JCET
The Joint Center for
Earth Systems Technology

First Annual Report
for
Cooperative Agreement NNX15AT34A

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

Submitted August 1, 2016

Message from the Director

This volume is the first in the new, five year renewal period (2015-2020), but it is the twenty-first 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 JCET administration. At UMBC, JCET is administered through the Office of the Vice President for Research. JCET's administrative office is located at the BWTech Research Park at UMBC. JCET also has offices in the Physics building, the Sondheim building, Technology Research Center, and the Academic Services building on the UMBC campus. Most of the 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 first year of the five-year cooperative agreement period, there are 46 JCET faculty members who conduct their research among 13 branches at Goddard and who collaborate and teach in four departments at UMBC. Overall, JCET is supported at the level of $6,867,874 by 48 tasks under the Cooperative Agreement, $2,019,609 by independent grant funding and $186,356 from state funds. The state funds are critical in the support for teaching in UMBC departments and proposal writing.

JCET is unique compared to other Cooperative Agreements of its kind at GSFC for its advocacy and inclusion of teaching 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 and Environmental Systems; Chemistry; Mathematics and Statistics; Chemical, Biochemical and Environmental Engineering; Computer Science and Electrical Engineering, the Honors College, 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 2016, the graduate students developed a mock-proposal to a real NASA solicitation to study dust transport across the Atlantic. More than 12 graduate and seven undergraduate students have benefited within the past year from these activities.

JCET Faculty and students are activity involved in on-campus activities. This year, JCET worked with the Office of the Vice President for Research in the coordination of two campus-wide research forums: Climate Change and the Environment in Fall 2015, and Seeing Science in Spring 2016. JCET faculty members serve on university-wide committees, such as the Sustainability Committee, the Faculty Advisory Committee for Interdisciplinary Activities and the Strategic Planning Committee.

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, 2015 to September 30, 2016. Each report includes a description of the research, and accomplishments for the reporting period. Following the Technical Volume is supporting material that includes academic affiliations, courses taught, publications, biographies, and a list of abbreviations and acronyms.

JCET continues to be a vibrant research organization, contributing to the Earth science mission at NASA Goddard Space Flight Center, as well as research and education of the next generation of Earth science researchers at UMBC. JCET looks forward to its continued collaboration in the coming year.

Belay Demoz, Director
Susan Hoban, Associate Director for Academics

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I. Technical Volume: Tasks

Task Number/Name
Task 101 Airborne-based Formaldehyde measurement studies

Task Sponsor
Thomas Hanisco, Code 614

JCET Personnel
Jason St. Clair, Research Assistant Professor

Summary
The research scientist is required to maintain and operate an instrument for the in situ measurement of formaldehyde on NASA aircraft. This position requires travel to NASA aircraft campaigns that may last a month or more. The individual is expected to be able to support the instrument independently and to provide necessary calibrations and data analysis. The candidate is also expected to perform basic laboratory research for new laser-based detection (laser induced fluorescence and integrated cavity absorption spectroscopy) and to work closely with engineers in the development of new aircraft instrumentation. This effort requires scientific interpretation of the data with a focus on photochemistry and gas-aerosol interactions and publication in peer-reviewed scientific journals.

Accomplishments
St. Clair contributed to the construction and led the commissioning of a new in situ instrument (CAFE) for measuring formaldehyde. The instrument was deployed to Korea for the NASA KORUS-AQ air quality campaign with CAFE flying aboard the Hanseo University KingAir aircraft. St. Clair was in Korea to support test flights and the first part of the mission, and has continued to provide technical support for colleagues currently operating the instrument in Korea.

Test flights were conducted for the CAFE instrument aboard the NASA ER-2 high altitude aircraft and operating the ISAF instrument for part of the ATom campaign aboard the NASA DC-8. In addition, St. Clair contributed to the assembly and commissioning of a second CAFE instrument and remotely supported its deployment to a site in Michigan for a ground-based measurement campaign.

The COFFEE instrument obtained its first 9 months of airborne formaldehyde measurements as part of the AJAX project out of NASA Ames, and St. Clair continues to support the instrument, including all data processing. St. Clair installed the CAFE instrument at the University of Michigan Biological Station for the PROPHET-AMOS ground site field campaign. The instrument was subsequently operated by Harvard University students during the campaign.

Analysis of data collected from a collaborative laboratory study at Caltech has resulted in a paper currently in Atmospheric Measurement Techniques Discussions on the potential for ISOPOOH, an oxidized organic compound, to cause a measurement artifact in the ISAF formaldehyde instrument.

Plans for next year

St. Clair is currently finishing one manuscript: an instrument description and first flight data from the COFFEE instrument. An instrument description paper for the CAFE instrument is planned, and the review process will be completed for the paper on formaldehyde measurement interference from ISOPOOH.

Fieldwork in FY 16-17 will include the continued flights of COFFEE aboard the Alpha Jet at NASA Ames for AJAX. Test flights for CAFE aboard the NASA ER-2 are planned for October-November 2016. On AToM (Atmospheric Tomography Mission), a NASA Earth Venture project, ISAF will be part of a NASA DC-8 payload that will travel pole-to-pole over the Pacific and the Atlantic to survey reactive gases globally. We have ATom deployments in August 2016 and January-February 2017-- St. Clair will fly part of the 2016 deployment and support both deployments.

Instrument development for FY 16-17 will be focused on assembly and commissioning of a duplicate of the CAFE instrument, and addressing CAFE instrument issues that became apparent during its first field deployments.

Task Number/Name

Task 102: Studies of formaldehyde (HCHO), carbon dioxide (CO_2), and methane (CH_4).

Task sponsor

Thomas Hanisco, Code 614

JCET Personnel

Glenn M. Wolfe, Research Assistant Professor

Summary

This task is entails collection and analysis of in situ airborne observations of trace gases, including formaldehyde (HCHO), carbon dioxide (CO_2), and methane (CH_4). 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. CO_2 and CH_4 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

Formaldehyde: Isoprene is a highly-reactive gas emitted by vegetation, and when it reacts in the atmosphere it makes a lot of HCHO. Space-based HCHO observations are often used to test isoprene emission models, but there is detailed (and uncertain) chemistry that links the two. In early 2016, Wolfe published a paper that used data from the 2013 SENEX aircraft campaign to quantify how human emissions modulate the relationship between HCHO and its primary precursor, isoprene. It was found that models using the most up-to-date chemistry can accurately simulate the isoprene-HCHO relationship, but there remains an unexplained source of this molecule in the SEUS.

In May 2016, Wolfe travelled to Korea to participate in NASA's KORUS-AQ field mission. A new HCHO instrument was flown on the University of Hanseo King Air, examining both local air quality (Seoul is home to 25 million people) and the transport of pollution from China. Wolfe is also participating in the NASA ATom mission (July/August 2016), which will circumnavigate North and South America to examine global background atmospheric composition.

Greenhouse Gases: Wolfe is the lead instrument operator and data analyst for the Carbon Atmospheric Flux Experiment (CARAFE), which will fly on the Wallops C-23 Sherpa in September 2016. Wolfe has done extensive work this year with characterizing the new CO_2 and CH_4 instruments, modifying them for use on the aircraft, and developing analysis software. Integration will occur in August 2016 and science flights in September.

Plans for next year

2017 promises to once again be a busy year. In the first quarter, Wolfe will focus on analysis of data collected during the CARAFE flux flights in September. He will also assist in analysis of ATom data and in preparing our instruments for the next phase of ATom. The latter will occur in January-February 2016, and Wolfe is scheduled to fly for part of this mission. Several proposals have been submitted to perform additional Sherpa flux flights in both MD and the Arctic, but these are pending. Wolfe will also likely be the deputy PI on an Earth Venture Suborbital proposal for airborne fluxes from the Sherpa, which will be submitted summer 2017. Wolfe also has a number of ideas for analysis projects centered on several recent field missions. For example, data from WINTER and SONGNEX (both 2015) could be used to evaluate primary HCHO emissions from urban and fracking/flaring regions. Execution of these ideas will depend on time, of which there is generally too little.

Task Number/Name
Task 103 Scientific guidance for Goddard Earth Sciences Data and Information Services Center

Task Sponsor
Steven Kempler, Code 610.2

JCET Personnel
Chung-Lin Shie, Associate Research Scientist

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
GES DISC UWG Telecon: A GES DISC UWG Quarterly Telecon/Meeting was held addressing and discussing several timely and crucial topics such as the newly proposed online "Forum" service (a potential Cross NASA DAAC coordination), the recently started project "Data Lists" (an approach for future data service that has evolved from a fine "Bundle Data" idea initiated by Shie), and the useful "Level-2 Data" service (currently in plan and development per an increasing user demand).

"Data Lists" Focus Team: The "Data Lists" project and its Focus Team have recently been started at GES DISC. This project aims to provide Earth science community with the advanced, i.e., knowledge-based and value-added Earth science datasets (e.g., an event-based "bundle data"), as well as to further advance the data service at GES DISC to a "virtual collection" era.

"Information Quality" Conference Paper: Shie has participated the ESIP Information Quality Cluster (IQC) working group, which has been formed aiming at ensuring and improving information quality for Earth science data and products, especially since quality of data products has always been user's genuine concern. An extended abstract introducing definitions and background of the information quality of scientific data generated by Earth observation systems and their derived data products, as well as discussing on the current activities of the ESIP IQC

recently submitted to the SciDataCon 2016 conference (Ramapriyan et al. 2016) has been accepted for an oral presentation.

"Dark Data" Conference Presentation: Shie has collaborated in a research project involving a study from a two-year project of "Dark Data" funded by the NASA AIST Program (Ramachandran at NASA GHRC DAAC as PI; Kempler as one of the Co-I's) aims to develop a search tool built on semantic technologies, via looking at massive Earth science metadata assets, to create new knowledge discovery pathways in Earth science for better serving the user community. Recently, a conference oral presentation introducing the currently accomplished and the ongoing works of this project has been presented at the Earth Science Technology Forum 2016 (Ramachandran et al. 2016). Another oral presentation addressing the relevant data curation service for Earth science phenomena has been performed at the 2016 ESIP Summer Meeting (Maskey et al. 2016).

Plans for next year

As project scientist at GES DISC, Shie will continue providing advices and suggestions, as well as coordinating the UWG activities, and participating the focus group activity in the ongoing "Data Lists" system development. He will also continue collaborative work involving the "Dark Data" project for developing the data curation system. Shie may start new collaborative works should the recently submitted proposals, i.e., to the NASA Data for Operation and Assessment (NDOA) program or/and to the NASA Citizen Science for Earth Systems Program (CSESP) be successfully funded.

Task Number/Name

Task 104: Ice cloud retrieval algorithms using the MODIS and polarimetry

Task Sponsor

Steve Platnick, Code 610

JCET Personnel

Zhifeng Yang, Graduate Student; Daniel Miller, Graduate Student

Summary

Graduate student required to develop and evaluate ice cloud retrieval algorithms using the MODIS instrument and the use of polarimetry to help assess imager cloud retrievals. Emphasis will be on the use of polarimeter measurement information content to assist in understanding imager cloud retrievals and the potential synergy between the imager and polarimetric measurements. Comparisons will be made with other A-Train sensors (e.g., MODIS, AIRS,

CloudSat, CALIPSO, POLDER) and field campaign data (e.g., SEAC4RS, PODEX). Second graduate student (Daniel Miller) will charge to this task for 4 weeks during the summer months.

Accomplishments

The first step is collecting data sets to be employed by this study and evaluating these data sets, then determining which data set should be used in this project. Three data sets from different sources have been collected. They are SEV-06 cloud product derived by Lille1 University, OPER cloud product from KNMI (Koninklijk Nederlands Meteorologisch Instituut), and CM-SAF cloud product from EUMETSAT. Currently, SEV-06 is still tentative and not ready for publication. The group evolved it in the study since it employed MODIS cloud retrieval algorithms, which may help to evaluate the other two data sets. OPER is operational product, and CM-SAF uses NWC-SAF (Nowcasting Satellite Application Facility) cloud retrieval algorithm. Since these three SEVIRI cloud products using various algorithms while retrieving the data, the discrepancies among them are inevitable. So the evaluation to these data sets is necessary in order to find out the most reliable product. At present, the group has evaluated these three instantaneous cloud products and find that CM-SAF is most reasonable product comparing with the other two products.

The group has aggregated the pixel-level data sets to the grid-level and derived the essential parameters for the further study (CM-SAF, July-October, 2008 & 2014), e.g. cloud fraction, cloud properties separated by cloud phases, and COT-CTP joint-histogram. The group is obtaining more data from the data provider. From the cloud fraction diurnal cycle, the cloud varies all the day following sinusoidal fitting. Cloud decreases from the sunrise to the sunset, and increases during the nighttime. The group also finds that the stratocumulus cloud is dominant in the southeast Atlantic Ocean. These findings are consistent with the previous study on this subject.

Plans for next year

- Analyze cloud diurnal cycle over southeast Atlantic Ocean region using SEVIRI (CM-SAF CLAAS2) data;
- Analyze the impact of cloud diurnal cycle on all-sky aerosol direct effect using CALIOP and SEVIRI data; and
- Analyze the impact of aerosol on cloud diurnal cycle using A-train data.

Task Number/Name
Task 105: Atmospheric Water Vapor Remote Sensing with Lidars

Task Sponsor
David Whiteman, Code 614

JCET Personnel
Kevin Vermeesch, Research Analyst

Summary
The tasks for this research included analysis of data from the NASA-GSFC ALVICE (Atmospheric Laboratory for Validation, Interagency Collaboration and Education) collected during various campaigns across the nation, as well as deployment and operation of related instrumentation. Analysis and deployment design of a multi-agency, multi-instrument, multi-nation field experiment, the Plains Elevated Convection at Night (PECAN) is a major task under this research work. PECAN is designed to advance the understanding of continental, nocturnal, warm-season precipitation. PECAN will focus on nocturnal convection in conditions with a stable boundary layer (SBL), a nocturnal low-level jet (NLLJ) and the largest CAPE (Convectively Available Potential Energy) located above the SBL. In addition, this task also supports activities related to the operation of ALVICE at the Howard University Beltsville Campus and work related to the NASA Network for the Detection of Atmospheric Composition Change (NDACC). These activities will include the preparation, launch and analysis of the Cryogenic Frost point Hygrometer (CFH) and analysis of climate trends associated with the Global Climate Observation Site (GCOS) Reference Upper Air Network (GRUAN).

Accomplishments
Monthly cryogenic frostpoint hygrometer (CFH) launches were performed to coincide with Suomi National Polar-orbiting Partnership (NPP) satellite overpasses at the Howard University Beltsville Research Campus (HUBRC). To aid in launch date determination, a program was written to plot forecast model soundings for times of potential CFH launches. Stratospheric water vapor trends were calculated using the Microwave Limb Sounder on the Aura satellite and compared with those same trends calculated from CFH data to monitor their agreement as recent research has evidenced that MLS and balloon-borne water vapor measurements are beginning to diverge. Received training to operate the Goddard Lidar Observatory for Wind (GLOW) and collected GLOW data during radiosonde launches at the HUBRC to compare with radiosonde wind profiles.

