JCET
The Joint Center for
Earth Systems Technology

October 19, 2018

Dr. Philip Rous

Provost

University of Maryland, Baltimore County

1000 Hilltop Circle

Baltimore MD 21250

Re: JCET 23nd Annual Report

Dear Dr. Rous:

It is with pleasure that I am able to provide you with a copy of the 23rd Annual Report for the Joint Center for Earth Systems Technology. This volume is the third in the new five year renewal period (2015-2020) but it is the twenty-third annual report for the Center. The research conducted by our faculty, the link to educating students at UMBC, and the support of Goddard Space Flight Center have obviously been recognized by our sponsors.

On behalf of JCET's Faculty, students and our lead-sponsor NASA Goddard Space Flight Center, I would like to thank you for your continued strong support of the Center and hope you enjoy reading about the exciting research being conducted by our Faculty. Should you require additional copies of this report, please contact me at 410-455-5706 or bdemoz@umbc.edu.

Sincerely,

Belay Demoz
Professor of Physics and Director of JCET

Encl.

UMBC
AN HONORS UNIVERSITY IN MARYLAND


JCET
The Joint Center for
Earth Systems Technology

# Third Annual Report
# for
# Cooperative Agreement NNX15AT34A

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

Submitted August 7, 2018

## Message from the Directors

This volume is the third in the new, five year renewal period 2015-2020, and it is the twenty-third 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 is administered through the Office of the Vice President for Research. JCET also 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 third year of the five-year cooperative agreement period, there are 56 JCET faculty members who conduct their research among 14 branches at Goddard, and who collaborate and teach in five departments at UMBC. JCET faculty are supported by tasks from Goddard within the Cooperative Agreement (68%), by independent grant funding (21%) and from state funding (10%). The state funding supports, for example, 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 members contribute to teaching, advising graduate students, and collaborate with and/or are affiliated with 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 selects a Graduate Fellow each year and supports her/his stipend, tuition, health care and travel to one professional conference. Each semester, the JCET-supported graduate students participate in a weekly seminar series. In the Fall semesters, the seminars are given by the students on their research topics. In the Spring semesters, an Earth-science related topic is chosen for exploration. In Spring 2018, the graduate students explored Precipitation Science, led by JCET faculty member Bill Olson.
The JCET faculty has been very active this year in bringing "NASA Science" into the UMBC campus and beyond. From a story about icebridge on a cover of *Time*© to teaming up and leading the OWLETS

campaign detailed in the *Baltimore Sun*, to leading the interdisciplinary "Carbon Zero" projects, to winning a Faculty Excellence award at UMBC, to discovering unexpected effect of African wildfires on climate and communicating it to the public and more detailed in our twitter feed @JCETUMBC and http://JCET.UMBC.edu. 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 Open House events at the UMBC Observatory. And yes, UMBC has been named one of the nation's top academic workplaces for 8th consecutive year and among the nations best Colleges by *Chronicle of Higher Education's 2018*.

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, 2017 to September 30, 2018. 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.

The JCET Executive Board held its annual meeting at Goddard on May 14, 2018. In attendance from Goddard were James Irons (Deputy Director of the Earth Sciences Division), Torry Johnson (COR – JCET), Steve Platnik (Deputy Director for Atmospheres , Earth Sciences Division), Christa Peters-Lidard (Deputy Director for Hydrosphere, Biosphere, and Geophysics), Lazarus Oreopolous (Chief of the Climate and Radiation Lab), Carlos Del Castillo (Chief, Ocean Ecology Lab), and James Gleason (Chief, Atmospheric Chemistry and Dynamics Lab). UMBC participants included Karl Steiner (Vice President for Research), Alan Yeakley (Chair, Geography and Environmental Systems), Zhibo Zhang (Physics & JCET Affiliated Faculty), and Bedřich Sousedík (Mathematics & Statistics); and from JCET: Belay Demoz (JCET Director), Susan Hoban (JCET Associate Director), Mary Dawson (JCET Assistant Director, now retired), Margo Young (JCET Senior Business Manager, now JCET Assistant Director) and Ali Tokay (JCET Faculty Representative).

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. JCET looks forward to its continued collaboration in the coming year.

**Belay Demoz**, Director
**Susan Hoban**, Associate Director
**Margo Young**, Assistant Director

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# I. Technical Volume: Tasks

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

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

**Accomplishments**
The COFFEE (Compact Formaldehyde Fluorescence Experiment) instrument continued to provide airborne formaldehyde measurements through June 2018 as part of the AJAX (Alpha Jet Atmospheric eXperiment) project out of NASA Ames, and St. Clair continues to support the instrument, including all data processing. The instrument paper describing COFFEE was published in Atmospheric Measurement Techniques. St. Clair supported the final two deployments of ISAF (In Situ Airborne Formaldehyde) for the Atmospheric Tomography (ATom) mission and traveled to New Zealand to join the research aircraft for the second half of ATom3. The objective of the ATom campaign is to survey the global atmospheric composition and understand what controls the composition in regions far from emission sources. Glenn Wolfe (JCET) also participated in ATom4, and Reem Hannun was a part of ATom3 and ATom4. St. Clair began analysis of ATom1&2 data to better understand the sources of HCHO in the remote upper troposphere. The work was a collaboration with Wolfe and Jin Liao (USRA) and was presented at the 2017 Fall AGU Meeting. The CAFE (Compact Airborne Formaldehyde Experiment) instrument was also flown on ATom3, and comparing the CAFE data to ISAF data at the low HCHO concentrations of ATom revealed a minor measurement artifact from H2O. Further investigation was conducted by St. Clair in lab and the artifact now largely eliminated for CAFE and COFFEE using new optical filters. Construction of a duplicate CAFE instrument, named Deux, was completed. Shortly after, we modified the instrument to measure NO2 rather than formaldehyde, with St. Clair leading the effort. The goal was to provide a small, reliable NO2 measurement that could meet the science needs of ATom. The new NO2 instrument, named CANOE (Compact Airborne Nitrogen diOxide Experiment), was deployed on the NASA DC-8 for ATom4 and the 2018 NASA SARP (Student Airborne Research Program) flights out of Palmdale, CA. CAFE also flew on the SARP flights, with St. Clair and Wolfe supporting the instruments. St. Clair and Hannun deployed a new commercial (Aeris Technologies) formaldehyde instrument at a ground site on the UMBC campus as part of the June-July 2018 OWLETS-2 (Ozone Water-Land Environmental Transition Study) campaign. The project aims to better understand the production and transport of pollution in the upper Chesapeake Bay area around Baltimore.

**Plans for Next Year**
Instrument papers for both CAFE and CANOE instruments will be submitted for publication and improvements to both instruments, especially addressing their respective ozone

interferences, will be made. CAFE will likely go to Europe for aircraft-based validation of the Trop-OMI HCHO data product, with St. Clair as lead of the effort. The FIREX-AQ campaign, a joint NASA-NOAA project, will deploy in summer 2019 and St. Clair will support that effort. Analysis of HCHO sources in the ATom data will continue, with the goal of submitting a publication the 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**
Wolfe has worked diligently to analyze airborne flux observations from the 2016 and 2017 Carbon Airborne Flux Experiment (CARAFE) missions. This type of observation is exceedingly rare, but it is also incredibly powerful as it can provide direct constraints on the near-surface sources and sinks of greenhouse and reactive gases. Wolfe developed a robust and flexible software package for analysis of airborne fluxes, which are anticipated to become a standard tool for future aircraft missions. His work was presented at the 2018 AMS Fall meeting and was published in Spring 2018. Wolfe has also worked with postdoc Reem Hannun (JCET) and other collaborators to apply GHG flux observations to evaluation of model products. In May 2018, Wolfe travelled to Punta Arenas, Chile to support observation of formaldehyde during the final phase of NASA's Atmospheric Tomography (ATom) mission. In June 2018, Wolfe traveled to sunny Palmdale to teach and interact with 28 students and operate several instruments onboard the NASA DC-8 as part of the Student Airborne Research Program (SARP). For the remainder of FY2018, Wolfe will continue analysis of ATom observations and assist in the repair of less-than-functional instrumentation.

**Plans for Next Year**
The primary research focus of 2019 will be on biomass burning (fires). Wolfe will assist in acquisition of formaldehyde observations on the NASA DC-8 during the join NASA/NOAA FIREX-AQ mission, which will characterize the emissions and evolution of gases and particles over agricultural burning and wildfires throughout the U.S. This work is also partially supported by a NOAA grant. Wolfe will also pursue, and assist others in pursuing, new analyses of observations from KORUS-AQ and ATom.

**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) since 2013. Two of his primary duties/tasks at GES DISC, aiming to optimize and (continually) improve the overall data service, are: 1) offering and sharing scientific advises/suggestions (with visions and ideas), mostly via participating various (routine or specific) meetings or activities held at GES DISC, 2) initiating and coordinating interaction activities between GES DISC and its User Working Group (UWG), such as organizing routine UWG meetings, i.e., the quarterly 1-hr telecon meetings and the 1.5-day face-to-face meeting (which temporal cycle has been changed from 1.5-yr to 1-yr since Sep 2017). Dr. Shie has started helping Dr. J. Wei (the new Lead Scientist at GES DISC) since early 2018 in her transition to assuming a full role as the co-chair and coordinator of the GES DISC UWG. This transition is expected to be completed by the end of Sep 2018. There were two GES DISC UWG telecom meetings co-organized by Dr. Shie (helping Dr. Wei) held on Feb 22 and May 23, 2018, respectively. A 1.5-day face-to-face UWG Meeting is scheduled for Sep 25-26, 2018. Dr. Shie has also 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 or 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 that it should help and lead to a comprehensive understanding of the essential and inseparable relations between "Data & Science". 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 four technical articles submitted to the

NASA ESDIS Standard Office (ESO) that are currently under peer-review. These four technical reports aim to ensure or/and better address the data quality matter by providing proper recommendation/guidelines to data producers or/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, such as the evaporation (weather or climate related) features in the polar regions; the renowned Butterfly Effects in Lorenz Models. The achieved productions (i.e., articles or conference papers) can be found in References via "Digital Measures". Dr. Shie has also participated in a new proposal (as a Co-I via a collaborative affiliation of Code 612) submitted in June 2018 to the NASA PMM Program. The objective of this 3-yr proposal (proposed for 2019-2021) aims to use GPM products in an optimal estimation Lagrangian framework to quantify moisture transport in Arctic cyclones. Here are a few meeting activities performed (or soon be) in FY 2018 worth mentioning:

1. 2017 PMM Science Team Meeting, 16-20 October 2017, San Diego, CA.
2. 2017 NASA Sounder Science Team Meeting, 24-26 October 2017, Greenbelt, MD
3. 2017 AGU Fall Meeting, December 11-15, 2017, New Orleans, LA.
4. 2018 ESIP Winter Meeting, January 9-11, 2018, Bethesda, MD.
5. 2018 (98th) AMS Annual Meeting, January 7-11, 2018, Austin, TX (coauthoring in presentations, but not personally attending)
6. 2018 ESDSWG Annual Meeting, 18-20 April 2018, Annapolis, MD.
7. 2018 EOSDIS Systems Engineering Technical Interchange, 28-30 August 2017, NASA/GSFC, Greenbelt, MD. (upcoming)

**Plans for Next Year**

Dr. Shie will continue serving as project scientist at GES DISC but with a reduced FTE as planned, i.e., from 0.75 FTE to 0.5 FTE. He may still help Dr. Wei 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 may also continue on performing collaborative scientific works that should include the newly proposed PMM project if the proposal is funded.

**Task Number:** 104
**GSFC Sponsor:** Platnick, S.
**UMBC PI:** Song, Qianqian
**UMBC Project Number:** 00010739

**Summary**

In comparison to short-wave (SW) direct radiative effect DRELW of dust in clear-sky conditions, clear-sky dust DRELW and DREs of above-cloud dust are less studied and not well understood. As a result, the net DRE of dust—the summation of the DRESW and DRELW in both clear-sky and cloudy-sky conditions—is still poorly constrained by the observations. The cutting-edge satellite-based remote sensing techniques from NASA (namely

the A-Train satellite constellation) and other space agencies have provided a great opportunity to fill this gap in our knowledge. Graduate student Qianqian Song is tasked to advance our understanding of the net DRE of dust aerosols, through observation-based quantification of both SW and LW DRE of dust aerosols in both clear-sky and above-cloud conditions. More specifically, the objectives of the project are:

- Quantify observation-based DRELW and DRESW of dust in clear sky and above cloud conditions.
- Perform a comprehensive uncertainty analysis of DREs and identify the property that most limit the accuracy in quantification of DREs.

**Accomplishments**
The student Qianqian Song has been studying the radiative effects of above-cloud aerosols and dust aerosols. She learned how to run single scattering models, such as Mie code and radiative transfer models such as DISORT and RRTM. She applied for and won the 2018 JCET fellowship.

**Plans for Next Year**
Qianqian will study the global radiative effects of dust.

**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**
In 2018, Casasanto published in Acta Astronautica, a paper entitled "Lasers, penguins, and polar bears: Novel outreach and education approaches for NASA's ICESat-2 mission." At the Annual AGU meeting in New Orleans, she presented a hyperwall talk at NASA's booth, and a poster "Art as a key tool for engaging the public with ICESat-2." Casasanto carried out many educational events related to ICESat-2 such as the Maker Faire in Alexandria. Casasanto completed and launched NASA peer-reviewed educational products, including the Augmented Reality sandbox to view digital elevation models of terrain. Also, during the reporting period, Casasanto carried out research into best practices for a future ICESat-2 Native American

Community engagement program. Casasanto plans to implement all education and outreach efforts up to and around launch of the ICESat-2 satellite in September.

**Plans for Next Year**
For post-launch of ICESat-2, Casasanto will collect data on effectiveness of programs, and continue to research and implement best practices for education and outreach to underserved communities. In addition, she will implement the GLOBE citizen science program for data collection of ground validation measurements for the ICESat-2 mission. Casasanto will work with educational members of the American Geophysical Union (AGU) to research and formulate an educational event for underrepresented students in conjunction with the AGU annual meeting in Washington, D.C. (December 2018). Casasanto will also attend and present papers at a variety of scientific conferences.

**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 finalized the current MAIAC algorithm research code, developed final version of MAIAC operational algorithm, and delivered it to MODAPS for operational run. By June 2018, global MAIAC data has officially released to the user community. Dr. Wang also further developed MAIAC data post process software to create derived MAIAC dataset, including global 0.05 degree 8-day composite Vegetation Index (VI) products (contains angular corrected NDVI, EVI and normalized BRF), global daily AOT products (both 0.05 degree and 1 degree) etc. Dr. Wang has created global ancillary dataset based on MAIAC processing. This dataset will provide very useful information of the earth surface such as spectral ratio coefficients (SRC), brightness temperature, dynamic land water mask, surface BRDF parameters etc. These information can be used for further improvement of MAIAC algorithm, and also can be used as ancillary dataset for atmospheric correction of measurements generated by other sensors. Using the ancillary dataset generated above, Dr. Wang also developed a new algorithm to process high resolution WorldView 2 data. Initial results had shown good performance. As another application, Dr. Wang adapted the full MAIAC data processing system to MODIS Directly Readout system to create near real time MAIAC products. First version of the code has already been delivered and released. Dr. Wang also adapted the improved MAIAC code to AHI sensor aboard Himawari 8/9, further improvement is underway.

**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. As an effort to standardize MAIAC algorithm testing data, Dr. Wang will develop a set of tool kits which provide standard testing subset data over certain area of the world with typical land cover type for testing and comparing MAIAC algorithm developed for different sensors. Dr. Wang will continue to provide user support of MAIAC data for the user community.

**Task Number:** 109, 165, 166 , 171
**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**
Deployed 25 Pandora spectrometers to support multiple national and international Air Quality

and Satellite Validations field campaigns. The last instrument was deployed in South Africa in collaboration with South West University.

**Plans for Next Year**
Strengthen the collaboration with National and internal Organizations such as NOAA, EPA and ESA to establish a long term instruments deployments. High quality and non interrupted data records using field calibration tools will be our primary objective

**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 collaborated in the evaluation of solar and lunar calibration trending of changes in the responsivity of the VIIRS instrument. He provided input regarding comparing absolute verse relative calibration of the VIIRS instruments using the solar diffuser. Dr. Turpie was engaged on various issues that arose regarding VIIRS calibration. He helped identify pre-launch pointing characterization and accuracy tests for VIIRS that could provide information towards the development of similar measures for PACE. He provided input regarding application of updated vicarious calibration data from the Marine Optical Buoy (MOBY), which incorporated a correction for arm depth and stray light. Dr. Turpie performed analyses of trends in Level-3 (L3) standard deviation for VIIRS remote sensing reflectance, which showed consistent upward increases in all bands. He compared these trends to MODIS and SeaWiFS, which were similar but less consistent. He intends to publish these results, which show how the data quality changes with instrument responsivity loss over time. 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 again evaded.

**Plans for Next Year**
Dr. Turpie intends to publish results from his analysis of L3 standard deviation trends, which show how the data quality changes with instrument responsivity loss over time. 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:** 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 their research on systematic cloud-related changes in satellite-based aerosol observations. They work on this issue because several studies found systematic changes in clear-sky observations near clouds, and also because over oceans, half of all clear areas lie within a few kilometers from clouds. This year the team expanded their dataset of MODIS observations by including information from the MERRA-2 global reanalysis (for exploring the statistical impact of humidity variations on near-cloud aerosol properties), and other datasets such as the CATS lidar (for insights such as diurnal variations in near-cloud aerosol changes). In addition to seeking new understanding, the team also synthesized their results on this topic in a review article. In August they will start exploring the statistical impact of their method for removing from MODIS near-cloud reflectances the sunlight scattered from nearby clouds, thus helping satellite measurements of near-cloud aerosols. The team also completed their study on using airborne multiangle measurements for characterizing the properties and radiative impacts of wildfire smoke. The three main steps of this study were: (i) Using observations by the Cloud Absorption Radiometer (CAR) to estimate the radiative properties (optical depth and absorptivity) of a wildfire smoke plume observed over Canada; (ii) Combining CAR observations with radiative transfer simulations and statistical analysis to estimate the total solar reflectance satellite instruments such as CERES would observe over the smoke plume, and comparing the angular distribution of this reflectance to the angular models used in the operational processing of CERES measurements; (iii) Examining the question "Over what range of scene characteristics we can analyze satellite

observations using the CAR-based angular distribution model of smoke reflection"? The results indicate that airborne multiangle measurements can help the interpretation of satellite observations over a wide range of conditions. Finally, the team continued the analysis of observations collected by the DSCOVR spacecraft from a location four times farther than the Moon. They examined sun glints that appear in DSCOVR images due to specular reflection from ice platelets that float inside clouds at a nearly perfect horizontal orientation. This year they expanded the analysis to areas over oceans and examined the differences between sun glints caused by clouds and the ocean surface. They found that cloud glints are brighter than the glints caused by the (often rough) ocean surface, but also that cloud glints can be observed only from a narrower range of view directions. In September, the team plans to start radiative transfer simulations to estimate how many and what kind of ice crystals can explain the appearance of observed glints.

**Plans for Next Year**
The team plans to continue research on the properties of near-cloud aerosols. As part of this work, they plan to further expand and analyze their dataset of aerosol, cloud, and atmospheric properties. During this analysis, they plan to estimate the role of various processes in creating the observed behaviors (such as aerosols swelling up in the humid air near clouds), and to further test their method for improving the accuracy of satellite measurements of near-cloud aerosols. The team also plans to further analyze DSCOVR observations of sun glint caused by horizontally oriented ice crystals floating in clouds. They plan to use radiative simulations to help characterize the ice crystals causing the observed glints, and to combine DSCOVR images with other datasets in order to identify the conditions favorable to the formation of such ice crystals.

**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 continued to identify and acquired characterization tables for the JPSS1 VIIRS instrument for use 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 instrument and identifying anomalies and their causes. Turpie continued to work with the OBPG to assess quality of the data from the new

instrument, including the quantification of striping and other imagery artifacts and characteristics of the calibration data.

**Plans for Next Year**
Turpie will be 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**
Lee published her scientific findings on "Solar cycle Variations in Mesospheric Carbon Monoxide" with MLS observation and also WACCM 5.3 simulations. She finds that an increased solar UV lead to more abundant CO amount in the mesosphere. In this publication, she addresses that , small change of solar forcing can drive significant impacts on earth's middle atmosphere composition by modulating dynamics and thermal conditions. She also published on AIRS surface temperature and its recent trends as a co-author. She presented her recent results in diverse topic on solar irradiance, sun climate connection, arctic radiation, and surface temperature trends in the number of conferences, including AGU 2017, AMS 2018, PARCA 2018, Sun Climate Symposium, and EGU 2018 meetings. For the project, Lee participated and support intensive review, media events, and launch of the instruments for the Total and Spectral Solar Irradiance Sensors, or TSIS-1, which was successfully deployed to International Space Station (ISS) in December 2017. After launch, she continues to support the mission by attending mission acceptance review, towards smooth mission operation and proper data acquisition for solar irradiance data continuity. She plans to keep support the first

light of the TSIS TSI and SSI data from the TIM and SIM instruments. She was awarded year 2017 performance award as a special recognition for outstanding support of the TSIS-1 mission development from the NASA Earth Science Division Atmospheres. Lee supports building TSIS-1 website for NASA and SunClimate website (https://sunclimate.gsfc.nasa.gov/) for Earth Science Division.

**Plans for Next Year**
Lee plans to continue her scientific study on middle atmospheric dynamics and chemistry with mesospheric ozone related species and their variation associated with 11-year solar cycle driven UV changes. She will keep a collaboration with TIMED/SABER team. For the project, she will keep supporting the TSIS mission, and will start a new inter-comparison study of multi-sensor satellite based solar irradiance products and in-situ measured solar proxies, to validate the TSIS solar irradiance data. She will continue to build and maintain the SunClimate website by constructing contents of the past, present, and future solar irradiance missions and instruments.

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

**Summary**
This research is focused on the development of cloud and boundary layer detection algorithms for the Micropulse Lidar Network (MPLNET). These retrieval algorithms are applied to a global network of elastic backscatter lidars in order to produce long-term climatologies showing diurnal, seasonal, and annual trends. In particular, boundary layer retrievals are used to quantify and understand spatiotemporal gradients in the Baltimore-Washington DC urban corridor. A regionally dense network of micropulse lidars, along with aircraft-, ship-, and satellite-deployed lidar systems, are used for comparison with modeled mixed layer heights in order to reduce errors in estimates of urban pollutant emissions and air quality modeling

**Accomplishments**
A regional study, which used the combination of ground-based, aircraft, and spaceborne lidars to assess the ability of the Weather Research and Forecasting model to simulate the variations in the boundary layer, has concluded. The results have been summarized in a manuscript submitted for publication. The investigator has also developed a data set of constrained extinction-to-backscatter ratios for synoptic, convective, and tropical tropopause layer cirrus clouds, based on measurements from the NASA Goddard and Singapore MPLNET sites. The initial results compare well with similar analysis from the NASA Cloud Physics Lidar and complement previous studies of the cirrus radiative effect. The sensitivity of the MPLNET Version 3 cloud retrieval algorithm to changes in the overlap correction as a function temperature has been tested. A proposal had been accepted by the European Space Agency to make MPLNET part of the EarthCare calibration and validation team. Lewis presented the initial validation strategy at a workshop in Germany. Another proposal has been submitted to the CloudSat and CALIPSO Science Team to develop a unified global parameterization for cirrus clouds physical properties that matches current state-of-the-art optical ice particle model properties.

**Plans for Next Year**
Research will be continued showing macrophysical and optical properties of cirrus clouds measured from ground-based and spaceborne lidar instruments as well as passive remote sensors. Lewis plans to participate in a study of cirrus cloud properties and boundary layer heights in the Mid-Atlantic region combining measurements from multiple lidar locations in Maryland and Virginia.

**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**
Huisheng Bian led the AeroCom III nitrate experiment to assess the diversity of nitrate simulations by AeroCom models and understand the reasons for intermodal differences by comparing model nitrate results with various measurements and by investigating how nitrate formation changes in response to the perturbation of precursor emissions and meteorological conditions. The paper of this work has been published in Nov. 2017 on ACP. Huisheng Bian assisted the study of decadal variations of aerosols in the upper troposphere and lower stratosphere (UTLS). She finished a 14-year GEOS5 GOCART model simulation with a new suite of tag aerosol and CO tracers in order to better understand source attribution to the pollution in UTLS region. The results have been reported on several meetings: Aerocom 16th workshop (October 2017), 3rd international conference on atmospheric dust (May 2018), and GSFC AeroCenter annual report (July 2018). Huisheng Bian is co-organizer of 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 with GEOS5 GOCART aerosol model and ATom measurements. This is the first-time comprehensive evaluation of the GEOS5 GOCART sea salt simulation over global oceans by investigating its emission, removals, vertical distribution, size distribution, and optical thickness. She is preparing a paper of this work and has circulated the first draft among co-authors. She also investigated how mid-latitude cyclones impact on trans-Pacific transport of aerosol and CO using ATom

measurement and GEOS5 GOCART simulation. A case study (ATom2 flight 3) indicates that the anticlockwise cyclic flows result in several convergence areas with high concentrations of aerosol and CO. The rising and sinking motions around the cyclone causes slantwise ascent and descent of dust and BC plumes. Cyclone-generated clouds and precipitation scavenge dust and BC from the atmosphere at seemingly different rates, which occurs mostly in the center of the cyclone. With these findings, an extended study has been proposed for NASA ROSES 2018 CloudSat and CALIPSO Science Team (PI Yu and Co-I Bian).

