with improving precipitation radar retrievals in orographic regions Accomplishments (Oct 1, 2018 - Sept. 30, 2019) Subtask 1 - Central Andes: As of July 2019, Nicholls has completed 19 of 20 convective system resolving (9-km grid spacing) regional climate model (RCM) simulations in the Central Andes. These simulations are comprised of year-long "snap shots" spaced throughout the 21st Century using four different global climate models as input. Results thus far suggest that precipitation in the Central Andes is expected to decrease by 11-18% of 2087 with 15-25 fewer days with precipitation and an increase in precipitation rates (0.5 mm/hr on average). Despite these changes, the spatial coverage and diurnal cycle timing of precipitation are not expected to change. Co-I Karina Yeager shared these results at community events throughout Bolivia in June 2019. For the remainder of FY2019, Nicholls will complete the last remaining model simulation and continue to develop codes to analyze the model output. Subtask 2 – WML algorithm development and analysis: Nicholls successfully developed and updated his open-source software and detection methodology, which is capable of objectively and consistently identifying Saharan-like, dry, well-mixed layers (WMLs) using temperature and moisture information derived from weather balloons (radiosondes), weather models, and NASA satellite data products. Updates were needed in response to reviewer comments during the publication process. This code is also applied as part of his work effort in subtask 3. He was invited to present his results at the Goddard Earth Sciences Data and Information Services Center (GES DISC) lunchtime seminar series in Oct. 2018. He published an algorithm description paper with Co-I Karen I. Mohr in the Journal of Atmospheric and Oceanic Technology in May 2019. For the remainder of FY2019, he will continue his efforts to build data analysis scripts to analyze the accuracy of WML detections and layer properties from both model and satellite data products and work toward publishing these results in a FY2020 publication. Subtask 3 – MERRA-2 WML and property analysis: Using the WML detection algorithm (subtask 2), Nicholls has ingested

MERRA-2 and both identified and characterized dry, WMLs over a 17-year period (2002-2018). Using his algorithm, he helped Co-I Roger Shi develop a WML detection script capable of showing the diurnal variation in Saharan-like WML height, temperature, moisture, and dust loading within WMLs over a seven-year period (2011-2017). Results showed dust loading and depth during the summertime to be roughly twice that during the winter month. Co-I Shi presented these results at the AMS Annual Meeting in January 2019. For the remainder of FY2020, Nicholls will develop the WML analysis algorithm (subtask 2) and then modify it to analyze the accuracy of MERRA-2 based WML detection and layer properties relative to weather balloon observations. Subtask 4 - HiMAT: Nicholls is the lead regional climate modeler in his GSFC-based HiMAT sub-team headed by PI Batuhan Osmanoglu. For FY2019, Nicholls continued to monitor and maintain the operation of the convection-resolving (4-km grid spacing) regional climate model of High Mountain Asia (HMA). As his contribution to the project, Nicholls has been running a 15-year long (1999-2014), coupled RCM since February 2018 over the entirety of High Mountain Asia at an unprecedented model resolution and level of detail that was required by his other team members to analyze individual glaciers and watersheds. As of July 2019, this model simulation has just passed its 12th year (2011). Analysis of RCM output shows that the simulation accurately captures seasonal precipitation and temperature patters as compared to satellite observations. Results from Nicholls' work were shared as part of Co-I Danielle Grogan oral presentation at the Fall 2018 American Geophysical Union Meeting in December 2018 and PI Batuhan Osmanoglu's oral presentation at the March 2019 HiMAT All-hands meeting. For the remainder of FY2019, he will continue his model simulation with a goal of completing it by the end of FY2019. Subtask 5 - IMPACTS: Following its selection in September 2018, Nicholls was invited to join the IMPACTS science team by project PI's in February 2019 and later asked to serve as lead forecaster following the IMPACTS science team meeting in April 2019. Since February, he has contributed at the monthly IMPACTS team telecons and attended in-person science team meeting back in April. More recently, he developed flight-planning software for IMPACTS and coordinated with PI Yorks to develop sample flight plans, which are being for the IMPACTS mission readiness reviews ahead of the first field campaign deployment in January 2020. For the remainder of FY2019, he will continue to provide forecast and flight-planning guidance to PI Yorks as IMPACTS continues through the pre-deployment review process. Subtask 6 – PMM Orography: This subtask officially started in February 2019 following its selection by the Precipitation Measuring Mission (PMM) proposal panel. As part of the proposal submission process, Nicholls ran three selected convection resolving (1-km grid spacing) model simulations in October 2018 from the two PMM field campaign and validation campaigns (IPHEX and OLYMPEX). Using these model data, he compared it PI Gerald Heymsfield's Ku- and Ka-band radar (HIWRAP). He found that model-generated radar cross-sections and probability density functions compared well to radar observations during large-scale, organized weather systems, but not for scattered storm activity. Nicholls presented a poster presentation with these results at the PMM science team meeting in October 2018. After selection, Nicholls has redoubled he efforts to improve and refine his model simulations for the PMM field campaign cases and as of July 2019 he has started to provide these improved model simulations to his project PI's for integration into their work efforts. For the remainder of FY2019, he will work closely with Co-I Steve Lang to start efforts to improve the Goddard microphysics package and analyze data from other microphysics packages.

Plans for Next Year

Plans for next year (Oct 1, 2019 - Sept. 30, 2020) Subtask 1 - Central Andes: For FY2020,

Nicholls will wrap up his investigation of the Central Andes and focus on publishing his research results in peer-reviewed journals. Additionally, he plans to work with his fellow investigators to write a follow-up proposal targeted toward the National Science Foundation. Subtask 2 – WML algorithm development and analysis: For FY2020, Nicholls' will analyze and inter-compare WML detections and associated layer properties across all model and satellite data of interest to identify any potential biases and systematic errors inherent to each dataset. Following the inter-model comparison, he will conduct an in-depth trajectory analysis using the best model or satellite data product to create WML climatology and meet the key objective of determining how often WMLs in North Africa are Saharan, local, or originate from other regions. Nicholls plans to publish this work with Co-I Mohr in peer-reviewed publications during FY2020. Subtask 3 – MERRA-2 WML and property analysis: Nicholls will apply his WML analysis code to MERRA-2 data for the entire 17-year period and conduct a corresponding trajectory analysis on MERRA-2 WML detections using the same methods developed for subtask 2. Unlike subtask 2, Nicholls will also include aerosol data retrievals from the CALIPSO spaced-based lidar to characterize and validate the vertical structure of dust aerosols within WMLs produced by MERRA-2. Results from the MERRA-2 WML analysis will be summarized for publication in a peer-reviewed journal. Subtask 4 - HiMAT: Nicholls will finish his RCM HMA simulation through 2014, shared these data with the HiMAT team, and then conduct his 15-year analysis of RCM model output. This analysis will focus on identifying trends, biases, and overall model performance (particularly precipitation). Once completed he will begin to summarize the results of his work for publication in peer-reviewed journals. Subtask 5 - IMPACTS: For FY2020, Nicholls will be deployed in early 2019 to NASA Wallops Flight Facility for the first of three deployments (2020, 2021, 2022) where he serve as forecast lead and help mission planners coordinate the ER-2 and P-3 aircraft observations to achieve mission goals. Using experienced gained from forecasting for IMPACTS, Nicholls will conduct his own weather model simulations and utilize model and observation data gathered during his deployment to investigate the capabilities of modern numerical weather prediction models to accurate simulate intense snowbands within winter storms. He will also continue to support PI Yorks with additional NASA-level project reviews both prior and following the 2019 deployment. Subtask 6 – PMM Orography: Nicholls will complete his initial set of model simulations and share these with the proposal team. Using these data, Co-I Mircea Grecu and Steve Lang will begin their effort to improve Global Precipitation Mission (GPM) retrievals and the Goddard microphysics packages, respectively. Nicholls will coordinate with PI Gerry Heymsfield to analysis model performance relative to HIWRAP and other field campaign observations. These initial results will be shared with the PMM science team in November 2019. For the remainder of FY2020, Nicholls will continue to tweak his model and test microphysics improvements developed by Co-I Lang.

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 attend weekly project (DSCOVR EPIC and NISTAR) meetings as part of the project team (EPIC instrument scientist). As part of the work for this project I have evaluated the suitability of the recently reprocessed EPIC data. I have also led the team for investigating possible calibration problems with NISTAR. I am responsible for archiving the reprocessed EPIC data on the NASA AVDC computers. I have published 3 journal articles as first author or co-author. I expect to submit a 4th paper before the end of July

Plans for Next Year
I plan to continue the project work for EPIC and NISTAR, help with the ozone retrieval from EPIC, participate in exoplanet simulations using EPIC 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 initial testing of the NASA Goddard Geomagnetic Ensemble Kalman filter system during the past year. This has included a series of assimilation runs encompassing the past 1000 years, with ensemble sizes that range from 50 to 400. We have found that the accuracy of 20 year geomagnetic forecasts is sensitive to the ensemble size and that it begins to converge with around 300-400 ensemble members. We have also investigated the impact of the forecast error covariance through different spectral degrees and through unobserved state variables. Larger ensemble sizes are found to be essential for obtaining a positive impact through these covariances as well. The observations in these experiments come from geomagnetic field models, which generally do not provide uncertainty estimates. So a substantial portion of this work has addressed how to improve our knowledge of the observational uncertainty. We have shown that the accuracy of forecasts during the satellite era (1960-present) provide a good means to determine the accuracy of observations from earlier time periods, since the geodynamo model carries forward observational information. This then has an impact on forecast accuracy in the current era.

Plans for Next Year
We will continue the experiments to determine observational and model errors. We also hope to reduce the ensemble size through the use of localization (both spatial and spectral), so as to improve the efficiency of these simulations. We will also address issues with both model and

observational bias, through the use of a bias correction scheme in the assimilation system. We also plan to participate in the International Geomagnetic Reference Field (IGRF) during the coming year, as we have done during the past 10 years.

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 very nearly complete. Along with country-by-country summaries of ice area changes already exist for all tropical ice areas except for portions of Peru. In addition to Landsat-based hyperwalls for ice remnants in Papua, New Guinea, and two locations in Peru (shown for the first time at Fall AGU 2018) created previously, four additional hyperwalls for tropical glacier locations in northern South America have been created and are being used for 'internal presentations' such as the 2019 Science Jamboree until the underlying paper is prepared for publication. An oral and poster presentation on the project also took place at Fall AGU 2018.

Plans for Next Year
Finishing the major cordillera of Peru may happen before the next reporting year begins but organizing the many ice areas into a coherent publication with all the necessary supporting imagery information will take some additional time. The supporting climate reanalysis data (MERRA-2) will also need to be worked into the final effort. And given their powerful visual impact, it is likely that one or more additional hyperwall stories will be created. This activity is also leading to experimentation with commercial high-resolution imagery from Digital Globe and Planet but to date, these imagery sources have proven difficult to work with and are much more temporally constrained than the ‘Landsat Stories’ that have been assembled, in some cases back to 1972.

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 – including carbon dioxide (CO2), methane (CH4), and formaldehyde (HCHO) – 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
In FY2019, Hannun continued analysis of the CO2 and CH4 flux dataset collected from the Carbon Airborne Flux Experiment (CARAFE) campaign (FY2017). Flux observations using the eddy covariance method have been combined with high-resolution maps of landcover information (e.g. land-use, forested biomass, etc) and a thorough analysis of the flux footprint, or land area underneath the aircraft that contributes to the observed flux. Hannun has completed a manuscript titled 'Spatial heterogeneity in CO2 and CH4 flux: Insights from airborne eddy covariance measurements over the Mid-Atlantic region.' She is also continuing analysis for a manuscript quantifying the dependence of observed CO2 uptake on forest canopy height using CARAFE data combined with remote-sensing maps of forested biomass. In addition, Hannun has completed development of the Rapid Ozone Experiment (ROZE), a high-precision, fast instrument to measure ozone and its fluxes from an airborne platform. Fluxes of ozone will enable quantification of ozone deposition rates, which are not well constrained, and have significant impacts on air quality as well as the biosphere. Currently, the instrument is set to deploy aboard the NASA DC-8 during the upcoming Fire Influence on Regional to Global Environments Experiment - Air Quality (FIREX-AQ) campaign. Flights will take place from July–September of 2019, based out of Boise, ID and Salina, KS. Hannun is currently preparing a manuscript on the instrument design and initial flight results.

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 campaign), as well as initial calculations of O3 deposition velocities from ROZE measurements (FIREX). Hannun plans to develop each of these analyses into a manuscript. Hannun will also begin instrument preparation for the Dynamics and Chemistry of the Summer Stratosphere (DCOTSS) campaign, scheduled to take place in Summer 2020 aboard the NASA ER-2 high altitude aircraft. The campaign 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 2020.

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 two main focus areas have been the development of a common aerosol backscatter retrieval methodology for planetary boundary layer and cloud heights for heterogeneous ground-based remote sensing networks and, an analysis of bay-breeze events and its impact on both boundary layer dynamics and air quality during the DISCOVER-AQ and OWLETS-2 campaigns. The objective of the first topic was to develop a standardized methodology that could be applied to varying aerosol lidar instrumentation and consisted of not only the application of retrieval methodologies but also an assessment of currently available ceilometer instrumentation. The results of these efforts are currently in preparation for publication, and real-time display of data has been established. Next steps include application of the algorithm into operational network testbeds. The second project, a collection of remote sensing instrumentation (doppler wind lidar, micro-pulse lidar, microwave radiometer, radar wind profiler, airborne aerosol lidars, and a tropospheric ozone lidar) was used to study coastal boundary layer dynamical processes in relation to air quality. The results from these works have been published in the Journal of Geophysical Research - Atmospheres, are in preparation for Journal submission and were recently presented at the 2018 AGU conference, 2018 National Ambient Air Monitoring Conference, 2019 AMS conference, and 2019 OWLETS Science Team Meeting.

Plans for Next Year
Continued efforts for the implementation of a common retrieval algorithm for mixing layer heights will be pursued. As real-time data display in the ceilometer network testbed has been achieved, next steps involve the optimization and application of operational procedures for retrievals. Additionally, strong collaborations with the NASA Micro Pulse Lidar (MPL) Network will combine efforts for standardization, quality assurance, and establish operational mechanisms of ground-based aerosol remote sensing networks. Further research with the MPL network data sets will also be explored. These works will be presented in the 2020 American Meteorological Society (AMS) and 2019 American Geophysical Union conference. Additionally, publications on the common retrieval algorithm, ceilometer network testbed, and bay-breeze studies will be finalized for publication.

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 WGBH's 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 presentations at multiple venues, both on and off the GSFC campus, one of the more memorable ones has been creating an updated time series for the Park Rangers at Glacier Bay National Park that shows ice losses park-wide using Landsat mosaics from the first melt season in 1972 to the most recent in 2018. This package also includes six inset maps of areas of distinct cryospheric change within the Glacier Bay area. Further, briefing telecons have been held Interpretative Staff at the Park so that they can convey the details of the 46+ year time series to thousands of park visitors. This content will also be presented at the Arctic Futures 2050 conference in early September. In addition, as these images have revealed several substantial landslides, the largest of these on Lamplugh Glacier in 2016, and this powerful event has been converted into a short hyperwall using both Landsat 8 and Sentinel-2 multispectral images. A secondary activity is updating a Pine Island Glacier (West Antarctica) imagery series for use at outreach events and providing distance-learning content when teachers contact us for climate change speakers.

Plans for Next Year
The full Glacier Bay imagery package is being converted into a hyperwall in the near future assuming that visualization resources are available to do so. Some of the same material will also be presented at the Fall AGU Meeting (abstract not yet submitted) and converted into a short paper with the support of a collaborator who specializes in mountain glaciers. Creation of portable activities for use at outreach events will continue as changes unfold around Antarctica.

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 major paper that discovers new science in hurricanes, "Coherent Turbulence in the Boundary Layer of Hurricane Rita (2005) During an Eyewall Replacement Cycle." Journal of the Atmospheric Sciences, 75: 3071-309; Co-I on a funded 5-year NASA EVS-3 campaign, Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) where my role will be radar remote sensing and dynamics studies; Co-author on an accepted paper, "Hurricane boundary layer height relative to storm motion from GPS dropsonde composites ."; Short article highlighted in BAMS, "Papers of Note: Coherent turbulence in Hurricane Rita (2005) during an eyewall replacement cycle." Bulletin of the American Meteorological Society, 100: 18-20.; Wrapping up paper on HIWRAP measurements in SHOUT that will be submitted to the Journal of the Atmospheric Sciences.

Plans for Next Year

Field deployments to study winter storms and take radar remote sensing measurements. Plan on assisting with mission science and radar instrument roles during the field deployment. Work on fine tuning my wind retrieval code and speeding up the algorithm to run on parallel computer systems. Currently writing several proposals so science plans for next year are unknown at this point.

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 Earth's 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 built a radiative transfer simulator for the Earth Polychromatic Imaging Camera (EPIC) onboard the Deep Space Climate Observatory. The wavelength ranges from 380 nm to 780 nm including the oxygen A and B bands. The radiative transfer simulator has been used to explore the information content of EPIC image for cloud retrieval. The research finding has been published in JQSRT (Gao et al., 2019)

Plans for Next Year
We will research on the possibility of ocean color research using EPIC images.