The ceilometer, surface meteorology, and radiometer data sets collected during the Plains Elevated Convection At Night (PECAN) campaign were converted to netCDF format for distribution to the PECAN research community. Converted data from other field campaigns to netCDF format for easier use in PI's data analyses.

Plans for upcoming year

- Assist with ALVICE data collection, processing, archiving, comparisons, and analysis
- Continue monthly CFH launches

Task Number/Name
Task 106: MODIS Calibration and Characterization Support

Task Sponsor
Xiaoxiong Xiong, Code 618

JCET Personnel
William Barnes, Senior Research Scientist

Summary
The Moderate Resolution Imaging Spectroradiometer (MODIS) sensors, currently operated onboard the EOS Terra and Aqua spacecraft, were launched on December 18, 1999 and May 04, 2002, respectively. This task supports the ongoing calibration and characterization of both MODIS sensors and the documentation of more than 30 years of on-orbit performance.

Accomplishments
Tasks during the last year were principally in the ongoing areas of sensor calibration and performance monitoring. Barnes provided support to the MODIS Calibration Support Team (MCST) at a calibration workshop in Greenbelt, MD, attended a MODIS Science Team meeting in Washington, DC (he resides in Texas), participated in a workshop at Greenbelt on the performance and operation of the Aqua/MODIS cold focal-plane assembly (CFPA), and provided input during bi-weekly calibration telecons with the MODIS sensor Working Group (MsWG).

Plans for next year

Monitoring of the performance of the MODIS sensors will continue with particular emphasis on Terra/MODIS which after more than 16 years on-orbit is beginning to display anomalous behavior.

Task Number/Name
Task 107

Task Sponsor
Thomas Neumann, Code 615

JCET Personnel
Valerie Casasanto, Education and Public Outreach Manager

Summary
ICESat-2 (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 3-D 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 ICESat-2 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
Throughout the reporting period, Casasanto coordinated the team, attended and reported at weekly senior mission management meetings, provided weekly status inputs to Code 610 management, and continued development and implementation of EPO goals and milestones.

An array of education and outreach projects were implemented. Casasanto and team completed and launched the redesign of the ICESat-2 public website http://icesat-2.gsfc.nasa.gov/. Casasanto was the lead coordinator of the ICESat-2 web re-design working with team members, NASA IT officials and project managers, and web developers.

Various communications products were realized. For example, the second part of a video feature series was produced and released on how light photons are received back to the satellite http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11726#22340. A kiosk video for conferences and for guests visiting ICESat-2's cleanroom area, was produced http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11944. Social media was consistently kept covered throughout the year.

The team participated in many outreach events during the year with booth space, presentations, and hands-on activities. The first was at the National Science Teachers Association in Philadelphia, PA (October 2015), the next at the American Geophysical Union (AGU) conference in San Francisco, CA, (December 2015) where Casasanto presented a poster, followed by the USA Science and Engineering Festival in Washington, DC, (May 15-17), Odyssey of the Mind Convention (May 20-23, 2016), Earth Day at Union Station, Washington,

DC, (April 2016), to name of few. In addition, Casasanto presented ICESat-2's Citizen Science Program to the Space Education and Outreach Committee of the International Astronautical Federation in Paris, March 2016.

The successful ICESat-2 Pilot collaborative program with the Savannah College of Art and Design (SCAD), and Bowling Green State University (BGSU) was continued with development of a "Digital Pop-up Book" as an interactive for ICESat-2's website. Designs and storylines were developed.

Plans for next year
Casasanto will continue planning and developing ICESat-2's FY17 initiatives into pre-launch operations. Specifically, she will implement the digital pop-up book, the educational cartoon, the GLOBE citizen science program, and lead preparations for the mission's outreach and communications programs including social media events.

She will also organize ICESat-2's participation in events such as the National Science Teachers Association (NSTA) meeting, the International Astronautical Congress (Mexico), and AGU in San Francisco (December 2016). This includes attending the conferences, presenting papers, and leading participants through hands-on activities.

Task Number/Name
Task 108: A Comprehensive Operational and Science Evaluation of Algorithm MAIAC for the MODIS Land Processing

Task Sponsor
Alexei Lyapustin, Code 613.2

JCET Personnel
Yujie Wang, Associate Research Scientist

Summary
The main objectives of this task consist of four areas: 1) Supporting operational performance of the Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm; 2) Adapting the MAIAC algorithm for GOES-R related risk reduction activities; 3) Conducting MODIS/VIIRS calibration-validation analysis for surface reflectance products; and 4) Providing 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 a 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 image-based, rather than pixel-based processing. Because 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

Wang continuously worked on MAIAC algorithm improvement, tested large scale areas with various land surface types and aerosol features such as heavily clouded and vegetated Amazon area, highly polluted Eastern Asia area and Sahara desert area with very bright surface. The results were used for aerosol mode improvements, also distributed to user communities and used in air quality, ecosystem studies.

Wang also worked on the testing of operational MAIAC algorithm which is used for global MAIAC data production. Three new version of improved MAIAC code has been successfully delivered to MODIS Adaptive Processing System (MODAPS).

In order to take into account the instruments degrading trend of Terra MODIS, Wang has performed thorough analysis of Terra MODIS calibration performance over four stable CEOS calibration sites. New polarization correction coefficients (from NASA OBGP team) have been applied and 15 year trend of calibration error for first ten MODIS bands has been identified and corrected, it was also cross-calibrated with collection 6 Aqua data so the combined process of Terra and Aqua data is possible. The results show that after detrending and cross-calibration gain adjustment, Terra and Aqua data agree well. The new updated Terra/Aqua C6+ calibration code is delivered to MODAPS for future data production.

Wang also adapted MAIAC algorithm to process Global Imager (GLI) data. The short wavelength channels of this instrument provide very useful information of Single Scattering

Albedo (SSA) retrieval. Global GLI data has been downloaded to local server, Wang developed standardized GLI gridding code for large scale GLI data processing.

Wang also developed standardized VIIRS gridding code for MAIAC processing of large scale VIIRS data.

Plans for next year
In the coming year, Wang will continue working on MAIAC algorithm improvements. The MAIAC global data production will start soon. Wang will also monitor operational code performance and test the quality of global MAIAC data. Various tools for MAIAC products visualization, time series analysis and product validation will be developed.

The improved MAIAC code will be adapted to VIIRS sensor and the calibration/comparison analysis will be conducted.

The improved MAIAC code will also be adapted to GLI sensor, large scale process of GLI data will be performed and the results will be analyzed.

Based on the MAIAC algorithm, Dr. Wang will also develop 1km and 250m vegetation index and normalized bi-directional reflectance factor as new MAIAC products.

Task Number/Name
Task 109

Task Sponsors
Kenneth Pickering, Code 614

JCET Personnel
Nader Abuhassan, Associate Research Engineer; Jay Herman, Senior Research Scientist

Summary
The goals of this task include 1) develop and improve the Pandora spectrometer system to determine ozone and nitrogen dioxide, their altitude profiles, and validate the results comparing with in-situ instrumentation; 2) correct a problem with the Pandora optics to enable retrieval of other trace gases such as formaldehyde and bromine oxide; 3) deploy Pandora at permanent sites to develop long-term records. Finish the DISCOVER-AQ campaign analysis for all four campaigns and prepare for the next set of campaign in Korea (KORUS-AQ); 4) provide support for the Pandora lab and field calibration; 5) provide support on a daily basis to all the site managers to make sure all Pandora spectrometers are running properly especially during the KORUS-AQ campaigns; 6) provide training to the Korean scientists to be able to do instrument

quality checks and preliminary local data processing for data quality assurance; and 7) validation and testing of a modified Pandora BOAT for greenhouse monitoring over the ocean.

Accomplishments

Nader Abuhassan and Jay Herman deployed 7 Pandora Spectrometer Instruments in Korea to support the KORUS-AQ campaign. The initial processing of the data was finished, showing that is of high precision and accuracy. The Pandora data were processed and analyzed from 5 long-term sites. An advanced design of the Pandora system was built that is more robust and can retrieve additional trace gases, such as Formaldehyde.

The data processing for DSCOVR/EPIC has been completed for the first year of data. From the resulting calibrated radiances, one year of ozone has been derived for the entire sunlit globe from sunrise to sunset 13 to 18 times per 24 hours.

The O3 and NO2 data from 10 Pandoras used in the KORUS-AQ campaign have been processed and are being prepared for delivery to the KORUS-AQ project in August. Results will presented at the Quadrennial Ozone Symposium in early September

We are participating in the CINDI-2 instrument comparison campaign in Cabauw, Netherlands during September 2016. Two Pandoras are being prepared and calibrated at Goddard for shipping to Cabauw in August.

Plans for next year

- Expansion of the Pandora network will continue.
- Long-term Pandora results will be analyzed and published.
- The results from profile determinations will be completed. Three publications are in-press or being reviewed.
- Presentations of the results of the Pandora and EPIC measurements will be made at scientific meetings (Quadrennial Ozone Symposium and AGU).

Task Number/Name
Task 110

Task Sponsor
Carlos Del Castillo, Code 616.2

JCET Personnel
Kevin R. Turpie, Research Associate Professor

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
Turpie co-authored a paper on the radiometric effects to the ocean color data record stemming from drift in the spectral response of the Sea-viewing Wide Field-of-view Sensor (SeaWiFS). This technique was a direct application of lessons learned with the VIIRS instrument, which has a noted drift in spectral response. He also participated in discussions and the analysis of new systematic papers arising in the calibration time series fit residuals and also unexplained trends in the remote sensing reflectance in certain bands of VIIRS. He organized semi-regular meetings between the ocean calibration team and the VIIRS Calibration Science Team (VCST), which included discussions on the effect of spectral drift in the Solar Diffuser Stability Monitor (SDSM) on the calibration time series. Turpie made an unsuccessful attempt at acquiring SDSM spectral response data from VCST, which was determined to be problematic because the data were considered proprietary to Raytheon. Turpie extended his analysis of calibration trend uncertainty with updated calibration time series and look at the implications for ocean color data product time series.

Plans for next year
Turpie will continue his study of uncertainty in the calibration of the S-NPP VIIRS instrument on ocean color data products and its effect on long-term time series trends. This will include quantifying the size of spurious trends in data times series for products such as pelagic chlorophyll-a concentration. Results will be published in SPIE proceedings paper and a peer review journal, such as JARS.

Turpie will work with the ocean color data production team to collect or develop, as necessary, documentation to describe the spectral response of the S-NPP VIIRS instrument. Effects of changes of spectral response characteristics of the instrument and those of detectors in its calibration system will be documented in the aforementioned publications.

Task Number/Name
Task 111: Maintain and further develop the NASA/Goddard Sulfur Dioxide Monitoring Web Site (http://so2.gsfc.nasa.gov), archiving OMPS, OMI and TOMS SO2 data in NASA required formats, and participate in NASA's ESDSWG

Task Sponsor
Nickolai A. Krotkov, 614

JCET Personnel
Keith D. Evans, Research Analyst

Summary
The goal of the NASA/Goddard Sulfur Dioxide Monitoring web site is to create and maintain long-term SO_2 cross-satellite climate data records that started with Nimbus7-TOMS UV SO_2 measurements in 1978 and presently continuing with AIRS, Aura/OMI and NPP/OMPS SO_2 data. 34 regions of the world are monitored and displayed on a daily basis. The web site will be developed into the "public face" of the volcanic disasters project that will be more useful for near-real time users from different agencies, the general public and for aviation safety. Evans participates in NASA's Earth Science Data Systems Working Group which focuses on the exploration and development of recommendations derived from pertinent community insights of NASA's heterogeneous and distributed Earth science data systems.

Accomplishments
Evans has maintained the SO_2 web site by updating images for the latest calibration and data processing. He added new data for the Norilsk and China regions. Evans was chairman of the ASCII for Science Data working group of the ESDSWG since 2014. The recommendations of the 2014 ASCII working group were accepted and have been published for use by the NASA earth science community. Evans participated in two new working groups of the ESDSWG; the Airborne Metadata and the Time Series working groups.

Plans for next year
SO_2 trajectory modeling capability will be added to the NASA SO_2 site. Continued involvement and contributing to the (ESDSWG). Evans will assist other team member with data program

generation. Evans will extend long-term monitoring of sulfur dioxide with new satellite instruments as they become available.

Task Number/Name
Task 112: Making Earth System Data Records for Use in Research Environments (MEASURES)

NASA grant "Long-term Satellite Data Fusion Observations of Arctic Ice Cover and Methane as a Climate Change Feedback", sub-contract from BRI

Task Sponsor
Nickolay Krotkov, 614

JCET Personnel
Leonid Yurganov, Senior Research Scientist; Nathaniel Lebedda, Undergraduate Student Assistant

Summary
This task is a part of the entire MEASURES project that is lead by Dr. Yurganov, focussing on development and quantification of the infrared retrieval techniques for sulfur dioxide using radiation data gathered by NASA satellites (Atmospheric InfraRed Sounder(AIRS)/Aqua, Cross-track Infrared Sounder (CrIS)/Suomi). The NASA grant supports satellite-based methane remote sensing using the thermal infrared radiation used by satellite-based instruments like AIRS (since 2002) and IASI (since 2007). In this project Dr. Yurganov is responsible for preparation, validation, and analysis of all satellite methane data. Dr. Yurganov supervises the work of the student on this task.

Accomplishments
It has been found that the spectral resolution of the AIRS spectrometer is insufficient for measurements of sulfur dioxide below 5 km of altitude. Meanwhile, the resolution of a new CrIS interferometer is ~ 300% higher than that for AIRS. Using CrIS will improve the performance of the method significantly. The full resolution data of CrIS and a fast radiation transfer code are expected to become available in a few months from now.

In a study of Arctic methane, wew results were summarized in three papers that have been published in the peer-reviewed journal CPRSES (http://jr.rse.cosmos.ru/?lang=eng). Regular measurements of methane concentrations over the surface of the Arctic Ocean are unavailable. Satellite methane retrievals at the Thermal IR (TIR) spectral region allows year round, day and night measurements, in contrast to the short-wave solar IR radiation that is lacking in the Arctic in winter time. In those papers methane satellite retrievals over the Arctic Ocean from AIRS and IASI spectrometers were analyzed. In the first paper it has been found that reliable satellite TIR

measurements require a sufficient temperature contrast. Maximal positive methane anomalies were observed along coasts of Norway, Novaya Zemlya, and Spitsbergen in November-December. The seas of the Western Arctic are responsible for ~2/3 of total emission from the Arctic Ocean. Total Arctic Ocean methane emission is comparable with the Arctic land emission to the North from 60° N. Maps of the spatial distribution of methane emission rates from the sea surface near Norway, Spitsbergen, Novaya Zemlya, the Laptev Sea, and the Sea of Okhotsk, as well as the territory of Alaska were derived in the second paper. These estimates are confirmed by the existing literature model and field data for Alaska, as well as by estimates of methane emissions derived from measurements of its supersaturation in the surface waters of the East Siberian Arctic Shelf (ESAS) area. The 2015/2016 winter data on the concentration of methane over the Sea of Okhotsk, obtained using satellite interferometers IASI-1 and IASI-2 have been presented in the third paper. During this autumn-winter season atmospheric methane concentrations were 70-100 ppb higher than during previous years. Maximum observed anomaly was observed over the prospected reserves of methane hydrates, that has been detected by sonars and other methods. Other anomalies were tentatively explained by methane emitted due to degradation of sub-marine permafrost. A significantly higher interannual variability of methane in the autumn-winter season in comparison to summer is explained by a transition from stable summer stratification of seawater to unstable one.