**Plans for Next Year**
Huisheng Bian will continue to work on an international assessment of aerosols and their impacts by integrating AeroCom model results and ATom measurements. She will participate in several national and international assessments of aerosols and their impacts, such as aerosol in UTLS and aerosol study using a broad aircraft measurement. She will submit the paper of sea salt study and prepare a manuscript of dust wet removal using GEOS5 and ATom data.

**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**
We successfully published a GRL paper titled Observations of Local Positive Low Cloud Feedback Patterns and Their Role in Internal Variability and Climate Sensitivity. It has been highlighted in a NASA GSFC monthly highlight and garnered attention of the community. During this period I also successfully get funded with a MEASURES proposal. I presented our research at the CFMIP cloud feedback international meeting in Tokyo. I was also invited to the DUST2018 to present my work on dust variability. In the next two months, I plan to finish up a dust paper.

**Plans for Next Year**
For the next year, I plan to dive deeper into the inter annual variability of dust for this task. I together with my co-workers will use model and observational data to investigate dust variability and its drivers at the inter annual to decadal time scales, which has implications for a wide range of studies.

**Task Number:** 124
**GSFC Sponsor:** Levy, R.
**UMBC PI:** Martins, J.
**UMBC Project Number:** 00010759

**Summary**
This task covers the detailed characterization of aerosol particles and its effects on the radiative balance of the atmosphere and in cloud microphysics by the Laboratory for Aerosol, Clouds and Optics (LACO) at UMBC. These topics are addressed with a variety of new techniques and methodologies covering instrument development, laboratory and field measurements from the ground and aircraft platforms, algorithm development, satellite remote sensing from existing and new platforms, and model calculations. In particular, this task covers the development and application of the HARP satellite, the ACE project, and similar platforms for the remote sensing of aerosol and cloud properties.

**Accomplishments**
This task covers general activities of the LACO team related to the development of instrumentation and the characterization of aerosol and cloud particles from different characteristics and sources. In particular, this task has covered the laboratory analysis of volcanic ash particles from different sources, in collaboration with groups from NASA Goddard and from the National Museum of Natural History of the Smithsonian institution. This work involves the laboratory resuspension of these samples as well as their gravimetric and densitometric analysis, Polarized Imaging Nephometer (PI-Neph) inversions, and Scanning Electron Microscopy imaging. These analysis will be continued over the next few months in order to complete the assessment of the studied particles.

**Plans for Next Year**
This task will continue to support our general developments and measurements of aerosol and cloud particles with NASA Goddard. We will continue the analysis of volcanic ash particles and will continue the development of in situ and remote sensing systems for the general observation of Earth's atmosphere.

**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 2017 and July 2018 Ana Prados provided overall program management for the Applied Remote Sensing Training (ARSET) program across three NASA centers. She managed a team of 15 scientists, students, and support staff; and supervised the execution of 8 remote sensing webinars and 6 in-person trainings between October 2017 and July 2018. These activities engaged 2147 participants from 108 countries and more than 1000 organizations. This work included a continuation of remote sensing training in support of the United Nations Sustainable Development Goals (water applications, October 2017), and an air quality training in Jakarta in collaboration with the Indonesian Agency for Meteorological, Climatological and Geophysics (March 2018). Dr. Prados also continued to serve on the NASA GES DISC and LANCE User Working Groups. In August and September 2018 there will be an online training on water quality and a second on change detection with Google Earth Engine. Brock Blevins led outreach and training coordination for the program, with the assistance of student Selwyn Hudson-Odoi. David Barbato conducted translations of training materials into Spanish, and student Heather Mortimer assisted with communications.

**Plans for Next Year**
A total of 15 online and in-person trainings are planned for the next year in air quality, climate, disasters, land, and water resources applications. Trainings in air quality and flood management are planned in collaboration with the Indian Space Research Organisation in November 2018. There will be a continuation of water related trainings in Latin America in collaboration with UNESCO, additional trainings on the UN Sustainable Development Goals, and new online webinars on remote sensing for freshwater habitats.

**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 worked towards the task to improve the description of the dust properties in the GEOS-5 model. For instance, we updated the dust optical table used in the GEOS-5 model using most recent dust spectral refractive indices available in the literature. This task showed us the need to extend the range of the refractive indices accepted in the database, and the need to confront different theoretical methods currently in use to take into account dust shape. In addition, we have run simulations incorporating maps of mineral composition weighting the dust source emission by the concentration of each individual mineral. This is a first step in order to evaluate dust mineralogical variability over North Africa and Middle East region.

**Plans for Next Year**
We plan to refine both tasks described above. In the first part, we need to intercompare and evaluate the effects of the new dust optical tables in the dust simulations. In the second part, we want to simulate the effects of dust mineralogical variability.

**Task Number:** 128
**GSFC Sponsor:** Middleton, E.
**UMBC PI:** Campbell, Petya
**UMBC Project Number:** 00010763

**Summary**
The goal of this task is to develop methods for using spectral optical and thermal measurements to characterize vegetation traits, physiological condition and productivity. The task consists of four components: 1. science support for the Earth Exploring 1 satellite mission; 2. collection and analysis of field measurements; and 3. science support for the development of NASAs Hyperspectral Infrared Imager (HyspIRI) mission concept. 4. Coordination of the GOFC-GOLD South Central and Eastern European Regional Information Network (SCERIN)

**Accomplishments**
This task includes two activities: 1) My contributions to the NASA/GSFC Science Definition Team for the Hyperspectral Infrared Imager (HyspIRI) mission concept; and 2) Coordination of the South Central and East-European Regional Information Network (SCERIN).
1) To facilitate the remote sensing assessment of vegetation photosynthesis, I have contributed for the development high spectral resolution time series, using EO-1 Hyperion repeated observations at eddy co-variance sites, for the evaluation of spectral indicators of vegetation function and stress. Currently I am summarizing the results and writing the findings in a peer review publication. Some of the findings include: Using EO-1 Hyperion spectral time series to study vegetation photosynthetic function, PRI was found optimal for coniferous forests (e.g. Loblolly pine (Pinus taeda; Duke forest, NC), Scots pine (Pinus sylvestris L., Hyytiälä, Finland) and Black spruce (Picea mariana; Howland, ME), but for the deciduous species it was outperformed by derivative indicators and feature depth parameters. Using a partial least square regression (PLSR) approach with Hyperion spectra we developed empirical models for prediction of canopy carbon assimilation. Currently, I am evaluating the importance of using spectral observations covering the complete growing season (as opposed to mid growing season) for a range of species and environmental conditions.

**Plans for Next Year**
1) Transitioning into new task - SBG 2) Continuing to coordinate the SCERIN network, organise SCERIN-7 workshop and organizing the work of the network and an information data base .

**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 annual HyspIRI Science Workshop in October, in Pasadena, California. He presented ideas regarding the development of a capability for remote sensing of coastal / inland water ecosystems from space focused on selected, representive sites around the globe. He also presented an update on community activities of the ASG. He hosted a Town Hall on the Future of Coastal and Inland Aquatic Remote Sensing at the bi-annual Ocean Science meeting, this year in Portland, Oregon. He also co-chaired a large session on coastal and inland aquatic remote sensing. He presented potential technology and approaches for coastal and inland water remote sensing at a workshop on Water Quality at Goddard Space Flight Center. Dr. Turpie engaged in weekly HyspIRI Steering Committee meetings and participated in teleconferences the Science Study Group (SSG). Dr. Turpie continued to contribute to the CEOS Water Strategy team feasibility study, which was finally released early in 2018. Turpie had been selected by NASA HQ as the representative for study, per the request of the international feasibility study team. He also co-authored a paper in the peer-review literature on potential technology and approaches for coastal and inland water rement sensing from space. Dr. Turpie participated in the Alliance for Coastal Technologies (ACT) Workshop on Hyperspectral Remote Sensing in May, 2018 in Honolulu, Hawaii. Dr. Turpie became engaged in the development of a proposal to scope the new Surface Biology and Geology (SBG) mission, which will likely carry on the HyspIRI mission concept to fruition.

**Plans for Next Year**
Dr. Turpie will continue to lead the HyspIRI Aquatic Studies Group (ASG). This will include developing a Town Hall on the future of coastal and inland water remote sensing at the Ocean Optics Meeting in Dubrovnik, Croatia to collect and organize input from the community. He will speak at the American Water Resource Association (AWRA) 2018 Annual Water Resources Conference regarding related aquatic science and applications supported by SBG. He will also continue to schedule and moderate ASG international teleconferences to gather community input and coordinate activities where useful. This may also include a workshop on atmospheric correction issues unique to coastal and inland aquatic environments. Dr. Turpie will co-organize a workshop at Goddard Space Flight Center on remote sensing science and applications for study and monitoring of the Chesapeake Bay. Turpie will also organize the next HyspIRI Aquatic Data Forum at the at the HyspIRI/SBG Science Workshop sponsored by JPL and Goddard Space Flight Center in Washington, D.C., and he will continue to

participate in the HyspIRI Project Steering Committee and Science Study Group teleconferences and other related meetings. 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.

**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**
The primary focus of this task has been to support development of the NASA Hyperspectral Infrared Imager (HyspIRI) mission. The HyspIRI preparation activities are ending this year with a transition to planning the Surface Biology and Geology (SBG) mission recommended by the National Academies of Sciences 2018 Earth Decadal Survey. 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 two main areas: the collection and analysis of field measurements and development and testing of satellite-based algorithms. Field activities included continued collection and processing of data for analysis and distribution from the FUSION and Fluorescence Box (FLoX) automated field spectrometer systems, and the Fluwat leaf clip. Data from these measurement approaches are combined to develop methods to relate spectral reflectance and solar induced fluorescence (SIF) with photosynthesis from leaf (Fluwat) to canopy (FUSION and FLoX) scales applicable for use by aircraft and satellite borne instruments. Satellite-based algorithm development has focused on describing plant functional diversity and ecosystem productivity using spectral reflectance imagery. One study used analysis of spectral reflectance from the Hyperion imaging spectrometer on the Earth Observing 1 (EO-1) satellite to estimate the cover fractions of plants using the C3 versus the C4 photosynthetic pathways in prairie grasslands. Another study used EO-1 data to describe light use efficiency for 33 different globally distributed sites with a variety of different vegetation types.

**Plans for Next Year**
Continue work with field measurements, contrasting responses by corn and soybeans. Continue work on developing algorithms describing ecosystem biodiversity and productivity using satellite imagery in support of SBG program development.

**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 a number on-line and in-person trainings for NASA Applied Remote Sensing Training (ARSET) program focusing on water resources and disasters monitoring and management. Mehta and another ARSET colleague from JPL provided a 6-day in-person training on 'Applications of Remote Sensing to Support the Management of Hydrographic Watersheds in Latin America and Caribbean in Centro Internacional de Hidroinformática (CIH), Brazil (November 29-December 2017). Mehta prepared training material and hands-on exercises to calculate water budget components using GPM precipitation, MODIS and Landsat based evapotranspiration, SMAP soil moisture, and GLDAS runoff using web-tools such as Giovanni, Google Earth Engine, and Global Data Explorer in the GIS framework. This training focused on facilitating decision support for water resources management in Parana river basin where water partitioning for Itaipu hydroelectric dam, agriculture and other usage is crucial. Close to 50 participants supported by UNESCO from a number of Latin American countries attended this workshop. Additionally, Mehta led two multi-hour, in-person trainings: i) Water Quality Monitoring Using Remote Sensing (October, 2017) was offered at the Group of Earth Observations symposium in Washington DC, and ii) Applications and Usage of the Goddard Earth Observing System Data and Information System (EOSDIS) was offered at Goddard EOSDIS (March, 2018). As a part of NASA Applied Sciences Programs' contribution to using remote sensing for the United Nations Sustainable Development goals (SDGs), Mehta will contribute to an in-person training at the United Nations in New York city (July 30-31, 2018) on monitoring water quality indicators using satellites in support of SDG-6. Mehta led multi-session webinars on 1) Introduction to Variable Infiltration Capacity Hydrologic Model with NASA Earth Observations (February-March , 2017), 2) Monitoring Tropical Storms for Emergency Preparedness (May, 2018), And 3) Monitoring Urban Floods Using Remote Sensing (July-August, 2018). In addition, Mehta gave a presentation at AGU (December 2017) about the ARSET water resources and disasters management program. Mehta will conduct a webinar in September on 'Water Quality Monitoring Using Remote Sensing Observations' focusing on advance image processing. All the training materials are available from (arset.gsfc.nasa.gov). These trainings were attended by 1000+ end-users from 150+ countries and very positive comments are received through ARSET post-training surveys. Details can be found in ARSET annual report available from https://arset.gsfc.nasa.gov/sites/default/files/users/2017-ARSET-Annual-Report.pdf. As an ARSET team member, Mehta attended a number of meetings (e.g. NASA-World Resources Institute meeting on Ocean Color Applications, Land Cover Land

Use Change Science Team meeting, and The Working Group on Capacity Building and Data Democracy- Committee on Earth Observations Satellites webinar) to exchange information about availability and applications of remote sensing data and web-tools.

**Plans for Next Year**
A number of trainings for ARSET water resources and flood monitoring and management themes will be developed and offered by Mehta in collaboration with ARSET colleagues in the next year. A 2-day, in-person training is planned in India (November, 2018) in collaboration with Indian Space Research Organizations on using remote sensing for flood monitoring and management. Additionally, an in-person training on advance hydrologic modeling will be offered in collaboration with UNESCO during summer of 2018. There is a possibility of an in-person training in the US (dates and location TBD) for monitoring in-land lake water quality using satellite observations. A number of webinars are also planned on 1) Advance Drought Monitoring Using NASA Earth Observations, 2) Introduction to Water Budget Estimation for Trans-boundary Rivers, 3) Applications of Visible Infrared Imaging Radiometer Suite Nigh Light Imagery, and 4) Disaster Scenario Planning for Risk Reduction Using Remote Sensing

**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 CrIS instruments for pre-launch testing, in-orbit instrument activation, and long-term calibration. This year saw the launch of the JPSS-1 satellite and starting in Jan 2018 we began participating in the activation of the J1/NOAA20 CrIS. We successfully determined the off-axis positions of the 27 CrIS detectors and provided these data to NOAA for their operational processing of the CrIS L1b/SDRs. In addition we provided absolute calibration of the CrIS Neon using the up-welling radiances. Characterization studies of the three focal plane detectors (9-each for long-wave, mid-wave, and short-wave) showed that the long-wave FOV-5 detector has slightly anomalous behavior that is especially apparent in the 650-670 wavenumber range. The mid-wave FOV-9 detector is very non-linear and at present adjustments to its non-linearity correction results in 0.1-0.2K radiance differences compared to the other detectors. We have established that the Neon calibration is very stable, slightly better than on SNPP. The NASA AIRS sounder flying on EOS-AQUA provided invaluable information on the SNPP- vs J1/NOAA20-CrIS instruments via Simultaneous Nadir Overpass

observations (SNOs). NOAA20 and SNPP are offset in time by 1/2 an orbit (~51 minutes), which makes SNO observations impossible directly between SNPP and NOAA20. We used the AIRS instrument as a transfer standard by collecting (NOAA20 minus AIRS) SNO and (SNPP minus AIRS) radiometric differences. The difference of these are the (NOAA20 minus SNPP) radiometric differences. This has proven to be an invaluable tool for understanding the radiometric differences between NOAA20 and SNPP CrIS and is being used to fine-tune the CrIS calibration as our understanding of the differences improves.

**Plans for Next Year**
The pre-launch testing of the third CrIS instrument scheduled to fly on JPSS-2 will take place in the fall (and winter?) of 2018/2019. We will be doing intensive analysis of the spectral testing of the instrument over the next year. We are presently trying to persuade the JPSS Project Office to drop one spectral test (ammonia gas cell spectra) since these measurements were not successful during J1 testing and are not needed for instrument characterization. The accuracy of the ammonia spectroscopic line parameters is insufficient for CrIS spectral characterization. In addition, it is difficult to remove ammonia from the CrIS TVAC gas cells and it can contaminate the other gas cell tests, presenting a risk to a successful TVAC for CrIS.

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

**Summary**
This task involves development of training modules and holding quarterly webinars describing sensor characteristics, data products, and potential applications of the Global Precipitation Measurement (GPM) mission that was launched in February 2014.

**Accomplishments**
Mehta, in collaboration with GPM Applications lead Dalia Kirchbaum and Education Specialist Dorian Janney, participated in planning and conducting two on-line webinars (May 8, and June 28, 2018), and participated in and a NASA-GPM and Woodrow Wilson Center workshop (May 17, 2018) on the theme ‘Using NASA Earth Observations Data for Monitoring and response to Vector-borne and Water-borne Diseases’. In the webinars Mehta provided information and presentations on using GPM precipitation, SMAP soil Moisture, AIRS-Aqua surface temperature and humidity data for monitoring mosquito habitat. Mehta provided demonstrations of using NASA web-portals such as Earthdata, Worldview, and Giovanni to analyze relevant satellite observations to facilitate mosquito-borne diseases tracking. A number of government and academic organizations participated in the workshop and the webinars. More information on these trainings are available from (https://pmm.nasa.gov/training).

**Plans for Next Year**
Mehta plans to contribute to GPM Applications trainings and tutorials in the areas of i) health, and ii) agriculture and food security in the next year, with the goal of engaging national and international end-user communities in using GPM and other remote sensing data for decision making activities.

**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**
The main effort during the reporting period was to adapt the current combined radar-radiometer precipitation estimation algorithm suited to GPM satellite radar and radiometer measurements to similar measurements from the TRMM satellite instruments. This adaptation was completed, and Dr. Olson also developed a post-processing algorithm to aggregate TRMM/GPM satellite estimates on 0.25 degree and 5.0 degree monthly grids. Both algorithms are currently being run in an operational test environment, and precipitation estimates will be compared to ground-based radar observations. The delivery of both algorithms is expected July 31, 2018.

**Plans for Next Year**
Work will continue on the TRMM/GPM combined radar-radiometer precipitation estimation algorithm. A primary concern is “low signal” regimes, typically at higher latitudes, where either the TRMM or GPM radars are not sensitive enough to detect very light precipitation (either drizzle or snow). For these regimes, the radiometer observations will be investigated by Drs. Munchak, Grecu, and Olson to see if there is sufficient signal to quantify precipitation rates. The radiometer-based estimates will augment the radar-radiometer estimates in the operational processing. In addition, new tables of the single-scattering properties of melting precipitation, based on the latest advances in melting layer simulations, will be introduced into the algorithm to study their impact. Finally, the GPM algorithm will be modified to accommodate the new DPR radar scan pattern, which now includes Ka-band observations (in addition to Ku-band) in the outer part of the radar swath.

**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**

Accomplishments (10/1/2017-09/30/2018) CLARINET – Dr. Nicholls had new project added to his existing task to join the CATS lidar instrument science team and to serve as modeling lead for the development of the CLARINET EVS-3 proposal, which was submitted to NASA in April 2018. As part of the CATS team, Dr. Nicholls conducted research investigating the diurnal characteristics of cloud cover. This study served as motivation for his PI proposal submission to the CCST, which was submitted in late July 2018. For CLARINET, Dr. Nicholls lead proposal development team meetings and provided key figures and analyses needed for the proposal itself. High Mountain Asia Team (HiMAT) – Dr. Nicholls conducted as 40-member model sensitivity study using the regional climate model, COAWST, during the onset of the Indian Monsoon in 2008. These simulations informed necessary changes to the model configuration to address dry biases in the pilot simulations from Summer 2017. Analysis upon these simulations revealed notable and even different weather patterns could be generated depending upon the model setup, which he shared at the HiMAT team science team meeting in Seattle, WA in March 2018. Using the best configuration from his sensitivity study, Dr. Nicholls is current running (Since late Febraury) a 16-year COAWST simulation (1999-2015) which will provide 4-km high resolution regional climate data his subgroup and to the entire HiMAT science team for use in their efforts, which is expected to finish in early 2019. He was also selected as lead author for an upcoming modeling analysis study encompassing he entire HiMAT team. Modeling Analysis and Prediction (MAP) – Dr. Nicholls serves a model and data analyst for a three-person proposal team tasked with improving the characterization of the Saharan Air Layer (SAL). His main effort was associated with code development, where he created an algorithm capable of readily detecting SALs in a range of environments and over a large set of input data. He is currently writing a first author paper on the algorithm. He presented an oral presentation on this algorithm at the 98th annual American Meterological Society meeting in Austin, Texas in January 2018. HIWRAP – Dr. Nicholls provides algorithm support for the HIWRAP airbourne radar

instrument. Leveraging his model background, Dr. Nicholls developed and working with instrument PI, Dr. Hymsfield, to author a proposal for the PMM science team proposal call, which was submitted in late June 2018. As part of this effort, Dr. Nicholls ran several high-resolution (1-km) weather model simulations testing the capabilities of these models to characterize precipitating systems in regions of significant topography. He also created scripts for analyzing these model data and HIWRAP data, useful for the HIWRAP instrument itself. Land Cover/Land Use Change (LCLUC) – Dr. Nicholls serves as lead climate model scientist. Dr. Nicholls conducted a detailed analysis upon his existing COAWST simulations and identified a dry bias in his simulations over the Amazon rainforest, which he found to be version dependent. He also tested COAWST with different configuration to address model resolution concerns raised by colleagues during the 98th AMS meeting. He has since reconfigured COAWST and has completed four model simulations diagnosing the capability of the model to simulated climate in the Central Andes.

**Plans for Next Year**

CLARINET – If the proposal is selected, Dr. Nicholls will start organizing the modeling efforts ahead of the first science team meeting in June 2019 and for the investigation confirmation review in October 2019. As modeling lead, Dr. Nicholls will be tasked with organizing CLARINET's modeling teams and starting preparatory research efforts. If his CCST proposal is selected, he will begin efforts to spin-up his science team and begin the investigation. High Mountain Asia Team (HiMAT) – Dr. Nicholls will monitor and maintain his 16-year long model simulation until it finishes in early 2019. He is working with his project team on the development of a team integration paper to be published in a peer review paper; initial result will be presented at the Fall 2018 AGU meeting in Washington D.C. Dr. Nicholls will also begin efforts to unify the HiMAT climate modeling teams to develop their join papers, including one where he will be lead author. Time permitting, he will also start running a second, 16-year COAWST model simulation, but in the 2050s. Finally, Dr. Nicholls will work with his project team to author a follow-on proposal for the HiMAT team recompete. Modeling Analysis and Prediction (MAP) – Dr. Nicholls will switch from algorithm development to analysis. Using the codes he has developed in FY2018, he will analyze the Saharan air layer and its characteristics as shown from space-based and model reanalysis and author a peer-reviewed journal paper based upon the results. HIWRAP – Dr. Nicholls will continue algorithm development for the HYWRAP instrument at the request of the task funder. He is also awaiting the result of the PMM proposal call. If selected, he will begin efforts to prepare the model simulation efforts as his part of the research effort. Land Cover/Land Use Change (LCLUC) – Dr. Nicholls will finish up his remain efforts on this project. If not already complete, he will run his 16 future climate model simulations for the Central Andes using the updated COAWST model and then analyze these results. He plans to travel to Bolivia to share his results with the local research community. He plans to have two first author publications discussing the current and future climate of the Central Andes.

**Task Number:** 149
**GSFC Sponsor:** Kurtz, Nathan
**UMBC PI:** DeSouza-Machado, Sergio
**UMBC Project Number:** 00011685

**Summary**
Using a fleet of research aircraft, NASA's Operation IceBridge images Earth's polar ice to better understand connections between polar regions and the global climate system. IceBridge studies annual changes in thickness of sea ice, glaciers and ice sheets. IceBridge, a six-year NASA mission, is the largest airborne survey of Earth's polar ice ever flown. It will yield an unprecedented three-dimensional view of Arctic and Antarctic ice sheets, ice shelves and sea ice. These flights will provide a yearly, multi-instrument look at the behavior of the rapidly changing features of the Greenland and Antarctic ice. Data collected during IceBridge will help scientists bridge the gap in polar observations between NASA's Ice, Cloud and Land Elevation Satellite (ICESat) -- in orbit since 2003 and providing data till 2009 -- and ICESat-2, planned for 2018. IceBridge will use airborne instruments to map Arctic and Antarctic areas once a year. IceBridge flights are conducted in March-May over Greenland and in October-November over Antarctica. Other smaller airborne surveys around the world are also part of the IceBridge campaign. S. DeSouza-Machado will provide output from the kCARTA radiative transfer model over flight lines from the Operation IceBridge mission beginning in 2015. The output will be used to correct surface temperature retrievals for absorbed and emitted atmospheric radiation at the level of the aircraft over the flight lines. Specific output will be the reflected and emitted atmospheric radiance as well as the optical depth. Collaboration will be used to identify flight and Arctic specific input parameters to consider in radiative transfer model (kCARTA), as well as the steps and quality control parameters to get in the finalized output.