Task Number: 160
GSFC Sponsor: Yang, Yuekui
UMBC PI: Gao, Meng
UMBC Project Number: 00012579

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 Earth's 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 used the radiative transfer simulator to explore the information content of EPIC image for cloud retrieval. The research finding has been published in JQSRT (Gao et al. 2019).

Plans for Next Year
This task has been ended.

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
We co-organized the 21st Int. Workshop on Laser Ranging in Canberra, Australia during November 4-9, 2018 and the one-day ILRS ASC meeting. We participated in the Fall AGU, Washington, DC, December 9-14, 2018, the 67th IERS Directing Board meeting (Dec. 8) and the GGOS Bureau of Networks and Observations (Dec. 10). On April 6, 2019 we organized and chaired the ILRS ASC meeting during the EGU 2019 week in Vienna, Austria, attended by 25 ILRS associates, where several pilot projects were discussed and reviewed, and more planned for the coming year. We finalized the process to alert stations of systematic errors in their data, which will become operational in September 2019. We participated in the 27th Int. Union of Geodesy and Geophysics—IUGG, General Assembly, 8-18 July, 2019 with two oral and a poster presentation. During this meeting we attended also several splinter meetings of GGOS, IAG and IERS. We continued the guest editorship of the Journal of Geodesy journal for the special issue on laser ranging. We have so far 14 articles accepted and 12 more currently in the review process. We have an international collaboration since 1996 with the Italian groups at the Rome university “La Sapienza” and the University of Salento which has led to the launch of the LARES s/c in 2012. We have now finalized the LARES-2 design proposed as follow-on mission, now approved by the Italian Space Agency (ASI) and under construction in Italy. With a free launch from ESA in March 2020, this effort focused this year on the selection of the material to be used for the LARES-2 spacecraft body to improve even upon the LARES design, despite the higher altitude of the LARES-2 mission (1450 km vs. 6000 km), and on the selection of the retroreflectors to be used. We co-organized the 1st LARES-2, 4th LARES and 2nd GRM Int. Workshop July 1-5, in Rome, Italy and participated

with a lecture on the contribution of these missions to geodesy. We completed a number of initial simulations for the proposed GEOCON mission, focusing on setting limits of errors due to various design parameters like s/c attitude, antenna phase center errors and clock noise errors. We generated numerous simulated data sets that contain these errors at various levels and determined the corresponding level of degradation of the measurements. We are now organizing the ILRS ASC meeting on October 1, 2019 in Paris, France, which will take place on the occasion of another two meetings that we co-organize and will participate in: the Unified Analysis Workshop of GGOS & IERS, 2-4 Oct. and the IERS Journées 2019, 7-9 Oct., 2019.

Plans for Next Year
The near-term plans for our SLR work are the practical implementation of the results from the "Station Systematic Error Model Pilot Project" and the transition to a routine service-like process by this coming September. By the end of summer 2019 we will complete the final reanalysis of all SLR data since 1983 and up to present, using the new "target signature" model (developed by the Herstmonceux, UK group) and newly adopted geophysical models. We expect to complete the Journal of Geodesy Special Issue on Laser Ranging by the end of this year. We will complete the final report on the GEOCON mission simulations.

Task Number: 162
GSFC Sponsor: Merkowitz, Stephen
UMBC PI: Pavlis, Erricos
UMBC Project Number: 00012581

Summary
The purpose of this task is to support the development of the GEOCON mission concept. Develop simulations and analysis techniques for measuring geodetic system ties using a CubeSat constellation. Modify existing network simulations to incorporate GEOCON observables and perform the simulation analysis.

Accomplishments
For the task 162 we have completed the verification of the proper functioning of the GEODYN software, generated orbits for the proposed GEOCON mission and simulated a test data set that contains attitude errors as expected for the actual mission. These were determined not to pose any danger of degradation of the measurements, staying well below the acceptable threshold. We then generated estimates of the level of errors on the GNSS antenna model that the design should incorporate to avoid data degradation due to that effect on the proposed GEOCON observable. These simulations demonstrated that there is no significant effect due to these errors either. The last error source to be checked is the oscillator noise (jitter). A realistic series of errors was generated by the engineering team and these were applied to the simulated data. A full arc simulation was executed including the solution for polynomials to absorb offsets and drifts. These tests demonstrated that in order to keep such errors in check, it will be required that an oscillator with an Allan deviation of at least 10^-13 s @ 300 s be used for the GEOCON mission. The results were presented on July 16 at the IUGG 2019 GGOS session in Montreal, Canada.

Plans for Next Year

This task ended this year and there are no plans for continuation.

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
Over this period, based on the research achievements from the last year we published an excellent paper in the journal of Atmospheric Chemistry and Physics: Song, Q.*, Z. Zhang, H. Yu, S. Kato, P. Yang, P. Colarco, L. A. Remer, and C. L. Ryder (2018), Net radiative effects of dust in the tropical North Atlantic based on integrated satellite observations and in situ measurements, Atmospheric Chemistry and Physics, 18(15), 11303–11322, doi:10.5194/acp-18-11303-2018. In this study, we integrate recent in situ measurements with satellite retrievals of dust physical and radiative properties to quantify dust direct radiative effects on shortwave (SW) and longwave (LW) radiation (denoted as DRESW and DRELW, respectively) in the tropical North Atlantic during the summer months from 2007 to 2010. Through linear regression of the CERES-measured top-of-atmosphere (TOA) flux versus satellite aerosol optical depth (AOD) retrievals, we estimate the instantaneous DRESW efficiency at the TOA to be −49.7±7.1 W m−2 AOD−1 and −36.5±4.8 W m−2 AOD−1 based on AOD from MODIS and CALIOP, respectively. We then perform various sensitivity studies based on recent measurements of dust particle size distribution (PSD), refractive index, and particle shape distribution to determine how the dust microphysical and optical properties affect DRE estimates and its agreement with the above-mentioned satellite-derived DREs. Our analysis shows that a good agreement with the observation-based estimates of instantaneous DRESW and DRELW can be achieved through a combination of recently observed PSD with substantial presence of coarse particles, a less absorptive SW refractive index, and spheroid shapes. Based on this optimal combination of dust physical properties we further estimate the diurnal mean dust DRESW in the region of −10 W m−2 at TOA and −26 W m−2 at the surface, respectively, of which ~ 30 % is canceled out by the positive DRELW. This yields a net DRE of about −6.9 and −18.3 W m−2 at TOA and the surface, respectively. Our study suggests that the LW flux contains useful information on dust particle size, which could be used together with SW observations to achieve a more holistic understanding of the dust radiative effect.

Plans for Next Year
We will compute the DRE of dust aerosols using the global dust climatology databased from Dr. Hongbin Yu and radiative transfer model and publish the results in scientific journals.

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
Over this period, based on the research achievements from the last year we published an excellent paper in the journal of Atmospheric Chemistry and Physics: Song, Q.*, Z. Zhang, H. Yu, S. Kato, P. Yang, P. Colarco, L. A. Remer, and C. L. Ryder (2018), Net radiative effects of dust in the tropical North Atlantic based on integrated satellite observations and in situ measurements, Atmospheric Chemistry and Physics, 18(15), 11303–11322, doi:10.5194/acp-18-11303-2018. In this study, we integrate recent in situ measurements with satellite retrievals of dust physical and radiative properties to quantify dust direct radiative effects on shortwave (SW) and longwave (LW) radiation (denoted as DRESW and DRELW, respectively) in the tropical North Atlantic during the summer months from 2007 to 2010. Through linear regression of the CERES-measured top-of-atmosphere (TOA) flux versus satellite aerosol optical depth (AOD) retrievals, we estimate the instantaneous DRESW efficiency at the TOA to be −49.7±7.1 W m−2 AOD−1 and −36.5±4.8 W m−2 AOD−1 based on AOD from MODIS and CALIOP, respectively. We then perform various sensitivity studies based on recent measurements of dust particle size distribution (PSD), refractive index, and particle shape distribution to determine how the dust microphysical and optical properties affect DRE estimates and its agreement with the above-mentioned satellite-derived DREs. Our analysis shows that a good agreement with the observation-based estimates of instantaneous DRESW and DRELW can be achieved through a combination of recently observed PSD with substantial presence of coarse particles, a less absorptive SW refractive index, and spheroid shapes. Based on this optimal combination of dust physical properties we further estimate the diurnal mean dust DRESW in the region of −10 W m−2 at TOA and −26 W m−2 at the surface, respectively, of which ~ 30 % is canceled out by the positive DRELW. This yields a net DRE of about −6.9 and −18.3 W m−2 at TOA and the surface, respectively. Our study suggests that the LW flux contains useful information on dust particle size, which could be used together with SW observations to achieve a more holistic understanding of the dust radiative effect.

Plans for Next Year
We will compute the DRE of dust aerosols using the global dust climatology databased from Dr. Hongbin Yu and radiative transfer model and publish the results in scientific journals.

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
Since Oct 2018, I have been working with Dr. J. Vanderlei Martins to develop a Level-1 data processing software for HARP2, a sensor that is designed by Dr. Martins's group at UMBC and will be onboard the NASA PACE satellite. The software, called HARP2 Image Processing Pipeline or HIPP, takes in the HARP2 measured raw image data, performs georegistration, radiometric and polarimetric calibration, and generates HARP2 Level 1B data products. We have completed a HIPP version 1.2, which contains all the major required processing modules. The software has been tested and is being used to process the HARP2 proxy (AirHARP) observation data. I presented the software development and AirHARP products in the 18th international Electromagnetic Light Scattering (ELS) conference hold in Hangzhou, China in 10-14 June 2019. In this September, we plan to deliver the HIPP software to PACE Project team in NASA GSFC, with which this project is contracted. In parallel, we will release more AirHARP Level 1 data products reprocessed by the current version of HIPP.

Plans for Next Year
In the following project year, I will continue the development of the HIPP software through closely working with Dr. Martins and the PACE Project team, and will help PACE Project team running the HIPP software on their processing platform. Meanwhile, the development of the software will be documented in an ATDB report. I will also prepare two journal articles to summarize its science and technical developments.

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

Dr. Tyler joined JCET in April, 2019 and in that time has worked on a mathematical formulation and numerical solution method for quickly solving the tides in planetary fluids under millions of differing scenarios. A paper has been submitted applying the method to Enceladus, and a comprehensive manual describing the approach and software will be released in August, 2019 and updated through the Fall. Work has also continued on the study of ocean tidal generated magnetic fields and their potential use in remote sensing ocean heat content. This was awarded a pilot study (by NASA Physical Oceanography Program) in June, 2019 (R. Tyler Science PI, T. Sabaka GSFC administrative PI).

Plans for Next Year
The plan for the coming year is to continue the development of the method and software used for calculating the planetary tidal fluid response. The pilot study on ocean tidal generated magnetic fields will also continue in the next year.

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
TASK 178: SCERIN and SBG The goals of this task are to coordinate the work of the South

Central and Eastern European Information Network (SCERIN). During the reporting period was organized the SCERIN-7 capacity building workshop, which addressed the current LC dynamics in the Agricultural and Protected Natural Areas in SCERIN. The work of SCERIN focused on identifying the typical pre-cursors of land cover change (LCC) and the group considered the current abilities in the area to monitor via remote sensing their dynamics and estimate their influence on the local biogeochemical cycling.

Plans for Next Year
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-MEDRIN (Mediterranean Research Information network) capacity building workshop and activities. The joint workshop is to be conducted in June 2020, however a full proposal outlining the joint activities and collaborative discussions is to be developed and submitted for consideration to START in December of 2019.

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 Earth's 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
Work on this Task began in May 2019. Before Oct. 1, I am planning on documenting the research on quantifying the heavy pollution over East Asia. As well as continue to work on developing the aerosol absorption algorithm and identifying the dust plume events using satellite data and MERRA model output.

Plans for Next Year
For the next year I will continue to work on identifying and documenting the dust deposition events globally. We will work with the ocean biology team to discover the dust role in fertilizing the ocean ecosystem. I will also continue to work on developing the aerosol optical depth along with absorption retrieving algorithm using combined OMPS and VIIRS. The bulk structure of the algorithm will be generated and tested over selected scenarios. I will also continue to improve the Dark Target algorithm by modifying the algorithm and evaluating and validating DT aerosol products on various sensors.

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
As being mentioned in Dr. Shie's "Task 103" Report, this Task (#181) is a new project (proposal) funded by the NASA PMM Program. The objective of this 3-yr proposal (2019-2021) aims to use GPM products in an optimal estimation Lagrangian framework to quantify moisture transport in Arctic cyclones. As a Co-I (0.05 FTE), Dr. Shie will utilize his expertise and knowledge in air-sea surface turbulent fluxes over global open seas to assist the PI (Dr. L. McPartland) and the team in analyzing and accessing the evaporation and precipitation products. Dr. Shie, who has also been a long-term modeler well experienced in cloud modeling and tropical cyclone/hurricane simulations using the WRF model, will also assist PI and Dr. Grecu (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 started (earlier) working with his team on this brand-new collaborative project around mid-April 2019, which was about one month prior to his "official" beginning date on May 26, 2019. He has so far helped PI/the team organizing two group meetings, while another one is upcoming on Jul 12. One strong 5-day (Dec 4-8, 2014) winter cyclone system has been identified and finalized as the

prototype case study to be examined at the beginning stage of this project/research. Dr. Shie, working closely with the group, has performed analysis on the storm data, and confirmed certain known features, as well as gained some preliminary insights. Dr. Shie expects and believes that the team will produce more promising results and findings that can then be properly presented at the upcoming 2019 PMM Science Team Meeting in Nov 2109.

Plans for Next Year

Dr. Shie will continue actively performing his Co-I duties such as organizing group meetings; performing science research/data analysis; co-authoring journal and conference papers.

JCET Grants

UMBC Project Number: 00008689
UMBC PI: Herman, Jay
Sponsoring Agency: Smithsonian Astrophysical Observatory
Project Title: Tropospheric Emissions, Monitoring of Pollution (TEMPO)

Summary
My duties for FY2017 under the Subcontract SV3-83018 are to attend TEMPO meetings and to plan for the deployment of Pandora instruments at various sites that are useful for the validation of TEMPO.

Accomplishments
I attended the annual TEMPO meeting and presented work on the optimized deployment of ground-based instruments for geostationary satellite validation. I also work with the Korean team on their similar GEMS geostationary satellite.

Plans for Next Year
I plan on continued support for TEMPO and ground-based validation

UMBC Project Number: 00008854
UMBC PI: Olson, William
Sponsoring Agency: NASA
Project Title: Extending Atmospheric Latent Heating Estimates to the Extra-tropics Using Satellite RadarRadiometer Data, High-Resolution Regional Model Simulations, and Reanalysis Products.

Summary
To extend latent and eddy sensible heating estimation from the tropics/subtropics to higher latitudes by carefully quantifying the heating contribution from extratropical cyclones. Show a spatial map transformation between the simulated cyclones and satellite microwave radiometer observed cyclones will be determined using water vapor and precipitation features in the simulated and observed storms. This mapping will make it possible to overlay contextual information (fronts, heating vertical structures) from the simulations onto the coincident, narrow-swath radar-radiometer derived precipitation fields. The simulated heating structures will then be re-scaled by the radar-radiometer derived surface rain rates to estimate vertical profiles of heating. The deliverable to NEWS will be GPM-derived latent and eddy sensible heating rate estimates in the extra-tropics that will seamlessly extend estimates from lower latitudes. Also, TRMM radar-radiometer data will be reprocessed to produce a consistent atmospheric heating record in the tropics/subtropics starting in 1998.

Accomplishments
The primary focus of recent work has been on the optimization of water and energy flux components, such as precipitation, evaporation, horizontal humidity fluxes, etc., in such a way that the revised fluxes will lead to global water and energy balance. In collaboration with Dr. Sara Q. Zhang, the variational optimization approach developed by Dr. Olson in the previous year was tested, and an alternative solver that avoids numerical instabilities was implemented. Applications to synthesized atmospheric water fields yielded rectified horizontal moisture

transport fields that were closer to the "true" fields.

Plans for Next Year
Funding ends with the current reporting period.