Plans for next year

CrIS spectral radiance will be available and development of a new code for sulfur dioxide will begin. Methane concentrations measured at ships in 2013-2015 will be compared with IASI data. During the next year methane data will be supplied to collaborators to compare with arctic ice cover, water color and chlorophyll. These comparisons will be published in a peer-reviewed journal.

Task Number/Name

Task 113

Task Sponsor

David Whiteman, Code 612

JCET Personnel

Igor Veselovskiy, Associate Research Scientist

Summary

Multiwavelength Raman aerosol lidar allows measurements of aerosol extinction and backscattering coefficients at multiple wavelengths. Normally three backscattering (355, 532, 1064 nm) and two extinction coefficients (355, 532 nm) are available from these measurements.

These optical data can be inverted to the particle microphysical properties, and this opportunity is considered in coming ACE space mission. Thus different approaches to the optical data inversion together with corresponding uncertainties of particle parameters estimation are studied.

Accomplishments

Improvements were made to the quality of Raman measurements by substituting the vibrational nitrogen scattering with rotational Raman (RR) scattering. One the main issues in inversion of Raman lidar measurements to the particle microphysics is insufficient signal strength provided by vibrational nitrogen Raman scattering. One of the ways to resolve it is the use of RR scattering instead of using vibrational measures. The approach selects a portion of the RR spectrum characterized by low temperature sensitivity inside one of the spectral branches. Selection of the RR lines is done by use of a wide-band interference filter, which transmits the desired portion of the RR spectrum. The edge of the interference filter transmission band is located close to the laser line, so blocking the elastic scattering component from penetrating into the RR channel is technologically more demanding compared to the measurements of vibrational scattering. However, the present state of optical coatings technology allows the manufacture of interference filters with high transmission and blocking characteristics adequate to this task.

Such an RR channel at 532 nm was implemented in the lidar system that was used in African dust measurements in Senegal in December 2015 – January 2016. Data analysis performed confirmed improvement of Raman measurements quality and allowed the extraction of height-temporal distributions of particle extinction with 2 min temporal resolution.

The approach presented was tested also at 355 nm and 1064 nm. The measurements performed have confirmed possibility to use corresponding RR signals for calculation of aerosol scattering coefficients at these wavelengths. The optical data measured during field campaign in Senegal were used to investigate the particle microphysics. The issues related to particle non-sphericity and spectral dependence of the refractive index were considered.

Plans for next year

- Compact multiwavelength Raman lidar capable to measure simultaneously three depolarization ratios at 355, 532, 1064 nm wavelengths will be designed. This system is planned for participation in the field campaigns.
- Study of cirrus clouds with Raman lidar will be performed. Special attention will be paid for:
    - Separation of the ice clouds and layers of supercooled liquid water;
    - Estimation of contribution of ice crystals corner reflection to the total backscatter.
- Development of algorithm for estimation of particle parameters from lidar measurements basing on the Direct Estimation Approach. The algorithm should allow separate retrieval of the fine and the coarse mode parameters.

Task Number/Name
Task 114: Development, Validation, and Scientific Evaluation of a Multi-Year Sounder Based Climate Data Set Using Products Derived from AIRS/AMSU, CERES, MODIS, and TOVS Observations

Task Sponsor
J. Susskind, Code 610

JCET Personnel
Jae Lee, Assistant Research Scientist

Summary
The objective of this task is to develop an accurate sounder based multi-decade climate data set using Aqua AIRS and TOVS Pathfinder Path-A products. The task involves studying characteristics of TOVS, AIRS, CERES, and MODIS data products, both from the inter-validation perspective and also to identify and help remove biases between AIRS and TOVS products.

Accomplishments
Under the task 114, As a member of the AIRS SRT (sounding radiative transfer) team, Lee is participating in the validation of AIRS products. She presented her work at AIRS 2016 spring sounding meeting. AIRS V-6 OLR (Outgoing Longwave Radiation) is analyzed and compared with those from CERES and MERRA 2 in terms of Averaged Rates of Change (ARCs), indicative of the slopes of anomaly time series, and El Nino Correlations (ENCs), indicative of correlations of anomaly time series with the El Nino Index, down to the spatial grid point level. Lee is working on record-breaking warm winter and spring of 2016 and their influence on Arctic environment, as the AIRS surface temperatures of spring 2016 show the greatest positive anomalies from average during March and May.

Plans for next year
For task 114, Lee will support her OLR analysis to be published in peer-reviewed journals. She will analyze the surface temperatures from AIRS, MERRA2, and GISSTEMP, to investigate warmest winter and spring of 2016 and their relations with ENSO and other tele-connections.

Task Number/Name
Task 115

Task Sponsor
Alexander Marshak, Code 613

JCET Personnel
Tamás Várnai, Research Associate Professor

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
A large part of the work this year focused on examining aerosol properties in the vicinity of clouds. The research revealed that three MODIS aerosol products—dark target, deep blue, and ocean color products—show similar near-cloud changes in aerosol optical thickness and Angstrom exponent. The changes being similar—despite using different wavelengths, cloud detection methods, data selection criteria, and data interpretation algorithms—suggests that they are not caused by data processing artifacts. The analysis also revealed that correlations between cloud cover and aerosol optical thickness are stronger in summer and in cases when cloud coverage is lower.

In order to improve the accuracy of satellite-based aerosol measurements in the vicinity of clouds, the so-called two-layer model for improving the accuracy of near-cloud aerosol measurements was expanded. The original model estimates the way sunlight scattered from clouds into nearby clear areas will affect near-cloud aerosol measurements when the cloud-scattered light is subsequently scattered toward the satellite by air molecules. The expanded model also considers the enhancement when the cloud-scattered light is reflected toward the satellite by the underlying surface. Theoretical simulations indicate that the new expansion reduces the bias of the method by half.

The work also included developing an empirical function that characterizes the full angular distribution of sunlight reflected by wildfire smoke based on measurements taken at a few view directions. This function can help estimating the impact of smoke plumes on solar heating.

Accomplishments included characterizing the statistical relationship between regional cloudiness and aerosol properties in satellite data. The analysis of MODIS and CALIOP data revealed that aerosol optical thickness increases with cloudiness throughout the globe. While the increase showed some regional and seasonal patterns, combining GEOS-5 reanalysis data with satellite observations revealed that the increase is well-pronounced for all types of aerosols. In order to better understand the observed increases, the relationship between cloudiness and aerosol particle size was also explored. The results indicated that over much of the globe, small particles change with cloudiness more than large particles do. This implies that the impact of undetected cloud particles on MODIS aerosol measurements is not the dominant reason why the measured aerosol optical thickness values increase with cloudiness, as has been proposed in some earlier studies.

In order to help improve the interpretation of remote sensing measurements taken from different view directions, the team also characterized the angular and spectral patterns of solar radiation reflected from wildfire smoke in partly cloudy regions. The angular and spectral variations in solar radiation passing through partly cloudy areas was also explored through three-dimensional (3D) radiative transfer simulations performed in collaboration with a researcher visiting from Spain.

The team continues the work toward better understanding aerosol properties and improving aerosol remote sensing capabilities in partly cloudy regions. A special focus of this work is to understand the differences between the cloudiness-aerosol size relationships observed by MODIS and CALIOP. The plans also include continuing work on patterns of solar reflection by smoke and clouds. For example, the CAR (Cloud Absorption Radiometer) airborne multiangle measurements of solar reflection are combined with with simulations of the atmosphere above the aircraft, with the goal of estimating the angular patterns satellites would observe from space. The team is also analyzing aerosol and cloud information from additional sources such as the EPIC satellite sensor, and is performing additional simulations of three-dimensional radiative processes in broken cloud fields.

Plans for next year

Continue research on the properties of near-cloud aerosols. As part of this work, combine MODIS and CALIOP observations with reanalysis data and examine how different types of aerosols respond to cloudiness and related environmental factors such as relative humidity.

Continue work to help improve satellite-based measurements of near-cloud aerosols. For this, expand the two-layer model to include enhancements in near-cloud solar reflectance that occur when cloud-scattered light is re-directed toward the satellite by aerosol particles.

Combine CAR (Cloud Absorption Radiometer) airborne multiangle measurements of solar reflection with radiation simulations in order to estimate the angular patterns one would observe at the surface. This can help improve the characterization of surface radiative properties. Also, estimate the broadband radiative forcing of wildfire smoke plumes observed by CAR.

Analyze EPIC measurements, focusing on understanding specular reflection and the spectral dependence of total Earth reflection.

Task Number/Name
Task 116

Task Sponsor
James Butler, Code 618

JCET Personnel
Kevin R. Turpie, Research Associate Professor

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
Turpie reviewed all of the e-mail discussions regarding the JPSS Level 1 Requirements Document (L1RD) by the Ocean Color Attributes Team and JPSS reviews of the document spanning from 12/2010 to 8/2011. He also referenced a draft copy of the JPSS L1RD from the review. He provided an explanation for the Open Ocean, Blue Band argument, originally put forward by Dr. Menghua Wang, who suggested that if the original Accuracy, Precision, and Uncertainty (APU) requirements for normalized water-leaving radiance (nLw) (originally given for all visible M bands) are met for the 443 nm band (M2), then you will get reasonable nLw performance in the rest of the visible bands. Turpie outlined the merits and problems with this argument. He also describe possible methods to determine the extend this argument holds using simulation or in situ data.

Plans for next year
Turpie will work with the ocean color team to identify and integrate characterization data for the JPSS-1 VIIRS instrument for production of ocean color data products. This will include providing documentation, data files, and analysis characteristics for instrument behavior.

Turpie will assess quality new data from the JPSS-1 VIIRS instrument after its launch as early as April 2017. 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/Name
Task 117: Collaboration on SORCE and TSIS

Task Sponsor
Dong Wu, Code 613

JCET Personnel
Jae Lee, Assistant Research Scientist

Summary
This task is focused primarily on analyzing multi-sensor spaced based observations of physical variables and atmospheric tracers in conjunction with the solar irradiance observations from SORCE (Solar Radiation and Climate Experiment), TCTE (TIM Calibration Transfer Experiment), and TSIS (Total Solar Irradiance Sensor) to develop appropriate Sun-Climate interaction processes. The primary science objective is to keep developing and validating the solar impact on Earth's climate using a variety of existing satellite observations and model results.

Accomplishments
For the task 117, the primary accomplishments during this period are focused on the spectral solar irradiance (SSI) variability from space-based observations and solar irradiance models. In her recent work with the SSI variation, Lee clearly identifies phases and amplitudes of solar rotational variations from TIMED/SEE, SORCE/SOLSTICE, and SORCE/SIM, throughout the whole observation periods of each instrument. Lee compared those modes with those from SORCE/TIM Total Solar Irradiance (TSI) observations, SATIRE-S solar model, and also with two other solar proxies. The rotational variations of SSI from independent observations are

generally consistent with each other, but show distinct solar rotational modulations at each wavelength.

While she was working as a member of the TSIS science team, she reviewed TSIS TIM and SIM Calibration/Validation plan and participated two TSIS quarterly review to examine the ground Cal/Val uncertainties and supported weekly telecoms. Lee has been an organizer of the SORCE meeting since 2008 and continues to serve for 2017 Sun-Climate Symposium.

Lee is continuing an investigation of the equatorial annual oscillation (EAO) in the tropical middle atmosphere and its relation to the dynamics and chemistry. Her analysis clarifies the principle roles of EAO and its relation with the QBO at the tropopause.

Plans for next year

For task 117, Lee will work on the Cal/Val plan of TSIS, and a review for the TSIS ATBD which describes details of the data and algorithms used to produce all data levels of total and spectral solar irradiance. Lee will also work on comparison of solar irradiance data from multi-sensor observations, and diverse solar spectral models to get a reference spectrum, which are scientifically valid.

Task Number/Name

Task 118, UV integration under MPLNET Lidar Network

Task Sponsor

Ellsworth J. Welton, Code 612

JCET Personnel

Simone Lolli, Research Assistant Professor

Summary

MPLNET (Micro Pulse Lidar NETwork) is in the process of incorporating other than Micro Pulse Lidar into the network, with different wavelengths than green, like in the UV. However, the wavelength and signal noise characteristics are different. Specifically, the current standard algorithms for layer height detection and aerosol and cloud retrievals should be tested on new data retrieved at different wavelength. Methods are being developed to incorporate the data successfully. Taking advantage of the two wavelengths, when available, it is possible to retrieve microphysical properties of the precipitation (evaporation), cloud and aerosols. The double wavelength measurements on cirrus clouds will help to assess the fundamental contribution to the radiative forcing by those higher troposphere clouds.

Accomplishments

Lolli was invited to be a visiting Professor at Silpakorn University, Thailand. The workshop was given in the frame of 7SEAS project, on how to use lidar measurements for atmospheric studies. The data from MPLNET Omkoi lidar station were exploited to compare lidar measurements with the radiative transfer model retrievals from flux measurements to assess cloud optical depth.

A study on rain evaporation was carried out from MPLNET and COPS campaign lidar measurements. A method to evaluate rain evaporation from single wavelength lidar was developed, as well as an analytical model and ground based disdrometer measurements.

Lolli conducted a study of cirrus cloud net radiative effect in Singapore during year 2010, 2011 from MPLNET lidar measurements. Lolli conducted a study of cirrus cloud radiative effect on arctic regions from CALIPSO measures to assess their effect on ice melting/forming.

Lolli collaborated with Dr. Xiaowen Li (NASA-GESTAR) and Graham Feingold (NOAA) to assess aerosol removal by strong precipitation using lidar measurements provided by MPLNET network. Collaboration with EARLINET Lidar Network continues, with the objective of developing common algorithms to be applied and tested to both networks in the frame of GALION network of networks project.

Lolli collaborated with Dr. Zhibo Zhang to retrieve cloud microphysical properties from multiple scattering and depolarization from MPLNET lidar network.

Lolli began work on setting up a measurement campaign to retrieve cloud microphysical properties from multiple scattering and depolarization channel from lidar measurements using different field of views. The campaign will be carried out together with Dr. Zhang (UMBC).

Lolli visited partners in South East Asia (Thailand, Malaysia, Taiwan) in the frame of 7-SEAS meeting to give short courses on lidar techniques for atmospheric studies.