**Accomplishments**
We provided output from the kCARTA radiative transfer model over flight lines from the Operation IceBridge mission for data collected in 2015 and 2016. The output was used to develop an Optimal Estimation based surface temperature retrievals for absorbed and emitted atmospheric radiation at the level of the aircraft over the flight lines. Specific output included the reflected and emitted atmospheric radiance as well as the optical depth. We also worked on improving our allsky radiative transfer code and single footprint retrieval codes (from hyperspectral data), so that in the future we can include the effects of (thin clouds) in the surface temperature retrievals.

**Plans for Next Year**
Since clouds from ERA are likely to be +/- 3 hours away from the observations, we plan to see if other models such as WRF can provide better cloud estimates. In addition we intend to train some algorithms on the data, so that the retrievals can be done without using radiative transfer.

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

**Summary**
Research for this task is carried out on geomagnetism and satellite observations of the atmosphere using the Atmospheric Infrared Sounder (AIRS), supported by three NASA grants. The work on geomagnetism involves the development and application of geomagnetic data assimilation methods to study the source and evolution of the Earth's magnetic field. The overall goals of this work are to understand the causes of changes in the geomagnetic field through geodynamo modeling, and to improve our ability to predict future changes to the field.

**Accomplishments**
In this project we continued the development and application of a geomagnetic data assimilation system to the understanding of the fluid motion in the Earth's outer core. Development work has been focused on the construction and testing of an ensemble Kalman filter (EnKF), which allows for a time varying estimate of forecast error covariances and a more optimal estimate of the true state of the Earth's core. Current testing of this system has been centered on how the assimilation makes corrections to unobserved variables, such as the velocity and temperature fields. The assimilation system has been applied to 2000 year long experiments that have demonstrated that archeomagnetic measurements assimilated into the geodynamo model can have a positive impact on modern day forecasts of the magnetic field [Tangborn and Kuang, 2018]. We have also begun a collaboration with Professor Matthias Morzfeld and graduate student Kyle Gwirtz at the University of Arizona. This involves the development of a simplified numerical geodynamo model, which can be used to test new data assimilation algorithms, and potentially be used for assimilation experiments on the order of hundreds of thousands of years.

**Plans for Next Year**
Plans for the coming year include the addition of a bias correction algorithm into the data assimilation system. This will help to improve the accuracy of geomagnetic forecasts which is needed for inclusion of the Goddard Geomagnetic data assimilation system in the International Geomagnetic Reference Frame (IGRF) at the end of 2019. Preparations for this will involve a significant portion of the coming year. We will also continue the development of the reduced order geodynamo model with colleagues at the University of Arizona.

**Task Number:** 151
**GSFC Sponsor:** Werdell, Jeremy
**UMBC PI:** Zhai, Pengwang
**UMBC Project Number:** 00011743

**Summary**
This task supports the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission for exploring novel methods for using the increased spectral resolution to be provided by PACE to advance their ocean color atmospheric correction process and improve their in-water bio-optical algorithms. One substantial part of this involves radiative transfer modeling. Dr.

Pengwang Zhai developed and maintains radiative transfer software that perfectly suits the PACE mission needs (vector-based, with polarization) for our PACE-related activities. Specifically, Dr. Zhai (and his Post-doc Dr. Meng Gao, to be supported under a separate JCET task) will utilize his radiative transfer code to produce aerosol look-up tables for atmospheric correction and enhance his existing radiative transfer code to include inelastic scattering processes, such as phytoplankton fluorescence. We will incorporate his aerosol tables into our prototype PACE data processing system and use his at-water radiative transfer output to generate synthetic datasets for algorithm development and testing. We expect all work to be done iteratively and collaboratively, with the additional goal of publishing all results and findings.

**Accomplishments**
I have developed a radiative transfer simulator for the Plankton, Aerosol, Cloud, and ocean Ecosystem. This simulator uniquely combined a number of features including polarization, atmosphere and ocean coupling, elastic and inelastic scattering, and gas absorption features. This simulator can be used to explore information content in the PACE ocean color instrument (OCI) for aerosol, cloud, and ocean color characterizations.

**Plans for Next Year**
This task has ended.

**Task Number:** 152
**GSFC Sponsor:** Werdell, Jeremy
**UMBC PI:** Gao, Meng
**UMBC Project Number:** 00011744

**Summary**
This task supports the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission for exploring novel aerosol inversion methods for accurate ocean color atmospheric correction. Non-linear least square inversion algorithm is implemented in the retrieval algorithm. Advanced forward radiative transfer modeling is developed and maintained by Dr. Pengwang Zhai with precise treatment of both the absorption and scattering in atmosphere and ocean. To improve retrieval algorithm efficiency and robustness, complex aerosol refractive index spectrum representation is optimized using the Principle Component Analysis technique, and multi-mode aerosol volume distribution is implemented in the algorithm. The scattering and absorption in the ocean water is evaluated through a bio-optical model suited for both open and coastal water. The water leaving radiance contribution at the top of atmosphere is estimated for the atmospheric correction.

**Accomplishments**
We have been developing a retrieval algorithm that uses polarimeter data for aerosol and ocean color remote sensing. The retrieval algorithm uses flexible aerosol and ocean particle properties, which are applicable to both open and coastal ocean waters, and has not been demonstrated before. Sensitivity and limited validation have been performed for the retrieval algorithm.

**Plans for Next Year**
This task has ended.

**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**
The tropical glacier studies seek to provide area change data and visual stories on these remaining, high-altitude, ice masses using primarily Landsat imagery. As lead of a team of interns and junior scientists, we are combing through the USGS online archive for 'clear and dry' images covering ice areas in North and South America, Africa, and one small part of Asia (a portion of the island of New Guinea acquired by Indonesia in the 1960s). An example is shown here in "Ice Losses In Tropical Asia – 1980 to 2018" (https://svs.gsfc.nasa.gov/30938) where ice remnants reduce from >6 km2 to < 0.5 km2 even though the mountain peaks here are ~3 miles high. The huge Grasberg Mine's expansion over the ~same time frame is also evident in the image series. Similar content for the largest ice caps in the tropics, Peru's Nevado Coropuna and Quelccaya, is currently being prepared for use in science papers, presentations, and as hyperwall shows. Within the past 10 years, Quelccaya's ice area losses changed it from the largest to the second largest tropical ice cap. A nearby cordillera named 'La Raya' that was not identified in the seminal USGS 1386 Report published in 1999, specifically section 1386-I-4 (https://pubs.usgs.gov/pp/p1386i/peru/) has also been mapped using a similar series of images. In addition, the team's studies have identified 'ice areas' in the Global Land Ice Measurements from Space (GLIMS https://www.glims.org/) data base that were ephemeral 'snow patches' incorrectly mapped as glacial ice in the 'Dry (Desert) Andes' (the name is from USGS 1386) area along the northern Chile and Argentina borders with southern Bolivia. As directed by my Headquarters Program Manager, I have been collaboratively tracking the evolving rift and eventual calving of Iceberg A-68 from the Larsen C Ice Shelf on the Antarctica Peninsula since early 2017. This lead to a huge media activity in May-July 2017 which then led to further media interest for other areas of the coast of Antarctica with the calving of B-44 from Pine Island Glacier in September 2017. The rapid fracturing of that iceberg in Antarctica's austral spring led to the realization of how fragile this large West Antarctic outlet glacier had become. With a collaborator's Sentinel-1 animation, I used Landsat imagery going back to the early 1980s to put recent calving events into context (https://svs.gsfc.nasa.gov/30914). The net retreat and losses from the floating ice shelf areas of Pine Island Glacier is close to 1000 km2 since 2000. A similar animation for the calving of A-68 from the Larsen C (https://svs.gsfc.nasa.gov/30923) was also prepared for use at Fall AGU. Crucially, all of these scientific events and their associated imagery are leading to collaborative publication efforts following presentation of preliminary results at meetings and workshops since Fall AGU 2017. The tropical glacier research will be emphasized at the

upcoming AGU meeting in Washington DC due to the reduced costs of travel to a local meeting.

**Plans for Next Year**
Besides the new hyperwall content planned for release before Fall AGU this year, we are continuing to map all the remaining ice areas from Mexico to Bolivia to New Guinea. Selected stories of change will be turned into science papers, especially if we grow confident in the climate data we plan to extract from GSFC's MERRA-2 model (https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/). Given that most of the ice remnants that are still found in the tropics are at elevations of ~5000 m or greater and are not reliably monitored for climate variables, we plan to rely on MERRA-2 even though the relatively coarse topography in the model is a concern. The A-68 story will be updated for Fall AGU with the introduction of modeled tide data and improved velocity estimates. There is just enough daily imagery, when the skies are clear, to show that the daily tide cycle in the Weddell Sea controls the motion of the ~trillion ton iceberg. Further tracking of this huge iceberg will continue as long as there is HQ/media interest in the story. Recent rotation of the iceberg may enable it to finally pass Bawden Ice Rise and continue northward in the Weddell Gyre (https://go.nasa.gov/2Oi9s01). I will provide content when I can. (https://earthobservatory.nasa.gov/images/92420/one-year-adrift-but-not-far).

**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 FY2018, Hannun participated in the Atmospheric Tomography (ATom) field campaign, which had deployments in October 2017 and May 2018. During this campaign, she operated the In Situ Airborne Formaldehyde (ISAF) instrument and the Compact Airborne Nitrogen Dioxide Experiment (CANOE), which were flown as part of a comprehensive payload aboard the NASA DC-8 aircraft to sample chemistry over the Pacific and Atlantic Oceans. Hannun has also continued analysis of the CO2 and CH4 flux dataset collected during 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. In the next months, Hannun will prepare a manuscript validating the sensitivity of observed fluxes to heterogeneous landcover

and upscaling these results using data from flux towers located along the CARAFE flight tracks. She will also co-author a manuscript quantifying the dependence of observed CO2 uptake to forested biomass and canopy height. In addition to these projects, Hannun has also begun the development of a compact instrument to measure ozone with the sensitivity and time response necessary to determine fluxes from an airborne platform. The instrument, which relies on a cavity enhanced absorption technique, is currently being prototyped in the lab.

**Plans for Next Year**
In FY2019, Hannun will continue analysis of the ATom HCHO dataset, with plans to analyze HCHO deposition over the ocean, a parameter that is not well constrained in atmospheric chemistry models. She will also continue analysis of the CARAFE dataset and landcover, completing publications from FY2018. Hannun will also continue developing the ozone instrument, which will be packaged for an aircraft platform. Currently, test flights for the ozone instrument are planned for June 2019. Hannun will also assist in deploying both ISAF and CANOE during the FIREX-AQ campaign to sample the effects of wildfires on chemistry and air quality. The instruments will fly aboard the NASA DC-8 aircraft during the Summer of 2019, based out of Boise, ID and Salina, KS.

**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**
Testing, validation, and development for a universal mixing layer height retrieval method have been performed. Various algorithms were tested on multiple aerosol lidars including MPLNET (Micro-Pulse Lidar NETwork) instrumentation and various commercial ceilometers in networks such as NOAA/ASOS, EPA, and university collaborators. This work was presented in the American Geophysical Union (AGU) 2018 conference. A study using a long-term application of mixing layer height algorithms in a coastal environment is currently under review. Further validation by instrumentation deployments during the Ozone Water-Land Environmental Transition Study (OWLETS-2), Ad-hoc Ceilometer Evaluation Study (ACES-1) and ACES-2 campaigns is currently underway. These campaigns deployed up to eight ceilometers and one wind lidar around the Baltimore area during 2018 summer and 2017-2018 winters months to test the efficiency and accuracy of algorithms in various weather and atmospheric stability conditions. These retrievals are compared and validated against radiosonde measurements allowing for the reconciliation between aerosol and thermodynamic mixing layer heights. Measurements will continue for the 2018 summer in particular collocated ceilometers and MPL instrumentation in Heart Miller Island which further offers an opportunity for the study of the marine boundary layer in high ozone events.

**Plans for Next Year**
Continued efforts for an automated algorithm for mixing layer height retrieval with an emphasis in optimal retrievals during air quality events will be pursued, with the next step at arriving at real-time data retrieval in a network testbed. This will require processing of OWLETS-2 and ACES-2 data and consequent publications of findings. Additionally, the application of the algorithm will give insight into the complex dynamics in the Baltimore area due to the Chesapeake Bay breeze circulations. Weather and air quality numerical models WRF and WRF-Chem will also be used to aid in the understanding of the area during high ozone events. These works will be presented in the 2019 American Meteorological Society (AMS) conference and published in atmospheric and air quality journals. Close work with the MPLNET and EPA is expected for real-time retrievals in an aerosol LIDAR network testbed. Additionally, work with the PANDARA network is expected to aid in the retrieval of planetary boundary layer trace gases by combining lidar profilers and PANDORA instrumentation. Further, the need and requirements for satellite based mixed layer heights will be explored.

**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**
My accomplishments for this task include supporting the following education and outreach meetings; 1) Earth Day at Union Station; 2) US Science and Engineering Festival, both in Washington DC; 3) NOAA's Office of Satellite and Products Operations (OSPO) Kids Day in Suitland, Maryland, and 4) NASA GSFC Science Jamboree in Building 28. A significant quantity of additional media content has also been generated with support from this task. I also created an interactive exhibit for the Science and Engineering Festival using a 'midnight' and highly shadowed image over Pine Island Glacier from 15 December when Landsat 8 was acquiring imagery on an ascending pass near local midnight. By utilizing the multi-channel imagery from Landsat 8 (panchromatic, multispectral and thermal infrared), the images gives the story of the breakup of Iceberg B-44 and the front of this major Antarctic outlet glacier to be conveyed to the general public. I contributed to NASA's Earth Observatory in many ways including to the EO Kids "Ice on Earth" (https://earthobservatory.nasa.gov/pdf/eokids/EOKids_Ice508.pdf). A good deal of additional material is available on the NASA Earth Facebook page as well as directly from Earth Observatory's pages (many are reposts from EO stories). Besides the hyperwall content

mentioned for Task 153, this SVS YouTube was made at the Fall AGU meeting (https://www.youtube.com/watch?v=jwOSWGlfZzI) as well as an interview conducted by Jefferson Beck immediately following that talk. I also presented for the NASA Goddard Podcast Series for the Blind and Visually Impaired - Water and Ice (http://www.ustream.tv/recorded/114166674). Finally, I also reformatted material from a former life into a multi-part ICESat (the original 2003-2009 mission) series of hyperwall content (https://svs.gsfc.nasa.gov/30942).

**Plans for Next Year**
Supporting these education and outreach events and the broader goals of NASA's Earth Science Division as well as creating new content to contribute to the overall goals of my University, Laboratory, and Division is a wonderful diversion from more stressful science studies such as proposals, reviews, and publications. I plan to continue to try to balance these complimentary activities with my research results providing valuable visuals for future meetings and also enabling 'change stories' to be conveyed to the interested public. This will be an especially important 'Year of the Cryosphere' as ICESat-2 will launch in late 2018 following the successful launch of the GRACE Follow-On mission in May (https://climate.nasa.gov/news/2701/nasa-renews-focus-on-earths-frozen-regions/). Consequently, additional 'stories of change' will be supported as part of the overall planned cryospheric education and outreach activities.

**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**
Presented NASA research using new NASA airborne radar observations at AMS Radar conference. Also presented research on new measurements and science in the hurricane boundary layer. These studies have advanced understanding of the eyewall replacement process and the role of waves and turbulence in intensity/structure change. Presented NASA research at AMS Hurricane conference including a talk on the formation of convective bursts in the rapid intensification process. Through this work I identified a satellite signature of mesovortices, which can be used to identify the formation and enhancement of new convective bursts from NASA data. These two studies are being prepared for publication.

**Plans for Next Year**
I plan on publishing work that was started this year including a potential J. Atmos. Sci. paper on the new NASA measurements from Hurricane Matthew (2016) and two smaller papers on the convective bursts/satellite signature and the large eddy simulations.

**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 use the radiative transfer solution coupled with ozone and oxygen absorption data to build a realistic 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.

**Plans for Next Year**
We will use our built radiative transfer simulator to further explore the information content of EPIC image for cloud retrieval. In addition, 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 have used the radiative transfer tool built for EPIC images to study cloud properties. A set of look-up table dataset have been generated in order to explore cloud property retrieval using EPIC images, which includes cloud mask, cloud top height, optical depth, and cloud geometric height.

**Plans for Next Year**
We will use our built radiative transfer simulator to further explore the information content of EPIC image for cloud retrieval. In addition, we will research on the possibility of ocean color research using EPIC images.

**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 ILRS Tech. Workshop in Riga, Latvia during October 2-5, 2017 and the one-day ILRS ASC meeting. In April of this year we organized and chaired the ILRS ASC meeting during the EGU 2018 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 are now in the process of developing a product to alert the stations of systematic errors in their data. We are developing a prototype of the routine service for the network that is envisioned by ILRS' Quality Control Board, expected to be launched by October 2018. Our group has an international collaboration for several years between with the Italian groups at the Rome university "La Sapienza" and the University of Salento. Following our successful launch of the LARES satellite in February 2012, we designed and proposed a follow-on mission, LARES-2, which was approved by the Italian Space Agency (ASI) on July 5, 2017. With a free launch from ESA in late 2019, this effort has focused this year on the qualification 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 the selection of the retroreflectors to be used.

**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 with direct delivery of the information to the network station engineers. By the end of summer 2018 we will complete a new reanalysis of all SLR data since 1983 and up to present, using a yet to be delivered "target signature" model (being developed by the Herstmonceux, UK group). We are currently working on two papers on the LARES-2 mission, to be published

in appropriate journals later this year, and on several papers that will be submitted to the Journal of Geodesy Special Issue on Laser Ranging (JOGSILR). E. C. Pavlis is the guest editor of JOGSILR and the expected manuscripts are over 35 at the moment. We are also planning the next ILRS International Workshop in Canberra, Australia, November 4-9, 2018.

**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 and generated initial orbits for the proposed GEOCON mission. We have generated simulated a test data set that contains attitude errors as expected for the actual mission and determined that they do not pose any danger of degradation of the measurements, staying well below the acceptable threshold.

**Plans for Next Year**
We are now generating estimates of the level of errors on the GNSS antenna model that the design should incorporate to avoid data degradation due that effect on the proposed GEOCON observable. This will be followed by a full arc simulation and combination with other types of tracking data.

**Task Number:** 163
**GSFC Sponsor:** McGee, Thomas
**UMBC PI:** Sullivan, John
**UMBC Project Number:** 00012625

**Summary**
This new task entails collection and analyses of ground-based observations of atmospheric composition, focusing primarily on air pollution studies. Specifically, measurements of trace gases, mainly tropospheric ozone, and atmospheric constituents are obtained using remote sensing techniques (e.g. lidar), balloon-borne instrumentation, and in-situ UV photometry. Ozone is a harmful atmospheric species and is federally regulated. Therefore, providing nearly continuous measurements of ozone profiles are critical for fully assessing pollution events that may be toxic to humans during extended exposure times. Unfortunately, it very difficult to measure tropospheric ozone from space with a high level of accuracy or vertical information. However, ozone lidar can provide high spatio-temporal measurements of ozone from near surface to the top of the troposphere. This is critical in connecting surface measurements to the next generation of geostationary air quality satellites (e.g. TEMPO, GEOCAPE). Work on this

topic centers on deploying lidar instrumentation and performing high quality analyses. With these observations of the detailed ozone structure, satellite science teams and the modeling 68 community can study the character of lower-atmospheric ozone and also assess the accuracy and vertical resolution with which a geosynchronous instrument could retrieve the observed laminar ozone structures.

**Accomplishments**
Participated with the NASA GSFC O3 lidar in the Ozone Water Land Environmental Transition Study in Hampton, VA. Calibrated instrumentation in Hampton, VA and transported it all back to NASA GSFC. Proposed to NASA Early Career Investigators research funds. Prepared for conference presentations with data analyses. (Converted to Civil Servant in December 2017).

**Plans for Next Year**
This task ended December 2017.

**Task Number:** 164
**GSFC Sponsor:** McIntyre, K.
**UMBC PI:** Martins, J.
**UMBC Project Number:** 00012887

**Summary**
JCET/UMBC will support NASA GSFC in the following areas: (1) provide a fully integrated and functionally tested HARPP for integration onto the PACE spacecraft, (2) participate in instrument integration, checkout and post launch commissioning activities. (3) share existing algorithms and data product concepts with the PACE Project. These activities will be conducted at GSFC and UMBC and will include participation in regular meetings and telecons, analysis of instrument performance data and documentation review in an effort to ensure the HARPP instrument will meet performance requirments.

**Accomplishments**
During this period we have worked in the preliminary design and overall analysis of the HARP2 instrument for the PACE spacecraft, covering all the required engineering disciplines as well as the overall science performance of the instrument. The UMBC team has also worked with NASA Goddard personnel to develop a comprehensive set of documents guiding the interaction between both teams and the whole development. Hardware prototypes were started in several disciplines including electrical systems, ground support equipment, detectors, and materials. The LACO team has lead several meetings and reviews on the project including a formal Engineering Peer Review (EPR) in June 2018 followed by a Preliminary Design Review (PDR) in August 2018. The concept of the HARP2 design has been presented to the science community in several forums including the AGU Fall meeting in December 2018, the PACE Science Team Meeting in January 2018, and the SOLAS meeting in February. Over the next months we will answer any requests for action (RFAs) resulting from our PDR discussion and will continue to advance the design of the HARP2 instrument as well as continue the prototyping/testing that we have started in several disciplines.

**Plans for Next Year**
The LACO team will continue to advance the design of the HARP two instrument, including the development of hardware prototypes and the procurement of materials need for the execution of the instrument. During this period, we expect to have the critical design review (CDR) of the HARP2 instrument, as well as the beginning of a critical phase on hardware fabrication drawings and procurements of flight components.

**Task Number:** 167
**GSFC Sponsor:** Platnick, S.
**UMBC PI:** Werner, Frank
**UMBC Project Number:** 00012983

**Summary**
Develop numerical codes and methodologies for evaluating the impact of cloud heterogeneity in NASA cloud retrieval algorithms used to produce MODIS, VIIRS and other imaging sensor products. Emphasis will be on low marine boundary layer water clouds, using both dynamic model cloud realizations and observations from the high spatial resolution ASTER imager that flys with MODIS on the Terra platform. Campaign data (e.g., SEAC4RS, PODEX, ORACLES) using the eMAS and RSP sensors also will be used as appropriate.

**Accomplishments**
Clear-sky contamination is a challenging and long-lasting problem for cloud optical thickness ($\tau$) and effective droplet radius (reff) retrievals using passive satellite sensors. This study explores the feasibility of improving both $\tau$ and reff retrievals for partly cloudy (PCL) pixels by using available subpixel samples in a visible to near-infrared (VNIR) band, which many satellite sensors offer. Data is provided by high-resolution reflectance (R) observations and cloud property retrievals by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) at horizontal resolutions between 30-960m. For partly cloudy 960-m observations, the clear-sky component of the pixels induces significant underestimations of up to -3 for $\tau$, while overestimations in reff can exceed 6$\mu$m. This yields underestimations in the subsequently derived liquid water path (LWP) and cloud droplet number concentration (N) of up to -35g m-2 and -58cm-3, respectively. It is shown that subpixel R observations in the VNIR can be used to estimate the subpixel cloud cover, as well as higher-resolution R for the second band in the retrieval scheme. The estimated values compare well to the actually observed ASTER results and are used to retrieve cloud properties, which are unbiased by the clear-sky component of the PCL pixels. While the presented retrieval approach is only evaluated for marine boundary layer clouds, it is computationally efficient and can be easily applied to observations from different imagers. As an example, the PCL retrieval scheme is applied to data by the Moderate Resolution Imaging Spectroradiometer (MODIS), where similar biases for PCL pixels are observed.

**Plans for Next Year**
We will apply this method to more cases.

**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, we focus on studying the direct radiative effects of dust aerosols in the Tropical North Atlantic Region. In this study, we integrate the recent in situ measurements with satellite retrievals of dust physical and radiative properties to quantify the dust direct radiative effects on the shortwave (SW) and longwave (LW) radiation (denoted as DRESW and DRELW, respectively) in the tropical North Atlantic during summer months from 2007 to 2010. Through linear regression of 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/m2/AOD and –36.5±4.8 W/m2/AOD 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 abovementioned 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/m2 at TOA and –26 W/m2 at surface, respectively, of which ~30% is canceled out by the positive DRELW. This yields a net DRE of about –6.9 W/m2 and –18.3 W/m2 at TOA and surface, respectively. Our study suggests that the LW flux contains useful information of dust particle size, which could be used together with SW observation to achieve more holistic understanding of the dust radiative effect.