UMBC Project Number: 00009444
UMBC PI: Zhang, Zhibo
Sponsoring Agency: DOE
Project Title: Evaluation of NCAR CAM5 simulated MBL cloud properties using a combination of satellite and surface observations

Summary
The main objective of the proposed work is to systematically evaluate the MBL cloud simulations in the latest CAM5 (i.e., CAM5_CLUBB with MG microphysics scheme) using a combination of satellite-based CloudSat/MODIS observations and ground-based observations from the ARM Azores site, with a special focus on the MBL cloud LWP bias

Accomplishments
This project, funded by DOE, is to evaluate the cloud simulation in NCAR's CAM5 model with a newly developed cloud parameterization scheme. In this period, we have been focusing on publishing the scientific results from this project on scientific papers. The following are the publications in this year: Lu, Z., X. Liu, Z. Zhang*, C. Zhao, K. Meyer, C. Rajapakshe*, C. Wu, Z. Yang, and J. E. Penner (2018), Biomass smoke from southern Africa can significantly enhance the brightness of stratocumulus over the southeastern Atlantic Ocean, PNAS, 115(12), 201713703–2929, doi:10.1073/pnas.1713703115 Song, H.*, Z. Zhang*, P.-L. Ma, S. J. Ghan, M. Wang, and H. Song (2018), An Evaluation of Marine Boundary Layer Cloud Property Simulations in the Community Atmosphere Model Using Satellite Observations: Conventional Subgrid Parameterization versus CLUBB, Journal of Climate, 31(6), 2299–2320, doi:10.1175/JCLI-D-17-0277.1. Song, H.*, Zhang, Z.*, Ma, P.-L., Ghan, S., and Wang, M. (2018): The Importance of Considering Sub-grid Cloud Variability When Using Satellite Observations to Evaluate the Cloud and Precipitation Simulations in Climate Models, Geosci. Model Dev. ., https://doi.org/10.5194/gmd-2018-13 Wu, P., B. Xi, X. Dong, and Z. Zhang (2018), Evaluation of autoconversion and accretion enhancement factors in general circulation model warm-rain parameterizations using ground-based measurements over the Azores, Atmospheric Chemistry and Physics, 18(23), 17405–17420, doi:10.5194/acp-18-17405-2018.

Plans for Next Year
The project will end in July of 2019

UMBC Project Number: 00009488
UMBC PI: Zhang, Zhibo
Sponsoring Agency: NASA/GSFC
Project Title: RETRIEVAL STUDIES IN SUPPORT OF CLOUD PROPERTY PRODUCTS FROM THEPACE OCEAN COLOR IMAGER

Summary

Result of this study: provide realistic sensitivities on the impact of OCI spatial resolution on cloud optical property retrieval and ability to have sufficient QA to understand/achieve data continuity with MODIS/VIIRS (at least over a subset of cloud types and locations). Will impact our discussion with the ocean color folks on instrument spatial resolution requirements.

Accomplishments
This is the ending year of this task, so we have been focusing on publishing the scientific achievements in journals. Below is a list of journal publications this year. Note that the paper by Werner et al. (2018) has been highlighted by AGU. Werner, F., Z. Zhang, G. Wind, D. J. Miller, S. Platnick, and L. Di Girolamo (2018), Improving cloud optical property retrievals for partly cloudy pixels using coincident higher‐resolution single band measurements: A feasibility study using ASTER observations, Journal of Geophysical Research-Atmospheres, doi:10.1029/2018JD028902. (Highlighted by AGU News Link) Miller, D. J.*, Z. Zhang*, S. Platnick, A. S. Ackerman, F. Werner, C. Cornet, and K. Knobelspiesse (2018), Comparisons of bispectral and polarimetric retrievals of marine boundary layer cloud microphysics: case studies using a LES–satellite retrieval simulator, Atmos. Meas. Tech. Discuss., 11(6), 3689–3715, doi:10.5194/amt-11-3689-2018. Werner, F.*, Z. Zhang*, G. Wind, D. J. Miller, and S. Platnick (2018), Quantifying the Impacts of Subpixel Reflectance Variability on Cloud Optical Thickness and Effective Radius Retrievals Based On High‐Resolution ASTER Observations, Journal of Geophysical Research-Atmospheres, 123(8), 4239–4258, doi:10.1002/2017JD027916.

Plans for Next Year
The task has ended

UMBC Project Number: 00009596
UMBC PI: Mehta, Amita
Sponsoring Agency: Hazen and Sawyer
Project Title: Decision Support System (DSS) to Enhance Source Water Quality Modeling and Monitoring using Remote Sensing Data

Summary
This project will culminate in a Remote Sensing-Water Quality DSS specifically focused on water utilities and water management agencies as the end users of remote sensing data. The DSS will provide water utility staff, who are not accustomed to viewing remote sensing data, with a powerful and convenient web interface for viewing relevant remote sensing data for their system; evaluating the potential for using these data as surrogates for in situ monitoring data; and using those surrogates and in situ data sets to increase their understanding of near- and long-term watershed impacts on source water quality and improve decision-making.

Accomplishments
This project focused on developing a web-based decision support system for water quality monitoring based on satellite and model data to monitor chlorophyll concentration, dissolved organic matter, and turbidity in Falls Lake, North Carolina; and selected reservoirs in New York and Colorado States. This project was conducted in partnership with Hazen and Sawyer (H&S), a private company working with drinking water utilities. The project ended in May 2019, however, under no-cost extension of this project two publications are currently being

prepared. With the assistance from a prospective student and consultant, Amanda Rumsey, and from the team from H&S, Mehta has developed an algorithm to derive chlorophyll concentration in selected in-land lakes using Landsat images. The DSS is currently being tested end will be operational by end of 2019. Mehta participated with H&S in submission of a proposal titled 'Improving the Effectiveness of Best Management Practice using Probabilistic Water Quality Predictions based on satellite-observed Watershed Conditions' to NASA, this proposal, however, was not selected for funding.

Plans for Next Year
Mehta, in collaboration with H&S will complete two papers based on this study and will participate in testing of the DSS.

UMBC Project Number: 00009920
UMBC PI: Zhai, Pengwang
Sponsoring Agency: NASA
Project Title: Water Cloud Depolarization Multiple Scattering Relation: A Novel Technique for Spaceborne Lidar Retrievals of Above-Cloud Aerosol Optical Depth

Summary
Utilizing retrieval algorithms for water cloud droplet sizes and variances using available RSP data and then deriving lidar ratio of water clouds (Sc) using the least squares fitting algorithm for the RSP data analysis and the vector radiative transfer model used to fit the RSP data will be the successive-order-of-scattering code.

Accomplishments
We have compared the lidar ratio derived from the RSP data with those from the active HSRL lidar measurements. Discrepancies exists due to imperfect geolocation, and measurement sensitivity. A document has been written and delivered to NASA Langley Research Center.

Plans for Next Year
This project has been ended

UMBC Project Number: 00009954
UMBC PI: Demoz, Belay
Sponsoring Agency: NSF
Project Title: NSF: PECAN: Ground Based Lidar and MicroWave Radiometer Profiling

Summary
This award is for participation in the Plains Elevated Convection at Night (PECAN) field campaign. PECAN will take place in the central United States in the summer of 2015. The focus of the overall project is on overnight thunderstorm complexes that regularly occur in the Great Plains area. A variety of observational systems will be put in place for the field experiment including multiple aircraft, mobile radars, and ground-based systems that can profile the wind and particles in the lower atmosphere. This individual project will provide funding for researchers to provide instrumentation at one of the campaign ground sites. The researchers will focus on measurements that describe the environment prior to the initiation of

the thunderstorms. This project will help to increase understanding of these convective systems in order to better predict and warn the public of hazardous weather. The project will also help train the future generation of scientists by involving a student in the research. The steering committee for the PECAN campaign has identified four main research topics to be addressed: 1) Nocturnal convection initiation and early evolution of mesoscale convective clusters; 2) Bore and other wave-like disturbances; 3) Dynamics and microphysics of nocturnal mesoscale convective systems; 4) Prediction of nocturnal convection initiation and evolution. This objective of this project is to provide a quantitative assessment of the evolution of the nighttime boundary layer and entire troposphere with particular attention to its potential for elevated convection. The researchers will coordinate and manage the deployment and data acquisition of highly resolved water vapor mixing ratio, temperature, aerosol structure and wind profiles at one of the Fixed PECAN Integrated Sounding Array (PISA) sites. The specific instrumentation includes a wind lidar, sounding system, ceilometer, and Raman lidar.

Accomplishments
The central objective of this proposed research was to provide a quantitative assessment of the evolution of the night-time troposphere and its potential for elevated convection. The primary goal of this proposal was to coordinate the acquisition of highly resolved water vapor mixing ratio, temperature, aerosol structure and wind profiles at the Fixed Plains Elevated Convection At Night (PECAN) Integrated Sounding Array (Fixed PISA or FP2) site in Greensburg, Kansas and to test a network of continuously operated (real-time, 24/7 operation) ceilometer-lidar instrumentation in the PECAN domain. Other specific goals include were to identify and quantify the time-dependent vertical water vapor structure and thermodynamic evolution during NLLJ, convergent boundary zones (CBZ), evolution of the Planetary Boundary layer (PBL) and night-time Boundary layer (NBL) evolution during transient waves (Bores, Solitons, and convergence of flows) and evaluate the consequence of this vertical stratification of the atmosphere for elevated convection. Six (6) refereed journal papers and reports as well as over ten (10) student-led conference papers were reported in addition to the data generated and continues to be used by the community.

Plans for Next Year
This Project has ended. A proposal to NSF for follow on work is in progress.

UMBC Project Number: 00010019
UMBC PI: Delgado, Ruben
Sponsoring Agency: Hampton University
Project Title: Hampton University Center for Atmospheric Research and Education (CARE)

Summary
The spatial and temporal resolution from ground based lidar remote sensors allows to relate satellite column measurements of aerosols and gases with their respective mass surface measurements. However, the techniques used today are correlative in nature, attempting to find a linear or non-linear relationship between AOD and PM2.5. Each uses some pre-existing knowledge of the expected aerosol type and microphysics and assumes that the behavior of these aerosols in the Planetary Boundary Layer (PBL) is sufficiently uniform that a regression (or even a neural network) can discern a robust relationship between AOD and PM2.5 that can be extrapolated elsewhere. A literature review on this subject (Hoff and Christopher, 2009)

pointed out that considerable "noise" exists in these relationships and without a better understanding of the microphysics and physical structure of the PBL, further "progress" would be unlikely. We will be obtaining high-resolution aerosol and wind profiles to understand the effects of local source variability, PBL structure, and microphysical processes on the ability of a column measurement to be related to a surface concentration. . This premise was substantiated from analysis of surface characteristics, transport and vertical structures of O3 during bay breezes using in-situ surface, balloon and aircraft data, along with remote sensing equipment. Localized late day peaks in O3 were observed during bay breeze days, maximizing an average of 3 h later compared to days without bay breezes. Mapping wind fields and aerosol distribution in the interface/transition of the land-marine PBL allows to study how satellite retrievals are influenced by the following: (1) what are the aerosol compositions and particle sizes associated with the upwelling and coastal breezes? (2) What is the temporal and spatial distribution of aerosol optical depth and the relationship to the environmental state? (3) What is the impact of the locally driven wind circulations on the dispersion of aerosols offshore and over land? In addition, the Tropospheric Ozone Lidar Network (TOLNet) is an interagency research initiative for ground–based ozone and aerosol lidar profiling, recently established for air quality applications/studies and to serve the GEOstationary Coastal and Air Pollution Events (GEO-CAPE) mission. UMBC is currently participating in the TOLNet initiative in conjunction with the NASA Goddard Space Flight Center (GSFC) (collaboration with Dr. Thomas McGee, NASA/GSFC) in the development of an ozone Differential Absorption Lidar (DIAL) system. The development of this system will contribute to research areas that will address key questions on the influence of gases and aerosols in air quality, atmospheric composition and climate. We propose to work with NASA LARC (Jay Al-Saadi/Russell De Young) who are working on a similar project and investigate ozone and its distribution coastal circulation. This will allow to a better understanding of coastal circulation at the regional level. We plan to work with a WRF modeling group at NASA/GSFC and develop a modeling framework for analysis and interpretation of the observations.

Accomplishments

The University of Maryland, Baltimore County (UMBC) Atmospheric Lidar Group research focus in laser remote sensing technology for atmospheric chemistry and physics applications. The impact of meteorology on air quality, and wind energy, is examined with the use of active and passive remote sensing techniques, and surface in-situ measurements of gases and aerosols. Brian Carroll submitted to the Journal of Geophysical Research the article titled "An overview of low-level jet winds and corresponding mixed layer depths during PECAN" and is currently under review. In addition, Brian Carroll provided the Doppler wind lidar analysis of measurements from the Ozone Water Land Environmental Transition Study: Enhanced Monitoring of Atmospheric Pollution of the Chesapeake Bay Using Vertical Profiles of Ozone, Wind, Temperature and Aerosols (OWLETS) field campaign. The goal for OWLETS is to look at land-water differences in ozone within the boundary layer and correlate the diurnal evolution to dynamics (bay-breeze evolution, coastal low level jets, etc) and chemistry. He also participated in February-March 2018 in the NOAA sponsored field campaign Saharan Dust AERosols and Ocean Science Expeditions (AEROSE). This trans-Atlantic field campaigns conducted onboard the NOAA Ship Ronald H. Brown is designed to explore African air mass outflows and their impacts on climate, weather, and environmental health. Atmospheric Physics graduate student Kylie Hoffman participated in a 8-week internship from July-August 2019 in lidar remote sensing at NASA Langley Research Center. MS. Hoffman will be mentored by Timothy Berkoff in ozone and aerosol lidar remote sensing for boundary

layer dynamics applications.

Plans for Next Year
UMBC will continue to provide a three dimensional (3D) evaluation of the aerosol pollution environment over by combining ground based sampling measurements with profile measurements provided by lidars and radiative aerosol properties measured by satellite instruments. In addition, will promote collaboration between JCET and the wider campus and scientific community as mean to expose new and current students to interdisciplinary research opportunities.

UMBC Project Number: 00010222
UMBC PI: Zhang, Zhibo
Sponsoring Agency: NASA/GSFC
Project Title: Satellite Data Analysis and Radiative Transfer Simulations in Support of Above-Cloud Absorbing Aerosols Studies

Summary
The proposed work responds to the CCST solicitation that encourages "the inventive combination of CloudSat and CALIPSO data with other A-train sensors" to study "aerosol direct radiative effect", and aerosol "evolution" and "vertical transport" particularly during long-range transport. Outcomes from this proposed investigation will include a better understanding of above-cloud aerosols on a basis of daily and extensive spatial coverage and more rigorous constraints for the assessment of aerosol intercontinental transport and radiative effects.

Accomplishments
This project should have finished by Jan, 2018

Plans for Next Year
N/A

UMBC Project Number: 00010284
UMBC PI: Huemmrich, Fred
Sponsoring Agency: University of Nebraska - Lincoln
Project Title: Evaluating Growing Season Length and Productivity Across the ABoVE Domain Using Novel Satellite Indices and a Ground Sensor Network

Summary
Within high-latitude ecosystems an accurate description of the spatial and temporal variability of photosynthetic CO2 uptake, or Gross Ecosystem Production (GEP), is central to quantifying the terrestrial carbon cycle. Spatially explicit knowledge of the timing of seasonality and detection of stress events are especially important in tundra and boreal forests for determining GEP patterns. This study estimates terrestrial GEP from satellite observations of vegetation spectral reflectance characteristics associated with seasonal and stress responses of photosynthetic pigments for boreal forest and tundra ecosystems within the NASA ArcticBoreal Vulnerability Experiment (ABoVE) study region. This approach combines both

the land and ocean bands of the Moderate-Resolution Spectroradiometer (MODIS) on Aqua and Terra to provide frequent, narrow-band measurements of terrestrial vegetation with high radiometric accuracy. MODIS data are used to examine spatial patterns of seasonal and multi-annual changes in plant pigments along with their effect on the carbon uptake. This approach provides an important new view of ecosystem carbon dynamics based on optical signals, an independent data source for GEP compared to those used in existing carbon models (observed reflectance responses vs. predicted responses based on meteorological data). It also provides new means of mapping functionally distinct vegetation types directly from satellite based on pigment dynamics.

Accomplishments
This project is also part of the ABoVE study. Dr. Huemmrich advised and reviewed datasets and documentation of processed MODIS data for archive.

Plans for Next Year
He will continue working on completing the data archive and support the publication of results.

UMBC Project Number: 00010465
UMBC PI: Tokay, Ali
Sponsoring Agency: NASA John C. Stennis Space Center
Project Title: Validation of GPM Precipitation Retrieval Algorithms across the Precipitation Continuum

Summary
Global Precipitation Measurement Mission (GPM) precipitation retrieval algorithms require quantitative, multi-scale descriptions of naturally-occurring liquid and frozen precipitation and its spatial variability. Of interest are distributed ground validation (GV) observations that can be used to quantify the intrinsic characteristics of precipitation such as gamma size distribution parameters (e.g., Nw, , Dm/0), hydrometeor phase (e.g., rain, snow, mix), water content and precipitation class (convective/stratiform). A “distributed” observation of these parameters can in turn be tied to a description of the precipitation process and multi-dimensional coupling of that process to spatial variability along and across individual to multiple GPM instrument rays/pixels. The research proposed herein leverages extensive and continued use of numerous GPM GV field-campaign and NASA Wallops GV radar and hydrometeor datasets together with targeted and coincident GPM constellation overpass data to investigate constraints on the variability and spatial correlation structure of hydrometeors in the column, and intra/inter GPM pixel fields of view. The work naturally extends into frozen precipitation regimes to evaluate impacts of hydrometeor variability (habit, density etc.) on estimation of falling snow water equivalent rates. Finally, in order to bridge physical and direct validation of GPM Level II and Level III (IMERG) products, the team will continue and external collaboration to apply GV datasets to rigorous and physically-based evaluation of uncertainties in IMERG products; i.e., within the context of precipitation scales of variability and processes impacting level II algorithms.