Plans for next year

- Research on cirrus cloud radiative forcing by lidar means. Proof of the existence of a gradient in net daytime radiative effect by thin cirrus cloud depending on latitude (warming toward the Equator, cooling toward polar regions). The study will be performed using the Fu-Liou-Gu Radiative Transfer model applied to cirrus cloud detected by MPLNET lidar network using multi-year data from different station at different latitudes.
- Participation in the frame of 7-SEAS NASA mission, to a measurement campaign that will take in late summer 2017 in the Philippines and in South East Asia region in general to assess direct and indirect aerosol interaction with meteorological phenomena. Meetings and workshop, part of the campaign, are already scheduled with partner universities and research institutes in the region to improve local scientists and researchers know-how in lidar measurements applied to the atmospheric physics.

- Development of an operative platform to assimilate MPLNET lidar data into ECMWF MACC-II aerosol model in near real time. Model performances will be quantitatively assessed at different permanent observational lidar stations before and after data assimilation.

Task Number/Name
Task 119 - Improvement of feature detection algorithms within the Micropulse Lidar Network (MPLNET)

Task Sponsor
Ellsworth J. Welton, Code 612

JCET Personnel
Jasper Lewis, Assistant Research Scientist

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
During this reporting period, Lewis was promoted from Post-doctoral Research Associate to Assistant Research Scientist. A science team meeting was held in April to outline future project tasks and possible publications concerning NASA Grant NNH14CM13C. Associated with this grant, evaluations of WRF (Weather Research and Forecasting) model runs using MPLNET and field deployed micropulse lidar systems has been conducted.

Operational testing of improved MPLNET algorithms to detect cloud layer heights and planetary boundary layer (PBL) heights began as part of the pending Version 3 data release. One year of data from the MPLNET sites at the NASA Goddard Space Flight Center site in Greenbelt, MD and Singapore were compared to overpasses of the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) aboard the CALIPSO spacecraft. The results show the Version 3 cloud layer heights are in better agreement with observations from CALIOP than the previous Version 2 products.

Plans for next year
Operational testing of the cloud and PBL algorithms will be completed. The Version 3 MPLNET products are expected to be released in the Fall of 2016. Comparisons to the GEOS-5 and WRF models will be conducted.

Task Number/Name
Task 120

Task Sponsor
Mian Chin, Code 614

JCET Personnel
Bian Huisheng, Associate Research Scientist

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) assisting the study of decadal variations of aerosols in the upper troposphere and lower stratosphere; (3) improvement of chemical lateral boundary conditions for the National Air Quality Forecasting Capability (NAQFC) operated within NOAA; (4) implementing nitrate aerosol simulation in the NASA GEOS-5 GOCART module; and (5) improving GEOS-5 GOCART wet scavenging scheme by introducing 3D physical rain productivity fields and aerosol snow scavenging.

Accomplishments
Huisheng Bian devotes much of her efforts to several national and international assessments of aerosols and their impacts. She is leading 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. She is preparing a manuscript based on the results submitted by the participating models and will present the results at the upcoming AeroCom workshop in September this year. Huisheng Bian is in charge of investigating the impact of AEDT prepared aircraft emission on surface PM2.5 level using the NASA GEOS-5 GOCART model and contributes to a paper of harmonized assessment of aircraft emission on air quality that has been submitted to JGR this May.

Huisheng Bian contributes to three continuously funded projects from NASA and FAA and a new one from NOAA. She is a co-I of an ACMAP project that improves the impact of aerosols from combustion sources on actinic fluxes. She has been working with other team members to evaluate aerosol optical property tables currently used by FAST-JX within the NASA GMI model using in situ observations of aerosol mass, composition, and optical properties from ARCTAS, which results in a paper that has been accepted for publication this year. As a co-I of a NASA AURA project, she joins in designing the model framework and assists model development of new capabilities in OCS simulation and evaluation of stratospheric sulfate simulation. She has started a new project by helping develop a framework to integrate the near-real time results out of NASA GEOS-5 into NAQFC for improved chemical lateral boundary conditions.

Huisheng Bian has conducted works on model development and improvement during the reported period. Working with her colleagues, she implemented the module of nitrate and ammonium aerosols in the NASA GEOS-5 GOCART based on her work in GMI CTM. She also improved the GEOS-5 GOCART wet scavenging scheme by introducing 3D physical rain productivity fields and aerosol snow scavenging. These works have been officially released and adopted in the GEOS-5 model.

In addition to the aforementioned scientific studies and model developments, Huisheng Bian has also participated in seven proposal submissions during the reported year with one as a principle investigator.

Plans for next year

Huisheng Bian will continue to lead the international multi-model assessment for nitrate study via AeroCom III activity. She will also continuously contribute to the three on-going NASA and NOAA projects. She is preparing to work on the proposed projects upon their selection. In the meanwhile, she is a co-organizer of an upcoming AeroCom-ATom activity (Global modeling and analysis of aerosol composition, distribution, and processes with observations from Atmospheric Tomography Mission). She will be working with Mian Chin and the instrument teams to provide quick, “first look” of GMI model simulation and analysis with respect to the origin of aerosols and related trace gases as well as information on the age of air the aircraft had encountered.

Task Number/Name

Task 121

Task Sponsor
Lazaros Oreopoulos, Code 613

JCET Personnel
Tianle Yuan, Assistant Research Scientist

Summary
The task involves producing original research on two projects. One is studying the effect of aerosols from a Hawaiian volcano on clouds downwind. This is a project funded by the NASA MAP program. The other project is to study how aerosols affect cloud regime properties. Cloud regimes are defined using MODIS data. The researcher divides cloud regimes into different pollution categories and determines how cloud properties systematically change.

Accomplishments
Yuan gave an oral presentation at the International Radiation Symposium in Auckland, New Zealand, April 16-22. Yuan gave an oral presentation at the Quarterly Town Hall meeting of NASA GSFC SED, May 12. Yuan gave an oral presentation at the 10th Kaufman Symposium at NASA GSFC, June 21-13.

Plans for next year
- Publish results on the modeling work on how Hawaiian volcanoes affect clouds downwind.
- Publish work on dust interaction with the climate
- Write a proposal to Terra Aqua call
- Attend AGU and other conferences

Task Number/Name
Task 122

Task Sponsor
Jeff Masek, Code 618

JCET Personnel
Forrest Hall, Senior Research Scientist

Summary
This task involves joint development of algorithm and analytic techniques from a variety of data sources to quantify vegetation/atmosphere energy and mass exchange from space.

Accomplishments
Dr. Hall continues his research in quantifying vegetation/atmosphere energy and mass exchange from space. In addition he is working with Piers Sellers to organize the October 2016 FIFE/BOREAS workshop to be held at GSFC. In addition, Dr. Hall continued teaching and delivering invited lectures.

Hall delivered an invited lecture on climate change to Howard County Executive Council. He delivered a lecture on the "Physics and Society" to the Montgomery College Scholars. Hall participated in the lecture series on Cosmology to the Johns Hopkins Odyssey program.
He delivered an invited paper to the 2016 IGAARS conference in Beijing China and delivered invited lectures on "Remote Sensing of Surface Energy Balance" at the University of Nanjing, Nanjing China.

Plans for next year
Hall will development an algorithm and analytic techniques from a variety of data sources to quantify vegetation/atmosphere energy and mass exchange from space.

Task Number/Name
Task 123

Sponsor
Robert Levy, code 613.2

JCET Personnel
Dominic Ceislak, Faculty Research Assistant

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

Our group continues to work on the HARP project for both, the CubeSat satellite and for an ER2 airborne version of the HARP imaging polarimeter called Air-HARP. The HARP CubeSat is scheduled for launch to the International Space Station in the end of 2016 and likely to be released for autonomous operation in the first half of 2017.

Ceilsak tested and validated several components of the HARP and AirHARP systems including stripe filters, detector assemblies, polarizers and calibration systems. I have also participated in the development of AirHARP's ER2 concept, design, airworthiness review and implementation.

The group has completed the optical testing of the HARP prism and performed first Muller matrix characterization of the HARP optics. The group has also finished the design and completed the airworthiness review for AirHARP instrument with NASA Armstrong's ER2 crew. The group will be seeking for opportunities to fly in the near future.

Plans for next year

- Prepare the HARP satellite for launch
- Continue to work on testing and implementation of HARP's components.
- Develop ground-based calibration strategies for HARP
- Participate in the implementation and test of the Air-HARP instrument
- Support work with the PI-Neph data analysis and preparation for future campaigns.

Task Number/Name
Task 124

Sponsor
Robert Levy, code 613.2

JCET Personnel
Vanderlei Martins, JCET Fellow, Professor/Physics

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
Our group continues to work on the HARP project for both, the CubeSat satellite and for an ER2 airborne version of the HARP imaging polarimeter called Air-HARP. The HARP CubeSat is scheduled for launch to the International Space Station in the end of 2016 and likely to be released for autonomous operation in the first half of 2017.

We have completed the optical testing of the HARP prism and performed first Muller matrix characterization of the HARP optics. We have also finished the design and completed the airworthiness review for AirHARP instrument with NASA Armstrong's ER2 crew. We will be seeking for opportunities to fly in the near future.

On the analysis of other in-situ data we have continued analysis and inversion of the microphysical data from the PI-Neph instrument. We have increased our collaboration with the Volcanology group at GSFC and have planned for additional joint work in analyzing worldwide volcanic ash samples. The first samples have been prepared and analyzed at UMBC.

Plans for next year
- Prepare the HARP satellite for launch
- Continue to work on GRASP microphysical retrievals for HARP
- Develop ground based calibration strategies for HARP
- Continue the analysis of PI-Neph data
- Continue the interaction with the Volcanology group at GSFC

Task Number/Name
Task 125

Sponsor
Robert Levy, code 613.2

JCET Personnel
Roberto Fernandez-Borda, Assistant Research Scientist

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
Our group continues to work on the HARP project for both, the CubeSat satellite and for an ER2 airborne version of the HARP imaging polarimeter called Air-HARP. The HARP CubeSat is scheduled for launch to the International Space Station in the end of 2016 and likely to be released for autonomous operation in the first half of 2017.

Borda has completed testing of the HARP PCI interface in order to connect the HARP TIM board electronics with the spacecraft interface. As part of ACE, we have also developed a concept for Air-HARP's operation and control on board the NASA ER-2 aircraft.

The group has completed the optical testing of the HARP prism and performed first Muller matrix characterization of the HARP optics.

The group has also finished the design and completed the airworthiness review for AirHARP instrument with NASA Armstrong's ER2 crew. The group will be seeking for opportunities to fly in the near future.

Plans for next year
- Prepare the HARP satellite for launch
- Continue to work on software interface between the HARP instrument and spacecraft.
- Develop ground based calibration strategies for HARP
- Participate in the implementation and test of the Air-HARP instrument

Task Number/Name
Task 126

Task Sponsor
Ken Pickering, Code 614

JCET Personnel
Ana Prados, Research Assistant Professor; Brock Blevins, Research Analyst; David Barbato, Graduate Student

Summary
Manage and coordinate NASA's Applied Remote Sensing Training Program. ARSET offers satellite remote sensing training that builds the skills to integrate NASA Earth Science data into an agency's decision-making activities. Trainings are offered in air quality, climate, disaster, health, land, water resources, and wildfire management. Through online and in-person training, ARSET has reached more than 5000 participants from more than 130 countries and 1,600 organizations worldwide.

Accomplishments
The team managed and coordinated five on-site and online trainings reaching +1400 people: 1) Webinar on Using NASA Remote Sensing for Flood Monitoring and Management (March 16-April 6), 2) A Short Course on Water Quality Monitoring Using NASA Remote Sensing Observations (May 5th), 3) A Webinar on the Fundamentals of Satellite Remote Sensing for Health Monitoring (June 2-30), 4) A Webinar on Using NASA Remote Sensing for Disaster Management (June 9-30), and 5) A Webinar on Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring (June 9-July 7).

On June 9, ARSET reached a new record of 1,023 live webinar participants in one day. Each webinar was broadcast twice a day to accommodate multiple time zones, and then recorded and made available to attendees after the live broadcasts.

Blevins organized a NASA Capacity Building Program Booth at the InterAction Forum 2016 in Washington D.C. on April 18-20. InterAction is an alliance of 180 Nongovernmental Organizations (NGOs). Participation in conference sessions and at the NASA booth served to raise awareness of NASA Earth Science and its application in the context of international development and humanitarian aid.

Prados attended the Eighth Meeting of the Virtual Laboratory for Training and Education in Satellite Meteorology (VLAB). The meeting was held at the Caribbean Institute for Meteorology and Hydrology in Bridgetown, Barbados on May 9-13th. VLAB is a global network of training centers and meteorological satellite operators, established by the World Meteorological Organization (WMO) and the Coordination Group for Meteorological Satellites (CGMS). The

goal was to establish collaborations and share best practices with other global centers engaged in training for satellite applications.

Barbato provided Spanish translations for 3rd quarter and 4th quarter ARSET training materials.

The team managed and coordinated the following ARSET activities: 1) A Webinar entitled 'Introduction to Remote Sensing for Coastal and Ocean Applications' on July 6-27, 2) a Webinar entitled 'Introduction to Satellite Remote Sensing for Air Quality Applications on July 6 – August 3, 3) A training entitled 'NASA Earth Observations, Data and tools for Air Quality Analysis' at Pusan National University, Korea on August 28-29, and 4) A training entitled 'Practical Use of Satellite Observations for Visibility and Air Quality Analysis' during the Atmospheric Optics: Aerosols, Visibility, and Radiative Balance conference on September 27-30, 2016, in Jackson Hole, WY.

Plans for next year

- Manage and coordinate about 14 online and in-person remote sensing trainings for air quality, climate, disaster, health, land, water resources, and wildfire applications. Some new topics include two webinars in support of the United Nations Sustainable Development Goals (SDG), a webinar on NASA Near Real Time products, and the first hands-on training on water quality applications.
- Develop a webinar on 'Train the Trainers', working with other space agencies and organizations to enable them to develop their own remote sensing training programs.
- Conduct targeted trainings for Latin America in the area of water and land resources management
- Translate training materials into Spanish
- Serve on three NASA data center User Working Groups: share feedback from ARSET participants so that NASA data centers can better serve the needs of environmental professionals.

Task Number/Name

Task 127: Study of the response of the Goddard Earth Observing System model (GEOS-5) to the variability in the optical properties of mineral dust and volcanic ash.

Task Sponsor

Peter R. Colarco, Code 614

JCET Personnel

Adriana Rocha Lima, Post-doctoral Research Associate

Summary

To better represent dust and volcanic ash aerosols in global models a more comprehensive description of their optical properties is needed. This research 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 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, and ultimately radiative forcing.

Accomplishments

During this period, GEOS-5 simulations were performed to evaluate the correlation between simulated total aerosol optical depth (AOD) and observations from MODIS and AERONET stations over the Saharan region. We also evaluated the sensitivity of the simulations for different emission maps, dust emission schemes, and wind speed threshold for dust lifting in the model. In addition, comparisons with observation were also extended to most recent model reanalysis meteorological data products, such and MERRA, MERRAero, and MERRA2 replay from NASA/GMAO. These reanalysis data products were also used to investigate how the emission, transport, and deposition of the different aerosol types have evolved over the last decades in the Arctic region. We have also started laboratory analysis of samples of volcanic ash from Alaska in collaboration with the Comparative Volcanology group at the GSFC and UMBC.