**Plans for Next Year**
In the next year, we plan to extend the above study to other regions with frequency occurrence of dust.

**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, we focus on studying the direct radiative effects of dust aerosols in the Tropical North Atlantic Region. In this study, we integrate the recent in situ measurements with satellite retrievals of dust physical and radiative properties to quantify the dust direct radiative effects on the shortwave (SW) and longwave (LW) radiation (denoted as DRESW and DRELW, respectively) in the tropical North Atlantic during summer months from 2007 to 2010. Through linear regression of 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/m2/AOD and –36.5±4.8 W/m2/AOD 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 abovementioned 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/m2 at TOA and –26 W/m2 at surface, respectively, of which ~30% is canceled out by the positive DRELW. This yields a net DRE of about –6.9 W/m2 and –18.3 W/m2 at TOA and surface, respectively. Our study suggests that the LW flux contains useful information of dust particle size, which could be used together with SW observation to achieve more holistic understanding of the dust radiative effect.

**Plans for Next Year**
In the next year, we plan to extend the above study to other regions with frequency occurrence of dust.

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

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

**Accomplishments**
This is a brand new task and I have not yet transitioned to working on it. Plans for August and September are to work with Dr. Levy and his team to identify, then write and submit two manuscripts describing the Dark Target aerosol algorithm's application to geostationary

satellite observations. The goal is to demonstrate the power of a unified global aerosol product with high temporal resolution.

**Plans for Next Year**

Provide senior leadership and advice to Dr. Levy and his team on four fronts. First, to help strategize and implement the plan to create a unified global aerosol product with high temporal resolution by combining polar orbiting and geosynchronous satellite data with a single aerosol algorithm. Second, I will provide assistance in a recently funded proposal to evaluate the contribution of biomass burning smoke to the aerosol burden over India, and to consider both air quality and climate consequences. Third, I will continue to provide the continuity to the Dark Target aerosol team in the maintenance of their algorithm as applied to Terra and Aqua MODIS, as these sensors age. Finally, I will continue to focus Dr. Levy's group towards more publications and provide mentoring to the younger scientists in his group as they write their first papers and proposals.

**Notes**

- Tasks 105, 106, 112, 113, and 143 ended early in the reporting period.
- Tasks 168 and 172 began at the end of the reporting period, and work has only just begun.

# II. Supplemental Information

## A. Departmental Affiliations

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

* Tenured or Tenure-track Faculty

## B. Courses Taught

| Fall 2017 | Spring 2018 |
|---|---|
| GES 311: Weather & Climate,<br>**Tokay** (3 credits) | GES 481/681: Remote Sensing,<br>**Campbell** (3 credits)<br>PHYS 335: Physics and Chemistry of the Atmosphere,<br>**Delgado/de Souza-Machado** (3 credits)<br>PHYS 622: Cloud Physics,<br>**Demoz** (3 credits)<br>PHYS 650: JCET Seminar: Precipitation Science,<br>**Olson** (1 credit)<br>HONR 300: Climate Change Policy,<br>**Prados** (3 credits)<br>SOCY 101Y: Basic Concepts in Sociology,<br>**Evans** (1 credit) |

## C. Publications


Anderson, D. C., Nicely, J. M., **Wolfe**, G. M., Hanisco, T. F., Salawitch, R. J., Canty, T. P., Dickerson, R. R., Apel, E. C., Baidar, S., Bannan, T. J., Blake, N. J., Chen, D., Dix, B., Fernandez, R. P., Hall, S. R., Hornbrook, R. S., Gregory Huey, L., Josse, B., Jöckel, P., Kinnison, D. E., Koenig, T. K., LeBreton, M., Marécal, V., Morgenstern, O., Oman, L. D., Pan, L. L., Percival, C., Plummer, D., Revell, L. E., Rozanov, E., Saiz-Lopez, A., Stenke, A., Sudo, K., Tilmes, S., Ullmann, K., Volkamer, R., Weinheimer, A. J., Zeng, G. (2017). Formaldehyde in the Tropical Western Pacific: Chemical sources and sinks, convective transport, and representation in CAM-Chem and the CCMI models. *Journal of Geophysical Research: Atmospheres*, n/a-n/a. http://dx.doi.org/10.1002/2016JD026121

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Berkoff, T. A., **Sullivan**, J., Pippin, M., Gronoff, G., Knepp, T., Twigg, L., Schroeder, J., Carrion, W., Farris, B., Kowalewski, M., others (2017). Overview of the Ozone Water-Land Environmental Transition Study: Summary of Observations and Initial Results. *AGU Fall Meeting Abstracts*.

**Bian**, H., Chin, M., Hauglustaine, D. A., Schulz, M., Myhre, G., Bauer, S. E., Lund, M. T., Karydis, V. A., Kucsera, T. L., Pan, X., Pozzer, A., Skeie, R. B., Steenrod, S. D., Sudo, K., Tsigaridis, K., Tsimpidi, A. P., Tsyro, S. G. (2017). Investigation of global nitrate from the AeroCom Phase III experiment, Atmos. *Atoms. Chem. Phys., 17*, 12911-12940. doi.org/10.5194/acp-17-12911-2017

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Cataford, S. A. Gadsden, K. **Turpie**, and M. Biglarbegian, Air-LUSI: Estimation, Filtering, and PID Tracking Simulation, 2018 IEEE Canadian Conference on Electrical and Computer Engineering (CCECE), Quebec City, Quebec, 2018.

Chan Miller, C., Jacob, D. J., Marais, E. A., Yu, K., Travis, K. R., Kim, P. S., Fisher, J. A., Zhu, L., **Wolfe**, G. M., Hanisco, T. F., Keutsch, F. N., Kaiser, J., Min, K. E., Brown, S. S., Washenfelder, R. A., González Abad, G., Chance, K. (2017). Glyoxal yield from isoprene oxidation and relation to formaldehyde: chemical mechanism, constraints from SENEX aircraft observations, and interpretation of OMI satellite data. *Atmos. Chem. Phys., 17*(14), 8725-8738. https://www.atmos-chem-phys.net/17/8725/2017/

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D'Adderio, L. P., Porcu, F., **Tokay**, A. (2018). Evolution of drop size distribution in natural rain. *Atmospheric Research*. doi.org/10.1016/j.atmosres.2017.10.003

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## D. Proposals

| **Proposal Title** | **Funding Agency** | **PI (JCET)** | **CO-I(s) (JCET)** | **Status** |
|---|---|---|---|---|
| Understanding airborne fertilization of oceanic ecosystems from analysis of MODIS, VIIRS, and CALIOP observations | NASA | Remer, L. | | Awarded |
| Mixing Layer Height Algorithm for Environmental Protection Agency Photochemical Assessment Monitoring Sites | NASA | | Delgado, R. | Awarded |
| The AIRS Radiative Transfer Algorithm | NASA | Strow, L. | | Awarded |
| The UMBC Monitoring of Atmospheric Pollution: The Ozone Water Land Environmental Transition Study Part 2 (OWLETS-2): Enhanced Monitoring of Atmospheric Pollution of the Chesapeake Bay Using Vertical Profiles of Ozone, Wind, Temperature and Aerosols | MDE | Delgado, R. | | Awarded |
| The dynamics of turbulent buoyant plumes | LANL | Guimond, S. | | Awarded |
| Atmospheric correction for complex scenes using co-located polarimetric and ocean color observations | NASA | | Zhai, P. | Awarded |
| Prototyping MuSLI canopy chlorophyll content for assessment of vegetation function and productivity | NASA | Campbell, P. | | Awarded |
| Prototyping MuSLI canopy chlorophyll content for assessment of vegetation function and productivity | NASA | | Huemmrich, F. | Awarded |

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| Vegetation functional amplitudes along a rainfall gradient in Indian ecosystems using AVIRIS-NG | NASA | | Campbell, P. | Awarded |
| Mixing Layer Height Algorithm for Environmental Protection Agency Photochemical Assessment Monitoring Sites | NASA | Delgado, R. | | Awarded |
| AIRS Plus CrIS/IASI Multi-Decadal Trends and Anomalies | NASA | Strow, L. | | Awarded |
| Coordinated Multi-Instrument UAS Constellations to Monitor Biophysical Traits, Function and Structure in Operational Field Environments | NASA | Campbell, P. & Huemmrich, F. | | Awarded |
| Feedbacks Between Wind-Driven Surface Fluxes and Cloud Population Evolution During MJO: A Combined Satellite and Modeling Study | NASA | | Nicholls, S. | Awarded |
| SNPP VIRS Aerosol Product Calibration and Validation Activities | NASA | Remer, L. | | Awarded |
| Optical Study of Particulates in the Ocean.<br>An Innovative Aerosol Correction Method Task | SSAI<br>NASA | Zhai, P. | | Awarded |
| Full Spectral resolution Fast Radiative Transfer Modules for CrIS | NASA | Strow, L. | | Awarded |
| Retrievals of Aerosol and Cloud Droplet Microphysical Properties with the Hyper- Angular Rainbow Polarimeter (HARP) | NASA | Martins, V. (NESSF for McBride) | | Awarded |
| Intra-Spacecraft Wireless communication network | Unsolicited | Mohamed Younis | | Awarded |
| Over mountainous regions using observations and models | MDE | Delgado, R. | | Awarded |
| AIRS Climate and calibration Algorithms | NASA | Strow, L. | | Awarded |
| The dynamics of turbulent buoyant plumes | LANL | Guimond, S. | | Awarded |
| Development of a consummate semi- analytical model for polarized ocean reflectance | NASA | Zhai, P. (NESSF for Mukherjee) | | Awarded |
| SNPP VIRS Aerosol Product Calibration and Validation Activities | NOAA | Remer, L. | | Awarded |
| Full Spectral resolution Fast Radiative Transfer Modules for CrIS | NASA | Strow, L. | | Awarded |
| The 3D Cloud Scanner CubeSat for Cloud and Aerosol Measurements | NASA | Martins, V. | | Declined |
| Improving Air Quality Forecasts of Ozone and Particulate Matter: Modeling- Observation Integrated Study | NASA | Demoz (for Yang) | | Declined |
| A National Supercomputing Accelerator Complex: An MSI Improbable Dream." | NSF | Hoban, S. (Sr Personnel) | | Declined |
| Analyses of Tropospheric Ozone Profiles within Complex Environments in Support of TEMPO | NASA | Sullivan, J. | | Declined |
| Earth Venture:CLARINET | NASA | | Nicholls, S. | Pending |
| Use of CALIOP data for understanding cloud- related variations in aerosol properties and aerosol radiative effects | NASA | | Varnai, T. | Pending |

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|---|---|---|---|---|
| Earth Surface and Interior | NASA | | Han, S. | Pending |
| A Sustainable Forest Management and Information System (SFMIS) Tool | NASA | | Mehta, A. | Pending |
| Relating in-cloud and sub-cloud processes for light rain events using cloud-resolving models and GPM ground validation campaign measurements | NASA | | Tokay, A. | Pending |
| Remote Sensing-based Integrated Floodplain Detection and Information System (IFDIS) for Emergency Risk Reduction and Response | NASA | Mehta, A. | | Pending |
| Comparison of precipitation phase algorithms: Ground Validation activity for PMM | NASA | Tokay, A. | | Pending |
| Using GPM in an Optimal Estimation Lagrangian Framework (OELaF) to quantify moisture transport in Arctic Cyclones" | NASA | | Shie, C-L | Pending |
| Organizational and structural characterization of precipitating system in cold and warm regimes over mountainous regions using observations and models | NASA | | Nicholls, S. | Pending |
| gnetometric remote sensing of ocean heat content and transport | NASA | | Tangborn, A. | Pending |
| The AIRS Radiative Transfer Algorithm | NASA | Strow, L. | | Pending |
| Earth Mars Connections Collaborative (EMC2): Preparing Next Generation Indigenous Astronomers | NASA | | Casasanto, P. | Pending |
| Cubesat Validation of a SWIR Imaging Spectrometer: Towards a Constellation for High Temporal Environmental Monitoring | NASA | Huemmrich, F. | | Pending |
| Mixing Layer Height Algorithm for Environmental Protection Agency Photochemical Assessment Monitoring Sites | EPA | Delgado, R. | | Pending |
| Comprehensive Analysis of SORCE/TSIS Total and Spectrally Resolved Irradiances | NASA | | Lee, J. | Pending |
| "Using CloudSat and CALIPSO observations to assess and inform Global Climate Model hydrometeor generators about the horizontal and vertical subgrid variability of clouds and precipitation | NASA | | Zhang, Z. | Pending |
| Improve the understanding of ship tracks by combining CloudSat and CALIPSO observations with other A-Train data through a machine learning algorithm | NASA | Yuan, T. | | Pending |
| A Probabilistic Precipitation Phase Discrimination for CloudSat using Multi-Radar/Multi-Sensor | NASA | Tokay, A. | | Pending |
| UMBC Remote Sensing Wind Power Reduction and Fluid-Structure Interaction Analysis-Design Approach For Deep-water Floating Offshore Wind Turbine Foundations | MDEA | Delgado, R. | | Pending |
| A Unified Cirrus Cloud Ice Microphysical Parameterization from CALIOP, IIR and MODIS for Consistent Radiative Transfer Modeling | NASA | | Lewis, J. | Pending |

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| Improve the understanding of ship tracks by combining CloudSat and CALIPSO observations with other A-Train data through a machine learning algorithm | NASA | Yuan, T. | | Pending |
| Characterizing the spatial distribution of cloud thermodynamic phase using CALIPSO, CloudSat and ground-based observations for improved parameterizations in large-scale models | NASA | Tan, I. | | Pending |
| Using IIR, CALIOP and Other Satellite Observations to Better Understand the Thermal Infrared Optical Depth and Radiative Effects of Dust Aerosols | NASA | | Zhang, Z. | Pending |
| Investigation of seasonal and diurnal characteristics of cloud profile properties amongst regional ecosystems | NASA | | Nichols, S. | Pending |

## E. Biographies

**Nader Abuhassan**, Associate Research Engineer, holds a PhD in Geophysics from the University of Pierre and Marie Curi. 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.

**Mustafa Aksoy**, Post-Doctoral Research Associate, holds a PhD in Electrical Engineering from The Ohio State University. Research interests are in remote sensing of earth using microwave radiometry, electromagnetic theory, data analytics, and signal processing. Specific research efforts involve remote sensing of ice sheets and developing radio frequency interference (RFI) detection and mitigation algorithms for microwave radiometers.

**William Barnes**, Senior Research Scientist, holds a PhD in Physics from Florida State University. Dr. Barnes is also an emeritus research scientist with the Earth Sciences Directorate of NASA's Goddard Space Flight Center. He served as the MODIS Sensor Scientist, and a 94 member of the MODIS Science Team for more than 12 years. He led the MODIS Characterization Support Team (MCST) for more than two years and was NASA's member on the National Polar Orbiting Environmental Satellite System's Joint Agency Requirements Group (NPOESS/JARG) for more than five years. He has over thirty years experience in the

development and radiometric calibration of Earth-observing imaging radiometers including TIROS/AVHRR, AEM-1/HCMR, NOSS/CZCS-2, OrbView-1/SeaWiFS, TRMM/VIRS¨ EOS/MODIS and NPP/VIIRS. Dr. Barnes has over thirty years experience in the development of space-borne, Earth-viewing sensors. His interests include the characterization, calibration and scientific support of imaging optical systems capable of mapping the Earth's surface in the visible and infrared portions of the electromagnetic spectrum.

**Huisheng Bian**, Senior Research Scientist, holds a PhD from the University of California Irvine. Dr. 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 atmospheric aerosol simulation by including nitrate aerosol and secondary organic aerosol and by investigating aerosol micro-physics for aerosol-cloud interaction.

**Brock Blevins**, Research Analyst, holds a BS in Biological Sciences from the University of Nebraska at Omaha and a Graduate Certificate in Geographic Information Systems from the University of Maryland, Baltimore County (UMBC). Mr. Blevins supports the NASA Applied Remote Sensing Training Program (ARSET) and has extensive experience working with NASA Earth Science Datasets and Geographic Information Systems (GIS).

**Roberto Fernandez Borda**, Assistant Research Scientist, holds a PhD in Physics from the University of Buenos Aires. 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 got an strong background in different instrument design areas like optics, digital electronics, sensors and real time software. He came to 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 an Assistant Research Scientist 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 received two awards for instrumental design∫ first by the Laboratory of Atmospheres, Climate & Radiation Branch, GSFC NASA (2007) and the second time by the Climate & Radiation Branch, GSFC NASA (2009).

**Steven Buczkowski**, Research Analyst, holds a MS in Physics from West Virginia University and an M.S. in Atmospheric Physics from UMBC. Mr. Buczkowski works in the Atmospheric Spectroscopy Lab at UMBC designing data analysis software for hyperspectral remote sensing products from orbiting instruments such as AIRS and CrIS. His research interests include remote sensing of clouds and aerosols¨ scientific computation, and the design of robust software systems for instrument control and data analysis.

**Vanessa Caicedo**, Post-doctoral Research Associate, holds a Ph.D. in Atmospheric Science from the University of Houston. Dr. Caicedo studies the atmospheric boundary layer by using various remote sensing instruments and boundary-layer height retrieval methods to continuously investigate the temporal, seasonal, and spatial evolution of the atmospheric boundary layer. Dr. Caicedo's Ph.D. dissertation focused on boundary-layer height retrieval methods and their implementation in studies of urban and coastal boundary layers. Dr. Caicedoßs research interests include atmospheric boundary layer observations and modeling, boundary layer meteorology and atmospheric chemistry.

**Petya Campbell**, Associate Research Scientist, holds a PhD in Forest Analysis/Remote Sensing from the University of New Hampshire. Dr. Campbell is an experienced scientist, forest engineer and ecologist by training, she has conducted numerous field campaigns in support of satellite and airborne acquisitions. Her research focus is on Remote Sensing for Natural Resources¨ specifically spectral analysis for vegetation assessment, ecosystem monitoring and forest damage detection using reflectance, fluorescence and thermal 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 retrieval of vegetation biophysical and morphological parameters for monitoring 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 has worked with optical data collected in the laboratory, on the ground, from aircraft, and from satellite for a variety of ecosystem types (forests and crops, C3 and C4 vegetation). She has experience using the integrated model for Soil-Canopy spectral radiance Observations, Photosynthesis and Energy balance (SCOPE, C. van der Tol and W. Verhorf) for estimating leaf and canopy spectral reflectance and fluorescence properties and GPP. Valerie Casasanto is the Education and Public Outreach Manager for the ICESat-2 mission. Ms. Casasanto has more than 20 years of experience in designing, managing and implementing Earth and space science educational programs to diverse audiences. She has successfully integrated student designed and PI science microgravity payloads on 15 space missions. Ms. Casasanto is member of the International

Astronautical Federation (IAF) Space Education and Outreach Committee, member of GSFC's Education Implementation Team and GSFC's Native American Advisory Committee.

**J. Dominik Cieslak**, Faculty Research Assistant, is a graduate of Poznan University of Technology. Cieslak is an experienced engineer that started his career working in the heavy printing industry. He gained his experience by servicing the instrumentation used in process of printing. In 2005 he joined JCET in J. Vanderlei Martins' group. Since then he has lead the design of new ground and airborne instruments that were built and used in many NASA campaigns. Mr. Cieslak uses cutting-edge techniques to build unique instruments that deliver new sets of data that are used by scientist to better understand human impact on climate changes. He has been involved in many NASA campaigns contributing to the development of the PiNeph Nephelometer, the PACS polarimetric camera, the RPI polarimetric camera and the OiNeph. All of this instrumentation was designed and built by UMBC LACO laboratory group.

**Belay Demoz**, Professor and Director of JCET, holds a doctoral degree in Atmospheric Physics from the University of Nevada and Desert Research Institute in Reno, Nevada. Dr. Demoz is Professor of Physics at UMBC and the current Director of the Joint Center for Earth Systems Technology. Prior to joining UMBC/JCET, Dr. Demoz was Professor of Physics at the Department of Physics and Astronomy at Howard University, where he was Director of Graduate Studies for the Physics Department and also one of the Principal PIs at the Beltsville Research Campus. At the Howard University Beltsville Campus, Dr. Demoz worked on a number of areas including LIDARs, Microwave Remote Sensing and upper air balloon measurements. Before joining academia, Dr. Demoz worked for the private industry as a NASA contractor, followed by time spent as a Civil Servant at NASA/GSFC in the Mesoscale Dynamics Branch. 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 as Associate Editor for the Journal of Geophysical Research, the web magazine *Earthzine* and many other editorial boards. Dr. Demoz is active in organizing national and international research field observations including WAter Vapor Experiment-Satellite (WAVES 2007), International H2O Project (IHOP2002), Plains Elevated Convection At Night (PECAN 2015) and numerous other experiments across the United States.

**Sergio DeSouza-Machado**, Research Assistant Professor, holds a phD in Plasma Physics from the University of Maryland, College Park. 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, as well as is the faculty advisor for one of the UMBC student clubs. 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 both under clear and cloudy conditions. In addition he uses 12 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 Scientist, holds a PhD in Chemistry from the University of Puerto Rico. Dr. Delgado 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 graduates 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's research interests focus on 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.

**Keith Evans**, Research Analyst, holds a M.S. in Physics from American University, and a MS in Meteorology from University of Maryland. Mr. Evans began work as a physicist at the Vitro Corp. in 1979 and worked on solar energy systems, submarine subsystems, and cruise missiles. In 1984, he worked as a contractor at the Naval Research Laboratory on the first SSM/I instrument, satellite subsystems testing, and in acoustics. He wrote the data retrieval program for the Broad Band X-ray Telescope when he started working as a contractor at NASA/Goddard Space Flight Center (GSFC) in 1989. He began working with LiDAR (Light Detection and Ranging) in 1991, performing various atmospheric studies including atmospheric temperature and spectral and multifractal analysis of atmospheric water vapor data. He is currently employed by the Joint Center for Earth Systems Technology of the University of Maryland, Baltimore County as a Research Analyst at NASA/GSFC. His current tasks include webmaster and scientific programmer for the Sulfur Dioxide Monitoring Group at NASA and scientific programmer in space geodesy. He is co-author on over 30 peer-reviewed publications and over 100 conference publications. Mr. Evans is interested in the determination of the impact of trace gases in the atmosphere radiatively and for aviation and human safety.

**Steve Guimond**, Assistant Research Scientist, hold a Ph.D. in Atmospheric Science from the Florida State University. Dr. Guimond studies atmospheric dynamics with a focus on hurricanes, radar remote sensing and numerical modeling. Dr. Guimond started at NASA/GSFC as a NASA Postdoctoral Program (NPP) fellow in 2010. Dr. Guimond's research interests include geophysical fluid dynamics with a focus on computational methods, hurricane science, radar remote sensing and algorithm development.

**Reem Hannun**, Postdoctoral Research Associate, 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, Dr. Hannun received her PhD in Chemistry from Harvard University, followed by a six-month Climate and Energy policy internship with the American Physical Society.

**Christopher Hepplewhite**, Associate Research Scientist, holds a PhD in Remote Sensing of Sea Surface and Atmosphere from the 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, holds a PhD in Physics from Pennsylvania State University. 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 Principal 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 99 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, holds a PhD in Astronomy from the University of Maryland, College Park. Dr. Hoban has worked with NASA for over two decades, first as a scientist studying comets and the interstellar medium, then as a STEM Educator. Dr. Hoban serves on the STEM Advisory Board for Anne Arundel County Public Schools. Dr. Hoban's research interests include composition and evolution of comets and analytics in astronomy. Dr. Hoban is currently on the faculty of the University of Maryland, Baltimore County, as an Affiliate Associate Professor of Physics, Affiliate Associate Professor of Computer Science & Electrical Engineering, and the Associate Director for Academics for the UMBC Joint Center for Earth Systems Technology.

**K. Fred Huemmrich**, Research Associate Professor, holds a PhD in Geography from the University of Maryland, College Park. 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.

**Leonid Iourganov**, Senior Research Scientist, holds a PhD in Atmospheric Physics from Obukhov Institute of Atmospheric Physics. Dr. Iourganov specializes in atmospheric physics, optics, spectroscopy, and remote sensing of atmospheric gaseous composition from satellites. He

has been being involved in different geophysical projects in USSR/Russia for 26 years. Between 1995 and 2011 he was working in Canada, Japan, and USA, and took part in validation 100 and analysis of carbon monoxide satellite measurements. During last three years he devoted most of his time to investigation of atmospheric sulfur dioxide and methane concentrations measured by US and European satellite sounders. Both of the projects that he is involved in now are connected with Global Change and funded by NASA. A goal of the first project is to study interconnections between the currently progressing Arctic warming that is twice as fast compared to the global warming and methane concentrations in the Arctic. Methane is known as an important greenhouse gas. Huge amounts of methane are buried in the Arctic permafrost and under the Arctic Ocean sea floor. Sooner or later these amounts would be released into the atmosphere and amplify the ongoing warming (positive feedback). Satellite data, analyzed by Dr. Yurganov, make possible monitoring of methane concentration in this climatically sensitive area. The second project is connected with climatic impact of volcanic aerosols. Volcanic sulfur dioxide is a precursor of sulfur aerosols and can be easily measured in the Thermal IR spectral region by several sounders (AIRS, IASI, TES, GOSAT, CrIS). These instruments deliver valuable global data on sulfur dioxide, year round, day and night. Retrieval algorithms being developed by Dr. Yurganov are supposed to be realized in the NASA processing schemes.