Accomplishments
Performance of micro rain radar (MRR) was evaluated through comparison to the 2DVD and

PARSIVEL2 disdrometers and NPOL during IFloodS field campaign. The comparative study included reflectivity, rain rate, and two DSD parameters. The manuscript has been submitted [Adirosi et al. 2019]. As a follow-up study, the vertical variability of DSD is currently investigated through coincident disdrometer and MRR measurements. A manuscript in this topic is currently drafted. The investigator participated reseach projects on the comparison of the GPM DPR and ground based radar derived DSD parameters over Italy [D'Adderio et al. 2018b], estimation precipitating ice from multi-frequency radar reflectivity measurements [grecu et al. 2018], and the radar-based precipitation estimate during Hurricane Harvey (2017) [Wolff et al. 2019]

Plans for Next Year
The newly analyzed datasets from ICE-POP and MQT will be investigated for spatial variability of snowfall in complex and flat terrain. The precipitation phase, snowflake size distribution, and radar estimated snow amount will be studied utizing the operational datasets over the continental US and research datasets at WFF and ICE-POP. The efforts will also be on publishing two drafted and two submitted papers.

UMBC Project Number: 00010468
UMBC PI: Tokay, Ali
Sponsoring Agency: MORGAN STATE UNVERSITY
Project Title: P0014616 Rain and Snow Particle Size Distribution Models and their Application to the DPR Retrieval Algorithm

Summary
An important goal of the Dual-frequency Precipitation Radar (DPR), aboard the Global Precipitation Measurement (GPM) core satellite, is to derive rain rate and snowfall rate by estimating parameters of the raindrop size distribution (DSD) and the snow particle size distribution (PSD). These distributions are often modeled by an analytical function, such as the exponential, gamma or lognormal distribution, with two or three unknown parameters. The inability of the modeled DSD/PSD to represent actual hydrometeor spectra as well as to characterize their intrinsic variations in time and space lead to uncertainties in the estimates of precipitation rate obtained from the DPR. Understanding the uncertainties in precipitation estimation that depend on DSD/PSD parameterizations and scattering models of individual particles is important not only in evaluating the overall performance of DPR retrieval algorithms but also in gaining an insight into the ways to improve the algorithms.

Accomplishments
The investigator provides newly available rain and snow data sets from International Collaborative Experiment for Pyeongchang 2018 Olympic and Paralympic (ICE-POP). The database includes PARSIVEL2, PIP, and Pluvio outputs and have been used for scattering calculations in conjunction with the NASA Global Precipitation Measurement mission algorithm development and validation program.

Plans for Next Year
The newly available dataset from Marquette, Michigan will be analyzed.

UMBC Project Number: 00010483
UMBC PI: Olson, William
Sponsoring Agency: NASA
Project Title: Integration and Testing of Improved Ice and Mixed-Phase Precipitation Models for GPM Combined Radar-Radiometer Retrieval Algorithm Applications

Summary

To develop and integrate the nonspherical snow and melting particle models, and then test these particle models for consistency with airborne and GPM radar-radiometer observations, as well as independent validation data. Extend the current database of nonspherical snow particles to include larger particle sizes as well as rimed particles; then calculate the singlescattering properties of these particles, simulate the melting of a subset of particles in the snow particle database and compute their single-scattering properties, and also generalize the 1-D thermodynamic model of the melting layer by adding particle aggregation, introduce the bulk single-scattering properties of the snow and melting particles into a combined algorithm framework suitable for testing the radiative consistency of the particle properties with simultaneous airborne radar and radiometer observations from field campaigns, and use in situ particle probe data to independently check radiatively-consistent particle distributions, evaluate the particle models in GPM combined radar-radiometer algorithm applications, and use available ground observations to perform a preliminary validation of estimates.

Accomplishments

Dr. Olson worked with colleagues Dr. Benjamin Johnson, Dr. Kwo-Sen Kuo, and Dr. Adrian Loftus on the calculation of the microwave single scattering properties or irregularly-shaped ice particles, including individual crystals, aggregates, and rimed particles. Recently, the Amsterdam discrete dipole approximation (ADDA) code was used to replace a predecessor DDA code to calculate these scattering properties, and this code is currently being tested. The properties of melting particle properties were also addressed, starting with the implementation of a method for averaging refractive index properties within multi-phase particles.

Plans for Next Year

The plan is to fully adopt the ADDA code and compute the single-scattering properties of a representative set of melting, mixed-phase particles. These properties will be incorporated into coupled thermodynamic-particle simulations of melting layers to create scattering property tables that can be used in TRMM (Tropical Rainfall Measuring Mission) or GPM (Global Precipitation Measurement mission) precipitation remote sensing algorithms.

UMBC Project Number: 00010688
UMBC PI: Hoban, Susan
Sponsoring Agency: Lowell Observatory
Project Title: Comprehensive Modeling of the Nucleus Rotational State and the Coma Morphology and Lightcurve Variability of Comet 1P/Halley

Summary

Accomplishments

The UMBC component of the project made considerable progress transferring Samarasinha's original modeling code to the UMBC High Performance Computing system. One beta parallel implementation of the code was developed for 'maya' (the previous version of UMBC's cluster). While working on this implementation, the cluster was upgraded (now called 'taki') and some of the library links were broken. Before the end of the year we plan to 1) package the movie code for distribution, 2) complete migration from maya to taki, and 3) as a back-up, implement a serial code on taki to take advantage of the upgraded processor speed-up.

Plans for Next Year
This project is ending July 31, 2019.

UMBC Project Number: 00010715
UMBC PI: Wolfe, Glenn
Sponsoring Agency: NOAA
Project Title: Emissions and Chemistry of Formaldehyde in Biomass Burning Plumes

Summary
This research addresses multiple aspects of the FY16 AC4 competition. Our work will incorporate multiple datasets from both airborne missions and remote sensing platforms to develop detailed chemical portraits of past and future fires in the Western U.S. Deployment of ISAF on the WP3D will enrich the FIREX dataset and provide a vital link between the aircraft, lab investigations and orbital observations. Anticipated outcomes include more accurate chemical mechanisms, improved observations of HCHO from space and better representation of biomass burning in regional air quality models. These goals are aligned with the first objective of NOAA's Next Generation Strategic Plan: to acquire an "improved scientific understanding of the changing climate system and its impacts."

Accomplishments
This project includes three major objectives: 1) analysis of airborne observations of the Rim Fire plume, 2) acquisition of formaldehyde (HCHO) observations as part of the FIREX-AQ mission, and 3) application of FIREX-AQ data to evaluation of chemical mechanisms and orbital HCHO retrievals. Regarding Task 1, Wolfe's analysis is ongoing and has included a combinations of air-mass trajectory and chemical analyses to isolate the Rim Fire from other fire plumes sampled on the same flight. He is also working on constructing a model simulation of this plume – no trivial task considering the complexity of a smoke-filled air mass. Regarding Task 2, Wolfe and St. Clair have invested significant time preparing our instruments for deployment, including upgrades, calibrations, and mission-specific modifications. It is worthwhile to note that we are flying 3 instruments on FIREX-AQ: ISAF (formaldehyde), CANOE (nitrogen dioxide), and ROZE (ozone). The latter instrument has never flown before but has great potential for acquiring fast, precise measurements of ozone. Our payload is currently installed on the NASA DC-8 awaiting deployment. Flights are scheduled for mid-July through mid-September.

Plans for Next Year
Following FIREX-AQ, data will be quality-assured by Wolfe and St. Clair through post-mission calibrations and inter-comparisons with other measurements where possible. Preliminary analysis will be partially based on results from the above-mentioned Rim Fire

study and may also incorporate satellite-based observations (e.g. from TROPOMI). Potential objectives will include 1) assessment of the time-evolution of fire plumes, and 2) evaluation of satellite-based HCHO observations and consideration of what these might tell us about biomass burning emissions. We anticipate presenting results from the Rim Fire analysis at the 2019 AGU fall meeting and attending a FIREX-AQ science team meeting in 2020.

UMBC Project Number: 00011114
UMBC PI: Bian, Huisheng
Sponsoring Agency: NOAA
Project Title: Towards the improvement of chemical lateral boundary conditions for the National Air Quality Forecasting Capability

Summary

The National Air Quality Forecasting Capability (NAQFC) suffers a major deficiency, i.e., the poor representation of chemical lateral boundary conditions (CLBCs) for both gaseous and aerosol species, which prevents it from providing a more accurate air quality prediction. NAQFC CMAQ currently uses the 2006 climatological CLBCs developed out of the GEOSChem global chemical transport model. As such the trans-continental and trans-boundary transport of pollution is outdated that does not represent the current conditions, in particular for aerosol species contributing to the regional background and episodic enhancement (fire, dust, volcano, etc.). To address this deficiency, we propose a three-year research project to develop a framework to integrate the near-real time results out of the NASA's Goddard Earth Observing System Model, Version 5 (GEOS-5) into the NAQFC for improved CLBCs. Specifically, we will: 1. Develop a software package to spatially and temporally project GEOS-5 global results into NAQFC's Continental U.S. (CONUS) domain in an appropriate chemical speciation. The gaseous mapping from GEOS-5 to NAQFC will largely rely on the existing GEOS-Chem – NAQFC species mapping. The aerosol size information will be used to map the GEOSGOCART aerosols to the NAQFC's AERO6 aerosols. 2. Conduct case simulations of the selected dust, wildfire and stratosphere-to-troposphere ozone transport events employing GEOS-5 with CCM and GOCART in a "replay" mode using the Modern-Era Retrospective Analysis for Research Application version 2 (MERRA2) meteorology. We will then use the satellite and ground-based observations to evaluate the case study results of total aerosol optical depth (AOD), surface ozone and PM2.5 concentrations, among others. 3. Conduct NAQFC simulations with the GEOS-5 CLBCs out of the case study. The entire system will be tested in the NOAA ARL NAQFC testbed with a selected experimental CMAQ system. The proposed research is expected to fill a major gap of improving NAQFC and thus to provide public a better early warning in response to poor air quality. This proposal is a direct response to the program priority of "Improved process modeling of boundary layer PM2.5 in the CMAQ forecast system, including improvements from lateral boundary conditions and postprocessing techniques" and of "Improved model representation of physical/chemical processes for long range transport and regional/local phenomena for improvement in skill of ozone forecast guidance near the new National Ambient Air Quality Standard (NAAQS) threshold of 70 ppb".

Accomplishments

The overall objective of this proposal is to develop a framework to integrate the near-real time results out of the NASA's Goddard Earth Observing System Model, Version 5 (GEOS-5) into

the National Air Quality Forecasting Capability (NAQFC) for improved chemical lateral boundary conditions (CLBCs). During the reporting period, Huisheng Bian participated the regular meetings between the NASA team and NOAA team to discuss ideas, exchange information, and check the progress. To help the team conducting case study of biomass burning events, she rerun the GEOS-5 model for the selected periods and provided 3-hourly aerosol and gas fields as lateral boundary conditions to drive the NAQFC regional model simulation. She also assisted the team to prepare semi-annual reports for NOAA agent.

Plans for Next Year
The project has been finished by the end of June, 2019 and will be under a no-cost extension (NCE) condition for the next year. During the request NCE period, we plan to 1) conduct research to operation transition work with the ARL and NCEP teams; and 2) analyze and publish the research results in peer-reviewed journals.

UMBC Project Number: 00011224
UMBC PI: Turpie, Kevin
Sponsoring Agency: North Carolina State University
Project Title: From Arboreal to Benthic Communities: the ABCs of Land to Ocean Biodiversity Observations

Summary
Drainage patterns, flooding, soil and nutrient transport, and saline stress help shape the distribution, species composition, and structural characteristics of brackish and salt marsh vegetation canopy. In high stress areas, vegetation tends to form monospecific canopies of graminoids, a process called zonation. Each species can have unique canopy structure characteristics, such as leaf angle distribution and canopy height. Drainage and repeated flooding affect marsh microtopology, such as tufting of the canopy into tussocks in areas of poor drainage. Changes in marsh salinity, hydrology, and other characteristics can be observed through the changes in species composition, distribution, and the structure of the marsh vegetation over the course of the growing cycle. Thus changes in biodiversity serve as an indicator of changes in environmental stress.

Accomplishments
This projected ended early in the report year and no new efforts were undertaken during that time. The PI (not Dr. Turpie) requested a no-cost extension to complete the final report.

Plans for Next Year
Quite possibly the contribute to and review the completion of the final report.

UMBC Project Number: 00011246
UMBC PI: Demoz, Belay
Sponsoring Agency: UMD-CP
Project Title: UMD:CICS Investigate and Validate the Effectiveness of the Vaisala CL31 Lidar for PBL

Summary

This document serves as an review/executive summary for the CL31 Planetary Boundary Layer (PBL) Proof of Concept Project. The ASOS program under utilizes the cloud height indicator ceilometer, Vaisala model CL31. The purpose of the CL31 PBL Project is two-fold. First, the project constructed an algorithm which captures and stores vertical backscatter profile data to assess the PBL. Second the project evaluated an algorithm to extend the technical range in reporting cloud bases of the CL31 ceilometer within the ASOS suite from the current limit of 12,000 feet, up to 25,000 feet. The CL31 PBL Project was initiated in 2012 to create a polling algorithm which captures vertical backscatter profile data and to investigate the restoration of observing cloud base data to the pre-ASOS era (up to 25,000 feet). When ASOS began in the middle 1990s, the ceilometer used at that time was the CT12K, which limited automated observations to 12,000 feet above the local terrain. Prior to ASOS, manual observations provided a complete view of cloud base levels at a given location. Utilization of the CL31 ceilometer to its full potential allows the National Weather Service to capture cloud base data up to 25,000 feet in the atmosphere.

Accomplishments
This grant is focused on student training towards NOAA-related science research. A total of six (6) UMBC students were recruited and offered fellowship that allows them to participate in climate and atmospheric air quality research. Part of this funding also was used for the ceilometer network guideline work that the PI led with NWS Sterling scientists and was reported in a peer reviewed journal paper and a peer reviewed report to NOAA. Part of this funding also facilitated a major analysis of data from Ozone Water Land Environmental Transition (OWLETS) campaign and associated presentations at the annual American Meteorological Society Meeting by students and faculty.

Plans for Next Year
A graduate student has been recruited and will be working on NOAA focused weather and climate topic. The exact problem will be defined in collaboration with Howard University and NOAA mentor.

UMBC Project Number: 00011246
UMBC PI: Demoz, Belay
Sponsoring Agency: UMD-CP
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Summary
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limited automated observations to 12,000 feet above the local terrain. Prior to ASOS, manual observations provided a complete view of cloud base levels at a given location. Utilization of the CL31 ceilometer to its full potential allows the National Weather Service to capture cloud base data up to 25,000 feet in the atmosphere.

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Plans for Next Year
A graduate student has been recruited and will be working on NOAA focused weather and climate topic. The exact problem will be defined in collaboration with Howard University and NOAA mentor.

UMBC Project Number: 00011460
UMBC PI: Bian, Huisheng
Sponsoring Agency: NASA Stennis
Project Title: Cloud scavenging of aerosols in the NASA GEOS-5 model: Physically based parameterizations, and impacts on aerosol simulations and direct and indirect effects

Summary
Precipitation scavenging is the dominant loss process for a whole suite of aerosols but model parameterizations of this process are highly uncertain, substantially contributing to large uncertainties in the simulated loadings and radiative forcing of aerosols. IPCC AR5 has identified the improvement of wet deposition and scavenging parameterizations in large-scale models as a priority. We are currently evaluating the existing highly parameterized wet scavenging scheme in the NASA GEOS-5 model using radionuclide aerosol tracers (210Pb and 7Be). We propose a 4-year project to develop more physically-based parameterizations of cloud scavenging of aerosols, which are urgently needed, and study the impact of their uncertainties on aerosol direct and indirect effects in GEOS-5. Our research objectives are: (1). Develop physically detailed size-dependent below-cloud (impaction) scavenging by rain and snow in GEOS-5. (2). Develop a microphysically based parameterization of in-cloud (nucleation and impaction) scavenging of aerosols in the framework of aerosol-cloud interactions (GOCART bulk aerosol or Modal Aerosol Module aerosol microphysics, coupled with two-moment cloud microphysics) in GEOS-5. (3). Examine the constraints from radionuclide aerosol tracers 210Pb and 7Be on the new wet deposition and scavenging parameterizations in GEOS-5. Assess the impacts of the new parameterizations on the predicted aerosol size, mass, number, optical depth, and depositional fluxes (for black carbon, sulfate, particulate organic matter, sea salt, and dust), cloud properties, and evaluate with surface, in situ, and satellite observations. Quantify the uncertainties in the new parameterizations and their impacts on GEOS-5 aerosol simulations. (4). Assess the impact of

the new parameterizations of cloud scavenging of aerosols and uncertainties therein on the aerosol direct and indirect effects upon the climate system. This project will result in more physically-based parameterizations of aerosol scavenging by rain and snow in GEOS-5, and will improve confidence in our estimates of the direct and indirect radiative forcing of aerosols. This proposal directly responds to the research theme "Constituents in the Climate System" in the solicitation by improving our understanding of the process of cloud scavenging of aerosols and its representation in the NASA GEOS-5 model.