Plans for next year

Continue the analysis comparing the GEOS-5 model with satellite and in situ observations aiming to create a new dust module in the model with improved description of the dust sources, emission schemes, and dust optical and microphysics. The new dust module will be tested under different scenarios to study the effects of this incorporation over simulated global dust.

Task Number/Name

Task 128: Next Generation UAV Based Spectral Systems for Environmental Monitoring

Task Sponsor

Elizabeth Middleton, Code 618

JCET Personnel

Petya Campbell, Research Associate Professor

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 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

The team conducted preliminary tests and assessment of the available spectrometers and calibration instruments for use in the project. The PI and Co-Is visited the calibration and validation facility at NASA/GSFC, the vegetation analysis laboratory and remote sensing facility at the University of Wisconsin, and communicated with the University of Edinburgh. At Wisconsin, QEPro tests were initiated in the laboratory. The instrument output was evaluated, and procedures are currently being tested for calibration of the signal output to radiance. The team is assembling existing pilot datasets for preliminary analysis, comparisons, and workflow prototyping. The team is conducting initial tests of algorithms for scaling ground-based measurements of chemistry and physiology to canopy spectra. The team held weekly/by-weekly telecons to discuss the list of ongoing action items and project developments.

The team is completing flight authorizations. The team is prototyping from additional platforms (mast, tower, tram and tractor). Algorithms were implemented for on-board retrieval of calibrated reflectance, fluorescence and vegetation traits. Development of a software was initiated for onboard UAS for real time data evaluation and to optimize and spectrometers to appropriate location autonomously. The spectrometers inter-calibration and calibration to radiance was completed.

Plans for next year

- Finish 2 papers that are in progress: on EO1 time series at flux sites, and one scaling vegetation fluorescence from leaf to canopy level

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Task Number/Name
Task 129

Task Sponsor
Elizabeth Middleton, Code 618

JCET Personnel
Kevin R. Turpie, Research Associate Professor

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
Turpie hosted a community-wide HyspIRI Town Hall at the Ocean Sciences 2016 meeting in New Orleans, Louisiana. He also chaired a four-part session titled, "Present and Future Coastal and Inland Aquatic Remote Sensing for Science and Societal Benefits." The following oral presentation was made: K.R. Turpie, V.V. Klemas, K. Byrd, M. Kelly, Y-H. Jo, "The Hyperspectral Infrared Imager (HyspIRI) and Global Observations or Tidal Wetlands." Turpie was the lead author of two white paper reports on coastal and inland aquatic remotes sensing in response to two requests for information by National Academia of Science, Engineering, and Medicine committee for the Decadal Survey for Earth Science and Applications from Space. He was also a co-author on three other reports in response to the same requests for information. Turpie was one of the organizers of the HyspIRI Data Product Symposium during 1-3 June at Goddard Space Flight Center. He organized and hosted the HyspIRI Aquatic Forum meeting the third day of the symposium. Turpie was an invited participant of the National Center for Ecological Analysis and Synthesis for the NASA-sponsored "Prospects and Priorities for Satellite Monitoring of Global Marine Biodiversity" in Santa Barbara, CA from 6-10 June. Turpie provided his expertise regarding coastal remote sensing of changes in communities of sessile organisms and other foundation species (e.g., emergent vegetation, submerged aquatic

vegetation, and corals) to develop an understanding of changes in biodiversity of coastal habitats in response to global stressors (e.g., climate change and impact of a growing human population along coasts). The objective of the meeting is to develop a perspectives paper on remote sensing of marine biodiversity for publication in the peer-review literature.

Turpie met with the ASG to prepare for upcoming meeting in the Autumn, including the HyspIRI Science Workshop in Pasadena, California and the HyspIRI Town Hall at the upcoming Ocean Optics XXIII meeting in Victoria, British Columbia, both in late October. The HyspIRI Town Hall will be entitled HyspIRI and Future Hyperspectral Coastal and Inland Water Remote Sensing, and will include a panel led community discussion. Turpie worked with co-authors in the publication of the white papers in the peer review literature, with the NCEAS team in writing and publishing a perspective paper on remote sensing of marine biodiversity, and participate with the CEOS team in writing a feasibility study on a remote sensing instrument for coastal and inland aquatic observations.

Plans for next year

Turpie will continue to work on the Committee on Earth Observation Satellites (CEOS) working group, performing a feasibility study for a space-borne instrument to assess and monitor inland and coastal waters for water quality and ecosystem status.

Turpie will advise the Ad Hoc Science Team for the Coastal Camera, now under study for inclusion with the PACE mission.

Turpie will continue to lead the HyspIRI Aquatic Studies Group (ASG). This will include developing a HyspIRI Town Hall meeting at Ocean Optics XXIII conference in October to collect and organize input from the coastal and inland water remote sensing community. That input put will be developed into a report for the Steering Committee, National Academies of Science, Engineering, and Medicine study, Earth Science and Applications from Space. Turpie will also organize the next HyspIRI Aquatic Data Forum at the HyspIRI Science Data Products Symposium at GSFC, will support the HyspIRI Science Workshop sponsored by JPL, participate in the HyspIRI Project Steering Committee meetings, and other related meetings.

Turpie will function as lead Research Topic editor for the open access journal Frontiers in Marine Sciences. Turpie and his co-editors have dedicated this Research Topic, entitled Science and Applications of Coastal Remote Sensing, to their colleague and co-editor, Dr. Tiffany Moisan, who passed away unexpectedly last June. To this end, the Research Topic publication opportunity was opened to a broader community, with announcements reaching thousands of researchers and scientists.

Turpie will publish material from his two white papers on coastal and inland remote sensing in the Frontiers in Marine Sciences Research Topic.

Turpie will continue to collaborate on a peer-review paper with the National Center for Ecological Analysis and Synthesis for the NASA-sponsored "Prospects and Priorities for Satellite Monitoring of Global Marine Biodiversity" working group led by Dave Siegel, David Schimel, Frank Davis, and Ryan Pavlick.

Task Number/Name
Task 130

Task Sponsor
Elizabeth Middleton, Code 618

JCET Personnel
Karl Fred Huemmrich, Research Assistant Professor

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
Support of field work included continued analysis of data from the FUSION automated field spectrometer system. Huemmrich evaluated bidirectional reflectance and emission patterns from corn and examined how they change diurnally and seasonally. Huemmrich developed programs in R to calculate statistical models relating FUSION reflectance and fluorescence with ecosystem productivity as measured by a nearby flux tower. Results from this analysis were presented as a poster at the fall AGU meeting in San Francisco Dec. 14-18.

Huemmrich prepared data from Fluwat leaf clip for distribution. This included processing the field measurements, quality checking the data, merging the Fluwat measurements with photosynthesis measurements of the same leaves, calculating indices from the Fluwat data, and creating metadata describing site characteristics.

Huemmrich set up automated sensor system using Decagon sensors for measuring plant reflectance. Deployed this system in cornfield at study site in Beltsville Agricultural Research Center. Prior to the AGU fall meeting, he presented results from the Decagon sensors to a side meeting of Specnet investigators. During the AGU meeting, Huemmrich made an oral presentation on the Decagon-Specnet network results.

Huemmrich attended the 2015 HyspIRI Science and Applications Workshop in Pasadena, CA, Oct. 13-15. At this meeting presented a poster "ISS as a Platform for Optical Remote Sensing: A Case Study Using HICO."

Huemmrich attended and co-chaired the Spectnet investigators meeting in San Francisco, CA, Dec. 12, 2015. Made oral presentation on preliminary results from Specnet.

Huemmrich attended AGU fall meeting, San Francisco, CA, Dec. 14-18. Presented poster titled "Tower-Based Optical Sensing of Ecosystem Carbon Fluxes."

Huemmrich took part in the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC) User Working Group meeting held at GSFC, Greenbelt, MD, May 24-24, 2016.

Huemmrich attended HyspIRI Data Products Symposium held at GSFC, Greenbelt, MD, June 1-3, 2016. At the symposium made two oral presentations: "FUSION: a GSFC Prototype for Field Spectroscopy Cal/Val" and "HICO Remote Sensing of Ecosystem Carbon Flux: A Case Study for Using the ISS Platform." I also chaired a session of the meeting.

As coauthor, Huemmrich finished a manuscript and submitted it for publication to the journal Remote Sensing of Environment. The paper is titled "Photosynthetic Efficiency of Northern Forest Ecosystems using a MODIS-derived Photochemical Reflectance Index (PRI)." It is presently in review.

As lead author, Huemmrich submitted manuscript "ISS as a Platform for Optical Remote Sensing of Ecosystem Carbon Fluxes: A Case Study Using HICO" to the Journal for Selected Topics in Geosciences and Remote Sensing. It is presently in review.

Huemmrich attended the International Space Station Research and Development meeting in San Diego, CA, July 12-15 and made an oral presentation "ISS as a Platform for Optical Remote Sensing: A Case Study Using HICO."

Plans for next year

Huemmrich will prepare a manuscript for publication: "Testing Global Approaches for Optical Remote Sensing of Ecosystem Light Use Efficiency Using EO-1 Hyperion."

Task Number/Name
Task 131: Capacity Building for NASA Applied Remote Sensing Training Program

Task Sponsors
George Huffman, Code 612

JCET Personnel
Amita Mehta, Research Assistant Professor

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
As a part of the Applied Remote Sensing Training (ARSET) program team, Mehta developed presentations and conducted five trainings on using NASA remote sensing and earth system modeling data for water resources management and flood monitoring. These trainings included webinars on i) Water Resources management using NASA Earth Science Data (October-November 2015, ii) Special Webinar on ARSET Water Quality Monitoring Using Remote Sensing Observations (November 30, 2015; January 13, 2016), and iii) Advanced Webinar on Using NASA Remote Sensing for Flood Monitoring and Management (March-April, 2016). Mehta also contributed to a webinar on and iv) Using NASA Remote Sensing for Disasters management (June 30, 2016). Mehta presented overview and demonstration of Flood mapping web-tools based on TRMM and MODIS. A number of flooding case studies were demonstrated. These webinars were attended by more than 1000 national and international participants. In addition, Mehta, in collaboration with Dr. Cedric Fichot (from NASA-JPL), conducted a short course (1/2 Day) on 'Water Quality Monitoring using NASA Remote Sensing Observation' at the National Water Quality Monitoring Conference (NWQMC) in Tampa, FL (May 5, 2016). The course was offered to stakeholders from USGS, EPA, and Water Managers from public and private sectors. This course focused on using NASA Ocean Color and Giovanni Web-tools to access and utilize MODIS and Landsat imagery and water quality data to monitor Color, Temperature, and Chlorophyll Concentration in lakes, coastal oceans and estuaries. All the training materials are available from (arset.gsfc.nasa.gov). Mehta attended the NASA Applied Sciences – Water Resources Science Team Meeting in Tuscaloosa, Al from April 26-28 and presented a talk on 'ARSET AmeriGEOSS Activities'. Amita also attended NASA Land Use

Land Change meeting on April 18-19 and presented a poster on 'Best Practices for Improving Workforce Skills to use Earth Observations in Environmental Management and Policy'

Plans for next year

Mehta will prepare and conduct several online and in-person trainings for ARSET using NASA remote sensing observations for water resources (quantity and quality) and disaster management. The focus of the trainings will be on the topics related to NASA data applications for climate, water resources, and disasters – floods, drought, wildfire -- monitoring. Mehta will continue to develop modules to teach procedure to incorporate NASA satellite and model data, particularly precipitation, soil moisture, evapotranspiration into Geographical Information System (GIS) for water resources and disaster management.

Task Number/Name

Task 132

Sponsor

James Gleason, Code 614

JCET Personnel

L. Larrabee Strow, Research Professor; Sergio De-Souza-Machado, Research Associate Professor; Howard Motteler, Associate Research Scientist; Christopher Hepplewhite, Associate Research Scientist; Steven Buczkowski, Research Analyst

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. Details on this effort are outlined in the proposal, "JPSS CrIS Satellite Flight Pre- and Post-flight Calibration and Commissioning."

Accomplishments

The performance of NPP CrIS has continued to be excellent in the past year. We have shown that it's radiometric stability continues to be at climate trending levels. Continued spectral calibration of CrIS indicates that we may need to update the Neon lamp calibration (for the first time in orbit) in the next year.

This past fall the CrIS instrument was commanded to download slightly extended interferogram to improve L1b processing. We have performed an extensive analysis of this new CrIS mode and found that it greatly improves residual ringing in the L1b products and allows the use of a very simple calibration algorithm, unlike a more complicated version now under consideration for JPSS-1. Our major concern is the ensure that multiple CrIS instruments can produce a seamless radiance climate record, and details of the calibration algorithm can impact that goal.

The CrIS midwave FOV7 detector is highly non-linear. This year we developed a more objective approach to ensuring all CrIS focal plane detectors have the same radiometric response, and in doing so have considerably improved the FOV-7 performance relative to the other detectors by adjustment of the "a2" nonlinearity parameter. However, this detector is still slightly out-of-family, suggesting a more sophisticated approach may be needed.

We finished an extensive intercomparison of CrIS and IASI and AIRS using simultaneous nadir observations (SNOs). These studies show that all three instruments agree to within 0.1-0.3K *using pre-flight calibration before any empirical adjustments.* This is a very encouraging results for the ultimate trending of climate with these hyperspectral sensors. Even more importantly, the SNO differences have standard errors on the order of 0.01K, allowing very accurate empirical intercalibration. Although we have a large number of AIRS-CrIS SNOs, we also have IASI-CrIS and IASI-AIRS SNOs. By subtracting the (IASI-AIRS SNOs) from the (IASI-CrIS SNOs) we should, and did, obtain the same offsets as the direct AIRS-CrIS SNOs. This is an exceedingly important result since it shows that we can transfer the AIRS/CrIS instrument empirical calibration offset via a third party (IASI) should there be a data gap between, say, CrIS-1 and CrIS-2, etc. Note that this work required us to convert the AIRS L1b data to the CrIS instrument line shape (ILS) so that channel-by-channel comparisons are possible. We are proposing that the AIRS (and IASI) radiance records for climate processing should be converted to the CrIS ILS in order to facilitate inter-satellite calibration and uniform L2 retrieval processing over long time periods that include several different instruments.

Plans for next year

We are presently preparing for the March 2016 launch of JPSS-1, which is scheduled to have a very short turn-on period (partly to satisfy Congressional concerns that without such a short commissioning that there could be a data gap between NPP CrIS-1 and JPSS-1 CrIS-2).

The CrIS vendor (Harris) has recently discovered that the documentation for the CrIS detector sizes was slightly incorrect. We will be re-analyzing the CrIS-2 TVAC spectral calibration data (which is sensitive to detector size) to determine if we need to generate new spectral calibration parameters for CrIS-2, which are uploaded to the spacecraft for use in the L1b/SDR calibration algorithms.