**Jae Lee**, Assistant Research Scientist, holds a PhD in Marine and Atmospheric Science from Stony Brook University. 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. Leeßs 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 find 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, holds a PhD in Physics from Hampton University, Physics. Dr. Lewis 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, holds a PhD in Physics from the University of Sao Paulo (USP, Brazil. 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, holds a PhD in Meteorology from 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**, Research Professor, holds a PhD in Computer Science from the University of Maryland, College Park. 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, holds a PhD in Atmospheric Science from 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.
**William Olson**, Research Associate Professor, holds a PhD in Meteorology from the University of Wisconsin. 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 precipitationØheating 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. Olson's 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 103 convective systems, stratocumulus modeling, the earthßs energy and water cycles, and data assimilation.

**Ana Prados**, Research Assistant Professor, holds a PhD in Chemistry from the University of Maryland, College Park. 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, 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, holds a PhD in Atmospheric Physics from the University of Maryland, Baltimore County. She 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, holds a PhD in Meteorology from Florida State University. Dr. Shie, originally trained as a dynamic meteorologist, is an experienced and versatile research scientist involving in numerous interdisciplinary studies. He has played crucial roles in several projects of diverse interests such as (1) Air-sea interaction, Goddard Satellite-based Surface Turbulent Fluxes (GSSTF) datasets production as PI in a MEaSUREs project, (2) Cloud modeling (GCE), Radiative-convective system simulations, Latent heating

retrieval, as Co-I in NEWS, as Collaborator in TRMM, and (3) Hurricane simulations using WRF, Impact of the Saharan Air Layer (SAL) dust on tropical cyclone and hurricane/typhoon, as PI/Co-I in EOS, as Co-I in NAMMA, as Collaborator in TCSP. Dr. Shie has served as the Project Scientist of GES DISC since January 2013, providing scientific consultations and advice to the data center and engaging with the GES DISC User Working Group (UWG) aiming to further improve the data distributions and user services. He also serves as an editor of International Journal of Atmospheric Sciences since September 2012. Dr. Shie has mentored numerous post-docs, and graduate, undergraduate, and high school students on diverse research subjects, particularly during 1996-2006. Dr. Shie has been involved and played crucial roles in several projects of diverse interests. He has studied air-sea interaction, as well as developed a series of successively improved global air-sea surface turbulent fluxes datasets (i.e., from GSSTF2b, GSSTF2c to GSSTF3), derived from improved remote sensing data and updated reanalysis data, by using updated algorithms. 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). 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. 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 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.

**Christopher Shuman**, Research Associate Professor, holds a PhD in Geoscience from Pennsylvania State University. Dr. Shuman works within the Cryospheric Sciences Laboratory at NASA Goddard Space Flight Center (GSFC). He has been employed by 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 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. Currently, Dr. Shuman is primarily working on in situ, satellite, and modeled temperature data sets from Greenland in collaboration with other researchers at NASA GSFC. 105 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 missionßs data over Antarcticaßs large subglacial lakes. He has also worked on composite temperature records derived from automatic weather stations (AWS), passive microwave data from SMMR and SSMØI 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). He began his cryospheric career helping to date the 3054 m long Greenland Ice Sheet Project 2 (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 also on the Executive Committee of the Cryospheric Focus Group of AGU.

**Hua Song**, Postdoctoral Research Associate, holds a PhD in Marine and Atmospheric Science from the Stony Brook University. Dr. Song has been at UMBC/JCET since January 2016, where she evaluates the cloud and precipitation simulations in the Community Climate System Model using the satellite data and satellite simulators. Prior to arriving at JCET, Dr. Song was a research associate at the Brookhaven National Laboratory, Upton, NY. Dr. Song's research interests include climate change analysis and modeling, model evaluations using the ARM measurements and NASA satellite observations, and cloud parameterization in GCMs.

**Jason St. Clair**, Assistant Research Scientist, holds a PhD in Physical Chemistry from Harvard University. Over the last 14 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. Dr. St. Clair's 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, holds a PhD in Physics from the University of Maryland, College Park. 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.

**John Sullivan** , Post-Doctoral Research Associate (now GSFC civil servant), holds a PhD in Atmospheric Physics from UMBC. He currently works in the Atmospheric Chemistry and Dynamics Laboratory at the NASA Goddard Space Flight Center (Greenbelt, MD). His expertise is in performing measurements of atmospheric constituents using active remote sensing techniques, such as lidar (light detection and ranging), for applications such as air quality, satellite validation, and climate change. Dr. Sullivan has been critical in designing, calibrating, and deploying a transportable lidar for measuring tropospheric ozone profiles in NASA campaigns, such as DISCOVER-AQ and KORUS-AQ. Dr. Sullivan was awarded the NASA Postdoctoral Program (NPP) Fellowship to continue his contribution of novel observations of the atmosphere to further NASA's science exploration.

**Andrew Tangborn**, Research Associate Professor, holds a PhD in Mechanical Engineering from the Massachusetts Institute of Technology. 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, holds a PhD in Atmospheric Sciences from the University of Illinois at Urbana-Champaign. Dr. Tokay is an atmospheric scientist and meteorological engineering by training and conducted numerous field campaigns under the umbrella of NASA's precipitation measurement mission. Dr. Tokay published 40 peer-reviewed journals and served as a 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 will be co-chair of an upcoming European conference on radar meteorology and hydrology. He is a member AMS radar meteorology committee and is also associate editor of Journal of Applied Meteorology and Climatology. 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.

**Kevin Turpie**, Research Associate Professor, holds a PhD in Geographical Sciences from the University of Maryland, College Park. Dr. Turpie is affiliated with the Geography and Earth Sciences (GES) department, where he teaches remote sensing classes. 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. Turpie's 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, including the Coastal Zone Color Scanner (CZCS), the Sea-viewing Wide Field-of-View Sensor (SeaWiFS), the MODerate resolution Imaging Spectroradiometer (MODIS), the Visible Infrared Imaging Radiometer Suite (VIIRS)¨ 107 and the Hyperspectral Infrared Imager (HyspIRI). 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 Agencyßs Compact High Resolution Imaging Spectrometer about the Project for On-Board Autonomy (CHRIS/Proba). He was the Ocean Color Science Principal 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 (HASG). 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's current research can be divided into two major areas∫ ocean color and coastal remote sensing. For the former, 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. With regard to the latter major area, 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 typical 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.

**Támas Várnai**, Research Associate Professor, holds a PhD in Atmospheric and Oceanic Sciences from McGill University. Prior to joining UMBC in 1999, Dr. Várnai worked as researcher at the Hungarian Meteorological Service, and as postdoctoral fellow at McGill University and at the University of Arizona. Dr. Várnai'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.

**Igor Veselovsky**, Associate Research Scientist (Leave of Absence), holds a PhD in Physics from Moscow Engineering Physical Institute (MEPI). His research interests include the development of the lidar systems for monitoring of atmospheric aerosol and ozone, inverse problems of atmospheric remote sensing and Raman spectroscopy.

**Yujie Wang**, Associate Research Scientist, holds a PhD in Geography from Boston University. 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, holds a PhD in Chemistry from the University of Washington. 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 University of Wisconsin, Madison, WI. Dr. Wolfe's research interests include atmospheric chemistry, forest-atmosphere interactions and instrument development.

**Tianle Yuan**, Assistant Research Scientist, holds a PhD in Atmospheric and Oceanic Sciences from the University of Maryland, College Park. Dr. Yuan has conducted several ground-breaking analyses 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 chang He uses the vast amount of satellite data 109 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 interest in developing novel theories to understand cloud statistics.

**Pengwang Zhai**, Assistant Professor, holds a PhD in Physics from 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, holds a Ph.D. in Atmospheric Sciences) from Texas A&M University. His Ph.D. thesis is on 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 |
|---|---|
| ACES | Ad-hoc Ceilometer Evaluation Study |
| ACT | Alliance for Coastal Technologies |
| AGU | American Geophysical Union |
| AHI | Advanced Himawari Imager |
| AMS | American Meteorological Society |
| AQ | Assurance Qualité (French: Quality Assurance) |
| AQUA | Automated Quantitative Analysis System |
| ASI | Italian Space Agency |
| ATom | Atmospheric Tomography |
| AWRA | American Water Research Association |
| BC | Black Carbon |
| BRDF | Bidirectional Reflectance Distribution Function |
| CALIPSO | Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation |
| CANOE | Compact Airborne Nitrogen diOxide |
| CATS | Cloud-Aerosol Transport System |
| CCST | California Council on Science and Technology |
| CERES | Clouds and the Earth's Radiant Energy System |
| CFMIP | Cloud Feedback Model Intercomparison Project |
| CH4 | Methane |
| CIH | Centro Internacional de Hidroinformatica |
| CLARINET | Contaminated Land Remediation Network |
| CloudSAT | Cloud-Aerosol Satelite |
| CO | Carbon Monoxide |
| Co-I | Co-Investigator |
| CO2 | Carbon Dioxide |
| COAWST | Center of Activity West |

| | |
|---|---|
| CubeSat | Miniaturized satellite for space research |
| DC-8 | Douglas DC-8 Airplane |
| DEM | Digital Elevation Map |
| DISC | Data Information Service Center |
| DISORT | Discrete Ordinate Radiative Transfer |
| DOI | Digital Object identifier |
| DORIS | Doppler & Ranging Information System |
| DPR | Dual-frequency Precipitation Radar |
| DRE | Direct Radiative Effects |
| DRELW | Automated Sensor System for |
| DRESW | Direct Radiative Effects Shortwave |
| DUST | Dual Use Science and Technology (program) |
| EGU | European Geosciences Union |
| eMAS | Enhanced MODIS Airborne Simulator |
| EnKF | Ensemble Kalman Filter |
| EO | Earth Observation |
| EPA | Environmental Protection Agency |
| EPO | Education and Public Outreach |
| ERA | Environmental Research Applications |
| ESA | European Space Agency |
| EVI | Enhanced Vegetation Index |
| FIREX-AQ | Free Flying Imaging Radar Experiment Quality Assurance |
| FLEX | FLame Extinguishment Experiment |
| FLoX | Fluorescence Box |
| Fluwat | Related to Photosynthetic Efficiency |
| FOV | Field of View |
| FTE | Full-time equivalent |
| FUSION | An automated sensor system collecting simultaneous observations of incoming and reflected radiance |
| GC-Net | Greenland Climate Network |

| | |
|---|---|
| GEOCON | NOAA 3-dmensional coordinate program |
| GES | Goddard Earth Science |
| GHG | Green House Gas |
| GIS | Geographic Information System |
| GLDAS | Global Land Data Assimilation System |
| GLOBE | Global Leadership and Organizational Behaviour Effectiveness |
| GPS | Global Positioning Satellite System |
| GRACE | Gravity Recovery and Climate Experiment |
| GRL | Geophysical Research Letters |
| H2O | Dihydrogen Monoxide (water) |
| HCHO | Formaldhyde |
| HICO | Hyperspectral Imager for the Coastal Ocean |
| HIWRAP | High Altitude Wind and Rain Profiling |
| IEEE | Institute of Electrical and Electronics Engineers |
| IGRF | International Geomagnetic Reference Frame |
| ISS | International Space Station |
| JOGSILR | Journal of Geodesy Special Issue on Laser Ranging |
| L-3 | Level 3 |
| LANCE | Land, Atmosphere Near real-time Capability for EOS |
| Landsat | Land Remote-Sensing Satellite |
| LARES | Laser Relativity Satellite (Italian Space Agency) |
| LCLUC | Land Cover/Land Use Change |
| LI | Lagrange Point |
| LIB | Laser Induced Breakdown |
| LW | Longwave |
| LWP | Liquid Water Path |
| MAP | Modeling Analysis and Prediction |
| MERRA | Modern Era Retrospective-analysis for Research and Applications |
| MIE | Minimum Ignition Energy |

| | |
|---|---|
| MLS | Microwave Scan Beam Landing System |
| MOBY | Marine Optical Buoy |
| MODAPS | MODIS Adaptive Processing System |
| N02 | Nitrous Oxide (dinitrogen oxide) |
| NASA | Nation National Aeronautics and Space Administrational |
| NDVI | Normalized Difference Vegetation Index |
| NOAA | National Oceanic and Atmospheric Administration |
| OCI | Ocean Color Instrument |
| ORACLES | Observations of Clouds above Aerosols and their Interactions |
| OSPO | Office of Satellite and Products Operations |
| PANDORA | Ground-based Spectrometer System |
| PARCA | Program for Arctic Regional Climate Assessment |
| PI | Principal Investigator |
| PLSR | Partial Least Square Regression |
| PMM | Permanent Multipurpose Module |
| PODEX | Polarimeter Definition Experiment |
| PRI | Photochemical Reflectance Index |
| PSD | Particle Size Distribution |
| QC | Quality Check |
| ROSES | Research Opportunities in Space and Earth Science |
| RRTM | Rapid Radiative Transfer Model |
| RSP | Research Scanning Polarimeter |
| SABER | Sounding of the Atmosphere using Broadband Emission Radiometry |
| SBG-2 | Surface Biology and Geology |
| SeaWiFS | Sea-viewing Wide Field-of-view Sensor |
| SIF | Solar Induced Fluorescence |
| SIM | Small Instrument Modules |
| SLR | Satellite Laser Ranging |
| SMAP | Soil Moisture Active Passive |

| | |
|---|---|
| SNO | Simultaneous Nadir Overpass |
| SNPP | Starry Night Pro Plus |
| SRC | Spectral Ratio Coefficients |
| SSG | Science Studies Group |
| SSI | Solar Spectral Irradiance |
| SW | Shortwave |
| TIM | Total Irradiance Monitor |
| TIMED | Thermosphere Ionosphere Mesosphere Energetics Dynamics |
| TOA | Top Of Atmosphere |
| Trop-OMI | Tropospheric Monitoring Instrument |
| TVAC | Thermal Vacuum |
| UN | United Nations |
| USRA | Universities Space Research Association |
| UV | Ultraviolet |
| VI | Vegetation Index |
| VLBI | Very Long Baseline Interferometry |
| WACCM | Whole Atmosphere Community Climate Model |

# III. JCET Grants

**UMBC Project Number:** 00008478
**UMBC PI:** Martins, Jose V.
**Sponsoring Agency:** NASA
**Project Title:** HARP CubeSat Satellite

**Summary**
The HyperAngular Rainbow Polarimeter (HARP) Cubesat mission objectives:

- Space validation of new technology required by the Tier 2 Decadal Survey Aerosol-Cloud-Ecosystem (ACE) mission science definition team.
- Prove the on-flight capabilities of a highly accurate wide FOV hyperangle imaging polarimeter for characterizing aerosol and cloud properties.

The HARP payload is a wide field of view (FOV) imager that uses modified Philips prisms to split 3 identical images into 3 independent imaging detector arrays. This technique achieves simultaneous imagery of the 3 polarization states and is the key innovation to achieve high polarimetric accuracy with no moving parts. The spacecraft consists of a 3U Cubesat with 3-axis stabilization designed to keep the polarimeter pointing nadir. An airborne version of HARP was flown on the NASA DC-8 during the DC3 field experiment during the summer of 2012. The performance of the airborne version was excellent with accuracy of linear degree of polarization to within 0.3%. The proposed spacecraft has already participated in a space mission and is at TRL = 8. The sensor is at TRL = 6. At exit, TRL for wide FOV hyperangle imaging polarimetry will be 8. The proposed time line for HARP Cubesat is two years to reach launch, 3 months on-orbit for technology validation and an optional continuation of 9 months of data collection for separate science objectives funded by NOAA. The integrated spacecraft can be ready for launch by December 2014. The HARP Cubesat mission will be a joint effort between UMBC who will provide the sensor hardware and characterization, and scientific analysis; SDL who will provide the 3U Cubesat spacecraft and mission operations; and STC who will lead the science algorithm development and science application funded by NOAA. NASA Wallops will support instrument environmental testing, mission operations, and communications.

**Accomplishments**
LACO (Laboratory for Aerosol, Clouds and Optics) personnel have worked with Space Dynamic Lab (SDL) staff to complete HARP CubeSat's spacecraft software and to perform extensive testing on the full system. We have also performed pre-environmental testing on HARP's payload. During environmental testing, the SDL team has identified a major problem with power system of the HARP spacecraft. Due to this failure, the system had to be de-integrated for troubleshooting, further delaying HARP's launch. LACO will continue to support HARP's preparation for Launch, which is currently scheduled for November 2018 and involve final calibration and testing, as well as implementation of the HARP data system and algorithms. HARP's science operation center will be implemented at UMBC's Earth and Space Institute (ESI) over the next few months.

**Plans for Next Year**
LACO will support HARP's environmental testing at SDL by performing pre and post check outs of the payload as well as any other needed characterization or pre-launch data analysis.

The HARP spacecraft is expected to launch in November 2018. In preparation for launch, we will also implement the HARP data system at UMBC and be ready for post-launch data analysis and science activities.

**UMBC Project Number:** 00008818
**UMBC PI:** De Souza-Machado, Sergio
**Sponsoring Agency:** NASA
**Project Title:** Climate Studies using Time Evolution of Probability

**Summary**

Radiances measured at the Top of the Atmosphere (TOA) by remote sounding instruments such as the Atmospheric Infrared Sounder (AIRS) depend both on the atmosphericstate (temperatures and constituent gas concentrations) and the microphysical properties of clouds that may be present between the instrument and observation point. The radiance timeseries thus contains information crucial to understand forcings and responses of the climate system. The AIRS instrument has been providing high spectral resolution radiances since September 2002, and is likely to continue doing so for another 5 years. AIRS L2 products include global estimates of atmospheric temperature and gas concentrations of water vapor and ozone. The accuracy of the products are good enough for the weather forecasting purposes for which they were designed, but are limited by mathematical difficulties encountered in the retrieval process. Problems in cloud clearing also means the retrieval occasionally fails in the lower troposphere. AIRS (and similar instrument) L2,L3 products therefore have some liens if used for climate purposes, where one would ideally want high accuracy and small errors at all vertical and horizontal locations and times. To navigate around these problems, we propose to directly use the full spectral radiance data record of the AIRS channels to study forcings and responses of the climate system, in particular the cloud forcings. We already have experience in carefully subsetting the AIRSdata for clear scenes. Averaging the large numbers of AIRS clear scenes in ' 10 degreelatitude bins allows us to significantly improve the S/N of the spectral measurements, from which we obtain the linear rates of changes in the radiances over 10 years. By computing linear trends from radiances of a well understood instrument, the spectral rates can finally be used to derive accurate estimates of linear trends in geophysical parameters such ascolumn carbon dioxide and CFC13, or humidity and temperature profiles. Additionally we propose to use these PDFs in studying dynamics of the atmospheric system. The study of the time series will yield both changes in extreme events, as well as estimates of time scales associated with physical processes, as measured by AIRS, by modeling the atmosphere using stochastic dynamics. Using parameters obtained from the actual data time series itself, we can then make meaningful comparisons against runs from climate models. Our expertise in radiative transfer and stochastic dynamics, coupled with almost 15 years of AIRS data by the end of this proposal cycle, should yield an improved understanding of physical processes in the climate system.

**Accomplishments**

To expand on the atmospheric stochastic forcing that we established under clear sky conditions, we worked on a model to estimate damping, stochastic forcing amplitude and external forcing amplitude from data. The data was taken from hyper-spectral observations averaged over different latitude bins. Preliminary results were obtained over the length of the AIRS mission (2002-now), and we plan to continue understanding these results. We also

planned on studying all-sky radiances. This is much more complicated, since there are numerous ways clouds can effect radiances. Hyper-spectral instruments provide millions of spectra each day, and so the simulated effects of clouds need to be performed accurately yet rapidly. Further complications arise because while temperature and humidity fields from Numerical Weather Prediction models are fairly accurate (since they are constrained by observations and do not extremely rapidly), clouds are much more difficult to model, and if they are in the wrong place, will provide large radiance errors in simulations. To mitigate this we worked on an allsky radiative transfer model and a code to provide better estimates of cloud parameters than from NWP models. The first resulted in two publications, one describing a single footprint allsky retrieval, and the other being a cloud radiative transfer algorithm (RTA) inter-comparison with a number of international groups. The allsky retrieval development also yielded a way to better estimate cloud a-priori fields.

**Plans for Next Year**
The funding for the grant ended in June 2018. However we plan to continue some of the work we started, as time permits.

**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. During the reporting period, Dr. Olson completed the development of a global, variational optimization framework that can be applied to water and energy flux datasets collected by other NEWS (NASA Energy and Water Cycle Study) team co-investigators on this project.

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

**UMBC Project Number:** 00008904
**UMBC PI:** Remer, Lorraine
**Sponsoring Agency:** NASA/GSFC
**Project Title:** Fine tuning the MODIS dark target aerosol algorithm and products: comprehensive error analysis

**Summary**
Maintenance and refinement of the MODIS aerosol algorithms. Continuation of producing a high-quality aerosol product from MODIS that can be applied with confidence to study global climate change and local environmental quality, and can be used in applied operational environments.

**Accomplishments**
This past year several lingering projects were finalized into comprehensive papers and submitted. These projects included: (1) Analysis of the eMAS data in proximity to clouds. Here the results show that (a) the MODIS DT cloud mask is doing its job and protecting the aerosol algorithm from cloud contamination. There is virtually no cloud contamination in the MODIS product. (b) at fine spatial resolution we sometimes see an enhancement of AOD retrieved in the proximity of clouds. This is not cloud contamination. (c) Through some clever analysis using collocated lidar data, we learn that the major cause of enhancement, in this data set, is due to 3D effects (side scattering of photons by clouds). Other possibilities, such as enhancement due to humidified aerosols were not as significant. The paper was submitted by the group and is in review. (2) Research algorithm for retrieval of heavy smoke in Indonesia. The problem was that the Dark Target global aerosol algorithm failed to make any retrievals in the heavy smoke produced by fires in Indonesia in 2015. By modifying thresholds on the masking, basing our cloud mask on the results of the MODIS cloud algorithm retrieval and offering a new locally-based smoke model for Indonesia we were able to both increase the number of retrievals and also improve the accuracy of these retrievals. Collocating and comparing with AERONET AOD shows that the research algorithm doubles the number of MODIS retrievals greater than 1.0, while also significantly improving agreement with AERONET. The final results show that the operational DT algorithm had missed approximately 0.22 of the regional mean AOD, but as much as AOD = 3.0 for individual 0.5° grid boxes. This amount of missing AOD can skew the perception of the severity of the event, affect estimates of regional aerosol forcing, and alter aerosol modeling and forecasting that assimilate MODIS DT data. These results will influence the future development of the global DT aerosol algorithm. A paper was written, submitted and is now under review. (3) Validation of MODIS 3 km aerosol product. We performed global validation of the MODIS 3km AOD product over global land by comparing against Aerosol Robotic NETwork (AERONET) measurements. The MODIS-AERONET collocated data sets consist of 161,410 high-confidence AOD pairs from 2000 to 2015 for MODIS-Terra and 2003 to 2015 for MODIS-Aqua. We find that 62.5% and 68.4 % of AODs retrieved from MODIS-Terra and MODIS-Aqua, respectively, fall within previously published expected error bounds of ± (0.05+0.2xAOD), with a high correlation (R=0.87). The scatter is not random, but exhibits a mean positive bias of ~0.06 for Terra and ~0.03 for Aqua. These biases for the 3 km product

are approximately 0.03 larger than the biases found in similar validations of the 10 km product. The validation results for the 3 km product did not have a relationship to aerosol loading (i.e. true AOD), but did exhibit dependence on quality flags, region, viewing geometry, and aerosol spatial variability. Time series of global MODIS-AERONET differences show that validation is not static, but has changed over the course of both sensors' lifetimes, with MODIS-Terra showing more change over time. The likely cause of the change of validation over time is sensor degradation, but changes in the distribution of AERONET stations and differences in the global aerosol system itself could be contributing to the temporal variability of validation. A paper was written, submitted and accepted. (4) Analysis of the bias between Terra and Aqua Dark Target aerosol optical depth. Global monthly mean AOD from Terra with morning overpass is consistently higher than that from Aqua with afternoon overpass by ~13% (~0.02 over land and ~0.015 over ocean), and this offset exhibits seasonal as well as long-term variability. Focusing on 2008 and deriving yearly gridded mean AOD and AE, we find that, over ocean, the Terra AOD is higher and the Angstrom Exponent is lower. Over land, there is more variability. The differences are not easily attributed to either aerosol diurnal cycles or sampling issues. Working with the hypothesis that the offsets must be linked to calibration, we tested different calibration possibilities. The first, known as C6+, corrects for long-term changes to each sensor's polarization sensitivity and the response versus the scan angle and to cross-calibration from Terra to Aqua. A second convolves the detrending and cross-calibration into scaling factors. Each method was applied upstream of the aerosol retrieval using 2008 data. While both methods reduced the overall AOD offset over land from 0.02 to 0.01, neither significantly reduced the AOD offset over ocean. We conclude that (i) users should not interpret global differences between Terra and Aqua aerosol products as representing a true diurnal signal in the aerosol. (ii) Because the Aqua product appears to have an overall smaller bias compared to ground-truth data, it may be more suitable for some applications. However (iii), since the AOD offset is only ~0.02 and within the noise level for single retrievals, both MODIS products may be adequate for most applications. A paper was submitted and accepted.