Accomplishments
This project aims to develop more physically-based parameterizations of wet scavenging, and study the impact of their uncertainties on aerosol direct and indirect effects in GEOS-5. During this reporting period, the team has conducted a comprehensive evaluation of current "bulk" scavenging scheme in GEOS-5 using the radionuclide tracers implemented in the previous period of performance. Lead-210 (210Pb) is the decay daughter of radon-222 (222Rn, half-life 3.8 days), a radioactive gas emitted from continental crust. Lead-210 attaches immediately after production to ambient submicron aerosols and is subsequently subject to dry and wet deposition. Because of its relatively well-known sources and chemically inert nature with wet deposition as the principal sink, 210Pb is a useful tracer for testing wet deposition processes in global models. The current wet scavenging parameterization in GEOS-5 is largely based on a highly-parameterized scheme, which parameterizes large-scale in-cloud and below-cloud scavenging as a function of rainfall production rate and precipitation fluxes, respectively, and scavenging in convective updrafts as a function of the updraft mass flux. The team assess the parameterization by evaluating simulated 210Pb with a variety of observations (long-term surface and upper troposphere / lower stratosphere concentrations, deposition fluxes, and vertical profiles from NASA aircraft campaigns), which provide valuable constraints on aerosol scavenging and lifetime in the model. Huisheng Bian assisted the team in the works via troubleshooting in the simulation of radionuclide tracer suite, evaluating model results with 222Rn and 210Pb observational data sets, and helping on preparation of meeting presentations.

Plans for Next Year
During the next period of performance, Huisheng Bian will closely work with the project team to implement size-dependent aerosol scavenging parameterizations, starting with below-cloud scavenging (BCS). The team are currently implementing a size-dependent parameterization for BCS, which is based on physically detailed collection efficiency theory (Croft et al., 2009). The new scheme keeps the same first-order framework and introduces size-dependent treatments (Brownian diffusion, interception, and inertial impaction) of the scavenging coefficients for rain and snow.

UMBC Project Number: 00011620
UMBC PI: Huemmrich, Fred
Sponsoring Agency: NASA
Project Title: Causes and consequences of arctic greening: the importance of plant functional types

Summary
This study attempts to understand how the structure and function of tundra ecosystems

respond to changes in biotic and abiotic conditions, and how these changes affect landatmosphere exchanges of carbon. We will further examine how these conditions change over time, impacting ecosystem structure and function and affecting tundra multi-year greening and browning trends. The first step in this study is to develop detailed maps of Plant Functional Types (PFT), Gross Ecosystem Production (GEP), and albedo for tundra regions within the NASA Arctic-Boreal Vulnerability Experiment (ABoVE) domain generated from Airborne Visible / Infrared Imaging Spectrometer Next Generation (AVIRIS NG) imagery from the ABoVE and National Ecological Observatory Network (NEON) flight campaigns. These AVIRIS snapshots will be linked to temporal changes by overlaying them in selected areas with high spatial resolution time series from commercial satellite and air photo imagery to examine how present distributions of PFT and productivity are related to ongoing processes, including herbivory, thermokarst, and changes in surface hydrology.

Accomplishments
Project title: Causes and consequences of arctic greening Changing climate in high northern latitudes is having profound impacts on tundra ecosystems. The goal of this study is to develop advanced remote sensing data products that can be used to address the ABoVE science questions - namely how the structure and function of tundra ecosystems respond to changes in biotic and abiotic conditions and how these changes affect land-atmosphere exchanges of carbon. The changes in vegetation composition due to climate change or alteration of surface hydrology due to thermokarst, can result in changes in photosynthetic activity and ecosystem productivity, which may not be detectable by NDVI alone. During the reporting period we implemented partial least square regression models, processing airborne AVIRIS-NG surface reflectance images over our study sites, to derive information products and map vegetation functional types, such as mosses, lichens and vascular plants; leaf chlorophyll content; standing water; and canopy photosynthetic function (e.g., gross primary productivity, GPP). The resulting image products characterize the spatial variability in vegetation types and carbon flux. Composite mosaics of canopy PFTs and GPP were generate for the study areas, which are currently evaluated against in situ and flux tower observations.

Plans for Next Year
We will compare our AVIRIS-derived maps with the existing aircraft and satellite data for the Barrow Peninsula, adding commercial high spatial resolution satellite imagery from ABoVE. We will use the data to examine the effects of herbivory, disturbance due to thermokarst, and wetting/drying on the present distribution of vegetation. We will also examine how our AVIRIS-derived variables in relation to broadband NDVI to better understand the ecological processes underpinning of the observed greening trend with changes in vegetation type, and carbon and energy fluxes. Where possible, we will use the BAID database for validation.

UMBC Project Number: 00011620
UMBC PI: Huemmrich, Fred
Sponsoring Agency: NASA
Project Title: Causes and consequences of arctic greening: the importance of plant functional types

Summary
This study attempts to understand how the structure and function of tundra ecosystems

respond to changes in biotic and abiotic conditions, and how these changes affect landatmosphere exchanges of carbon. We will further examine how these conditions change over time, impacting ecosystem structure and function and affecting tundra multi-year greening and browning trends. The first step in this study is to develop detailed maps of Plant Functional Types (PFT), Gross Ecosystem Production (GEP), and albedo for tundra regions within the NASA Arctic-Boreal Vulnerability Experiment (ABoVE) domain generated from Airborne Visible / Infrared Imaging Spectrometer Next Generation (AVIRIS NG) imagery from the ABoVE and National Ecological Observatory Network (NEON) flight campaigns. These AVIRIS snapshots will be linked to temporal changes by overlaying them in selected areas with high spatial resolution time series from commercial satellite and air photo imagery to examine how present distributions of PFT and productivity are related to ongoing processes, including herbivory, thermokarst, and changes in surface hydrology.

Accomplishments
Project title: Causes and consequences of arctic greening Changing climate in high northern latitudes is having profound impacts on tundra ecosystems. The goal of this study is to develop advanced remote sensing data products that can be used to address the ABoVE science questions - namely how the structure and function of tundra ecosystems respond to changes in biotic and abiotic conditions and how these changes affect land-atmosphere exchanges of carbon. The changes in vegetation composition due to climate change or alteration of surface hydrology due to thermokarst, can result in changes in photosynthetic activity and ecosystem productivity, which may not be detectable by NDVI alone. During the reporting period we implemented partial least square regression models, processing airborne AVIRIS-NG surface reflectance images over our study sites, to derive information products and map vegetation functional types, such as mosses, lichens and vascular plants; leaf chlorophyll content; standing water; and canopy photosynthetic function (e.g., gross primary productivity, GPP). The resulting image products characterize the spatial variability in vegetation types and carbon flux. Composite mosaics of canopy PFTs and GPP were generate for the study areas, which are currently evaluated against in situ and flux tower observations.

Plans for Next Year
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UMBC Project Number: 00011652
UMBC PI: Rocha Lima, Adriana
Sponsoring Agency: NASA/GSFC
Project Title: Assessment of the spatial and temporal variability of mineral dust aerosols in the Middle East and North Africa using observations and modeling

Summary
Mineral dust aerosols play an important role in a series of chemical and physical processes in

the Earth's atmospheric system. The spatial and temporal dust distributions and the total dust mass loading are key parameters for quantifying the effects of dust related processes in regional and global scales. The main goals of this study are to evaluate dust simulations distributions near dust sources in the North Africa and Middle East and to assess how they are impacted by aerosol data assimilation in the GEOS-5 Earth system model, to identify the contribution of apportioned dust sources to the total dust mass loading, and to investigate the ability of the model to simulate observed trends in dustiness. Modeling simulations already performed, including the original MERRAero aerosol reanalysis, the more recent MERRA-2 joint atmospheric and aerosol reanalysis, and the MERRA-2 Replay reanalysis performed without aerosol data assimilation. In addition to investigating dust emission and transport features in the respective simulations, we will explore the role of aerosol data assimilation in improving the accuracy of the dust representation in the model with respect to independent observations from satellite, ground-based, and in situ aircraft measurements. For that purpose, we will perform detailed target experiments where the model is sampled coincidently with relevant locations and periods where independent data sets exist. In the second part, we will implement an apportionment study of dust sources in GEOS-5 to assess the contribution and overall importance of dust sources for the dust mass loading. Finally, we will evaluate the ability of the model to represent observed trends in dustiness. The integration of models and measurements proposed in this study will improve our understanding of dust processes and the importance of different dust sources to the overall dust global budget. In addition, this study has a broad implication for air quality, and for observing simulation for forecast and future field campaigns, including transport and deposition that are important to ocean and land fertilization. Likewise, this study will contribute to the understanding of the dust lifecycle in the atmosphere and ultimately to the assessment of the importance of dust processes. These efforts address NASA strategic needs to better understand the dynamics of atmospheric composition, and how it has changed over time.

Accomplishments
During this period, we have investigated how well the current versions of the GEOS model is able to capture recent dust aerosol optical depth variability in the Middle East region. We plan to have a first version of a manuscript with results of this study by end of August 2019.

Plans for Next Year
For the next year, we plan to continue this study by testing and incorporating a dynamic vegetation index in the model.

UMBC Project Number: 00011668
UMBC PI: Bian, Huisheng
Sponsoring Agency: NASA
Project Title: The effect of atmospheric aerosols and clouds on Amazon forest productivity

Summary
The Amazon is a home for more than 34 million people and a paradise of a huge variety of plants and animals. The Amazon rainforest plays a vital role in the global ecosystem and climate change, regulating temperatures and storing vast quantities of carbon dioxide. A question we need to thus ask is: what is the limiting factor that controls plant growth over Amazonia: light or water? Considerable evidence demonstrates that sunlight indeed drives

Amazon forest growth although water deficit could be a limiting factor during severe drought seasons. Atmospheric aerosols and clouds impact solar radiation reaching plant canopy, not only in total amount but also in the ratio of direct and diffuse radiation, the latter enhancing plant light use efficiency. Yet, although presence of aerosols and clouds has a significant influence on forest productivity via their impact on radiation fields, a systematical assessment of such an influence on multi-season and multiyear scales over the Amazon basin has not yet been explored. We propose a three-year project to fill this gap by addressing the following questions: • How do atmospheric aerosols and clouds impact solar radiation and thus impact vegetation over the Amazon basin? • What is the seasonal dependence (dry, wet, and transition) of such a relationship among aerosol/cloud, radiation, temperature, soil moisture, and forest productivity? • Does natural year-to-year variation in light intensity owing to cloud cover (trend or extreme El Niño event) dominate the interannual variation of photosynthesis and carbon uptake over the Amazon? We will synergistically use various observations and the GEOS-5 AGCM model in this study. First, we will analyze various satellite products (i.e. aerosol, cloud, radiation, precipitation, NDVI, and SiF) over 1997-2017 to reveal their magnitude, trend, and correlation on monthly, seasonal (dry, wet, and transition), and annual basis. The analyses will be performed further by separating climate backgrounds of normal, El Niño, and La Niña years. Second, we will conduct a global baseline simulation with GEOS-5 for the same period. The GEOS-5 model will include a capability of coupling aerosol-cloud-radiation-vegetation processes to allow dynamic feedback of aerosol and cloud on radiation and vegetation fields. We will use observations from ground-based, aircraft, and satellite to evaluate the model focusing on the Amazon region and use the evaluated model to confirm the satellite findings obtained in step one. Third, we will conduct a series of sensitivity experiments using the GEOS-5 model by perturbing: 1) the Amazon biomass burning emission to explore a better strategy of controlling the Amazon fires from a perspective of preserving forest carbon; and 2) cloudiness to gain insight into the impact of potential future cloud change on the Amazon forest productivity. Our proposed study directly addresses the ACMAP's research themes "How does atmospheric composition respond to and affect global environmental change?" and "What trends in atmospheric composition and solar radiation are driving global climate?"

Accomplishments

This project aims to investigate how atmospheric aerosols and clouds impact solar radiation, and thus vegetation over the Amazon basin on seasonal and inter-annual scales. During the reporting period, Huisheng Bian led the team achieve the proposed objectives. The team conducted four GEOS model improvements by collaborating with scientists in both Atmospheric Chemistry and Dynamic Branch (ACDB) and Global Modeling and Assimilation Office (GMAO) to improve the aerosol and cloud simulations over Amazon. These improvements provide solid foundation to achieve the objectives proposed by this project. With the new model version (Jason2) that integrates these improvements, the team conducted a series sensitivity studies to examine new dust emission algorithm, different constrain options setup for dynamic VOC emissions from Model of Emissions of Gases and Aerosols from Nature (MEGAN) module, and the uncertainties associated with four biomass burning emissions (i.e. QFEDv2.5, GFED4s, FEERv1, and CMIP6). The team has finished the comprehensive evaluation of the model simulation for aerosol, cloud, radiation, and meteorology fields using various satellite observations and ground measurements. A new long-term simulation over 1994-2017 has been finished and the results are under analysis.

Plans for Next Year
Huisheng Bian will continually lead the project to achieve the proposed objectives in year 3. She will work with the team to analyze the model and measurement data over Amazon by conducting the study on different time frames (e.g. dry/wet season and El Nino / La Nina year). She is going to prepare a manuscript for this work.

UMBC Project Number: 00011704
UMBC PI: Nicholls, Stephen
Sponsoring Agency: MORGAN STATE UNVERSITY
Project Title: Feedbacks Between Wind-Driven Surface Fluxes and Cloud Population Evolution During MJO: A Combined Satellite and Modeling Study

Summary
The proposed study will use both the soon-to-be-launched Cyclone Global Navigation Satellite System (CYGNSS) data and a coupled atmosphere-ocean-wave model to study feedbacks between surface winds and cloud population evolution over two focused study regions: the Indian Ocean and the Maritime continent. The high-resolution, all-weather CYGNSS data allow us to address two primary research questions: 1) How much does the wind-driven surface fluxes vary amongst the MJO phases and at the two regions? 2) How do cloud-system scale wind variations (e.g., the cloud outflow, gust front, and cold pool) modify surface fluxes and mean wind? To address these questions, both the mean and diurnal statistics from CYGNSS L2 surface wind and roughness data will be compiled for different MJO phases. Surface fluxes will need to be derived by combining CYGNSS data with sea surface and air temperatures from ECMWF analysis. Cloud population distributions and their changes throughout the MJO phase cycle will be extracted from cloud top heights observed by the Global Precipitation Mission (GPM) L2 precipitation radar data. The Coupled Ocean Atmosphere Wave Sediment Transport Modeling System [COAWST], which has been successfully used in simulating the DYNAMO MJO events in our previous study, will enable us to identify physical mechanisms and corroborate hypotheses derived from satellite data analyses.

Accomplishments
Accomplishments (Oct 1, 2018 - Sept. 30, 2019) Subtask 1 – Madden-Julian Oscillation (MJO): Nicholls brings his expertise with the COAWST atmosphere-ocean regional climate model to this project. For FY2019, he worked closely with PI Xiaowen Li, to test 16 different model configurations during two strong MJO periods (Oct and December 2011) with convection-resolving capabilities (1-km grid spacing). He completed these simulations for both the equatorial Indian Ocean and for the Maritime Continent (i.e., Malaysia / Indonesia). Given its global scale and uncertain formation mechanism, accurate simulations of the MJO without data assimilation remain difficult. Simulations provided by Nicholls applying 12-hour grid nudging method were found to notably improve the accuracy of precipitation generation associated with the MJO, however as compared to TRMM, COAWST model simulations still tended to rain too much and be dominated by western propagating waves. Results from Nicholls's work were shared on PI Xiaowen Li's poster at the 99th American Meteorological Society Annual Meeting in January 2019. For the remainder of FY2019, Nicholls will incorporate two wave models (SWAN and WW3) into COAWST to determine whether model simulations could be further improved via simulating waves.

Plans for Next Year
Plans for next year (Oct 1, 2019 - Sept. 30, 2020) Subtask 1 – Madden-Julian Oscillation (MJO): Nicholls will complete all requested ocean-atmosphere-wave coupled simulations requested by PI Li and help analysis the model data. He will also help PI Li to summarize the overall project results for publication in a peer-reviewed journal.

UMBC Project Number: 00011947
UMBC PI: Herman, Jay
Sponsoring Agency: Morgan State Univ
Project Title: Using the 2017 Eclipse view from space and spectral radial from below to perfom a 3-D

Summary
The purpose of this project is to first make measurements from space (DSCOVR-EPIC) and from the ground using the Pandora Spectrometer Instrument. Second, is to help analyze the resulting data for use in a 3D radiative transfer program to test the calculations fidelity to the measurements

Accomplishments
I published two papers describing the eclipse seen from Casper Wyoming using both EPIC satellite data abd from ground-based observations.