Once CrIS-2 is operational and we have done the in-orbit spectral calibration, we will focus on radiometric and spectral differences between CrIS-1 and CrIS-2 in order to prepare NASA processing of these data set to be as close to climate quality as possible.

Task Number/Name
Task: 133 GPM Applications Training Program

Task Sponsors
Dalia Kirschbaum, Code 617

JCET Personnel
Amita Mehta, Research Assistant Professor

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 conducted three webinars for the GPM Applications Program on: i) Overview of GPM Mission, Precipitation Data and Data Access Tools (December 8, 2015); ii) GPM Data Product Updates and Demonstration of Web-tools for Data Search, Analysis, Visualization, and Download (March, 15, 2016); iii) Demonstration of Case Studies of GPM Data Import and Analysis in GIS (June 14, 2016).

Mehta started working on assessment and analysis of precipitation data collected on TAO, PIRATA, and RAMA buoys in the Pacific, Atlantic, and Indian Oceans respectively (McPhaden et al., 2009). Mehta composited the precipitation data collected at every 10-minute interval by the buoys on 30-minutes, 3-hour, daily, and monthly time scales to compare with TRMM and GPM multi-satellite precipitation data products (TMPA and IMERG). Preliminary analysis shows good correlation between daily TMPA and buoy precipitation data, however, significant differences in amplitudes are noted at several buoy locations.

Plans for next year
Mehta will continue to conduct webinars for GPM applications community. Mehta will teach GES-415 in Fall 2016 and mentor a team of graduate students though NASA DEVELOP program.

Task Number/Name

Task 134: Global Retrieval of Precipitation and Latent Heating Distributions from Spaceborne Radiometer/Radar Observations

Task Sponsor
Scott Braun, Code 612

JCET Personnel
William S. Olson, Research Associate Professor

Summary
The general goal of the supported research is the estimation of precipitation and latent heating distributions using combinations of spaceborne radar, passive microwave radiometer, and infrared radiometer observations. Task work is specifically to develop operational algorithms for inferring vertical profiles of precipitation from a combination of 14 GHz radar (Tropical Rainfall Measuring Mission; TRMM) or 14 + 36 GHz radar (Global Precipitation Measurement mission; GPM) observations and passive microwave radiometer multispectral observations. Regarding the Mixed-Phase Precipitation Grant, the specific objectives are to improve the representations of ice and mixed-phase particles in combined radar-radiometer precipitation estimation algorithms. The remote sensing of latent heating distributions using spaceborne radar and microwave/infrared radiometer data is a related area of study, supported by the Latent Heating Grant, with implications for understanding the Earth's water and energy cycles at different space-time scales.

Accomplishments
Regarding the GSFC Task, the focus of work through March, 2016 was the development and testing of Version 4 of the operational GPM combined radar-radiometer precipitation estimation algorithm (2nd public version). Advances in this algorithm include the statistical deconvolution of the coarser-resolution radiometer data to the resolution of the 5-km radar footprints, which leads to greater impact of the radiometer data on estimates. The physical consistency of estimates based upon different precipitation spatial inhomogeneity (within the radar footprints) assumptions was also examined, leading to optimal assumptions for the operational algorithm. Beginning in April, 2016, work began on the correction of high biases in Version 4 rain rate estimates over land and the development of the Version 5 algorithm, to be released in the late fall of 2016. This work included better state-dependent parameterizations of the inhomogeneity of precipitation within the GPM radar footprints and the inclusion of the scattering properties of nonspherical snow particle models in the algorithm's physical models.

Regarding the Mixed-Phase Precipitation Grant, funding for this work only began in January, 2016, and the coordination of effort between the PI and co-investigators who would simulate the scattering properties of nonspherical ice-phase precipitation was established. Larger

nonspherical snow particles (larger than the previous limit of 3 mm liquid-equivalent diameter) were computer-simulated and the microwave single-scattering properties of these particles were calculated. The larger particles extend the useful range of bulk scattering properties to snow polydispersions with larger median diameters, which is important because these types of polydispersions may be observed in heavier snow events. The larger snow particles will also serve as seed particles to create melting snow.

Regarding the Latent Heating Grant, initial high-resolution simulations of extratropical cyclones over the eastern US and western Atlantic Ocean were performed. These simulations will serve as a testbed for new heating estimation techniques under development. These heating estimation techniques will require information regarding the storm-relative location of narrow-swath satellite precipitation observations to properly infer heating rates from the observations. Therefore, merged global geostationary infrared data and reanalysis data were collected for the aforementioned storms to provide contextual information. A method for tracking extratropical low centers in reanalysis data was also implemented.

Plans for next year

Regarding the Task, final testing of software for the next public release (Version 5) of the GPM combined radar-radiometer precipitation estimation algorithm will be performed. In addition to other measures, it is anticipated that collocated ground-based radar reflectivity data and satellite-based, attenuation-corrected reflectivity data will be compared to assess the algorithm's physical consistency. After Version 5 release, more advanced state-dependent parameterizations of the inhomogeneity of precipitation within the satellite radar footprints will be implemented in new algorithm prototypes. In addition, nonspherical ice and mixed-phase precipitation particles and their scattering properties will be introduced into the algorithm's physical models for simulating radar reflectivities and microwave radiances. A new radiometer-only precipitation algorithm will also be implemented, to augment the radar-radiometer algorithm at high ($> 45\ ^{o}N$ or $< 45\ ^{o}S$) latitudes where light drizzle and snow cannot be detected by the spaceborne radar.

Regarding the Mixed-Phase Precipitation Grant, a thermodynamic melting layer microphysical model will be improved to include the effects of aggregation; this model will provide a framework for specifying the scattering properties of mixed-phase polydispersions at different depths below the freezing level in precipitation estimation algorithms. A greater array of simulated melting particles and their microwave single-scattering properties will also be generated to help generalize the physical models of precipitation estimation algorithms.

Regarding the Latent Heating Grant, a TRMM-derived 3D latent/radiative heating dataset will be produced for the entire TRMM record in the tropics/subtropics (1998 – 2014). A preliminary algorithm for estimating heating rates in extratropical cyclones will be developed and applied to synthetic test data (from model simulations) as well as actual satellite observations (infrared, microwave, and radar) and reanalysis data.

Task Number/Name
Task 135

Task Sponsor
Omar Torres, Code 614

JCET Personnel
D. Allen Chu, Associate Research Scientist

Summary
This task focuses on good validation of linear approximation of normalizing AOD by HLH with GOCART-GEOS-5 data leads to applicability of MERRA-2 12 km reanalysis to local $PM_{2.5}$ air quality.

Accomplishments
DISCOVER-AQ field campaigns baselined remote sensing measurements for satellite application in $PM_{2.5}$ air quality. However, the benchmarks were made at specific month of the year. Though surface-based network measurements (such as MPLNET and AERONET at NASA GSFC) can span multiple years, the coverage however is still limited over the US. The use of NASA MERRA-2 12 km reanalysis is a reasonable and practical choice for air quality and public health related studies. The GOCART-GEOS-5 data in Baltimore-Washington Corridor are analyzed for MERRA-2 12 km reanalysis when released. GOCART and GEOS-5 are the core components of NASA assimilation model. The dynamically scaled-down 12-km MERRA-2 data would better capture local variability of aerosols. When applied by the linear approximation of normalizing AOD by HLH (Haze Layer Height), it shows the validity of AOD/HLH in simulating mean boundary layer extinction (correlation ~0.97; slope ~0.9; intercept ~0.0) with 3-hour GOCART-GEOS5 in July 2010. In the other words, the linear approximation of AOD/HLH is applicable to GOCART-GEOS5 data in simulating $PM_{2.5}$. Note that the correlation of 0.96 is derived between MAE and AOD/HLH, irrespective of season, and in turn correlation ~0.87 and RMSE ~3.27 mg/m^3 are derived between estimated and observed $PM_{2.5}$ based upon 5-year (2007-2011) MPL-AERONET measurements. Thus the high correlation between HLH/AOD and mean PBL extinction can be seen as the validation for GOCART/GEOS5 in estimating surface $PM_{2.5.}$

Plans for next year
This task ended on June 7, 2016.

Task Number/Name
Task 136: Pandora development at GSFC

Task Sponsor
Anne Thompson, Code 614

JCET Personnel
Jay Herman, Senior Research Scientist

Summary
This task is implemented to 1) develop and improve the Pandora spectrometer system to determine ozone and nitrogen dioxide, their altitude profiles, and validate the results comparing with in-situ instrumentation, 2) correct a problem with the Pandora optics to enable retrieval of other trace gases such as formaldehyde and bromine oxide, 4) deploy Pandora at permanent sites to develop long-term records and 5) finish the DISCOVERAQ campaign analysis for all four campaigns and prepare for the next set of campaign in Korea (KORUS-AQ).

Accomplishments
Herman deployed 7 Pandora Spectrometer Instruments in Korea to support the KORUS-AQ campaign. The initial processing of the data is complete, showing that is of high precision and accuracy. The O_3 and NO_2 data from 10 Pandora instruments used in the KORUS-AQ campaign have been processed and are being prepared for delivery to the KORUS-AQ project in August. Results will presented at the Quadrennial Ozone Symposium in early September. An advanced design of the Pandora system was built that is more robust and can retrieve additional trace gases such as Formaldehyde.

We are participating in the CINDI-2 instrument comparison campaign in Cabauw, Netherlands during September 2016. Two Pandora instruments are being prepared and calibrated at Goddard for shipping to Cabauw in August.

Plans for next year
- Continue the expansion of the Pandora network.
- Analyze and publish long-term Pandora results
- Publish the results from profile determinations. Three publications are in-press or being reviewed.
- Present or prepare presentations of the results of the Pandora and EPIC measurements at scientific meetings (Quadrennial Ozone Symposium and AGU).

Task Number/Name
Task 137; Noise assisted signal analysis theory

Task Sponsor
Paul Racette, Code 555

JCET Personnel
Mustafa Aksoy, Post-Doctoral Research Associate

Summary
In active atmospheric remote sensing, Doppler velocity measurements are important for hydrometeor particle size retrieval and classification, thus understanding the weather system dynamics. Techniques to improve Doppler measurements via space-borne radar systems are a focus of this task. Specifically, the task is implemented to develop a computational framework for an ensemble detector which mixes correlated noise signals with radar returns to improve Doppler estimations by eliminating the spectral spread of Doppler velocity induced by the high velocity of the spacecraft.

Accomplishments
Aksoy, with Dr. Racette, has mathematically described the ensemble detection theory as a noise assisted signal analysis method to examine uncertainty and stability of a signal using wide sense stationary Gaussian noise signals. This theoretical description has been developed and tested in the context of radiometer calibration, where the measured antenna power is calibrated using radiometer gain and thermal reference noise signals. Using data measured by NASA's Aquarius and MIR (Millimeter-wave Imaging Radiometer), and NIST's Noise Figure Radiometer instruments, it was shown that, utilizing the ensemble detection theory, it is possible to characterize uncertainty and stability of calibrated antenna power and gain in radiometer systems by mixing a set of Gaussian noise signals with the gain and antenna power to be calibrated. Once the uncertainty in the calibrated antenna power is measured, any arbitrary gain can be modeled and replaced with wide sense stationary Gaussian signals with certain mean and standard deviations using the mathematical description of the ensemble detection theory. Therefore, stability of radiometer systems can be defined by parameters of the Gaussian signals which will provide a simple, novel, and reliable approach for inter-comparison and inter-calibration of different radiometer systems with different gain and calibration schemes. Aksoy and Racette are currently preparing a journal paper on their efforts regarding the ensemble detection theory, which will be submitted soon.

Plans for next year
Aksoy will focus on implementing the ensemble detection theory to eliminate the spectral spread of Doppler velocity induced by the high velocity of the spacecraft in space-borne radar Doppler measurements. Simulated radar return signals will be mixed with Gaussian noise signals to

extract the properties of the spectral spread and eliminate it. Furthermore, the ensemble detection theory will be applied to analyze the stability in significant geophysical measurements as it was used to examine stability in radiometer gain. For example, the change in global temperature measurements will be investigated using Goddard Institute for Space Studies (GISS) Surface Temperature Analysis datasets to investigate the climate change and global warming.

Task Number/Name
Task 138; NASA Grant NNX13AI86G: Validation of GPM Precipitation Retrieval Algorithms across the Precipitation Continuum

Task Sponsor
Matthew Schwaller, Code 612

JCET Personnel
Ali Tokay, Research Associate Professor

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

Accomplishments
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 radar was simulated through kriging and inverse distance weight methods. Non-uniform beam filling was quantified for the algorithm developers.

A manuscript on the pixel-space variability of raindrop size distribution has been accepted in Journal of Hydrometeorology. This study uses disdrometer network at NASA Wallops Flight Facility where the spatial variability of the fifteen different physical parameters was investigated.

Level 1 requirement of GPM mission has been studied starting February 2016. The investigator is taking action on mean mass diameter retrieval from GPM dual frequency radar and the measurement accuracy will be presented to NASA headquarter GPM mission extension meeting in Spring 2017.

The investigator participated Olympic mountain field study during January 2016. The disdrometer data is currently analyzed and early findings reveal that the orographic enhancement results in large concentration of small drops.

The investigator co-authored two studies including simulation of snow size distribution retrieval from dual frequency radar measurements (Liang et al. 2016) and validation of level-three GPM imerg product (Tan et al. 2016).

The investigator presented the comparative study of polarimetric radar observables through NASA's s-band polarimetric radar and two-dimensional video disdrometer during European geophysical union meeting in April 2016. He also chaired the session and co-authored his former student paper on dual frequency radar rainfall retrieval.

The investigator is a co-chairperson of upcoming European Radar Meteorology Conference in Turkey. He is also chair of AMS radar meteorology committee and associate editor of Journal Applied Meteorology and Climatology and Journal of Atmospheric and Oceanic Technology.

Plans for next year

Major effort will be given to Level 1 requirement of GPM mission. Progress has been discussed biweekly telecoms. The footprint scale variability of raindrop size distribution study should reach a state of draft paper. During July 2016, A visitor from Italy, Elisa Adirosi will conduct a study on vertical variability of rainfall through micro-rain radar. This study will be an integral component of ongoing efforts of comparing NASA's S-band polarimetric radar and disdrometer measurements.

Task Number/Name
Task 139: Feedbacks, Processes and Impacts of Contemporary Changes in the Arctic

Task Sponsor
Sophie Nowicki, Code 615

JCET Personnel
Jae Lee, Assistant Research Scientist

Summary
This task is designed to (1) provide a more complete documentation of conditions associated with recent melt events, (2) improve our understanding of forcing mechanisms that influence surface conditions on the Greenland Ice Sheet, and (3) identify the impacts of recent, enhanced runoff on Greenland's eustatic contribution and on productivity and circulation in the adjacent ocean.