**Plans for Next Year**
This project is ending. Other than answering reviewer comments on the two papers still in review, this project has concluded.

**UMBC Project Number:** 00008969
**UMBC PI:** Strow, Larrabee
**Sponsoring Agency:** NASA
**Project Title:** NASA: AIRS Forward Model Improvement

**Summary**
Improve the atmospheric radiative transfer model used by the NASA/AIRS sensor in order to create reliable climate records.

**Accomplishments**
The existing V6 AIRS Level 2 software uses an older version of our RTA. We discovered that RTA tuning, done by the Level 2 algorithm, was introducing unphysical secant dependent (striping errors) into the high-altitude Level 2 temperature products. We (instead of the Level 2 team) derived new tuning that removed this problem. Most of this year was spent working

on techniques for improved parameterization of the AIRS fast forward model using neural-net and gaussian kernel fitting techniques. This approach appears feasible but improved training sets are still needed. It is not clear yet if implementation of these new approaches will impact cpu/memory limits in the operational processing of AIRS Level 2.

**Plans for Next Year**
This grant is now over.

**UMBC Project Number:** 00009346
**UMBC PI:** Wolfe, Glenn
**Sponsoring Agency:** NASA
**Project Title:** Understanding the response of tropospheric chemistry to trends in natural and anthropogenic emissions through in situ and remote observations of formaldehyde

**Summary**
By detailing the influence of NOx on isoprene chemistry across multiple spatial and temporal scales, we will improve model representations of key processes affecting air quality. A detailed understanding of isoprene chemistry is crucial for predicting how atmospheric composition is responding, and will continue to respond, to changes in both emissions and climate. This work will also enhance the value of current (OMI) and future (TEMPO) NASA missions, e.g. by improving estimates of isoprene emissions derived from space-borne HCHO observations.

**Accomplishments**
Under this grant, all personnel have contributed to the analysis of observations from NASA's Atmospheric Tomography mission. Wolfe and St. Clair, along with collaborators Jin Liao and Julie Nicely (USRA), are investigating the link between formaldehyde (HCHO) and hydroxyl radical (OH), the latter being the primary detergent of the atmosphere. Synthesizing airborne and satellite-based observations, they have developed a quantitative constraint on the global distribution of OH, which is extremely valuable for evaluating global models and understanding controls on the lifetime of methane and other reactive gases. In addition, St. Clair has initiated a preliminary analysis of the combined influence of convection and biomass burning on the composition of the remote upper troposphere. Hannun's work has mainly focused on analysis of greenhouse gas fluxes from the CARAFE missions. She has performed a detailed comparison of airborne observations with ground-based measurements and developed new tools to evaluate the correlation of fluxes with land surface characteristics (e.g. land cover type, canopy height, etc.).

**Plans for Next Year**
This grant will close out in August 2018. Research efforts will continue under the respective tasks for all personnel.

**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**
Over this period, we carried out two major research activities which lead to two journal publications. In the first study, we investigated The Importance of Considering Sub-grid Cloud Variability When Using Satellite Observations to Evaluate the Cloud and Precipitation Simulations in Climate Models,Satellite cloud observations have become an indispensable tool for evaluating the general circulation models (GCMs). To facilitate the satellite and GCM comparisons, the CFMIP (Cloud Feedback Model Inter-comparison Project) Observation Simulator Package (COSP) has been developed and is now increasingly used in GCM evaluations. In this study, we use COSP cloud simulations from the Super-Parameterized Community Atmosphere Model (SPCAM5) and satellite observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) and CloudSat to demonstrate the importance of considering the sub-grid variability of cloud and precipitation when using the COSP to evaluate GCM simulations. We carry out the two sensitivity tests: SPCAM5 COSP and SPCAM5-Homogeneous COSP. In the SPCAM5 COSP run, the sub-grid cloud and precipitation properties from the embedded cloud resolving model (CRM) of SPCAM5 are used to drive the COSP simulation, while in the SPCAM5-Homogeneous COSP run only grid mean cloud and precipitation properties (i.e., no sub-grid variations) are given to the COSP. We find that the warm rain signatures in the SPCAM5 COSP run agree with the MODIS and CloudSat observations quite well. In contrast, the SPCAM5-Homogeneous COSP run which ignores the sub-grid cloud variations, substantially overestimates the radar reflectivity and probability of precipitation compared to the satellite observations, as well as the results from the SPCAM5 COSP run. The significant differences between the two COSP runs demonstrate that it is important to take into account the sub-grid variations of cloud and precipitation when using COSP to evaluate the GCM to avoid confusing and misleading results.
Thsecond paper presents a satellite observation based evaluation of the marine boundary layer (MBL) cloud properties from two Community Atmospheric Model Version 5 (CAM5) simulations, one with the standard parameterization schemes (CAM5-Base), and the other with the Cloud Layer Unified By Binormals scheme (CAM5-CLUBB). When comparing the direct model outputs, we find that CAM5-CLUBB produces more MBL clouds, a smoother transition from stratocumulus to cumulus and a tighter correlation between in-cloud water and cloud fraction than CAM5-Base. In the model-to-observation comparison using the COSP satellite simulators, we find that both simulations capture the main features and spatial patterns of the observed cloud fraction from MODIS and shortwave cloud radiative forcing (SWCF) from CERES. However, CAM5-CLUBB suffers more than CAM5-Base from a problem that can be best summarized as “undetectable” clouds, i.e., a significant fraction of simulated MBL clouds are thinner than MODIS detection threshold. This issue leads to a smaller COSP-

MODIS cloud fraction and a weaker SWCF in CAM5-CLUBB than the observations and also CAM5-Base in the tropical descending regions. Finally, we compare modeled radar reflectivity with CloudSat observations, and find that both simulations, especially CAM5-CLUBB, suffer from excessive drizzle problem. Further analysis reveals that the sub-grid precipitation enhancement factors in CAM5-CLUBB are unrealistically large, which makes MBL clouds precipitate too excessively, and in turn results in too many "undetectable" thin clouds.

**Plans for Next Year**
We will evaluate cloud properties simulations in the latest Community Atmospheric Model V6 and the newest DOE E3SM model.

**UMBC Project Number:** 00009460
**UMBC PI:** Remer, Lorraine
**Sponsoring Agency:** NASA
**Project Title:** Towards a consistent aerosol data record, create from MODIS, VIIRS, and beyond.

**Summary**
Creating an aerosol climate data record that spans the MODIS and VIIRS eras.

**Accomplishments**
The MODIS Dark Target (DT) algorithm has been successfully ported to run with S-NPP VIIRS inputs, with Himawari (AHI) inputs and with GOES-16 (ABI) inputs. It is still unclear whether or not the DT algorithm will run operationally on VIIRS, as it has become an orphan product in terms of NASA operational funding. However, it is ready to go, and can run with minimal supervision. Meanwhile the porting to AHI and ABI continues to be actively pursued. At this point in time we have done serious analysis of the DT algorithm applied to AHI, examining validation against AERONET during KORUS-AQ, comparing AHI retrievals against MODIS retrievals across the full disk image of AHI, and evaluating the meaning of resolving a diurnal aerosol signal. These results are being finalized and we intend to have a draft manuscript prepared by the end of September with submission before Thanksgiving. During this period of porting and evaluating the DT algorithm, strong communication links between the NASA DT team and the NOAA VIIRS aerosol team were maintained for the benefit of both groups. One consequence of this communication is the finalization and submission of a paper describing the modified snow mask for the NOAA Enterprise VIIRS aerosol product that is based strongly on the snow mask that the NASA team has used through the past several Collections. This paper is in review.

**Plans for Next Year**
This project is concluding. Other than following through on the submission of the Dark Target AHI paper, which will transfer to the project JCET0173, there are no plans for next year.

**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**
Over this period, we performed a Comparisons of bispectral and polarimetric retrievals of marine boundary layer cloud microphysics: case studies using a LES–satellite retrieval simulator. Many passive remote-sensing techniques have been developed to retrieve cloud microphysical properties from satellite-based sensors, with the most common approaches being the bispectral and polarimetric techniques. These two vastly different retrieval techniques have been implemented for a variety of polar-orbiting and geostationary satellite platforms, providing global climatological data sets. Prior instrument comparison studies have shown that there are systematic differences between the droplet size retrieval products (effective radius) of bispectral (e.g., MODIS, Moderate Resolution Imaging Spectroradiometer) and polarimetric (e.g., POLDER, Polarization and Directionality of Earth's Reflectances) instruments. However, intercomparisons of airborne bispectral and polarimetric instruments have yielded results that do not appear to be systematically biased relative to one another. Diagnosing this discrepancy is complicated, because it is often difficult for instrument intercomparison studies to isolate differences between retrieval technique sensitivities and specific instrumental differences such as calibration and atmospheric correction. In addition to these technical differences the polarimetric retrieval is also sensitive to the dispersion of the droplet size distribution (effective variance), which could influence the interpretation of the droplet size retrieval. To avoid these instrument-dependent complications, this study makes use of a cloud remote-sensing retrieval simulator. Created by coupling a large-eddy simulation (LES) cloud model with a 1-D radiative transfer model, the simulator serves as a test bed for understanding differences between bispectral and polarimetric retrievals. With the help of this simulator we can not only compare the two techniques to one another (retrieval intercomparison) but also validate retrievals directly against the LES cloud properties. Using the satellite retrieval simulator, we are able to verify that at high spatial resolution (50 m) the bispectral and polarimetric retrievals are highly correlated with one another within expected observational uncertainties. The relatively small systematic biases at high spatial resolution can be attributed to different sensitivity limitations of the two retrievals. In contrast, a systematic difference between the two retrievals emerges at coarser resolution. This bias largely stems from differences related to sensitivity of the two retrievals to unresolved inhomogeneities in effective variance and optical thickness. The influence of coarse angular resolution is found to increase uncertainty in the polarimetric retrieval but generally maintains a constant mean value.

**Plans for Next Year**
We will extend this study to more LES cases.

**UMBC Project Number:** 00009497
**UMBC PI:** Remer, Lorraine
**Sponsoring Agency:** NASA
**Project Title:** Aerosol absorption retrievals from base-line OCI observations: Risk reduction for atmospheric correction of the PACE mission

**Summary**
This grant encompasses Dr. Remer's role as PACE Science Team Deputy Lead, as well the work towards obtaining aerosol absorption from the broad-spectrum OCI observations. As science team deputy lead, Dr. Remer is responsible for organizing science team meetings and writing the final report. For the aerosol absorption work, a series of theoretical studies to determine the uncertainties involved in 1) identifying absorbing aerosol at low aerosol optical depth (AOD) for the purposes of atmospheric correction, and 2) retrieving aerosol information including AOD and absorption at moderate to high AOD. The focus is on the over ocean retrievals, where the new broad spectrum OCI offers enhanced possibilities, but this will be overlaid on a global (ocean and land) product that would represent adapting existing OMI and MODIS algorithms to OCI radiances.

**Accomplishments**
This past year was dedicated to winding up the activities of the PACE Science Team, while continuing to pursue research into retrieving aerosol absorption properties. In terms of the PACE Science Team, we planned and executed the fourth (bonus) Science Team meeting in January 2018. The meeting was held once again at the Harbor Branch Oceanographic Institute and the focus was reporting on the accomplishments by the team and by the individual researchers over the course of the three years the team worked together. Also of note were presentations by the PACE project office and by the three funded cal/val projects and contributed polarimeter teams. The atmosphere at this fourth meeting was very different than at the start of the Science team in 2014. At the beginning there was no PACE mission, and now the mission is progressing with a determined instrument suite that includes two cubesat-size polarimeters, although without a coastal camera. The Science Team itself celebrated an interdisciplinary camaraderie that has enriched the scientific output of both self-identified ocean and atmosphere scientists. The atmospheres/atmospheric correction discipline of the PACE Science Team has succeeded for the most part in producing a comprehensive set of reports that assess the state of the science and way forward during the PACE era for cloud retrievals, aerosol retrievals, atmospheric correction over oceans, fundamental radiative transfer components necessary to realize these remote sensing objectives and the societal benefits anticipated from the PACE mission's atmospheric science. Some of these topics are completely finished and exist as stand-alone documents that are now or will be submitted as NASA Technical reports. Also in that category is the report discussing the possibility of including polarimetry on PACE that was submitted to NASA Headquarters in 2015. Other topics are still in their finishing stages, and three of these topics will be submitted as the basis of a Research Topic in the peer-reviewed journal of Frontiers in Earth Science, with special editors David Antoine and Oleg Dubovik. A paper describing anticipated societal benefits of the PACE mission was submitted to the Journal of Applied Remote Sensing and is in review. The research into remote sensing of aerosol absorption focused on developing better characterization of aerosol properties at their most fundamental level in order to provide better aerosol models for remote sensing. Using measurements made by UMBC in the laboratory or in real time in the field we were able to characterize spectral scattering and absorption

properties of Saharan desert dust collected at two sites in north Africa. These results are the first spectral characterization of dust optical properties that spanned from the ultraviolet to the shortwave infrared. The dust at the two sites showed different spectral signatures in some important parameters, which presents an interesting challenge in the development of generalized remote sensing techniques. A paper on this study was published in Atmospheric Chemistry and Physics. In addition to the desert dust study, we also characterized particle scattering properties from in situ measurements of particles from aircraft during two North American field campaigns in 2012 and 2013. The instrument flown during these campaigns was the Polarized Imaging Nephelometer (PI-Neph). The analysis of this data showed that we can retrieve particle size distribution and the real part of the refractive index at the three wavelengths measured by the PI-Neph at least as well as standard instruments and measurement techniques flown on the same aircraft at the same time. Furthermore, we found that there is sufficient information in the PI-Neph measurements to distinguish between different aerosol types, even between biomass burning smoke from wildfires and biogenic aerosols produced naturally by living trees. These results were published in two papers, one in Atmospheric Measurement Techniques and the other in Atmospheric Chemistry and Physics. These published studies did not address directly the ability of the PI-Neph to also retrieve absorption properties of the aerosol. That work was continued up to the present. We are now writing the manuscript describing the results of that work and intend to submit it to a journal in the next few months.

**Plans for Next Year**
This project is ending. Except for going through the review process with the submitted papers, no new work is anticipated.

**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 is conducted in with partnership with Hazen and Sawyer (H&S), a private company working with drinking water utilities. This project is designed to develop a web-based decision support system for water quality monitoring based on statistical relationship between NASA satellite and model data and in situ water quality data to monitor chlorophyll concentration, dissolved organic matter, and turbidity in Falls Lake, North Carolina; and selected reservoirs in New York and Colorado States. With the assistance from a prospective

student and consultant, Amanda Rumsey, and from the team from H&S, Mehta contributed in developing Landsat-based water quality regression analysis on a subset of small lakes in New Your state. A major effort was provided toward developing software for the DSS, specifically extracting land cover information for watershed within the study areas. Moreover, processing and statistical analysis of land surface temperature, emissivity, and land cover with in situ water quality parameters was conducted to include in the DSS. The DSS will be tested by early 2019. This project will conclude after the DSS becomes operational.

**Plans for Next Year**
Based on the project mentioned above, a Step-1 proposal was submitted to NASA Applied Sciences Water Resources program by H&S in which Mehta is a CoI. This proposal has been accepted for a submission in August 2018. Mehta will contribute to the proposal titled 'Improving the Effectiveness of Best Management Practice using Probabilistic Water Quality Predictions based on satellite-observed Watershed Conditions'. Her contribution to the proposed project will be to analyze a newly available Harmonized Landsat and Sentinel-2 optical reflectance data in selected watershed for water quality predictions. Contingent upon the proposal approval, Mehta will continue to work on this project in FY19 and beyond.

**UMBC Project Number:** 00009764
**UMBC PI:** Campbell, Petya
**Sponsoring Agency:** NASA
**Project Title:** Next Generation UAV Based Spectral Systems for Environment

**Summary**
This project will produce a UAV based capacity for accurate measurement of spectral reflectance at high temporal frequencies and stability to depict diurnal/seasonal cycles in vegetation function. We will test our approaches first using spatially-resolved discrete point measurements characterizing VNIR reflectance and solar-induced fluorescence Y1, followed in Y2 by imaging spectroscopy. The ultimate goal is to produce science-quality spectral data from UAVs suitable for scaling ground measurements and comparison against airborne or satellite sensors. Provided that the measurements are suitably calibrated and well characterized, this opens up opportunities for calibration/validation activities not currently available. There is considerable interest in UAVs from the agricultural and forestry industries but there is a need to identify a workflow that yields calibrated comparisons through space and time. This will increase the likelihood that UAVs are economically feasible for applied and basic science, as JCET GR-9 well as land management. We target the consistent retrieval of calibrated surface reflectance, as well as biological parameters including chlorophyll fluorescence, photosynthetic capacity, nutrient and chlorophyll content, specific leaf area and leaf area index- all important to vegetation monitoring and yield. We will utilize SensorWeb functionalities to strategically run a data gathering campaign to optimize data yield. As well, we will implement a mission deployment system to optimize flight paths based on real-time in-flight data processing to enable effective data collection strategies. Ultimately, we will demonstrate the acquisition of science-grade spectral measurements from UAVs to advance the use of UAVs in remote sensing beyond current state of application, providing measurements of a quality comparable to those from handheld instruments or well-calibrated air- and spaceborne systems. A key benefit is that UAV collections at 10-150m altitude bridge the gap between ground/proximal measurements and airborne measurements typically

acquired at 500m and higher, allowing better linkage of comparable measurements across the full range of scales from the ground to satellites.

**Accomplishments**
Our goal is to demonstrate a spectral system able to acquire science quality spectral data using small Unmanned Aerial Systems (UAS). During the performance period we collected Visible and Near Infra-Red (VNIR) measurements of corn and forest at ARS/USDA, Greenbelt, MD and of set of bio-diversity plots at the Ceder Creek LTER, MS. We tested and further developed the optimization and processing techniques. We are using an Intelligent Payload Module (IPM), to optimize the acquisitions and are processing the spectral data upon return at GSFC. The project started at TRL 3. Currently, the different components have transition to higher levels, but the overall system TRL is 5. We were able to produce science quality spectral data and biophysical parameters (BP), suitable for scaling ground measurements and comparison to other field and airborne data products.

**Plans for Next Year**
Our objectives for the next FY19, and the reaming time of the project are to collect diurnal and seasonal observations in corn from maturity to senescence, retrieve biochemical and physiological traits and test the ability of the systems to detect the diurnal variations in vegetation function, and characterize the changes in canopy traits with advancement of senescence. At the completion of this project the expected TRL is 5 or 6.

**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 used the RSP data to find water cloud particle size distribution. Based on the size distribution, we have calculated the lidar ratio values and compared the information with active HSRL lidar measurements. Reasonable agreements are found, but inconsistency exists. Further research is on going to find out why.

**Plans for Next Year**
We will continue to analyze the data and find potential explanation for the discrepancy between RSP and HSRL lidar measurements.

**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**
We organized and Chaired A special Symposium on Plains Elevated Convection At Night (PECAN)at the 98th American Meteorological Society (AMS) annual meeting in Austin, Texas. Presented on status of the data from the PECAN field campaign submitted to the archive, highlights of case studies from the measurements on the thermodynamics of undular bores and cold pool dynamics leading to convection, and a summary of the wind and boundary layer evolution during Nighttime Low-Level-Jet (NLLJ) conditions.

**Plans for Next Year**
This project ends the next physical year. We plan to submit a renewal proposal to NSF and complete the work on two publications regarding NLLJ evolution and relationships to convection.

**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. In this project, Brian Carroll (4th year graduate student) achieved PhD candidacy and continues to work towards graduation. His thesis research focuses on studying low-level jets (LLJs) observed during the 2015 Plains Elevated Convection at Night (PECAN) field campaign. This includes interactions of the jets with the nocturnal boundary layer, dynamic theory and modeling of LLJs, and LLJ moisture transport over the Great Plains. UMBC students were trained on the NASA/GSFC Atmospheric Lidar for Validation/Interagency

Collaboration and Education (ALVICE) system. This Raman lidar instrument is a well-known benchmark for water vapor and other measurements in the troposphere and lower stratosphere. Finally, during the month of June 2018 Brian Carroll conducted lidar and ozonesonde measurements as part of 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.

**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**
Over this period, we focused studying the Seasonally transported aerosol layers over southeast Atlantic. From June to October, low–level clouds in the southeast (SE) Atlantic often underlie seasonal aerosol layers transported from African continent. Previously, the Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) 532 nm lidar observations have been used to estimate the relative vertical location of the above–cloud aerosols (ACA) to the underlying clouds. Here we show new observations from NASA's Cloud–Aerosol Transport System (CATS) lidar. Two seasons of CATS 1064 nm observations reveal that the bottom of the ACA layer is much lower than previously estimated based on CALIPSO 532 nm observations. For about 60% of CATS nighttime ACA scenes, the aerosol layer base is within 360 m distance to the top of the underlying cloud. Our results are important for future studies of the microphysical indirect and semidirect effects of ACA in the SE Atlantic region.

**Plans for Next Year**
We will study the radiative effects and indirect effects of above-cloud aerosols

**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**
The goal of this project is to use Moderate Resolution Imaging Spectroradiometer (MODIS) data to determine seasonal and multiyear patterns in ecosystem productivity for boreal forest and tundra ecosystems within the NASA Arctic-Boreal Vulnerability Experiment (ABoVE) study region. In this, the final year of this project efforts have been directed to organizing and documenting the data products and arranging for final archive of the results.

**Plans for Next Year**
Continue working on organizing and documenting data from the project, moving some data sets to be made available on the ABoVE web site, and, finally, seeing that these data are permanently archive in the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC).

**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**

A footprint scale variability of raindrop size distribution has been investigated through two-dimensional disdrometer network during Midlatitude Continent Convective Clouds experiment. Specifically, the footprint of GPM Dual-frequency precipitation radar (DPR) was simulated through kriging and inverse distance weight methods. Non-uniform beam filling was quantified for the algorithm developers. A peer-reviewed article was published in Journal of Hydrometeorology [Tokay et al. 2017]. A manuscript on the evaluation of raindrop size distribution (DSD) was appeared in Atmospheric Research [D'Adderio et. al. 2018a]. This study used two-dimensional video disdrometer (2DVD) observations from GPM field campaigns where the equilibrium size distribution was observed in convective moderate to heavy rain. As part of the GPM Level-1 requiement, empirical relationhsips between the size distribution parameters and radar observables were developed through disdrometer observations from GPM field campaigns [Tokay et al. 2018a]. The study was extended to comparison of the NASA's S-band polarimetric radar (NPOL) derived and 2DVD measured DSD parameters and a manuscript is now under preparation [Tokay et al. 2018]. The vertical variability of DSD is currently investigated through joint disdrometer and micro rain radar measurements during GPM IFloodS field campaign. A manuscript in this topic has been drafted [Adirosi et al. 2018]. Three interns worked on the comparison of snow detection algortihms at NASA Wallops Flight Facility (WFF) and Continental US. This work is also linked to the GPM Level-1 requirement. The first intern examined 10 events using operational and research assets at WFF, while the second and third interns compared the radar based precipitation type algorithms with surface reports at 11 sites for 172 events. The findings were presented at the AMS annual meeting and the 10th European conference on radar meteorology and Hydrology (ERAD2018) [Swick et al. 2018]. 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). The investigator also analyzed the calibration tests of PARSIVEL2 disdrometer that was conducted at WFF throughout the year. The PLUVIO network at Marquette (MQT), Michigan was also analyzed. The investigator participated research projects on the comparison of the GPM DPR and ground based radar derived DSD parameters over Italy [D'Adderio et al.

2018b] and the radar based precipitation estimate during Hurricane Harvey (2017). During calendar year, the investigator participated four proposals. An international proposal to the United Arab Emirates was selected for full proposal but not funded. Three NASA proposals are pending, one of which he is the principal investigator. The theme of NASA proposals is the validation of GPM and CloudSat phase algorithms and light rain observations. The investigator participated the organization committee of ERAD2018 in The Netherlands. He is also chair of AMS radar meteorology committee and associate editor of Journal of Atmospheric and Oceanic Technology.