Plans for Next Year
This project has ended

UMBC Project Number: 00012062
UMBC PI: Zhai, Pengwang
Sponsoring Agency: NASA
Project Title: Development of a consummate semi-analytical model for polarized ocean reflectance

Summary
A universal semi-analytical model for polarized ocean reflectance is proposed which would incorporate reflectance due to wide range of bottom depths, bottom albedo, refractive indices of organisms under water, particle phase function, phytoplankton varieties and sediment concentration at di↵erent solar zenith angles and wavelengths. Both polarization and inelastic scattering will be included. The major inelastic scattering mechanisms are Raman scattering, and fluorescence from chlorophyll and dissolved organic matters. The study of polarized reflectance helps to distinguish hydrosols based on their di↵erent physical morphologies (sizes and shapes) and dielectric properties (refractive index). The e↵ect of vertical distribution of IOPs in water column and the wind speed on the water leaving radiance would also be explored to interpret global ocean color measurements. This would lead to a better explanation for the ecological and biogeochemical processes of coastal and open ocean. The semi-analytical model will be validated using rigorous radiative transfer solutions to the coupled atmosphere and ocean systems. This work directly ties in with the work done by NASA under

PACE (Pre-Aerosol, Clouds, and ocean Ecosystem) mission to detect the harmful algal blooms by studying their spectral signature. Also, this model would include UV wavelengths and visible wavelengths which would help in di erentiating dissolved organic material from chlorophyll present in upper part of ocean and study the coastal areas. The proposed work will be the primary field of research of the author 's PhD. dissertation over the three years.

Accomplishments
We used the neural network method to develop an ocean reflectance model. The radiative transfer model has been used to simulate synthetic dataset, which are used to train and validate the neural network.

Plans for Next Year
We will develop the reflectance model for polarized components.

UMBC Project Number: 00012136
UMBC PI: Zhai, Pengwang
Sponsoring Agency: NASA
Project Title: Atmospheric correction for complex scenes using co-located polarimetric and ocean color observations

Summary
This study will demonstrate a viable framework for utilizing the co-located dataset from polarimeter and ocean color sensors to improve the retrieval of ocean color radiometry in complex oceanic and atmospheric conditions. More importantly, the algorithm being developed is directly applicable to NASA's future Plankton, Aerosol, Cloud, and ocean Ecosystem (PACE) mission [PACE, 2017], which plan to carry the ocean color instrument (OCI) and the multi-angle polarimeter (MAP). A primary purpose of MAP on PACE is to improve the performance of the OCI atmospheric correction for more accurate retrieval of ocean color. However, there is as yet no study that demonstrates the use of polarimeter data to improve atmospheric correction of the OCI measurement. This research will fill the gap of performing atmospheric correction using co-located polarimeter and radiometric measurements. Our algorithm development and information content analysis activities can improve the capability of water quality remote sensing by providing a better atmospheric correction algorithm for coastal and in-land waters.

Accomplishments
We have developed a remote sensing algorithm which retrieve aerosol and ocean color information simultaneously using multiangle multiple wavelength polarimeter data. We apply the retrieval algorithm to a number of field campaign datasets including both open ocean and coastal waters. The research finding has been published in Optics Express (Gao et al., 2018).

Plans for Next Year
we will apply the retrieved aerosol information to atmospheric correction to hyperspectral ocean color instrument measurements.

UMBC Project Number: 00012536

UMBC PI: Campbell, Petya
Sponsoring Agency: NASA
Project Title: Prototyping MuSLI canopy chlorophyll content for assessment of vegetation function and productivity

Summary
Imaging spectroscopy exhibits great potential for mapping foliar functional traits that are impractical or expensive to regularly measure on the ground, and are essentially impossible to characterize comprehensively across space. Knowledge of the variability in such traits – such as nitrogen concentration (%N), leaf mass per area (LMA) or pigments – is critical to understanding vegetation productivity, as well as responses to climatic variability, disturbances, pests and pathogens. Application of imaging spectroscopy algorithms to map foliar traits globally requires the development of "universal" algorithms that work across vegetation types, locations and years. Existing models that meet these requirements – such as those of Singh et al. (2015) for temperate forests – need to be tested in new regions and vegetation communities to ensure that the models are stable and transferrable, as well as to identify gaps in coverage needed to improve those models. Such testing will help ensure that relatively robust models that operate well globally within or among physiognomic types (e.g. forests) are available once a spaceborne imaging spectrometer such as HyspIRI is launched. Here we propose the application of models developed by Singh et al. (2015) and new ones in development in the Townsend Lab in support of NEON's cross-site mapping activities to the imagery collected over Indian forests as part of the 2015-2016 joint NASA-ISRO AVIRIS-NG campaign in India. We will partner with Dr. N.S.R. Krishnayya at The Maharaja Sayajirao (M.S.) University of Baroda, who collected foliar samples for validation at three of the forest sites imaged during the AVIRIS-NG campaign. We will collect additional foliar samples in ~January 2018 (approximately 2-year anniversary of the original acquisition) at two other sites for further evaluation. These forests sites fall along a series of climatic (rainfall) and geologic gradients. We will use the results of our functional trait mapping to assess how forests across these regions vary functionally with well-characterized environmental gradients.

Accomplishments
Project title: Prototyping MuSLI Canopy Chlorophyll Mid-resolution Product There is a critical need for temporally dense remote sensing time series to accurately monitor the key parameters governing vegetation function, map them at a temporal scale relevant to their dynamics, and at a spatial scale that allows practical assessment and management of their impacts on hydrological and biological cycles. Leaf chlorophyll content, is arguably the most important photosynthetic indicator of vegetation function and physiological condition. The goals of this project are to produce consistent medium resolution Chl product prototypes and robust algorithms that can reliably be scaled to regional and continental scales. During the reporting period we assembled the available from 2015-current leaf and canopy Chl, and other field data. We collected Chl, and spectral leaf and canopy measurements at key crop growth stages at both OPE3 and SERC sites. At the sites there are also routinely collected additional pigment measurements, canopy LAI and yield estimates, which will be available for the research. We collected field data in the crop sites at each growth stage, and in the SERC and other Forest areas during each growing season. Leaf Chlorophyll (Chlleaf, µg cm-2) was measured using standardized protocols routinely used by the team and pigments were extracted in dimethylformamide, identifed spectro-photometrically, and calculated according to Wellburn (1994). Fresh sample weight (FW, g) and dry sample weight (DW, g) were

determined, relative water content (RWC) in foliage (%) and specific leaf area (SLA: the ratio of the leaf area [cm2] to DW) were also calculated. Laboratory measurements leaf optical reflectance (R) and transmittance (T) were collected using an integrating sphere (Li-Cor Model 1800) outfitted with a halogen light source supporting 350- 2500 nm measurements (Sphere Optics Inc., Durham, NH USA) and coupled to an ASD field spectrometer.

Plans for Next Year
All field canopy and leaf spectral data will be assembled and stored in a MySQL (Structured Query Language) open source relational database implemented for the use in the algorithm development with satellite and field data within the Automated Radiative Transfer Models Operator (ARTMO) Graphic User Interface (GUI). We will develop and test algorithms by study site, to optimize (reduce errors) their performance across the growing season. The key factors effecting canopy reflectance VIs, and potential sources of prediction errors, include variations in canopy density, soil background and Chl, which all change with phenology. We will train the algorithms to perform across a phenology gradient arises, and add new collections of training datasets if the training data is not fully representative of the period. During the next year we will generate robust workflows and produce high density time series for representative vegetation covers. We will develop algorithms for Chl for monitoring and mapping of the seasonal dynamics in vegetation function, to enhance the detection of vegetation stress. We will evaluate the importance of using a consistent correction of the data for canopy structural and topographic effects, for obtaining improved Chl estimates and understanding of vegetation dynamics for both crop and forested ecosystems. The research will quantify the impact on VIs, algorithms and Chl of suboptimal vegetation function caused by acid rain damage and dynamic environmental perturbations.

UMBC Project Number: 00012536
UMBC PI: Campbell, Petya
Sponsoring Agency: NASA
Project Title: Prototyping MuSLI canopy chlorophyll content for assessment of vegetation function and productivity

Summary
Imaging spectroscopy exhibits great potential for mapping foliar functional traits that are impractical or expensive to regularly measure on the ground, and are essentially impossible to characterize comprehensively across space. Knowledge of the variability in such traits – such as nitrogen concentration (%N), leaf mass per area (LMA) or pigments – is critical to understanding vegetation productivity, as well as responses to climatic variability, disturbances, pests and pathogens. Application of imaging spectroscopy algorithms to map foliar traits globally requires the development of “universal” algorithms that work across vegetation types, locations and years. Existing models that meet these requirements – such as those of Singh et al. (2015) for temperate forests – need to be tested in new regions and vegetation communities to ensure that the models are stable and transferrable, as well as to identify gaps in coverage needed to improve those models. Such testing will help ensure that relatively robust models that operate well globally within or among physiognomic types (e.g. forests) are available once a spaceborne imaging spectrometer such as HyspIRI is launched. Here we propose the application of models developed by Singh et al. (2015) and new ones in development in the Townsend Lab in support of NEON’s cross-site mapping activities to the

imagery collected over Indian forests as part of the 2015-2016 joint NASA-ISRO AVIRIS-NG campaign in India. We will partner with Dr. N.S.R. Krishnayya at The Maharaja Sayajirao (M.S.) University of Baroda, who collected foliar samples for validation at three of the forest sites imaged during the AVIRIS-NG campaign. We will collect additional foliar samples in ~January 2018 (approximately 2-year anniversary of the original acquisition) at two other sites for further evaluation. These forests sites fall along a series of climatic (rainfall) and geologic gradients. We will use the results of our functional trait mapping to assess how forests across these regions vary functionally with well-characterized environmental gradients.

Accomplishments

Project title: Prototyping MuSLI Canopy Chlorophyll Mid-resolution Product There is a critical need for temporally dense remote sensing time series to accurately monitor the key parameters governing vegetation function, map them at a temporal scale relevant to their dynamics, and at a spatial scale that allows practical assessment and management of their impacts on hydrological and biological cycles. Leaf chlorophyll content, is arguably the most important photosynthetic indicator of vegetation function and physiological condition. The goals of this project are to produce consistent medium resolution Chl product prototypes and robust algorithms that can reliably be scaled to regional and continental scales. During the reporting period we assembled the available from 2015-current leaf and canopy Chl, and other field data. We collected Chl, and spectral leaf and canopy measurements at key crop growth stages at both OPE3 and SERC sites. At the sites there are also routinely collected additional pigment measurements, canopy LAI and yield estimates, which will be available for the research. We collected field data in the crop sites at each growth stage, and in the SERC and other Forest areas during each growing season. Leaf Chlorophyll (Chlleaf, µg cm-2) was measured using standardized protocols routinely used by the team and pigments were extracted in dimethylformamide, identifed spectro-photometrically, and calculated according to Wellburn (1994). Fresh sample weight (FW, g) and dry sample weight (DW, g) were determined, relative water content (RWC) in foliage (%) and specific leaf area (SLA: the ratio of the leaf area [cm2] to DW) were also calculated. Laboratory measurements leaf optical reflectance (R) and transmittance (T) were collected using an integrating sphere (Li-Cor Model 1800) outfitted with a halogen light source supporting 350- 2500 nm measurements (Sphere Optics Inc., Durham, NH USA) and coupled to an ASD field spectrometer.

Plans for Next Year

All field canopy and leaf spectral data will be assembled and stored in a MySQL (Structured Query Language) open source relational database implemented for the use in the algorithm development with satellite and field data within the Automated Radiative Transfer Models Operator (ARTMO) Graphic User Interface (GUI). We will develop and test algorithms by study site, to optimize (reduce errors) their performance across the growing season. The key factors effecting canopy reflectance VIs, and potential sources of prediction errors, include variations in canopy density, soil background and Chl, which all change with phenology. We will train the algorithms to perform across a phenology gradient arises, and add new collections of training datasets if the training data is not fully representative of the period. During the next year we will generate robust workflows and produce high density time series for representative vegetation covers. We will develop algorithms for Chl for monitoring and mapping of the seasonal dynamics in vegetation function, to enhance the detection of vegetation stress. We will evaluate the importance of using a consistent correction of the data for canopy structural and topographic effects, for obtaining improved Chl estimates and

understanding of vegetation dynamics for both crop and forested ecosystems. The research will quantify the impact on VIs, algorithms and Chl of suboptimal vegetation function caused by acid rain damage and dynamic environmental perturbations.

UMBC Project Number: 00012729
UMBC PI: Zhai, Pengwang
Sponsoring Agency: Science Systems & Application, Inc.
Project Title: Optical Properties of Particulates in the Ocean and An Innovative Atmospheric Correction Method Task

Summary
This task shall continue to support the ongoing studies of optical properties of particulates in the ocean.Specifically, to show the improvement of coupled ocean-atmospheric polarized radiative transfer model,and to reveal the relations among passive ocean color measurements, lidar measurements, particulate organic carbon, phytoplankton carbon. The subcontractor shall continue to support efforts to demonstrate an innovative aerosol correction method. Data analyses approaches are to be demonstrated and documented. Analysis and interpretations of science data are to be documented and/or presented to the Technical Point of Contact (TPOC) and the results of studies, investigations, and modeling activities delivered within the agreed upon schedule

Accomplishments
We studied nonphotochemical quenching process to the chlorophyll fluorescence simulation in our radiative transfer model. The research has been published in Remote Sensing (Zhai et al. 2018).

Plans for Next Year
This task has been ended.

UMBC Project Number: 00012963
UMBC PI: Zhai, Pengwang
Sponsoring Agency: Science Systems & Application, Inc.
Project Title: Optical Properties of Particulates in the Ocean and An Innovative Atmospheric Correction Method Task

Summary
This task shall continue to support the ongoing studies of optical properties of particulates in the ocean.Specifically, to show the improvement of coupled ocean-atmospheric polarized radiative transfer model,and to reveal the relations among passive ocean color measurements, lidar measurements, particulate organic carbon, phytoplankton carbon. The subcontractor shall continue to support efforts to demonstrate an innovative aerosol correction method. Data analyses approaches are to be demonstrated and documented. Analysis and interpretations of science data are to be documented and/or presented to the Technical Point of Contact (TPOC) and the results of studies, investigations, and modeling activities delivered within the agreed upon schedule

Accomplishments
We tested a hybrid atmospheric correction algorithm for polarimeter and spectrometer. The atmospheric correction algorithm can use the aerosol microphysical properties from polarimeter and determine the atmospheric path radiance of spectrometers. The algorithm works better for coastal waters.

Plans for Next Year
Project is ended.

UMBC Project Number: 00012967
UMBC PI: Delgado, Ruben
Sponsoring Agency: Science Systems & Application, Inc.
Project Title: Mixing Layer Height Algorithm for Environmental Protection Agency Photochemical Assessment Monitoring Sites

Summary
The UMBC Atmospheric Lidar Group will develop an algorithm to retrieve MLH for ceilometers and/or lidars. The MLH determination will be based on the evaluation of aerosol backscatter profiles collected. Data collected will be evaluated with Second Derivative, Covariance Wavelet Transform, and Cluster Analysis mathematical expressions to determine the MLH based in the sharp change in the aerosol gradient within the profiles collected. As part of the algorithm development and its subsequent validation, EPA will provide UMBC's Atmospheric Lidar Group datasets collected or instruments (ceilometers or lidars) considered for Photochemical Assessment Monitoring Sites for a period of two months, so that collocated measurements between the ceilometers and UMBC's Micropulse Lidar can be carried out at the UMBC campus. During this time, the fate and evolution of the MLH will be examined under various weather conditions, to validate the algorithms for estimation of MLH. The algorithm development will also allow the evaluation of MLH retrieved from software included within the operating system of commercial ceilometers/lidars. MLH will be validated with heights obtained from analysis of potential temperature profiles obtained from radiosondes launches carried out at UMBC.

Accomplishments
The determination of the mixing-layer height (MLH) is vital in air pollution studies as it determines the extent of vertical mixing of pollutants. While this is a key parameter in air pollution modeling and air quality studies, continuous monitoring of the MLH is rarely available. For this reason, the United States Environmental Protection Agency (EPA) will require state and local air quality agencies to measure continuous MLHs at national Photochemical Monitoring Assessment Stations (PAMS) through the deployment of various remote sensing instrumentation. This creates a need for tools, methodologies, and standards that can accurately determine the height of the mixing-layer. A first step in this effort is to develop and evaluate a common MLH retrieval algorithm that can be implemented across a heterogeneous network consisting of varying ceilometer/lidars. The UMBC Atmospheric Lidar Group is developing an algorithm to retrieve MLH for ceilometers/lidars. The MLH determination will be based on the evaluation of aerosol backscatter profiles collected. As part of this project the performance of several commercial ceilometers were evaluated. Monthly reports were provided to the US Environmental Protection Agency discussing ceilometer

signal evaluation: determination of signal-to-noise ratios, reduction of artifacts, overlap correction and software limitations.

Plans for Next Year
Deliverables for this project were migrated to PN CORP0013 when the funding was renewed last year. UMBC will continue the development of common MLH algorithm and move toward a prototype data base development and web interface for an heterogeneous (lidar/ceilometer) aerosol profiling network.