Accomplishments
Under the task 139, Lee is working on the surface temperature and cloud fraction changes and their impact on Greenland Ice Sheet mass loss. She worked on validation of AIRS surface skin and air temperatures in comparison of in-situ measured from the Greenland Climate Network and NOAA station. She contributed to two publications as a co-author on recent temperature anomaly pattern changes and their relations with tele-connections.

Plans for next year
For task 139, Lee will work on the surface temperature changes and their relations with arctic environmental changes, in conjunction with cloud and radiation observations from AIRS, MODIS, and CERES.

Task Number/Name
Task 140: Assessment of reanalysis and in situ temperatures over the Greenland ice sheet

Task Sponsor
Sophie Nowicki, Code 615

JCET Personnel
Christopher A. Shuman, Research Associate Professor

Summary

This task is to study temperature data in central Greenland's 'Summit' Station area. The researcher will expand this work more broadly across Greenland including investigations of the MERRA and related output and reanalysis products from other institutions.

Accomplishments

Shuman has concluded a project with Dr. Scambos and Dr. Berthier assessing changes to the Antarctic Peninsula's ice cover from 2001-2015. Because of the scale of these changes and the ease of visualizing them, Shuman has been able to utilize remote sensing imagery to show the ice changes on NASA's hyperwall, updated into 2016 with Landsat 8 imagery, and also in presentations at NASA and UMBC. Such education and outreach activities remain an area of interest both at GSFC and UMBC.

The past year's efforts generated the content for a paper that quantifies why current re-analyses and typical AWS from ice sheet locations may provide inconsistent data for satellite calibration studies. By extracting and quality controlling near-surface temperature data from NOAA ESRL TAWO sensors and two adjacent 'standard' AWS installed near Greenland's Summit Station, Shuman has been able to document the magnitude and 'seasonality' of temperature errors in central Greenland due largely to passive shield errors. This led to poster presentations at the NOAA GMAC conference (http://www.esrl.noaa.gov/gmd/annualconference/) as well as the determination that a backup NOAA sensor was degrading.

The initial goal was to provide a reference data set for assessing reanalysis products such as MERRA but has now expanded to providing insights on sub-seasonal issues in the MERRA code that is likely related to solar illumination. Some of this has been incorporated in a 'white paper': http://www.iarpccollaborations.org/uploads/cms/documents/sirta-white-paper-posted.pdf

The publication "Ice loss processes in the Seal Nunataks Ice Shelf Region from satellite altimetry and imagery" was a long overdue completion of collaborative research with Drs. Scambos and Berthier (collectively, contributing to 5 papers since 2011) over a small section of the northern Antarctic Peninsula's changing Larsen A/B region. A high density of ICESat tracks crossing both an ice shelf remnant as well as grounded ice at either end of the remnant enabled surface and subsurface contributions to overall thinning to be estimated during 2003-2009.

The publication of a anomalous Antarctic mass loss assessment showing, effectively, that about 0.5 mm/yr of sea level was not accounted for (i.e. Antarctica was gaining mass overall by about the same amount that many other studies showed that Antarctica was losing mass) led to the coauthored 'comment' in the Journal of Glaciology with Dr. Scambos. A group from the Technical University of Dresden published a separate comment on the same mass change study in parallel with our comment; both are in the Journal of Glaciology. And finally, a paper based on previous field work with Dr. Scambos in the Antarctic 'megadunes' is in development, using updated remote sensing imagery and DEMs and a presentation is planned for Fall AGU.

Plans for next year
Obtaining stable funding from a NASA ROSES proposal or other Task activities at GSFC is the highest priority for the coming year. Dr. Shuman will continue to work towards a publication with Drs. Nowicki, Hall, and Culather toward the assessment of in situ and reanalysis temperature records from central Greenland. A multi-parameter assessment of East Antarctic megadunes is also forthcoming.

Task Number/Name
Task 141

Task Sponsor
James Gleason, Code 614

JCET Personnel
L. Larrabee Strow, Research Professor; Sergio De-Souza-Machado, Research Associate Professor; Howard Motteler, Associate Research Scientist; Christopher Hepplewhite, Associate Research Scientist; Steven Buczkowski, Research Analyst

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

Accomplishments
Three beta-versions of the new CrIS L1b radiance product software were delivered to the JPL Sounder SIPS this year, and V1 targeted for mid-August 2016. The beta-1 software delivery in November 2015 was primarily to determine integration issues, evaluate file formats, with no guaranteed scientific accuracy. Based on feedback from the Sounder SIPS a beta-2 version was

delivered in January 2016, again concentrating on integration, processing issues. This version (mostly Python and Matlab) was able to run successfully on JPL Sounder SIPS hardware. This was followed by a beta-3 delivery in Feb. 2016 with mostly correct (and present) scientific data that was used by the Sounder SIPS to generate three months of output (the first three months of 2016) that was distributed to the NASA CrIS Level 2 science team members for evaluation.

We recently generated an internal beta-4 delivery and sent sample data to the JPL Sounder SIPS primarily for comparison of the CrIS geolocation to the NPP-ATMS microwave L1b product geolocation. The ATMS L1b software is being developed at JPL and it is important that the CrIS and ATMS geolocation be internally consistent since both products are used together in Level 2 retreivals.

The CrIS L1b V1 software delivery is targeted for mid-August 2016. It will contain enhanced geolocation products requested by the Level 2 science team such as sun glint flags, surface topography, etc. More importantly, V1 will include a number of new science changes, primarily to reduce ringing in the instrument spectral lineshape, and improvements to the non-linearity coefficients.

A new L1a product has also been developed that is used to generate the L1b radiances. The L0 to L1a conversion has been the tall pole in cpu utilization for this project, so considerable work was done to migrate some of the L1a Python code to C, which provided a large speed-up in processing time.

The V1 L1b software only generates normal spectral resolution (NSR) data, which was the only spectral resolution possible with NPP-CrIS until Dec. 2014 when CrIS was placed in full spectral resolution mode (FSR).

An initial delta-ATBD for the CrIS L1B calibration algorithm was delivered to the Sounder SIPS in June 2016. Note that all L1b and L1a formats are now NetCDF4 and are reasonably compliant with CF and ACDD.

Plans for next year

A second release of the CrIS L1b and L1a software is scheduled for the summer of 2017. It will include full spectral resolution data (from Dec. 2014 on) and will include validated (or fixed) science improvements from V1. CrIS-2 on JPSS-1 should be providing data before this delivery, and we hope that any early lessons learned on minimizing the radiometric differences between CrIS-1 and CrIS-2 will be included in this V2 delivery. Note that the existing delivery has two slightly different calibration algorithms, and the availability of CrIS-2 will help determine which is the least sensitive to small instrument changes.

We also expect that a re-calibration of the Neon lamp may have to take place in the 2017 time-frame and that may also be included in the V2 delivery.

Task Number/Name
Task 142: Terra/Aqua + others: land cover/land use change, XBADGER radar development

Task Sponsor
Karen I. Mohr, Code 610

JCET Personnel
Stephen D. Nicholls, Post-Doctoral Research Associate

Summary
The Saharan Air Layer (SAL) is a warm, dry, and dusty isentropic layer resulting from sensible heating and dry convection in the Sahara Desert and is an integral component of North African climate. Although generated in the Sahara, the SAL modifies influences precipitating systems throughout North Africa and out into the Atlantic Ocean which has consequences on both regional agriculture and tropical cyclone development. Despite these far-reaching impacts, North Africa's rawinsonde network is sparse populated and data quality and usability can be questionable. These limitations with rawinsondes data make characterizing the SAL's bulk properties at useful resolutions all but impossible. The focus of the task is to evaluate capability of the Atmosphere Infrared Sounder (AIRS) to detect and characterize the SAL throughout North Africa at given observation sites. Unlike rawinsondes, AIRS is a space-based platform which offers quality controlled data with wide data swathes and detections up to 90% cloud cover, but coarser vertical resolution. In addition, AIRS SAL information will be combined with other NASA datasets to provide a more complete picture of the SAL, its evolution, and its interactions with precipitating system and African easterly waves.

Accomplishments
The research efforts have focused on tasks related to the "Science of Terra Aqua" proposal. Efforts in recent months have focused on improving the SAL detection algorithm. Instead of merely diagnosing the existence of SALs, the algorithm now diagnoses various SAL physical properties (temperature, moisture, dust levels, etc.) and has been refined to allow for multiple SAL detection. These properties were of keen interest to the AIRS Science Team to whom I will present these updated results in the coming weeks. Additionally, the algorithm now adds useful diagnosis tools for both the highly regarded model re-analysis products (ECMWF interim analysis and NASA's MERRA-2). Another major research focus was expanding the SAL research to become cross-platform, by combining SAL-related trajectory paths with available precipitation data (TRMM) and Saharan dust (MODIS Aqua).

The remaining portion of this task was dedicated to algorithm development work involving the XBADGER radar currently stationed at Wallops Island, VA and for an ongoing research into the regional climate model prediction of change to the future precipitation characteristics of the Central Andes. For XBADGER, the task included translating and improving existing software for this platform to remove its MATLAB dependence, to make it more portable for field work,

and to provide a means to process raw radar data in real-time (less than 5 minutes after a detection period). Efforts resulted in a Python-based algorithm, which met all these above conditions and is now being actively used in XBADGER research. For the South American Research, this has been a multi-year effort, where all the necessary data are now available .

Results from research on Saharan Air Layer detection from the Sounder were presented as a poster at the Air-Sea Interaction section of the 32nd Conference on Hurricanes and Tropical Meteorology on April 19th. Results from the SAL/AIRS research were also presented at the MODIS/VIIRS Science Team Meeting on June 7th. To foster inter-branch interactions at Goddard, results were shared with the AIRS science team on April 28th and to the Goddard Earth Science Data and Information Service Center on May 31st.

Research has shown AIRS to be an effective platform for SAL detection, so efforts are underway to develop an SAL climatology using AIRS data. For XBADGER, support was provided on product development where needed. Much more emphasis has been placed on the South American climate research, to solidify the results and begin production on a journal paper.

Plans for next year

- Continue working on a journal publication to the European Geophysical Journal Geophysical Data Analysis "An Analysis of the Recent Climate of the Central Andes with a Regional Climate Model" in support of the land cover/land use component
- Complete an analysis regional climate model output from future years 2031, 2059, and 2087. Submit a journal paper to the Journal for Advances in Earth System Modeling for review and publication.
- For the Terra/Aqua component, the analysis period shall be extended to cover the entire Aqua Era (2002+) and start inter-instrument comparison of the detected layers relative to precipitation, high dust concentrations and African Easterly waves.
- When combined, the inter-instrument comparison will lead to a first of its kind climatology of the SAL and its interactions with the remainder of the complex climate system in North Africa.
- Give a talk on Central Andes research at the American Meteorological Society Annual Meeting (Jan 2017).
- For the XBADGER component, continue development and testing the raw data processing and plotting program.

Task Number/Name
Task 143: Analysis and Deployment of the Mobile Goddard Lidar Observatory for Winds (GLOW)

Task Sponsor
Bruce Gentry, Code 612

JCET Personnel
Kevin Vermeesch, Research Analyst

Summary
The tasks for this research included analysis of data from GLOW (the Goddard Lidar Observatory for Winds) collected during various campaigns across the nation, as well as deployment and operation of related instrumentation. Also included in this task is the operation and design of lidar/ceilometer network instrumentation and production of Planetary Boundary Layer (PBL) values useful for model and air pollution dispersion use. Integration of multi-instrument atmospheric observations, in particular lidar-based water vapor, temperature and wind profiles, is important in understanding atmospheric lower atmospheric dynamics and physics. Analysis and deployment design of a multi-agency, multi-instrument, multi-nation field experiment, the Plains Elevated Convection at Night (PECAN) is a major task under this research work. PECAN is designed to advance the understanding of continental, nocturnal, warm-season precipitation. PECAN will focus on nocturnal convection in conditions with a stable boundary layer (SBL), a nocturnal low-level jet (NLLJ) and the largest CAPE (Convectively Available Potential Energy) located above the SBL. In addition, this task also supports activities related to the operation of GLOW at the Howard University Beltsville Campus.

Accomplishments
Task members received training to operate the Goddard Lidar Observatory for Wind (GLOW) and collected GLOW data during radiosonde launches at the Howard University Beltsville Research Campus (HUBRC) to compare with radiosonde wind profiles. A paper analyzing GLOW-radiosonde comparisons at the HUBRC was submitted for peer review for journal publication.

Raw ceilometer data from all study locations were put into netCDF files so that raw data, regardless of its original format, would have a uniform format to use for data analysis and averaging. Applied published planetary boundary (PBL) height estimate algorithms to radiosonde data from locations of ceilometers in our study. These estimates were used to compare with PBL height estimates calculated from ceilometer backscatter. Also within the NOAA ceilometer project, the Automated Surface Observation Station (ASOS) Sky Condition algorithm was coded from NOAA documentation and applied to ceilometer data.

The ceilometer, surface meteorology, and radiometer data sets collected during the Plains Elevated Convection At Night (PECAN) campaign were converted to netCDF format for distribution to the PECAN research community. Converted data from other field campaigns to netCDF format for easier use in PI's data analyses.

Plans for next year

- Experiment/simulate collection of ceilometer backscatter data using ASOS hardware/software configuration
- Assist with GLOW data collection, processing, archiving, comparisons, and analysis

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Task Number/Name
Task 144 : GLOW and TWiLiTe wind algorithm studies

Task Sponsor
Bruce Gentry, Code 612

JCET Personnel
Brian Carroll, Graduate Student

Summary
This task provides support for a graduate student to support two GSFC wind lidar systems: 1) the Goddard Lidar Observatory for Winds (GLOW), a ground based mobile direct detection Doppler lidar, and 2) the Tropospheric Wind Lidar Technology Experiment (TWiLiTE), a fully autonomous Doppler lidar system designed to fly on NASA research aircraft including the DC-8, ER-2 and Global Hawk. Both instruments collected extensive data sets during field experiments in 2015. The task involves working with the PI and instrument team members to design and develop algorithms and computer code to optimize the acquisition, analysis and validation of the wind profile data from the two lidar systems. The task also involves analysis of the data sets obtained during the field missions and comparisons with wind data obtained from other instruments. Researcher will also participate in the scientific and technical interpretation of the data and collaborate with members of relevant science teams to publish the results of these investigations.

Accomplishments
Throughout the year Carroll completed his predefined goals of studying dual-Doppler data from the Lidar Uncertainty Measurement Experiment (LUMEX) and beginning data processing and analysis for the Plains Elevated Convection at Night (PECAN) field campaign. The LUMEX work was presented at two conferences. He also worked with NASA GSFC's Goddard Lidar Observatory for Wind (GLOW) and Tropospheric Wind Lidar Technology Experiment

(TWiLiTE) research team, learning direct detection Doppler lidar theory and how to operate the instruments.