**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 utiziling 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:** 00010482
**UMBC PI:** Hoban, Susan
**Sponsoring Agency:** Northwest Indian College
**Project Title:** NASA Inspires Native American Students (NINAS)

**Summary**
The goal of the NINAS project is to improve computer science literacy of Native American students by providing professional development in programming and robotics to educators of Native American students.

**Accomplishments**
The activities for this project (two robotics workshops for educators of Native American students) were completed during the previous reporting period. During this reporting period, the final report was written and submitted to NASA.

**Plans for Next Year**
This projected ended 5/1/2018.

**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 continued to develop a model for the microwave single-scattering properties of melting snow, adding aggregation of melting particles to his thermodynamic model of the melting layer. It was demonstrated that the process of aggregation changes attenuation-reflectivity relationships that are critical for satellite-borne radar remote sensing of precipitation where melting precipitation is present. Calculation of the single scattering properties of improved simulations of individual aggregate crystals by colleagues Dr. Benjamin Johnson, Dr. Kwo-Sen Kuo, and Craig Pellisier also commenced.

**Plans for Next Year**
Calculations of individual melting aggregate particle single scattering properties will be completed, and these properties will be assigned to particles with the same mass and liquid water fraction in the thermodynamic model simulations of the melting layer by Dr. Olson. The goal is to use the coupled thermodynamic-particle simulations of bulk single-scattering properties to create tables that can be used in TRMM (Tropical Rainfall Measuring Mission) or GPM (Global Precipitation Measurement mission) precipitation remote sensing algorithms.

**UMBC Project Number:** 00010484
**UMBC PI:** Hoban, Susan
**Sponsoring Agency:** Howard University
**Project Title:** NASA Early Opportunities Program for Underrepresented Minorities in Earth and Space Science

**Summary**
UMBC supports Howard university in providing research and learning opportunities for six minority undergraduates.

**Accomplishments**
UMBC participated in the NASA site visit to Howard University. Hoban & Demoz gave a presentation outlining UMBC's role in the project and describing the Year 2 activities. UMBC sponsored a trip to the National Weather Service in Sterling, VA, for the Howard University students participating in the project. A tour of the facility was provided and participants were able to view a weather balloon launch. The Howard Students were in attendance as well as six graduate students and one undergraduate student from UMBC -- thus, furthering our objective of connecting the Howard undergraduates with UMBC students for near peer mentoring. Graduate Students from the UMBC Physics Department and JCET organized the second annual Earth Day Symposium, held at UMBC on Friday, April 20, 2018. The symposium was held in the Physics Building from 9 AM to 4 PM. The program included speakers from

Goddard, UMBC, the University of Maryland, George Mason University and Howard University. The Symposium was open to the public. The undergraduates from the Howard NASA MOO project were invited to the symposium to participate and give poster presentations. Due to academic schedules, only two students were able to attend.

**Plans for Next Year**
UMBC is planning a "Measurement Bootcamp" for the Howard University students to interact with UMBC Atmospheric Physics graduate students in October 2018. The students will be introduced to measurement techniques, and data analysis techniques, including error analysis and visualization.

**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**

The project seeks to determine definitively the rotation period of Comet P/Halley by studying jet morphology in archival data. The UMBC component involves developing software to animate simulated and observed images, as well as to parallelize exisiting modelling code to increase preformance, using the UMBC High Performance Computing Facility.

**Accomplishments**
During the reporting period, python code was developed for the animation of comet images in FITS format. This code will be used to demonstrate how the coma models fit with the observed comet images. Also during the reporting period, the investigator participated in a 15-week course at UMBC to learn to use MPI on the UMBC High Performance Computing system. This activity will support the development of parallel code for modeling jets in cometary comae.

**Plans for Next Year**
Next year we plan to develop a parallel version of the jet modeling code. The code will be ported from Fortran to python. The parallel implementation will be carried out on the UMBC High Performance Computing system.

**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**
Wolfe has initiated an analysis of observations from CA's 2013 Rim Fire, which was sampled in detail during the SEAC4RS airborne mission. This work has involved trajectory analysis to determine air mass age and segregate multi-fire influences and development of box model simulations to estimate the impact of unmeasured compounds on the production of formaldehyde as the fire plume ages. St. Clair's work has focused on maintenance and improvement of gas-phase instrumentation, which will be deployed during the FIREX-AQ mission in FY2019.

**Plans for Next Year**
Wolfe will complete and publish his analysis of the 2013 Rim Fire. In July 2019, Wolfe and St. Clair will deploy an instrument on the NASA DC-8 to acquire formaldehyde observations during the joint NASA/NOAA FIREX-AQ mission. This mission will characterize the emissions and evolution of gases and particles over agricultural burning and wildfires throughout the U.S. Data will be quality-assured by Wolfe and St. Clair through careful calibrations and inter-comparisons with other measurements where feasible. 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). The latter will require collaboration with satellite retrieval groups at GSFC and elsewhere.

**UMBC Project Number:** 00011028
**UMBC PI:** Strow, Larrabee
**Sponsoring Agency:** NASA
**Project Title:** NASA: A Homogenous Infrared Hyperspectral Radiance and Level 3

**Summary**
Research to create a 25+ year long radiance record of the earth's infrared emission from multiple satellites (AIRS, CrIS, and Europe's IASI)

**Accomplishments**
The goal of this research is to product a homogenous climate radiance product from AIRS + CrIS for the 1:30 polar orbit and IASI for the 9:30 orbit. Working with AIRS alone we have shown very reasonable 14-year zonal temperature trends in the troposphere with cooling in the stratosphere (as predicted by climate models). Interesting differences between our observations and reanalysis products indicate some liens in their lower-stratospheric trends. We also converted 10-years of AIRS (subsetted) radiances to the CrIS instrument function and inter-compared 10-year trends of these converted AIRS data, to 10-year trends where we use AIRS (converted to CrIS) for the first five years and SNPP-CrIS for the second five years. CrIS is connect to AIRS using both statistical and SNO observations to determine the radiometric offsets of these two instruments. This static (meaning global) single adjustment

used to create the AIRS + CrIS 10-year time series gave nearly identical trends to the AIRS-only time series. This important results shows that we can build a climate-level radiance climatology using multiple hyperspectral infrared sounders that is already nearly 17 years in length, and will continue for the foreseeable future.

**Plans for Next Year**
We will concentrate on preparing papers on the accomplishments of this year and will perform single footprint retrievals on AIRS radiances versus AIRS radiances converted to CrIS to hopefully show that conversion of AIRS to the CrIS instrument function does no significantly impact the retrieval. This is an essential step to providing a long-term homogenous climate product using these sensors.

**UMBC Project Number:** 00011071
**UMBC PI:** Martins, Jose V.
**Sponsoring Agency:** NASA /GSFC
**Project Title:** Development and applications of the Air-HARP imaging polarimeter in preparation for the ACE mission

**Summary**
More comprehensive and accurate measurements of aerosol, clouds and their interaction are essential to reduce the uncertainty that they pose to the energy balance of our planet, climate, and precipitation. The last National Academy of Sciences Decadal Survey for Earth Sciences defined the Aerosol-Clouds-Ecosystems (ACE) mission and recognized the need for a highly accurate multiangle, multiwavelength polarimeter to measure cloud and aerosol properties, with wide cross-track and along-track swaths and a pixel size of about 1 km. Multiangle polarization measurements over a broad spectral range and wide field of view are identified as part of the ACE mission as the next frontier on passive measurements of aerosols, clouds, ocean and land surface properties from space. A small subset of these measurements will be soon launched to space as part of the HARP CubeSat effort for cloud microphysical retrievals but there is long ways to go before we reach the accuracy, spectral range, data volume and coverage required by the Earth Sciences community for comprehensive aerosol measurements. These measurements will require the addition of effective onboard polarization calibration systems as well as the full combination of hyper-angular observations and wide FOV polarization measurements over a broad spectral range from short visible to shortwave infrared wavelengths. The ER2 flight ready Air-HARP as proposed here attempts to address these issues. Air-HARP carries a state of the art, yet simple, wide FOV, broad spectral range (440-2250nm), hyper-angular imaging polarimetric system with the goal to demonstrate its capabilities for the measurement of aerosol and cloud microphysical and thermodynamic properties. Air-HARP is built upon the heritage of the HARP CubeSat satellite designed for the measurement of cloud microphysical variables and will enhance and complement its capabilities to accurately measure aerosol microphysical properties. To achieve this goal we will add a laboratory tested internal calibration system to the second copy of the HARP CubeSat instrument (Air-HARP VNIR), and will merge its counterpart laboratory tested SWIR imaging polarimeter (Air-HARP SWIR) to produce an unprecedented airborne hyperangular wide FOV imaging polarimeter system. Air-HARP will also be furnished with improved/faster electronics, additional data storage, and a powerful data system computer to allow for substantial data acquisition and on board data processing on board the ER2 aircraft.

This system will significantly enhance the capabilities of AirHARP when compared with the HARP CubeSat instrument or even the previous PACS airborne polarimeter. Air-HARP is specifically designed with consideration for the requirements of the second tier Decadal Survey Aerosols-Clouds-Ecosystems (ACE) mission and is also consistent with the NASA 2014 Strategic Plan. This proposed Air-HARP effort covers the period between April 2017 till March 2018.

**Accomplishments**
We have competed integration of the HARP airborne sensor (AirHARP) to the NASA ER2 aircraft and have successfully flown its first airborne campaign in a high-altitude aircraft during the ACEPOL campaign in October-November 2017. During ACEPOL we collected data over the dark ocean, sunglint, clouds, different land types, and smoke. The ACEPOL data set was used to produce level 1 calibrated and georeferenced and geolocated data. The LACO team has invested extensively on the calibration and characterization of AirHARP in order to better interpret the ACEPOL data set. We have also worked on intercomparisons between AirHARP and the NASA GISS RSP (Research Scanning Polarimeter) instrument, as well as with the JPL AirMSPI instrument. We will continue the analysis of the ACEPOL data as well data from the previous LMOS aircraft campaign.

**Plans for Next Year**
We will continue to analyze data from the LMOS and ACEPOL aircraft campaigns by completing the level 1 data release, and move into the level 2 data production. The AirHARP instrument and data systems will be upgraded with lessons learned from these two field campaigns in preparations for any future flight activities. The LACO team will continue to seek other flight opportunities for the AirHARP instrument.

**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. She has run the GEOS-5 model by coupling a gas phase chemistry module (GMI) with an aerosol chemistry module - Goddard Chemistry Aerosol Radiation & Transport (GOCART) - in order to provide a full set of tracers' CLBC to drive CMAQ. She ran the model over the years 2011-2015 in the replay mode using the Modern-Era Retrospective analysis for Research and Applications version 2 (MERRA-2) meteorological system that applied data assimilation. The emissions from anthropogenic, biomass burning, and natural source were used for both gas and aerosol tracers. The GEOS-5 5-year monthly mean global 3D gas and aerosol fields were compiled to be used as the climatological monthly CLBCs to NAQFC.

**Plans for Next Year**

Huisheng Bian will continue to work with the project team to fulfill the proposed objectives in the proposal. Specially, she will run the GEOS5 model to provide high time frequent (3-hourly) gas and aerosol fields to study the impact of pollution events, such as fires from Canadian and Mexico, dust from Asia and Africa, and O3 long-range transport. She will assist the team to build up the boundary conditions under various potential events that will occur toward US border.

**UMBC Project Number:** 00011127
**UMBC PI:** Martins, Jose V.
**Sponsoring Agency:** NASA
**Project Title:** Retrievals of Aerosol and Cloud Droplet Microphysical Properties with the Hyper-Angular Rainbow Polarimeter (HARP)

**Summary**
Aerosols and their interactions with cloud processes are among the most important and still least understood contributors to climate change. Remote sensing instruments in all regimes: satellite, aircraft, and ground stations, fill the vital role in sampling and imaging aerosols and aerosol-cloud interactions with global coverage. Despite this, traditional radiometric studies of clouds and aerosols suffer by assuming spherical aerosols in all cases and have little to no sensitivity to aerosol or cloud droplet size variance in a scene. Imaging polarimeters, conversely, are better apt to sample the microphysics of aerosols and clouds at the particle or droplet level, and can serve as vital support platforms for validation of radiometer microphysical retrievals. Building on successful imaging polarimeter concepts of the past, including POLDER and the APS concept, the Laboratory for Aerosols, Clouds, and Optics (LACO) at the University of Maryland, Baltimore County (UMBC) has developed a powerful, wide FOV, hyper-angular imaging polarimeter for the microphysical sampling of clouds and aerosols from aircraft and space. The instrument, the Hyper-Angular Rainbow Polarimeter (HARP), is a precursor to the multi-angle imaging polarimeter required of the upcoming NASA Aerosols, Clouds, and Ecosystems (ACE) mission. Though funded through NASA ESTO only as a technology demonstration, this NESSF renewal will extend the HARP mission and produce science-quality, highly accurate retrievals of aerosol and cloud microphysical parameters to the benefit of the climate community. The HARP instrument operates in four polarized wavelengths (0.44, 0.55, 0.67, 0.87um) and at least 20 unique view angles per wavelength, with no moving parts. The first of its kind, the hyper-angular capability of 60 view angles at 0.67um and a push-broom method of data acquisition provides the angular and spatial resolution required for highly accurate, full cloudbow retrievals. The space version of HARP is a 3U CubeSat with 3-axis nadir stabilization and a 2.5 x 2.5 km nadir ground resolution; the aircraft version, AirHARP, expands on the HARP CubeSat with an internal polarization calibrator, designed for accurate polarization characterization. Built from successful technology, the HARP instrument is based on the Passive Aerosol and Cloud Suite (PACS, LACO-UMBC), a hyper-angular imaging polarimeter that flew during the PODEX campaign in 2013. This second NESSF renewal will continue support for the detailed processing and analysis of Level 1 and Level 2 microphysical products on aerosols and clouds from both AirHARP and HARP platforms. Special attention will be given to the collaboration between and validation of the HARP instruments with MODIS and VIIRS radiometers, and other polarimeter instruments from the ACEPOL campaign, including the Research Scanning Polarimeter (RSP), Airborne Multi-Spectral Polarimetric Imager (AirMSPI), and the Airborne Spectro-Polarimetric Experiment (AirSPEX). Not only will the HARP project provide the foundation for future polarimetric studies into investigations of aerosol and cloud microphysics, but Level 2 data products will aid in greater knowledge of climate uncertainties: aerosol direct/indirect effects, global fluctuations in aerosol composition, cloud growth processes, precipitation, and the variability of cloud droplet size distributions. HARP CubeSat anticipates a launch in May 2018 into an inclined, ISS orbit, placing it in a perfect position to interface with A-Train satellites.

**Accomplishments**
This project covers the activities of the PhD student Brent McBride and supports AirHARP and HARP2 activities. As part of this project, Mr. McBride has supported the LMOS and ACEPOL aircraft campaigns by performing pre and post calibration activities, leading the field campaign, and working on the overall algorithms and data analysis. During the next few months Mr. McBride will continue the performance analysis of both instruments and will

review the AirHARP level 1 data that has recently been released to the science community.

**Plans for Next Year**
Mr. McBride will continue to support HARP CubeSat activities including final testing, launch and science operations, AirHARP data analysis, testing and possible deployments, and HARP2 developments. In particular, Mr. McBride will perform further science analysis on the LMOS and ACEPOL data sets from the AirHARP instrument and will use lessons learned from these campaigns toward the actual data from the HARP CubeSat sensor.

**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**
Arboreal to Benthic Canopy Land and Ocean Biodiversity Observations (ABC LOBO) is an interdisciplinary project to scope an airborne study of biodiversity, habitat connectivity, and biogeochemical processes in the interconnected arboreal, water column, and benthic habitats of the South Florida peninsula; from the watershed upstream of the Everglades to the reefs of the Florida Keys. Dr. Turpie co-chaired a focused workshop in Miami, Florida in January of 2018. The workshop brought to together terrestrial, fresh water, and marine scientists, resource managers and stakeholders from the region to identify how to best integrate science and applications from the watershed to the reefs, and provide guidance for developing and implementing applications for conservation biology and sustainable use of resources. His involvement in the workshop including organizing, moderating, and participating by presenting on aquatic image spectroscopy and engaging in the dialogue with other participants. An overview of the results from that workshop was presented at the 2018 Ocean Sciences meeting in Portland, Oregon in February of 2018. In the next few months, a final report for ABC LOBO will be written and submitted to NASA HQ. In addition to the input collected at the workshop, Dr. Turpie will provide his unique insight regarding flying sensors aboard the ER-2 aircraft, which would have at least two imaging spectometers and potentially a lidar system and an imaging bolometer. Dr. Turpie will also use input from a workshop on remote sensing science and applications for the Chesapeake Bay on another project.

**Plans for Next Year**
The ABC LOBO project is expected to conclude this fiscal year, however the PI may apply for a no-cost extension.

**UMBC Project Numbers:** 00011246, 00012025
**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 physical year was the last year for this project. This project finalized a report that NOAA/NWS commissioned on finding a cost-effective way to save and archive the lidar back scatter profile data from about a thousand ceilometer in the Automated Surface Observing System's Ceilometer (ASOS) lidar network. Following is a list of major points, recommendations, and conclusions based on the extensive study and proof of concept undertaken under this study. The Automated Surface Observing System's Ceilometer, the Vaisala© CL31, is a lidar-backscatter instrument capable of providing multi-layer cloud base height, planetary boundary layer (PBL) height, as well as information that visualize the lower atmospheric dynamics. The CL31 is perhaps the lidar most deployed by many national weather service organizations globally and well compared as to its capability against other lidars and ceilometers. This study's work as well as multi-nation comparisons show that the CL31 data, while noisier (lower signal-to-noise ratio) above the PBL, compares reasonably well with other more capable systems on the market (primarily CL51 from Vaisala©; CHM from Lufft©). At present, the ASOS CL31 data is not fully exploited. The primary "bottleneck" for this is the fact that ASOS grid and mainframe computers are connected through an IP radio link that has limitations in its bandwidth and data throughput. A direct-wire link of the ASOS grid with the main frame, although the easiest solution does not seem to be in the planed upgrade of the ASOS.

**Plans for Next Year**
This is the last year of this project. A publication is in progress that summarize the results of this work.

**UMBC Project Numbers:** 00011263, 00012345,UNIV0001, UNIV0002, UNIV0003
**UMBC PI:** Demoz, Belay
**Sponsoring Agency:** Howard University
**Project Title:** NOAA Cooperative Science Center in Atmospheric Sciences and Meterorology at Howard University

**Summary**
Research in GRUAN and lidar-based profiling, unmanned airborne systems for the execution of NOAA center for Atmospheric Studies (NCAS). GCOS Reference Upper Air Network (GRUAN): radiosonde work with WMO, NOAA/NWS/SFSC and NOAA/NESDIS/STAR scientists as part of the Global Climate Observation Sites (GCOS) Reference Upper Air Network (GRUAN). Weekly radio sonde launches with students. PBL determination from the ASOS Ceilometer Network: proof of concept of saving the full data profile of the NOAA/NWS Automatic Surface Observing System's (ASOS) ceilometer network. Required work to help define and design the network and possible science outcomes. In particular, an extensive effort is spent in retrieval of the planetary Boundary Layer (PBL) from the regional lidar networks developed at NCAS partner sites, UMBC, and the NOAA College Park Bldg site (NOAA/ARL). A fast algorithm developed at UMBC, Howard University and NOAA/NWS-SFSC is tested and compared. A graduate student and 2-3 undergraduate interns will be recruited and trained to help carry most of the day-to-day work in this project and coordinate with Howard University. This lidar-based work will also include the testing and coordination of advanced lidar systems (Water vapor, wind, and aerosol) at the Beltsville research Station. Coordination of lidar testing for NOAA, in collaboration with NCAS staff and faculty, at the Beltsville research station is a key aspect of this work. Also included in this task is advice and mentoring of PostDocoral and graduate student as well as scientific staff at Beltsville. Unmanned Aircraft System research: At HUBRS a low-cost Unmanned Aerial Vehicle (UAS) based sensor system is being developed. This system is portable, scalable, and affordable Autonomous Measurement System (AMS). The AMS is designed to measure in situ meteorological, biophysical, chemical, and surface parameters of a designated area with minimal user supervision, and it is designed to be easily reconfigurable, portable, and rapidly deployable.

**Accomplishments**
The goal of this project is primarily for the PI (Belay B Demoz) to collaborate with Howard University Scientists and students at the Beltsville research site in Beltsville, MD. This collaboration includes UMBC student advisement and mentorship in STEM, research in radio sounding, lidar, unmanned airborne systems, and other activities as needed for the execution of NOAA center for Atmospheric Studies (NCAS) and the many collaborations with NOAA. The Howard University Beltsville Research Site (HUBRS) and UMBC have developed a strong partnership with the NOAA NWS, NASA through this grant. We are mentoring UMBC four undergraduate students in research applicable to NOAA and NWS.

**Plans for Next Year**
This project primarily supports student training and as such we plan to continue to recruit and mentor STEM minority student working on subjects that are of interest to NOAA. The project is renewed annually up to five years and will continue to be focused on student training.

**UMBC Project Numbers:** 00011266, 00012423, 00012433, 00012967
**UMBC PI:** Delgado, Ruben
**Sponsoring Agency:** Research Foundation of CUNY
**Project Title:** CSC-Earth System Sciences and Remote Sensing Technologies - ESSRST

**Summary**
The University of Maryland, Baltimore County (UMBC) will participate in research and student training activities in Center of Remote Sensing Science and Technology (CREST, lead institution City College of New York) the thematic area “Weather and Atmospheric Processes and Hazards”. This theme area contributes to the National Oceanic and Atmospheric Administration (NOAA) “Weather Ready Nation” initiative. UMBC’s work addresses the following objectives within this goal: 1) “Healthy people and communities through improved air and water quality”, and 2) “Reduced loss of life, property, and disruption from high-impact events”, and focus in innovative technology and integrative observations to study atmospheric processes, validate and improve satellite products, and carry out field work to advance understanding and prediction of atmosphere.

**Accomplishments**
This grant is to provide students of academic and research experiences aligned with NOAA's mission goals. UMBC research task is centered in remote sensing measurements of Atmospheric Hazards. Development of a universal mixing layer height algorithm is ocurring at this time and is to be used with future heterogeneous aerosol profiling network such as the new EPA PAMS ceilometer network and the NWS ASOS ceilometer network. Algorithm for overlap correction in aerosol backscatter was developed and currently is being evaluated in several commercial ceilometer units. UMBC students continue to contribute to the Smog Blog, a daily diary of the U.S. air quality. Blog post require knowledge and assessment of NOAA satellite products. PI participated in the 2017 Fall POWER-US Technology Workshop Partnership for Offshore Wind Energy in the United States, in Boulder, CO in October 2017. In addition, he was part of the planning committee of National Academy of Science, Engineering and Medicine workshop on “The Future of Boundary Layer Observing”. UMBC students participated of the American Meteorological Society Short Course: A Beginner’s Course to Using Python in Climate and Meteorology, as part of their profesional development requirements. This course was offered during the AMS Annual meeting held in January 2018 in Austin TX.

**Plans for Next Year**
Atmospheric profiling of particle pollution events for air quality advisory alerts and forecasting model validation/verification. Mixing layer height (MLH) and atmospheric profiling database for modeling assessment. Work in collaborations with NOAA on transport and air quality model validation. UMBC-CREST is working on dissemination of observations products to both state and NWS air quality forecasters (i.e. MLH from CREST profilers for verification of forecast atmospheric parameters).

**UMBC Project Number:** 00011416
**UMBC PI:** Hoban, Susan
**Sponsoring Agency:** Univ of Md - Ctr For Environmntl Science
**Project Title:** MADE CLEAR mini grants: Something to CHEW On: (Climate, Health, Ecosystems, Weather)

**Summary**The project designed, developed and delivered professional development in the area of climate change to educators from Anne Arundel County Public Schools.

**Accomplishments**
The CHEW Educator workshops were held with eight participants from Anne Arundel County Public Schools in February, 2018. A website that contains all of the materials for educators, as well as additional resources, was developed (https://chew.umbc.edu/).

**Plans for Next Year**
This project ended 6/30/2018

**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 focused on fully implementing the radionuclide tracer suite (222Rn, 210Pb, 7Be, and 10Be) in GEOS-5 and evaluating current “bulk” scavenging scheme. Huisheng Bian assisted the team in the works of implementing the radionuclide tracer suite as part of the model tracer component, coupling the tracers with the GOCART wet deposition routines, and evaluating with 222Rn and 210Pb observational data sets. She also participated in three telecom meetings that were held with the GMAO GEOS-5 microphysics modeling group to discuss the status of the project with respect to developing and evaluating wet scavenging schemes in the model.

**Plans for Next Year**
During the next period of performance, Huisheng Bian will closely work with the project team to (1) complete the evaluation of the current scavenging scheme in GEOS-5 and present results at the 2018 AGU Fall Meeting; (2) focus on testing size-dependent below-cloud and in-cloud scavenging schemes under development for GEOS-5.