UMBC Project Number: 00013106
UMBC PI: Guimond, Stephen
Sponsoring Agency: Los Alamos National Laboratory
Project Title: The dynamics of turbulent buoyant plumes

Summary
Summary: The goal of this project is to develop an understanding of turbulent buoyant plume dynamics and the response of the atmosphere to large heat sources. The knowledge gained will be used to guide defense applications where plume behavior and predictability are important. Numerical simulations of one or more plumes with various background flow conditions and stratifications will be conducted primarily with the WRF (a finite difference/finite volume model) and NUMA (a spectral element model) models with comparisons to HIGRAD (a finite difference/finite volume model) where appropriate. These simulations will be run at grid spacings capable of resolving turbulence and entrainment processes (e.g. 10 - 50 m) with various domain sizes. Output from the simulations will be used in various analyses and budget calculations to understand the dynamics and predictability of the plumes.

Accomplishments
Completed several GEOS-5 numerical simulations of the climate response to nuclear weapon induced black carbon perturbations. One simulation at 2.0 degree resolution and one at 0.25 resolution. Performed analysis with the simulation output to uncover the regional and global short-term climate response. Compiled a presentation of the results and gave a talk to NASA GMAO and sent presentation to DOE sponsor.

Plans for Next Year
No plans for next year since the funding was cut. I am currently a Co-I on an internal LANL/DOE proposal that would fund this work more, but outcome is uncertain.

UMBC Project Number: 00013132
UMBC PI: Delgado, Ruben
Sponsoring Agency: MD Dept of the Environment
Project Title: The UMBC Monitoring of Atmospheric Pollution: Tropospheric Profiling of Aerosol and Gases in Baltimore-Washington Metropolitan Area for Air Quality Applications

Summary
SSAI will provide the labor support needed to setup TROPOZ at UMBC and LMOL at Hart-

Miller Island, or some other mutually agreeable location, to enable measurements during the campaign. SSAI will operate the LMOL and TROPOZ systems for at least 10 intensive days within June 6 to July 6, 2018 OWLETS science window at a minimum of 6 hours per day. Some days may have longer or shorter data collection times based on mutually agreeable schedule changes. The operating schedule will primarily be determined by OWLETS science team teleconferences during the campaign with decisions occurring on a day-today basis for intensive observation periods depending on forecasted meteorology and air quality conditions.

SSAI will carry out preliminary data processing of lidar ozone profiles (and surface O3) on a quick-look basis and will be transmitted to JCET/MDE no later than the following day of the measurement. Standard quality-assured profile data in H5 format following standard NASA archive practices and procedures will be supplied to JCET/MDE before the end of the period of performance. SSAI will support the removal of equipment from the study area when the campaign is complete. As time and resources permit, SSAI will conduct investigative studies of the data collected and publish and present significant findings in collaboration with other OWLETS investigators. The GSFC/SSAI personnel will support ozone-sonde launches at UMBC with prelaunch/conditioning procedures, day of flight, and QC/QA of the UMBC-based sonde launches.

Accomplishments

Analysis of remote sensing measurements during Ozone Water Land Environmental Transition Study: Enhanced Monitoring of Atmospheric Pollution of the Chesapeake Bay Using Vertical Profiles of Ozone, Wind, Temperature and Aerosols (OWLETS) took place in this reporting period. OWLETS analysis revealed a correlation of bay-breeze dynamics and late-afternoon ozone chemistry from measurements taken at the Hart Miller Island in the Chesapeake Bay. Quicklooks and data from UMBC remote sensing measurements are available in the NASA OWLETS data portal (https://www-air.larc.nasa.gov/cgi-bin/ArcView/owlets.2018). In addition, measurements revealed a contribution of Maryland Eastern Shore agricultural and poultry industry to the ammonia budget in the Chesapeake Bay. These measurements are aiding to address these fundamental research questions: 1-What is the spatial and vertical extent of the ozone (and ozone precursors) in and around the Chesapeake Bay? 2-What are the mechanisms (chemistry or dynamics) that produce high ozone over the Chesapeake Bay and lead to high ozone in surrounding locations? 3-How much of the ozone (ozone precursors) is a result of local sources (EGUs, mobile, ship, boat, etc) and/or pollutant transport (westerly, nocturnal low level jet) into Maryland? 4-Why do the photochemical models appear to over-predict ozone concentrations in and around the Chesapeake Bay? 5-What source groups and locations do policy makers need to focus on to reduce ozone over in the Chesapeake Bay?

Plans for Next Year

Lidar measurements will continue to support federal and state air quality management agencies. Publication of peer reviewed articles will carried out and provided to Maryland Department of the Environment stakeholders direct policy decisions towards fair and equitable emission control strategies.

UMBC Project Number: CORP0013
UMBC PI: Delgado, Ruben
Sponsoring Agency: Science Systems & Application, Inc.

Project Title: Mixing Layer Height Algorithm for Environmental Protection Agency Photochemical Assessment Monitoring Sites

Summary
The UMBC Atmospheric Lidar Group will develop an algorithm to retrieve MLH for ceilometers and/or lidars. The MLH determination will be based on the evaluation of aerosol backscatter profiles collected. Data collected will be evaluated with Second Derivative, Covariance Wavelet Transform, and Cluster Analysis mathematical expressions to determine the MLH based in the sharp change in the aerosol gradient within the profiles collected. As part of the algorithm development and its subsequent validation, EPA will provide UMBC's Atmospheric Lidar Group datasets collected or instruments (ceilometers or lidars) considered for Photochemical Assessment Monitoring Sites for a period of two months, so that collocated measurements between the ceilometers and UMBC's Micropulse Lidar can be carried out at the UMBC campus. During this time, the fate and evolution of the MLH will be examined under various weather conditions, to validate the algorithms for estimation of MLH. The algorithm development will also allow the evaluation of MLH retrieved from software included within the operating system of commercial ceilometers/lidars. MLH will be validated with heights obtained from analysis of potential temperature profiles obtained from radiosondes launches carried out at UMBC.

Accomplishments
A mixing layer height (MLH) algorithm is being developed to be implemented across a heterogeneous profiling network consisting of lidars/ceilometers and radar wind profilers. The MLH determination is based on the evaluation of aerosol backscatter profiles collected with this instrumentation. The retrieval algorithm addresses the areas listed below for continuous operation: 1. Signal corrections (noise, artifacts, overlap, etc.). 2. Continuation parameters for layer attribution. 3. Time-tracking height limitations to reduce misidentification of aerosol layers during transition times. 4. Cloud identification independent of commercial cloud retrievals. 5. Range of Haar wavelet transforms to calculate uncertainties in retrievals. 6. Cloud classification in order to include convective cloud-topped boundary layers and cloud cover information. 7. Define dilations and ranges based on uncertainties A prototype network testbed of aerosol profilers between UMBC, Howard University, US Environmental Protection Agency (EPA) and Maryland Department of the Environment (MDE) has been established. This prototype network will be a scalable demonstration in support of the EPA Photochemical Assessment Monitoring Sites program and the MDE-Enhanced Monitoring Plan (EMP) capable of hosting data from other state/local agencies profiling sites implemented under the PAMS program, as well as academic institutions. This initial network will consist of remote sensing instrumentation deployed in the state of Maryland. Lidar/ceilometer remote sensing technology will be deployed at UMBC, Howard University Beltsville Research Center, and the Essex, Edgewood and Fairhill MDE Air Quality Monitoring Sites.

Plans for Next Year
Roll out of MLH retrievals and all data collected via web interface for prototype network testbed of aerosol profilers.

UMBC Project Number: NASA0004
UMBC PI: Yuan, Tianle

Sponsoring Agency: NASA
Project Title: A Comprehensive Data Record of Marine Low-level and Deep Convective Cloud Systems Using an Object-Oriented Approach

Summary
To build a novel and science- based earth system data record of marine low-level and deep convective cloud objects and their environmental conditions. The unique elements of the record will include: 1. A cloud objective-oriented approach with the best possible characterization of the environmental conditions by integrating measurements from multiple sensors and reanalysis/observation data at the native level-2 resolution; 2. a long-term (30+ year) data record of marine low-level cloud objects with mesoscale organization classification based on a machinelearning method; 3. a long-term (10+ year) data record of deep convective cloud objects based on a detect-and-spread method; 4. an intensive observation period (IOP) product using A-Train passive and active sensors that allows process level analysis and more complete characterization of cloudy scenes.

Accomplishments
We hired a programmer for the project and created a database of images and corresponding meteorology data. We created a project at a website to start working on expert labeling of these images. We also developed algorithms to extract features in an unsupervised manner.

Plans for Next Year
We will attempt to create a preliminary algorithm for the project and start to produce data.

UMBC Project Number: NASA0008
UMBC PI: Tan, Ivy
Sponsoring Agency: NASA
Project Title: Investigating the Extratropical Cloud Optical Depth Feed

Summary
examine how to implement the concept of Cloud Regimes, and specifically my group's MODIS CRs to examine the optical depth feedback of mid-latitude clouds and especially the role of decoupling in the boundary layer. She will compare observational and modeling (from Global Climate Models) results potentially using cloud radiative kernels.

Accomplishments
We used the level 3 MODIS Aqua C6 dataset in conjunction with the MODIS cloud regimes developed by Oreopoulos et al. (2016) to compute the change in cloud optical depth separately for cloud regimes containing predominately stratocumulus and cumulus clouds over a 14 year period. The changes in cloud optical depth were partitioned into changes within and in between cloud regimes. We also tried refining the cloud classifications to include Sc and Cu clouds at the pixel level by attempting to identify patterns of effective cloud fraction, cloud-top temperature and cloud phase from AIRS level 2 Standard and Support data collocated with 2B-CLDCLASS-LIDAR and 2B-GEOPROF-LIDAR profiles. From August to September, the plan is to try another new product, CASCCAD, to isolate Sc and Cu clouds for our calculation. The PI will present the results in the CFMIP meeting in Mykonos, Greece in late September/early October.

Plans for Next Year
We plan to continue to refine the classification of clouds into Sc and Cu clouds using the cloud regimes as a guide and compare the results of using different products from various satellite instruments. Then, we will use cloud kernels to estimate a value for the cloud optical depth feedback.

UMBC Project Number: NASA0018
UMBC PI: Huemmrich, Fred
Sponsoring Agency: NASA
Project Title: Clarifying linkages between canopy solar induced fluorescence (SIF) and physiological function for high latitude vegetation

Summary
Remote sensing of Solar-Induced Fluorescence (SIF) is a growing and dynamic research field that has the potential to provide innovative tools for monitoring plant status and photosynthetic function and transform global carbon cycle research, especially for large and understudied regions like the ABoVE domain. Utilizing SIF to its full extent requires an understanding of the relationship between SIF and the photosynthetic function of the vegetation present, and how these vary with lant type and environmental conditions. High latitudes have been under-represented in SIF studies to date, but arctic and boreal plants are particularly interesting as they have photosynthetic properties and environmental responses that appear to be different to those described from better-studied temperate vegetation. We will examine the relationship between SIF and vegetation photosynthetic capacity from the plot to landscape level at multiple locations within the ABoVE domain. measurements will include multi-temporal sampling of leaf and canopy chlorophyll fluorescence (ChlF) and photosynthesis for a range of plant communities, plant functional types, and species present along environmental gradients and in experimental manipulations at each location. Higher temporal frequency measurements will be made using automated sensors at select locations and subsampling will focus on quantifying spatiotemporal heterogeneity in SIF emissions. Relationships of red and far red ChlF (and spectral reflectance) with plant biophysical status derived from the field studies will be established and scaled up using both empirical approaches and physically-based modeling to provide the critical information linking canopy SIF and photosynthetic function needed for interpreting satellite SIF data for high latitude ecosystems. The satellite data record will be used to examine the spatial and temporal variability of high latitude ecosystem function and carbon uptake across the ABoVE domain.

Accomplishments
Project title: Clarifying linkages between canopy solar induced fluorescence (SIF) and physiological function for high latitude vegetation Our goals with this project are to determine in-situ the relationships between SIF and vegetation photosynthetic capacity under different illumination conditions, temperature and moisture, and scale them to the plot/canopy, landscape and satellite level at multiple locations within the ABoVE domain. The project was initiated and the milestones and tasks defined. To ensure the collection of time series of consistent measurements during the project we fully characterized the spectral instruments (FloX box) to be used for reflectance and solar induced fluorescence (SIF) measurements, and calibrated their output signals to provide similar readings for vegetation, bright and dark

targets. In preparation for filed measurements in Alaska we have obtained samples from four representative tundra vegetation types and during the next month would test the instrumentation, optimize the experimental setups and prepare for filed deployment in 2020. The tundra contains mosses and lichens which are very different from green plants, so it is important to characterize in a similar way the 3 major functional groups. We will measure in-situ SIF spectra, collect simultaneous gas exchange and ChlF measurements, and obtain preliminary diurnal Flux measurements, Moni-PAM and FLoX. Canopy reflectance and solar induced fluorescence (SIF) will be measured using two FLoX (Dual FLuorescence bOX; JB Hyperspectral Devices, Inc.; Düsseldorf, Germany) systems. The data will be processed using an open source software (Julitta et al. 2017), facilitating consistent signal retrievals and inter-comparison with other FLoX measurements. SIF will be derived using both the Franhofer Line Depth (iFLD) and the Spectral Fitting Methods (SFM, Cogliatti et al, 2015) and the results will be compared.

Plans for Next Year

During 2020 at selected well characterized and instrumented with FLUX towers areas, representative of major functional types we will conduct field measurements and process the data following the workflow below. Using a portable photosynthesis system with a bryophyte holder option, outfitted with a fluorimeter chamber (Li6400XT, LI-COR BIOSCIENCES, Inc.) we will collect in-situ simultaneous gas exchange and ChlF measurements, including dark and light adapted fluorescence maximum, minimum and steady state (e.g. : Photosynthesis, Fm, Fo, F'm, F'o, and Fs). We will collect light response curves to characterize the relationship between photosynthetic and ChlF responses to increasing absorbed light for lichens, mosses and vascular plants, under ambient CO2 and optimal temperature and moisture availability. These relationships will be used to characterize the light use efficiency of the plants and parameterize the photosynthesis module of SCOPE. These relationships will be evaluated under the natural ranges in temperature and moisture availability at the sites, comparing the diurnal cycles in Photosynthesis, photosynthetic and fluorescence efficiencies, ETR and ΦPSII by collecting continuously diurnal measurements using portable photosynthesis systems with fluorimeters (LI-COR) and extrapolated to various locations with different moisture availability, using an automated MONITORING-PAM (Waltz, Effeltrich Germany) Fluorometer for Long-term Monitoring of Photosynthesis system outfitted with 7 emitter-detector probes measuring modulated chlorophyll fluorescence and performing saturation pulse analysis. The chlorophyll fluorometer MONITORING-PAM is designed for unattended, long-term and multi-site monitoring of chlorophyll fluorescence. Only few such measurements have been conducted long term on moss and lichens, most recently in the arctic. We will use top of canopy (TOC) reflectance measurements from FLoX with the RTMo module of SCOPE to derive the canopy structural parameters, for calibrating the SCOPE model. TOC reflectance will be collected at each site continuously during the day from ~3 m above the canopy with FloX, and seasonally for the study areas by the NASA/AVIRIS NG airborne campaigns. The derived with RTMo canopy structural parameters, together with the Fluspect photosynthetic and fluorescence efficiencies (e.g. fqe1 and fqe2 for PSI and PSII, and the SIF spectra) will be used to calibrate SCOPE for tundra vegetation species and plant functional groups.

UMBC Project Number: NASA0018
UMBC PI: Huemmrich, Fred

Sponsoring Agency: NASA
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II. Supplemental Information

A. Departmental Affiliations

Chemistry	**Computer Science & Electrical Engineering**	**Geography & Environmental Systems**	**Mathematics & Statistics**	**Physics**
St. Claire, J. Wolfe, G.	Hoban, S. **Information Systems** *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. Hoban, S. *Martins, V. Olson, W. Remer, L. Varnai, T. *Zhai, P. *Zhang, Z.

* Tenured or Tenure-track Faculty

B. Courses Taught

Fall 2018	**Spring 2019**
GES 301; Arctic geography **Huemmrich** (3 credits) GES 311: Weather & Climate, **Mehta** (3 credits) PHYS 650: Atmospheric Chemistry **Reem, St. Claire, Wolffe** (3 credits)	GES 481/681: Digital Image Processing, **Remer** (3 credits) PHYS 335: Physics and Chemistry of the Atmosphere, **Delgado/de Souza-Machado** (3 credits) PHYS 440/640: Computational Physics **Tangborn** (3 credits) PHYS 622: Cloud Physics, **Demoz** (3 credits) PHYS 650: JCET Seminar: Data Assimilation, Biswah, **Tangborn** (1 credit) SOCY 101Y: Basic Concepts in Sociology, **Evans** (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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Barajas, C., Guo, P., Mukherjee, L., **Hoban**, S. M., **Wang**, J., Jin, Daeho, Gangopadhyay, A., Gobbert, M. K. (2018). Benchmarking Parallel Implementations of K-Means Cloud Type Clustering from Satellite Data. *2018 BenchCouncil International Symposium on Benchmarking, Measuring and Optimizing (Bench 18)*.

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Carroll, B., **Demoz**, B. B., Bonin, T., **Delgado**, R. (2018). Mixed layer depths via Doppler lidar during low-level jet events. *EPJ Web of Conferences, 176*, 06017. http://dx.doi.org/10.1051/epjconf/201817606017

Chong, H., Lee, H., Koo, J.-H., Kim, J., Jeong, U., Kim, W., Kims, S.-W., **Herman**, J. R., **Abuhassan**, N., Ahn, J.-Y., Park, J.-H., Kim, S.-K., Moon, K.-J., Choi, W.-J., Park, S. S. (2018). Regional Characteristics of NO2 Column Densities from Pandora Observations during the MAPS-Seoul Campaign. *AEROSOL AND AIR QUALITY RESEARCH, 18*(9), 2207-2219.

Ciufolini, I., Paolozzi, A., **Pavlis**, E. C., Matzner, R., Koenig, R., Ries, J., Sindoni, G., Paris, C., Gurzadyan, V. (2019). Tests of General Relativity with the LARES Satellites. In D. Puetzfeld and C.

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D. Proposals & Status

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
CISESS: Conducting research to develop, improve, and evaluate dust emissions algorithms used in NOAAs atmospheric models.	UMD CP	Baker, Barry		Awarded
NOAA: Cooperative Institute for Satellite Earth System Studies (CISESS)	UMD CP	Demoz, Belay		Awarded
Tropospheric Emissions, Monitoring of Pollution (TEMPO)	Smithsonian	Herman, Jay		Awarded
Clarifying linkages between canopy solar induced fluorescence (SIF) and physiological function for high latitude vegetation	NASA	Huemmrich, K. Fred		Selected
Development of a consummate semi-analytical model for polarized ocean reflectance	NASA	Zhai, Pengwang		Selected
Investigate the Radiative and Microphysical Effects of Above-cloud Dust Aerosols in North-East Atlantic	NASA	Zhang, Zhibo		Selected
Neutral Atom Distributions beyond the Heliopause from IBEX-Lo Observations	NASA	Park, Jeewoo		Invited
Next Generation UAV Spectral Systems and Analytics for Monitoring the Dynamics in Vegetation Function	NASA	Campbell, Petya		Submitted
Collaborative Research: Inter-Hemispheric Transports of Ozone and Smoke across the Equatorial Atlantic Ocean.	NSF	Demoz, Belay		Submitted
UMBC Center for Atmospheric Research and Education Solutions (UMBC-CARES)	NASA	Demoz, Belay B		Submitted
Thermodynamic profiles and cloud parameters retrieved from allsky AIRS single footprint radiances	NASA	De Souza Machado, Sergio G.		Submitted

Terrestrial Ecology Products from PACE	NASA	Huemmrich, K. Fred		Submitted
Intermediate-Mass-Ratio Black Hole Mergers in the LISA Era	NASA	Kelly, Bernard J		Submitted
Hybrid Fluid-Kinetic Model of the Processes in the Moon's Plasma Environment	NASA	Lipatov, Alexander S		Submitted
Measurement of Microphysical, Optical Properties, and Chemical Composition of Volcanic ash in Support of Remote Sensing and Modeling for Earth and Planetary Applications	NASA	Martins, J. Vanderlei		Submitted
The 3D Cloud Scanning System for Cloud Microphysics and Aerosol Measurements	NASA	Martins, J. Vanderlei		Submitted
Understanding and modeling magnetospheric boundaries as a function of solar wind and geomagnetic conditions and their history	NASA	Merka, Jan		Submitted
How do solar wind structure impact angles control the spatiotemporal evolution of magnetospheric plasma populations?	NASA	Oliveira, Denny		Submitted
Airborne In Situ Validation of TROPOMI HCHO	NASA	St Clair, Jason		Submitted
The “rest” is NOT noise: Feasibility of estimating atmospheric water vapor from repeat-pass InSAR using data assimilation techniques	NASA	Tangborn, Andrew		Submitted
High Volume Disdrometer	Radiation Monitoring Devices, Inc.	Tokay, Ali		Submitted
Magnetometric remote sensing of ocean heat content and transport	NASA	Tyler, Robert		Submitted
Considering heterogeneity in satellite measurements of cloud optical properties	NASA	Varnai, Tamas		Submitted
Mapping the Global Variability of Tropospheric Oxidizing Capacity	NOAA	Wolfe, Glenn		Submitted

Retrieval of Aerosol Vertical Distributions with Measurements from O2 A/B Bands and Polarimetric Data from Blue Bands: Algorithm Development and Synergistic Analysis	NASA	Xu, Xiaoguang		Submitted
Create a Customizable Expert-Machine Hybrid Deep Learning Pipeline for Efficient NASA Data Exploration and Discovery	NASA	Yuan, Tianle		Submitted
An advanced radiative transfer testbed for aerosol, cloud, and ocean color remote sensing algorithms	NASA	Zhai, Pengwang		Submitted
Information Content Analysis on Hydrosol Property Retrieval using Hyperspectral Images	NASA	Zhai, Pengwang		Submitted
A Study of the Three-Dimensional Radiative Effects on Multiangular Polarimetric Retrievals of Cloud Microphysics and Above-Cloud Aerosol Optical Thickness	NASA	Zhang, Zhibo		Submitted
Characterizing the Variation and Covariation of Cloud Microphysical Properties and Implications for Simulation of Subgrid-scale Warm-Rain Processes in Earth System Models	DOE	Zhang, Zhibo		Submitted
Application of SMAP Soil Moisture and Freeze/Thaw State in Understanding and Predicting Dzud Events in Middle and High Latitude Drylands	CCNY		Metha, Amita	Submitted
Remote sensing of cloud properties using PACE SPEXone and HARP	Columbia University		Zhang, Zhibo	Submitted
Aerosol layer height retrieval: enriching PACE aerosol products for air quality and public health applications	University of Iowa		Xu, Xiaoguang	Submitted
Accurate Retrieval of Absorbing Aerosols Over Turbid Waters	JPL		Xu, Xiaoguang	Submitted
Chrisp Compact VNIR/SWIR Imaging Spectrometer Development	MIT Lincoln		Turpie, Kevin	Submitted

Validation of GPM Precipitation Retrieval Algorithms across the Precipitation Continuum	NASA MSFC		Tokay, Ali	Submitted
Laser Transmitter System for Ground-to-Space Laser Calibration of Spaceborne Radiometric Sensors	NASA		Martins, Vanderlei	Submitted
Real-time Observations of the Three-Dimensional Hurricane Boundary Layer Winds and Ocean Surface Vector Winds with an Imaging Airborne Profiler	NOAA		Guimond, Steve	Submitted
A versatile payload system for multi-sensor integration on 6U satellites	Radiation Monitoring Devices, Inc.		Martins, Vanderlei	Submitted
Radiative transfer support for simulating the TOA reflectance with different white cap reflectance spectra	University of Connecticut		Zhai, Pengwang	Submitted
Rapid Intensification in Tropical Cyclones	NRL	Guimond, Steve		Declined
Characterizing ice clouds using EPIC observations of sun glint	NASA	Varnai, Tamas		Declined

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. His is mainly interested in integrating the multiple instruments and their physics in understanding atmospheric dynamics to improve now casting and climate.

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.

Susan Hoban, Senior Research Scientist and Associate Director for Academics
Ph D, University of Maryland (1989)

Dr. Susan Hoban worked with NASA for over two decades, first as a scientist studying comets and the interstellar medium, then as a STEM Educator. Dr. Hoban's research interests include the formation and evolution of comets, the effectiveness of various pedagogical models on teacher preparation and student outcomes, and comparisons among aerosols in the Earth's atmosphere, refractory material in the Solar System and dust in the Universe. Dr. Hoban is also interested in using analytics for cybersecurity.

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.

Stephen Nicholls, Post-doctoral Research Associate
Ph D, Rutgers University

Dr. Nicholls has extensive expertise with ocean and atmosphere numerical prediction models, proficient in multiple scientific programming languages, and experienced with analyzing large space-based and in-situ datasets in the GIS environment. Models used and adapted for weather and regional climate modeling include the Weather Research and Forecasting (WRF) model, Regional Ocean Modelling System (ROMS), the Coupled-Ocean-Atmosphere-Wave-Sedimentation Transport (COAWST) modeling system, and Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) Model. Programming languages applied in his research include Python, Matlab, IDL, FORTRAN, BASH and C-shell.

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, Post-Doctoral Research Associate
Ph D, University of Maryland, Baltimore County (2015)

Adriana Rocha Lima is working in the Atmospheric Chemistry and Dynamics Laboratory in NASA Goddard since 2015. Dr. Rocha-Lima has conducted laboratory experiments to characterize optical and microphysical properties of different types of aerosol particles, including mineral dust and volcanic ashes. Currently, Dr. Rocha-Lima is performing simulations of aerosol distributions using the Goddard Earth Observing System Model (GEOS-5). Her goal is to improve the representation of aerosol optical

properties 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 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

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, Assistant Professor
Ph D, Texas A&M University.
Dr. Zhang studies the satellite-based remote sensing of ice clouds. In Jan. 2009 he joined the Goddard Earth Sciences and Technology Center at UMBC, where he worked with the MODIS cloud science team led by Dr. Steven Platnick on the development of infrared cloud property retrieval algorithm. In 2011, he joined JCET as a Research Associate, he was then appointed to Assistant Professor with UMBC’s Physics Department and became a Fellow with JCET.

F. Acronyms

Acronym	Description
ABoVE	ArcticBoreal Vulnerability Experiment
ACCLIP	Asian Summer Monsoon Chemical and Climate Impact Project
ACS	American Chemical Society
ADAPT	Advanced Data Analytics Platform
ADDA	Amsterdam Discrete Dipole Approximation
AEROSE	Aerosols and Ocean Science Expeditions
AGU	American Geophysical Union
AOD	Aerosol Optical Depth
ARM	Atmospheric Radiation Measurement
ARSET	Applied Remote Sensing Training
ASL	Atmospheric Spectroscopy Laboratory
ASOS	Automated Surface Observing System
ASG	Aquatic Studies Group
Atom	Atmospheric Tomography
AVHRR	Advanced Very High Resolution Radiometer
AVIRIS NG	Airborne Visible InfaRed Imaging Spectrometer Next Generation
AWRA	American Water Resources Association
BRF	Bi-directional Reflectance
BARC	Beltsville Agricultural Research Center
CAFE	Compact Airborne Formaldehyde 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)
CBZ	Convergent Boundary Zones
CCST	California Council on Science and Technology
CH4	Methane
CHIRP	Climate Hyperspectral InfraRed Product
ChlF	Canopy Chlorophyll Fluorescence
CLAIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
COAWST	Coupled Ocean Atmosphere Wave Sediment Transport Modeling System
COBRA	Combined Radar-Radiometer Algorithm
CYGNSS	Cyclone Global Navigation Satellite System
DCOTSS	Dynamics and Chemistry of the Summer Stratosphere
DDA	Discrete Dipole Approximation
DOE	Department of Energy
DSS	Decision Support System
DIAL	Differential Absorption Lidar
DSCOVR:EPIC	Deep Space Climate Observatory: Earth Polychromatic Imaging Camera
DYNAMO	Dynamics of the Madden-Julian Oscillation

ECMWF	European Center for Medium Range Weather Forecasting
EMP	Enhanced Monitoring Plan
EOSDIS	Earth Observing System Data and Information System
EPA	Environmental Protection Agency (United States)
EPIC	Earth Polychromatic Imaging Camera
EPO	Education and Public Outreach
ESA	European Space Agency
ESIP	Earth Scienc Information Partners
EVHR	Enhanced Very-High Resolution
FIREX	Fire Influence on Regional to Global Enviornments Experiment
FIREX-AQ	Fire Influence on Regional to Global Enviornments Experiment-Air Quality
FP2	Functional Parallel Programming
GAW	Global Atmospheric Watch
GEMS	Global and Regional Earth-System Monitoring Using Satellite and In-Situ Data
GEO-CAPE	GEOstationary Coastal and Air Pollution Events
GEOS-5	Goddard Earth Observing System Model, Verison 5
GEP	Gross Ecosystem Production
GES DISC	Goddard Earth Sciences Data and Information Service Center
GMAO	Global Modeling and Assimilation Office
GOES ABI	GeostationaryOperational Environmental Satellites-R Series Advanced Baseline Imager
GOFC GOLD	Global Observation for Forest and Land Cover Dynamics
GPM	Global Precipitation Measurement Mission
GSFC	Goddard Space Flight Center
GV	Ground Validation
F0AM	Framework for 0-D Atmospheric Modeling
HARP2	Hyper-Angular Rainbow Polarimeter #2
HCHO	Formaldehyde
HIGRAD	High-Resolution Model for Strong Gradient Applications
HiMAT	High Mountain Asia Team
HITRAN	High-Resolution Transmission Molecular Absorption database
HIWRAP	High-Altitude Imaging Wind and Rain Airborne Profiler
HSRL	High Spectral Resolution Lidar
HyspIRI	Hyperspectral Infarred Imager
ICE-POP	International Collaborative Experiment for Pyeongchang 2018 Olympic and Paralympic
ICESat2	Ice, Cloud,, and land Elevation Satellite
IGRF	International Geomagnetic Reference Field
IFloodS	Iowa Flood Studies
ILRS	International Laser Ranging Service
IMB	Ice Mass Balance
IMPACTS	Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms
IPHEX	Integrated precipitation and Hydrology Experiment
ISAF	In Situ Airborne Formaldehyde
ISRO	Indian Space Research Organization

IMERG	Integrated Multi-satellite Retrievals for GPM
JPSS	Joint Polar Satellite System
JQSRT	Journal of Quantitative Spectroscopy & Radiative Transfer
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
LiDAR	Light Detection And Ranging
LMA	Leaf Mass per Area
LMOL	Langley Mobile Ozone Lidar
LWP	Liquid Water Path
MAP	Multi-Angle Polarimeter
MDE	Maryland Department of Environment
MERRA-2	Modern-Era Retrospective analysis for Research and Application, Version 2
MERRAero	Modern Era Retrospective analysis for Research and Applications Aerosol Reanalysis
MAIAC	Multi-Angle Implementation of Atmospheric Correction
MJO	Madden-Julian Oscillation
MLH	Mixing-Layer Height
MODIS	Moderate-Resolution Spectroradiometer
MPL	Micro Pulse Lidar
MPLNET	Micro pulse Lidar Network
MRR	Micro Rain Radar
NCCS	NASA Center for Climate Simulation
NCEP	National Center for Environmental Prediction
NEON	National Ecological Observatory Network
NDVI	Normalized Difference Vegetation Index
NBL	Night-time Boundary Layer
NCAR	National Center for Atmospheric Research
NO2	Nitrogen Dioxide
NPOL	NASA S-Band Polarimetric Radar
NPP	National Polar-orbiting Partnership
NUMA	Non-uniform Memory Access
O3	Ozone
OA	Organic Aerosol
OBPG	Ocean Biology Processing Group
OCI	Ocean Color Instrument
OELaF	Optimal estimation Lagrangian Framework
OLYMPEX	Olympic Mountain Experiment
OSSE	Observation System Simulation Experiments
OWLETS	Ozone, Wind, Temperature and Aerosols
PACE	Plankton, Aerosol, Cloud, and ocean Ecosystem

PAMS	Photochemical Monitoring Assessment Stations
PNAS	Proceedings of the National Academy of Sciences
PARSIVEL2	Particle Size Distribution - Second Generation
PBL	Planetary Boundary Layer
PECAN	Plains Elevated Convection at Night
PSD	Particle Size Distribution
PFT	Plant Functional Types
PGN	Pandonia Global Network
PI	Principal Investigator
PIP	Precipitation Intercomparison Projects
PMM	Precipitation Measurement Missions
PSD	Particle Size Distribution
QA/QC	Quality Assurance/Quality Control
RCM	Reginal Climate Model
ROZE	Rapid Ozone Experiment
SAFE	Structure and Function of Ecosystems
SAL	Saharan Air Layer
SAR	Synthetic Aperture Radar
SBG	Surface Biology and Geology
SCERIN	South Central and Eastern European Network
SERC	Smithsonian Environmental Research Center
SDSM	Solar Diffuser Stability Monitor
SIF	Solar-Induced Fluorescence
SLR	Satellite Laser Ranging
SME	Subject Matter Experts
SORCE	Solar Radiation and Climate Experiment
SSAI	Science Systems and Applications, Incorporated
STEM	Science, Technology, Engineering and Math
SSEC	Space Science and Engineering Center
SSG	Science Study Group
SWAN	Simulating Waves Nearshore
TCTE	TIM Calibration Transfer Experiment
TEMPO	Tropospheric Emissions, Monitoring of Pollution (TEMPO)
TOLNet	Tropospheric Ozone Lidar Network
TRMM	Tropical Rainfall Measuring Mission
TPOC	Technical Point of Contact
TROPOMI	Tropospheric Monitoring Instrument
TROPOZ	Tropospheric Ozone Campaign
TSIS-1	Total Solar Irradiance
TSIS-1	Total and Spectral Solar Irradiance Sensor-1
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
UWG	User Working Group
VCST	VIIRS Calibration Science Team
VIIRS	Visible Infrared Imaging Radiometer Suite
WML	Well-Mixed Layer
WFF	Wallops Flight Facility
WRF	Weather Research Forecasting