**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**
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 land-

atmosphere exchanges of carbon. We have been working on the development of algorithms making use of information from over 100 spectral bands derived from ground measurements of tundra vegetation cover types, such as lichens, mosses, and vascular plants, ecosystem productivity, and plant chlorophyll content and applying those algorithms to the Airborne Visible / Infrared Imaging Spectrometer Next Generation (AVIRIS NG) data collected in the ABoVE 2017 flight campaign. We are comparing how the descriptions of the tundra from these derived products relate to the commonly-used two-band Normalized Difference Vegetation Index (NDVI), trading space for time to describe the nature of ecosystem changes that are related to changes in NDVI. Results from this work were presented at the ABoVE science team meeting in Seattle January 23-26, 2018.

**Plans for Next Year**
Create maps of data products from AVIRIS NG imagery over entire Barrow region and along north-south flight lines across Alaska North Slope. Work with AVIRIS NG data collected in ABoVE 2018 flight campaign.

**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 investigated the changes in the simulated dust distributions over the Middle East region using two recent GEOS-5 simulations. The Modern-Era Retrospective analysis for Research and Applications, version 2 (MERRA-2) Reanalysis covers the period 1980 – present and includes prognostic aerosols and assimilation of AOD from ground-based and satellite observations. The MERRA-2 Replay covers the same period and is run with the same core GEOS-5 model version replaying the MERRA-2 meteorological fields but does not include AOD assimilation in the aerosol scheme. As the two simulations have the same meteorology a comparison highlights the impact of aerosol data assimilation on the ability to reproduce observed trends in dustiness. Our analysis finds that the observed positive AOD trend is reproduced in MERRA-2 Reanalysis (with aerosol data assimilated) but not in the MERRA-2 Replay (no aerosol data assimilated). This result highlights the importance of data assimilation in the model to simulate long term trends of atmospheric aerosols. It also indicates that the current representation of the dust processes in the model is not able to fully describe such long-term changes.

**Plans for Next Year**
We plan to correlate the results of our investigation of the sensitivity of the dust emissions to changes in the normalized difference vegetation index (NDVI) over the Middle East region. We want to evaluate if using the NDVI in the simulations will impacts the ability of the model to describe the observed dust trends over this region. Also, we plan to analyze the rate of change of important dust emission parameters, such as vegetation, soil moisture, and wind fields.

**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 project team to analyze 18-year (1997-2014) GPP, aerosol, cloud, radiation, and precipitation fields over Amazon from GEOS5 model results and various satellites and ground station measurements. The measurement fields examined by the team include observation based gross primary product (GPP), fractional photosynthesis active radiation (FPAR) from MODIS collection 6.1, the solar-induced fluorescence (SiF) from satellite MetOp-A, the downward surface shortwave radiation (Rsfc) at all-sky condition from satellite CERES-EBAF, aerosol optical depth (AOD) from satellite MODIS 6.1 and ground station AERONET, cloud fields (cloud cover, effective radius, cloud path, and optical depth) from MODIS 6.1, and atmospheric precipitation from the GPCP measurement (a consistent analysis of global precipitation from an integration of various satellite data sets over land and ocean and a gauge analysis over land). Our preliminary analysis indicated that the GEOS5 model underestimates aerosol and cloud cover fraction over Amazon significantly. To improve aerosol and cloud simulation over Amazon, the team collaborated with GSFC colleagues to develop and evaluate new GEOS5 model capabilities, which include 1) improving dust wet removal that results in more Africa dust transported to Amazon; 2) improving SOA simulation with online VOC calculation using dynamic meteorological fields of temperature and sun light; and 3) improving cloud droplet formation by separating the properties of organic aerosol with sulfate aerosol.

**Plans for Next Year**
Huisheng Bian will continually lead the project to achieve the proposed objectives in year 2. She will re-run the GEOS5 with the new model capabilities over 1994-2017. 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 Niño / La Niña year). She is going to prepare a manuscript for this work.

**UMBC Project Number:** 00011687
**UMBC PI:** Turpie, Kevin
**Sponsoring Agency:** NASA
**Project Title:** Development of a Highly Accurate Lunar Spectral Irradiance Measurement Capability - The Airborne LUnar Spectral Irradiance Instrument (air-LUSI)

**Summary**
The project is an inter-agency effort, involving NASA/GSFC, NIST and USGS. air-LUSI, a VisNIR spectrometer, will be integrated onto the ER-2, formerly a high-altitude spy plane originally known as the U2. Its nighttime mission is to make high accuracy measurements of lunar spectral irradiance at a target phase angle.Obtaining a clear vantage of the Moon though the dorsal aperture of the wing super pod aft body. The data collected will provide accurate at-sensor spectral irradiance for the targeted phase angle. USGS and UMBC staff will apply atmospheric correction (largely stemming from ozone attenuation) to obtain the extraterrestrial spectral lunar irradiance, which is what is observed by orbiting satellite. The atmospheric correction is achieved by applying a radiative transfer model (e.g., MODTRAN or S6) combined with satellite ozone data used for ocean color retrievals, e.g., data from the Earth Probe Total ozone Mapping Spectrometer (EPTOMS) or the Total Ozone Analysis using SBUV/2 and TOVS (TOAST). Further refinement can be accomplished using the well-known lunar reflectance spectrum to apply a spectral differential analysis across the measurements to isolate any ozone attenuation of the lunar signal. The resulting extraterrestrial spectral lunar irradiance would then be divided by the corresponding ROLO output for the air-LUSI acquisition. The ratio forms a correction factor that when divided into ROLO gains for a spaceborne instrument for a nearby phase angle (and libration angles) would reduce any offset in ROLO.

**Accomplishments**
Dr. Turpie led regular communications between the air-LUSI team and the ER-2 engineering team, coordinated changes design changes, including the addition of a hard instrument enclosure to keep the instrument and on-board reference source thermally and barometrically stable. He oversaw development of a schedule to monitor progress and worked to keep tasks within budget. He worked with AFRC personnel to schedule ER-2 flights for air-LUSI. He wrote quarterly reports, including organizing 6-month interim review and annual review and develop quad charts. He also managed monthly team reports and the development of test plans, flight check list, and airworthiness documentation. Dr. Turpie worked with his team at NIST during the instrument integration and testing phase and coordinated further development and testing of the instrument for upload onto the aircraft at AFRC in preparation for engineering test flights at the beginning of August. After the engineering flights, the team will analyze and prioritize what was learned and develop a plan to enhance the instrument. Dr.

Turpie presented the air-LUSI project at CalCon 2018, NASA/ESTO's Earth Science and Technology Forum (ESTF), and provided a seminar on air-LUSI for the Ocean Ecology Branch at Goddard Space Flight Center. A conference paper on the robotic control system of the telescope mount was also presented at a Canadian engineering meeting.

**Plans for Next Year**
Dr. Turpie will continue to work with the team to and implement a plan to improve the instrument system in preparation fo the demonstration flights at AFRC, which will start as early as November. Two demonstration flight campaigns are planned from November 2018 through February, 2019. Of particular focus will be the calibration methodology, system engineering improvements, including aircraft interfaces, and looking into more thermally stable solution for the fiber optics that convey the lunar signal from the telescope to the instrument. Dr. Turpie will present a poster on air-LUSI at the 2018 Ocean Optics meeting in Dubrovnik, Croatia in October.

**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 (10/1/2017 – 7/31/2018) WEATHER – Dr. Nicholls's work effort focuses on providing model simulation support. He ran 20 high-resolution model simulations to support the PI's efforts to investigate the mechanisms underpinning the Madden-Julian

Oscillation. Results from this work effort were presented by the Project PI at the AMS Tropical Conference in March 2018. Upcoming Activities (8/1/2018 -9/30/2018) WEATHER – Dr. Nicholls will focus his efforts on incorporating the wave model into COAWST.

**Plans for Next Year**
Plans for FY 2019 (10/1/2018-09/30/2019) WEATHER – Dr. Nicholls's primary objective in the short term is to implement wave modeling into COAWST, which is a request made by the task manager. Once implements, Dr. Nicholls will run COAWST simulations during two MJO events and provide data analysis support to the project. Results from this study are planned for publication in a peer-reviewed publication where Dr. Nicholls would be a co-author.

**UMBC Project Number:** 00011713
**UMBC PI:** Remer, Lorraine
**Sponsoring Agency:** NOAA
**Project Title:** SNPP VIIRS Aerosol Product Calibration and Validation Activities

**Summary**
To evaluate aerosol products from new satellite sensors, in terms of their overall accuracy and precision, and how well they meet the needs of the air quality community. The project works directly with the Suomi National Polar-Orbiting Partnership (NPP) Visible Infrared Imager Radiometer Suite (VIIRS) cal/val team to evaluate the VIIRS aerosol products, to prepare documentation of the evaluation process, to assess the new product and to make algorithmic changes that improve the product.

**Accomplishments**
This contract shifted into maintenance of the NOAA VIIRS EPS aerosol product. I participated in weekly meetings of the NOAA VIIRS aerosol cal/val group, investigating potential issues as they appeared, and providing comment. A paper describing improvements to the snow mask was submitted, and is currently in review. It was my responsibility to monitor long term trends for drifts caused by either algorithm adjustments or instrument calibration changes, but none were detected over the past year. It was also my responsibility to interact with the Cloud Mask team and represent the aerosol team's concerns about the new cloud mask. We did find cause for concern in the results of the new cloud mask. While the original VIIRS cloud mask worked fine for aerosol retrievals, the new Enterprise cloud mask appears to be overly conservative over desert scenes, identifying almost all bright desert surfaces as cloud. This will conflict with the aerosol algorithm's internal cloud mask and cause perfectly fine bright surface retrievals to be degraded. We note that this would not have been a problem with the original VIIRS aerosol algorithm because it was a dark-target-only algorithm and did not retrieve over deserts. We intend to organize our results during August/September to present them to the cloud mask team so that they can understand the problem. Also this past year we discussed and defined a plan to use webinars to raise the consciousness of the community to the existence of the high quality NOAA product. Our first webinar is planned for August 22nd. Software has been purchased, registered and advertising has begun. We will present two 90 minute seminars on the same day, one targeting the Eurasian time zones and one for time zones in the Americas. These will be introductory, basic, presentations with audience interaction encouraged. Each session is limited to 100 participants. Sessions will be recorded and made available to registrants.

**Plans for Next Year**
We intend to continue the webinar series, providing more detailed and advanced information. We also intend to include VIIRS aerosol products in a greater analysis and submit that paper for publication.

**UMBC Project Number:** 00012013
**UMBC PI:** Campbell, Petya
**Sponsoring Agency:** University of Wisconsin - Madison,
**Project Title:** Vegetation functional amplitudes along a rainfall gradient in Indian ecosystems using AVIRIS-NG

**Summary**
Enhancing the Multi-Source Land Imaging (MuSLI) Science component of LCLUC by prototyping (MuSLI Type 2) new mid-resolution (30m) chlorophyll algorithms and products. Using a suite of multi-satellite data suitable to develop a seamless inter-comparison among multiple species and canopy structures. Our prototyping activities will evaluate the suitability of the currently existing approaches, to provide robust and mature algorithms and products in preparation for routine implementation and generation of large scale continental and global chlorophyll time series.Climate change and anthropogenic activities have significantly affected agricultural and forest production by imposing severe and novel combinations of multiple stresses on the natural ecosystems which act to alter plant biochemistry. 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 (5-16 days), and at a spatial scale that allows practical assessment and management of their impacts on hydrological and biological cycles (e.g. moderate 30 m resolution). Datasets with the required spatial, temporal, and spectral characteristics can now be produced through combinations of Landsat-8 (L-8) and Sentinel-2 (S-2) imagery. While spectral VIs may be transferable between sensors, there are significant challenges and potential discrepancies associated with the inter-comparison of the biophysical products. Different spectral and spatial resolutions and sensor sensitivities, as well as variable ground data used in algorithm training are all confounding factors (Fernandes et al. 2002, Baret et al. 2006, Huete et al. 2006). Depending on the platform,and vegetation type, changing solar zenith angles can also be a factor (Gutman 1999, Sims et al. 2006).Huete (2004) reported that inter-sensor NDVI relationships at 250-1000m vary with land cover type and composition. However, using 30 m Landsat data Gitelson et al. successfully transfered GPP equations based on Chl VIs between multiple sites and between soybean and maize (C3 and C4). The VI approach for Chl estimation has been validated with 30 m Landsat data across multiple agricultural crops. Recently, based on a VIs including a broad range of crops, and empirical models were also established for use with Sentinel-2 bands, which were accurate for Chl determination across species (Delegido et al. 2011, Peng et al. 2017). In this research we will validate that with 30 m resolution data direct relationships are transferable among different land cover types.

**Accomplishments**
During this period we tested the modeling approach for deriving vegetation traits using EO-1 Hyperion canopy spectra for crops and forests.

**Plans for Next Year**
During the next FY19 I will evaluate the retrievals against field measurements and improve the parameterization and performance of the approach. I am preparing to use the collected in India AVIRIS-NG images and field data, under a gradient of moisture availability, to derive vegetation traits such as: canopy biomass, leaf area, chlorophyll and water content.

**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 have published a paper on light scattering properties of hydrosols, which changes in response to geometric shape, size, and refractive index.

**Plans for Next Year**
We will continue to develop a semi-analytical model for ocean reflectance using approximate two stream model, in combination with rigorous radiative transfer simulations. Neural network and principal component analysis will be used to reduce data volume and increase efficiency.

**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. The algorithm has been validated using synthetic radiative transfer data with great success. Furthermore, the algorithm has been applied to RSP measurements and limited success has been achieved.

**Plans for Next Year**
We will apply the retrieval algorithm to more polarimeter data measurement, and validate it against in-situ measurements. Once it is successful, we will apply the retrieved aerosol information to atmospheric correction to hyperspectral ocean color instrument measurements.

**UMBC Project Number:** 00012343
**UMBC PI:** Strow, Larrabee
**Sponsoring Agency:** Jet Propulsion Laboratory
**Project Title:** JPL: AIRS Climate and Calibration Algorithms

**Summary**
Assist NASA JPL in the ongoing calibration of the AIRS sensor for climate research.

**Accomplishments**
We are assisting the JPL NASA AIRS Project Office to determine if a new "v7" Level 1b radiance product is superior to the existing product at the GES DAAC. To date we believe the improvements are relatively minor and my not warrant a reprocessing effort. We have shown that AIRS has a detectable asymmetric scan angle calibration error (in the 0.1K range) that appears to be due to polarization issues. Our SNO intercomparisons of AIRS (converted to the CrIS instrument line shape, ILS) to CrIS have shown that the AIRS ILS functions, which have know uncertainties, can be improved using these SNOs.

**Plans for Next Year**
Improve the AIRS instrument response functions using CrIS and AIRS SNOs, and use these improved response functions when building new AIRS radiative transfer models.

**UMBC Project Number:** 00012471
**UMBC PI:** Wang, Yujie
**Sponsoring Agency:** Bay Area Environmental Research Institut
**Project Title:** Adapting MODIS MAIAC Algorithm to Geostationary Sensors

**Summary**
Develop an efficient algorithm for HIMAWARI AHI and GOES-R ABI sensor, based on MODIS MAIAC algorithm.

**Accomplishments**
Dr. Wang has developed subsetting tools to generate testing data from AHI data acquired from JMA (Japan Meteorology Agency). After that, Dr. Wang also processed ancillary water vapor, ozone, wind speed data from NCEP, aligned them with subsetted AHI data, so they can be feed into MAIAC algorithm. Collaborating with Dr. Lyapustin, Dr. Wang has adapted MODIS MAIAC algorithm to ingest AHI data. The wavelength and resolution difference are adjusted. New mechanism of surface spectral ratio estimation has been developed to adapt to the large variation of sun-view geometry change in geostationary data. With the help of Dr. Weile Wang, Dr. Wang also tested the new algorithm in NASA Pleiades supercomputing cluster. Dr. Wang finished a large scale testing in Australia area, preliminary validation results showed that the adjusted algorithm works well. Based on this, new sets of AHI products include Aerosol Optical depth (AOT), Surface reflectance (SR), cloud mask (CM), land/water mask (LWM) and surface BRDF parameters are generated.
**Plans for Next Year**
This project ended in 2017.

**UMBC Project Numbers:** 00012472, 00011336
**UMBC PI:** Strow, Larrabee
**Sponsoring Agency:** NOAA
**Project Title:** NOAA: Calibration and Validation of the CrIS Operational Sensor

**Summary**
Assist NOAA in the development of their new infrared weather satellite instrument (CrIS). Worked with various weather forecasting centers to fully understand and utilized this sensor, including ECMWF, NRL, NOAA, NASA

**Accomplishments**
We provided NOAA with spectral calibration adjustments used to produce the CrIS radiances products for the new J1/NOAA20 satellite. These data were made available to NWP weather centers starting in early 2018.

**Plans for Next Year**
We will be working with NOAA NCEP and other weather centers (ECMWF, UKMO) to determine ways to improve their utilization of CrIS data via improvements in the raw data calibration, specifically variations in the 9 detector radiances in each of the three focal planes.

**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**
This project started in February 2018. The overall goal of the project is: We have organized a team of collaborators, actively contributing their existing and currently acquired field measurements, conducted bi-monthly telecoms, initiated field collections and the MuSLI HLS data processing for all sites, placed standing requests for acquisitions of very high resolution World View data. We have collected the following sets of leaf samples for chlorophyll determination: 1) Smithsonian Environmental Research Center (SERC), Edgewater, MD: young and mature deciduous forest species 2) OPE3 ARS/USDA, Greenbelt, MD: young and mature soybean and corn 3) High elevation tundra, Giant mountains, Czech Republic: measurements of mature tundra functional groups 4) Nebraska (NE1, NE2 and NE3): bi-weekly measurements of corn and soybean, irrigated and rain-fed

**Plans for Next Year**
During the next FY19: we will continue the field collections, to sample the changes in vegetation canopy chlorophyll with senescence; we will process the collected data; as soon as the satellite becomes available we will assemble corresponding satellite images and field measurements; and tests the first algorithms and prototypes of canopy pigments fro the sites.

**UMBC Project Numbers:** 00012729, 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 implemented nonphotochemical quenching process to the chlorophyll fluorescence simulation in our radiative transfer model. A manuscript is written on the subject and will be submitted for publication after coauthors' comments are returned.

**Plans for Next Year**
Study the impacts of different ocean particle properties on the radiance field at different levels, including the top of the atmosphere and sensors in oceans.

**UMBC Project Number:** 00012761
**UMBC PI:** Strow, Larrabee
**Sponsoring Agency:** NOAA
**Project Title:** Full Spectral resolution Fast Radiative Transfer Modules for CrIS

**Summary**
Supporting simulation of measurements and real-time processing from the Cross-track Infrared Sounder (CrIS) for the JPSS-1 instrument to be launched in October 2017 and for the Infraredd Atmospheric Sounding Interferometer (IASI) that is processed operationally by the NOAA/NESDIS CrIS/ATMS Product System (NUCAPS). Developing the capability to compute thermal radiances from a complete geophysical state (temperature, moisture, aerosols, clouds, and trace gases) using a rapid transmittance algorithm (RTA). These algorithms must be functionally and spectroscopically compatible with each other.

**Accomplishments**
We created a full spectral resolution fast forward model (radiative transfer algorithm) for the NOAA NUCAPS retrieval system. This new model used the HITRAN 2012 data base and improved line mixing. This model was recently updated with variable ammonia.

**Plans for Next Year**
This grant is 1-year only.

**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. Data collected is 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.

**Plans for Next 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**
This is a new project sponsored by Los Alamos National Laboratory that was started in mid-spring of 2018. I have installed, compiled and run the NASA GEOS-5 general circulation model at coarse resolution. I am currently learning the code and plugging in a 3D black carbon source to represent the effects of a nuclear explosion. Once this is completed and understood, the model will be run at high resolution to examine the effect of moist convective processes on the black carbon evolution.

**Plans for Next Year**
I am planning to present preliminary work on this topic at the AGU meeting this December. I hope to have a high resolution simulation completed and present results in a poster format.

**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**
Participated with the NASA GSFC O3 lidar in the Ozone Water Land Environmental Transition Study in Baltimore, MD. Prepared and conditioned ozone-sondes for atmospheric profiling of the atmosphere. Calibrated and deployed mobile ozone sensors to better understand air quality variability. Data QC/QA of multiple sensors. Data archiving and quick look preparations for OWLETS and NASA.

**Plans for Next Year**
Utilize OWLETS analyses for conference presentation (TBD).

**UMBC Project Number:** NASA0001
**UMBC PI:** Strow, Larrabee
**Sponsoring Agency:** NASA
**Project Title:** The AIRS Radiative Transfer Algorithm

**Summary**
A new AIRS L2 algorithm retrieves geophysical products from single fields-of-view (partially cloudy), rather than the "pseudo" cloud-cleared observations in present use. Support that work with scattering extensions to our RTA. This work is largely done, and is very fast, and almost as accurate as existing implementations, which are not compatible with the AIRS software infrastructure. We will continue to update this scattering RTA with better scattering cross-sections for water, and ice/dust/aerosol distributions. The clear-scene RTA parameterization software and RTA code itself will be finished, with extensive testing to find the right mix of accuracy, speed, and ease of implementation in the L2 software. Once the new HITRAN2017 database is released we will upgrade kCARTA. The increasing length of the AQUA-AIRS mission has stressed some of our existing algorithms for both slightly variable gases (CO2, N2O, CH4) and for fixed gases (especially chlorofluorocarbons), that have now changed significantly. We will work to make the updated AIRS RTA better able to handle these changes, either through better parameterizations or using parameterization coefficients that vary with time. In addition, we will include variable NH3 which is under development as an AIRS product, and will separate HDO from H2O instead of tying them together with a fixed ratio. We also plan to re-visit our non-LTE (daytime solar) parameterization, which presently has an empirical 10% adjustment based on comparisons to ECMWF. A key concern is the lack of interactions between the L2 algorithm development and the RTA. For example, the present AIRS L2 algorithm has a static brightness temperature adjustment to all radiances, supposedly to account for RTA problems. This is totally unphysical and should instead be integrated into the RTA gas optical depths, etc. The only way to fully utilize the wealth of information in the AIRS radiances is to intertwine RTA and L2 development, which is our goal for this research.

**Accomplishments**
This is a new grant that just started in March 2018. Our goal is to improve the AIRS fast forward model (radiative transfer algorithm). We have made improvements so far to our line-by-line radiative transfer algorithm (kCARTA) thus far by implementing very new research on the effects of water vapor collisions with the nitrogen continuum and the far-wings of carbon dioxide lines.

**Plans for Next Year**
We will complete the line-by-line improvements and generate a new AIRS forward model using a new set of AIRS channel frequencies defined by the new AIRS L1c radiance product.

**UMBC Project Number:** NASA0003
**UMBC PI:** Remer, Lorraine
**Sponsoring Agency:** NASA/GSFC
**Project Title:** Understanding airborne fertilization of oceanic ecosystems from analysis of MODIS, VIIRS and CALIOP observations.

**Summary**
an interdisciplinary and multi-sensor remote sensing study that will target deposition events in the oceanic regions susceptible to airborne fertilization and favorable for remote sensing observations. By creating sufficient statistics from these events we intend evaluate when and under what atmospheric and oceanic conditions will a deposition event trigger a phytoplankton bloom, and to characterize independently the physiological and biomass characteristics of that bloom. Unlike any previous study, we will combine observational and reanalysis data to identify deposition events at fine temporal scale, and look beyond simple chlorophyll concentrations to evaluate a range of specific oceanic ecosystem responses. This work represents significant new science that can only be obtained with the availability of long time series of reliable remote sensing assets. Our study takes a global and long-term perspective, but approaches the problem on an event-by-event basis. The goal is to understand the processes that link atmospheric aerosol to ocean biology so that in the future we can predict consequences to ocean food chains, fisheries and the carbon cycle, as atmospheric circulations and composition change.

**Accomplishments**
This project began at the end of May 2018, and funding to our colleagues through a sub award only went through at the end of June. Already we have established monthly tag-up telecons and have embarked on a pilot study focused on specific volcanic eruptions with ash plumes extending over nutrient-limited ocean waters. We use MODIS observations to track the extent of the ash and MERRA reanalysis products to quantify deposition into the water. The pattern of the ash dispersion, both temporally and spatially, is linked to MODIS observations of anomalous phytoplankton chlorophyll concentrations, biomass, physiology, and fluorescence quantum yields. Mixed layer depths did not change during the events, suggesting therefore that the observed ecosystem changes were a consequence of atmospheric deposition rather than physical oceanic processes. The possibility of artifacts in the interpretation of the satellite products was also considered. This preliminary pilot study provides encouragement that we will be able to approach the global analysis successfully with similar tools and methods.

**Plans for Next Year**

We will present the results of the pilot study at the Fall AGU meeting, and hopefully prepare a manuscript for publication in early 2019. Then we need to adapt the methodology for the global picture involving desert dust, not volcanic ash. By the end of next year we intend to have the strategy worked out to create the global data base of desert dust events over oceans, linked to specific ecosystem response parameters.