Plans for next year

- Investigate notable case studies of wind and storm dynamics from the Plains Elevated Convection at Night (PECAN) campaign, utilizing water vapor lidar, radiometer, radiosondes, and more to complement the UMBC Doppler lidar.
- Plan and propose for PhD candidacy, focusing on PECAN case studies and bolstered by other Doppler lidar experiments/research.
- Cooperate with Dr. Bruce Gentry of NASA GSFC on his work with GLOW (Goddard Lidar Observatory for Winds) and TWiLiTE (Tropospheric Wind Lidar Technology Experiment).

Task Number/Name
Task 145, NASA's BEST (Beginning Engineering, Science & Technology) - GSFC Component

Task Sponsor
Dean Kern, Code 160

JCET Personnel
Catherine Kruchten, Instructional Designer

Summary
Based on collaborative experience with a previous NASA Grant "NASA's BEST Students" (Hoban, PI), wherein over 7,000 participants were provided Science, Technology, Engineering and Mathematics (STEM) professional development using NASA content, Catherine Kruchten collaborates with Goddard Education to develop and deliver authentic Earth and space science and engineering experiences for NASA's Educator Professional Development (EPD) Institutes and Community-requested EPD events. These activities draw upon the expertise of Kruchten in the area of STEM education and are designed and delivered using research-based methods.

Accomplishments
Kruchten delivered EPD on existing NASA's BEST curriculum. For EPD delivery, a week-long workshop for participants in Rhode Island was conducted using NASA DLN technology during the week of April 25. Over the course of the week, 31 educators (all 4th grade teachers from a single district) took part, and DLN staff conducted a survey showing that teacher confidence in engineering increased as a direct result of the workshop. Training for NASA Goddard education staff was also conducted in order for BEST content to be presented at the MEI (MUREP Education Institute, for Minority Serving Institutions) program the week of June 6. Planning has also been underway for future EPD sessions. Workshops were conducted at the Intrepid Sea, Air, and Space Museum (NYC) in July.

Plans for next year
Plans are underway a Girl Scout program in October/November, and ongoing workshops with Goddard Institute of Space Studies throughout the year.

Task Number/Name
Task 146: NASA's BEST (Beginning Engineering, Science & Technology) - AFRC Component

Task Sponsor
Dean Kern, Code 160

JCET Personnel
Susan Hoban, Senior Research Scientist

Summary
Based on collaborative experience with a previous NASA Grant "NASA's BEST Students" (Hoban, PI), wherein over 7,000 participants were provided Science, Technology, Engineering and Mathematics (STEM) professional development using NASA content, Susan Hoban collaborates with NASA Armstrong to develop and deliver authentic Earth and space science and engineering experiences for NASA's Educator Professional Development (EPD) Institutes and Community-requested EPD events. These activities draw upon the expertise of Hoban in the area of STEM education and are designed and delivered using research-based methods.

Accomplishments
Funding bagan for this project in June 2016. Hoban participated in the NASA's BEST kick-off meeting, hosted by NASA AFRC during the week of June 6. Hoban reviews and edits the new curriculum that is under development. Hoban participated in the NASA-sponsored SEAP Evaluation Workshop on June 17.

Plans for next year
The first unit of the new curriculum will be rolled out, tested and revised in the coming year. A second unit will be drafted, reviewed and tested.

Task Number/Name
Task 147: NASA's BEST (Beginning Engineering, Science & Technology) - AFRC Component

Task Sponsor
Dean Kern, Code 160

JCET Personnel
Catherine Kruchten, Instructional Designer

Summary
Based on collaborative experience with a previous NASA Grant "NASA's BEST Students" (Hoban, PI), wherein over 7,000 participants were provided Science, Technology, Engineering and Mathematics (STEM) professional development using NASA content, Catherine Kruchten collaborates NASA Armstrong to develop and deliver authentic Earth and space science and engineering experiences for NASA's Educator Professional Development (EPD) Institutes and Community-requested EPD events. These activities draw upon the expertise of Kruchten in the area of STEM education and are designed and delivered using research-based methods.

Accomplishments
The funding for this task began in June 2016. Kruchten developed the newest iteration of BEST lesson plans. A new quadcopter build was drafted in collaboration with educators at NASA Armstrong, and subsequently tested among BEST educators from other NASA centers at the BEST kick-off meeting June 8 and 9. The complete draft of the unit was delivered on August 2, and the final draft was rolled out on September 2.

Plans for next year
The first unit of the new curriculum will be rolled out, tested and revised in the coming year. A second unit will be drafted, reviewed and tested.

Task Number/Name
Task 148: EPIC on DSCOVR

Task Sponsor
Adam Szabo, Code 672

JCET Personnel
Jay Herman, Senior Research Scientist

Summary
As Instrument Scientist for EPIC satellite instrument on board the DSCOVR (Deep Space Climate Observatory) satellite, the researcher will lead the effort to characterize the optical performance of the EPIC instrument including stray light determination, laboratory and in-flight

calibration, and provide initial algorithms for retrieving ozone, aerosol index, and surface reflectivity. The researcher will assist and manage the transformation of the initial algorithm development to the ROSES-supported science team.

Accomplishments

Herman worked on developing the in-flight calibration and processing the UV DSCOVR EPIC data obtained at the Lagrange-1 point to retrieve ozone, aerosol index, and cloud reflectivity. The results have been validated against low-earth orbiting satellites such as OMI and OMPS. The entire UV EPIC data set has now been processed during the months of April and May.

Global ozone values have been derived from EPIC for the first year from June 2015 to July 2016. These values have successfully been compared with ozone data derived from low-earth orbiting satellite instruments (OMPS and OMI). As part of this effort, new calibration coefficients have been derived using on-orbit calibration techniques. The results will be presented at the Fall AGU meeting.

Plans for next year

- In-flight EPIC instrument calibration and analysis of the calibrated data for the standard products will continue.
- Presentations of the results of the Pandora and EPIC measurements will be made at scientific meetings (Quadrennial Ozone Symposium and AGU).

II. Supporting Information

A. Departmental Affiliations

JCET Faculty Member	Departmental Affiliation
Petya Campbell	Geography & Environmental Systems
Ruben Delgado	Physics
Sergio de Souza-Machado	Physics
Forrest Hall	Physics
Susan Hoban	Computer Science & Electrical Engineering; Physics

Karl Fred Huemmrich	Geography & Environmental Systems
Simone Lolli	Physics
Amita Mehta	Geography & Environmental Systems
William Olson	Physics
Lorraine Remer	Geography & Environmental Systems; Physics
Christopher Shuman	Geography & Environmental Systems
Jason St. Clair	Chemistry
Andrew Tangborn	Mathematics & Statistics
Ali Tokay	Geography & Environmental Systems
Kevin Turpie	Geography & Environmental Systems
Tamás Várnai	Physics

B. Courses Taught

JCET Faculty Member	**Course**	**Term**
Forrest Hall	PHYS 335: Physics & Chemistry of the Atmosphere	Fall 2015
Lorraine Remer	GES 381: Remote Sensing (50%)	Fall 2015
Ali Tokay	GES 311: Weather & Climate	Fall 2015
Kevin Turpie	GES 381: Remote Sensing (50%)	Fall 2015
Belay Demoz	PHYS 622: Aerosols, Climate & Radiation	Spring 2016
Simone Lolli	PHYS 440/620: Computational Physics	Spring 2016
Christopher Shuman	GES 400x: Earth's Cryosphere	Spring 2016
Catherine Kruchten	FYS 108: Mathematics in Literature	Fall 2015 Spring 2016

C. Publications

Alvarado, M. J., Lonsdale, C. R., Macintyre, H. L., **Bian, H**., Chin, M., Ridley, D. A., Heald, C. L., Thornhill, K. L., Anderson, B. E., Cubison, M. J., Jimenez, J. L., Kondo, Y., Sahu, L. K., Dibb, J. E., Wang, C. (2016). Evaluating Model Parameterizations of Submicron Aerosol Scattering and Absorption with In Situ Data from ARCTAS 2008. *Atmos. Chem. Phys.*, doi:10.5194/acp-2015-935.

Anderson, D. C., Nicely, J. M., Salawitch, R. J., Canty, T. P., Dickerson, R. R., Hanisco, T. F., **Wolfe, G. M**., Apel, E. C., Atlas, E., Bannan, T., Bauguitte, S., Blake, N. J., Bresch, J. F., Campos, T. L., Carpenter, L. J., Cohen, M. D., Evans, M., Fernandez, R. P., Kahn, B. H., Kinnison, D. E., Hall, S. R., Harris, N. R., Hornbrook, R. S., Lamarque, J. F., Le Breton, M., Lee, J. D., Percival, C., Pfister, L., Pierce, R. B., Riemer, D. D., Saiz-Lopez, A., Stunder, B. J., Thompson, A. M., Ullmann, K., Vaughan, A., Weinheimer, A. J. (2016). A pervasive role for biomass burning in tropical high ozone/low water structures. *Nature Communications, 7*, 10267. http://www.ncbi.nlm.nih.gov/pubmed/26758808

Arvani, B., Pierce, R., Lyapustin, A., **Wang, Y**., Ghermandi, G., Teggi, S. (2016). Seasonal monitoring and estimation of regional aerosol distribution over Po valley, northern Italy, using a high-resolution MAIAC product. *Atmospheric Environment, 141*, 106-121.

Arvani, B., Pierce, R. B., Lyapustin, A. I., **Wang, Y**., Teggi, S., Ghermandi, G. (in press). High spatial resolution aerosol retrievals used for daily particulate matter prediction over Po valley, northern Italy. *Atmospheric Environment*, DOI:10.1016/j.atmosenv.2016.06.037.

Barnes, R. A., Brown, S. W., Lekke, K. R., Guenther, B., Butler, J. J., Schwarting, T., **Turpie, K. R.,** Moyer, D., DeLuccia, F., Moeller, C. (2015). Comparison of two methodologies for calibrating satellite instruments in the visible and near-infrared. *Applied Optics, 54*(35), 10376-10396. doi:10.1364/AO.54.010376

Barth, M. C., Bela, M. M., Fried, A., Wennberg, P. O., Crounse, J. D., **St. Clair, J. M**., Blake, N. J., Blake, D. R., Homeyer, C. R., Brune, W. H., Zhang, L., Mao, J., Ren, X., Ryerson, T. B., Pollack, I. B., Peischl, J., Cohen, R. C., Nault, B. A., Huey, L. G., Liu, X., Cantrell, C. A. (2016). Convective transport and scavenging of peroxides by thunderstorms observed over the central U.S. during DC3. *Journal of Geophysical Research: Atmospheres, 121*(8), 4272–4295. http://dx.doi.org/10.1002/2015JD024570

Bela, M. M., Barth, M. C., Toon, O. B., Fried, A., Homeyer, C. R., Morrison, H., Cummings, K. A., Li, Y., Pickering, K. E., Allen, D. J., Yang, Q., Wennberg, P. O., Crounse, J. D., **St. Clair, J. M**., Teng, A. P., O'Sullivan, D., Huey, L. G., Chen, D., Liu, X., Blake, D. R., Blake, N. J., Apel, E. C., Hornbrook, R. S., Flocke, F., Campos, T., Diskin, G. (2016). Wet scavenging of soluble gases in DC3 deep convective storms using WRF-Chem simulations and aircraft observations. *Journal of Geophysical Research: Atmospheres*, *121*(8), 4233–4257. http://dx.doi.org/10.1002/2015JD024623

Bi, J., Myneni, R., Lyapustin, A., **Wang, Y**., Park, T., Chen, C., Yan, K., Knyazikhin, Y. (2016). Amazon Forests' Response to Droughts: A Perspective from the MAIAC Product. *Remote Sensing, 8*(5), doi:10.3390/rs8040356.

Busilacchio, M., Di Carlo, P., Aruffo, E., Biancofiore, F., Dari Salisburgo, C., Giammaria, F., Bauguitte, S., Lee, J., Moller, S., Hopkins, J., Punjabi, S., Andrews, S., Lewis, A. C., Parrington, M., Palmer, P. I., Hyer, E., **Wolfe, G. M**. (2016). Production of peroxy nitrates in boreal biomass burning plumes over Canada during the BORTAS campaign. *Atmospheric Chemistry and Physics*, *16*(5), 3485-3497.

Campbell, J. R., Ge, C., Wang, J., Welton, E. J., Chew, B. N., Lieu, S.-C., Salinas, S. V., **Lolli, S**., Kaku, K. C., Lynch, P., Mahmud, M., Mohamad, M., Holben, B. N. (2015). Applying Advanced Ground-Based Remote Sensing in the Southeast Asian Maritime Continent to Characterize Regional Proficiencies in Smoke Transport Modeling. *Journal of Applied Meteorology and Climatology*. dx.doi.org/10.1175/JAMC-D-15-0083.1

Cazorla, M., **Wolfe, G. M.,** Bailey, S. A., Swanson, A. K., Arkinson, H. L., Hanisco, T. F. (2015). A new airborne laser-induced fluorescence instrument for in situ detection of formaldehyde throughout the troposphere and lower stratosphere. *ATMOSPHERIC MEASUREMENT TECHNIQUES*, *8*(2), 541-552.

Choi, J., Jo, J. H., Roh, K.-M., Son, J.-Y., Kim, M.-J., Choi, Y.-J., Yim, H.-S., Moon, H.-K., Kim, B.-Y., Park, J.-H., others (2015). Analysis of the angle-only orbit determination for optical tracking strategy of Korea GEO satellite, COMS. *Advances in Space Research*, *56*(6), 1056–1066.

Chu, D.-C., Ferrare, R., Szykman, J., Lewis, J. R., Scarino, A., Hains, J., Burton, S., Chen, G., Tsai, T., Hostetler, C., Hair, J., Holben, B., Crawford, J. (2015). Regional characteristics of the relationship between columnar {AOD} and surface PM2.5: Application of lidar aerosol extinction profiles over Baltimore–Washington Corridor during DISCOVER-AQ. *Atmospheric Environment*, *101*(0), 338 - 349. http://www.sciencedirect.com/science/article/pii/S1352231014008991

Chu, D.-C., Ferrare, R., Szykman, J., **Lewis, J. R**., Scarino, A., Hains, J., Burton, S., Chen, G., Tsai, T., Hostetler, C., Hair, J., Holben, B., Crawford, J. (2015). Regional characteristics of the relationship between columnar {AOD} and surface PM2.5: Application of lidar aerosol extinction profiles over Baltimore–Washington Corridor during DISCOVER-AQ. *Atmospheric Environment*, *101*(0), 338 - 349. http://www.sciencedirect.com/science/article/pii/S1352231014008991

Ciufolini, I., Paolozzi, A., **Pavlis, E. C.,** Koenig, R., Ries, J., Gurzadyan, V., Matzner, R., Penrose, R., Sindoni, G., Paris, C. (2015). Preliminary orbital analysis of the LARES space experiment. *The European Physical Journal Plus*, *130*(7), 1–5.

Ciufolini, I., Paolozzi, A., **Pavlis, E**. C., Koenig, R., Ries, J., Gurzadyan, V., Matzner, R., Penrose, R., Sindoni, G., Paris, C., et al. (2016). A test of general relativity using the LARES and LAGEOS satellites and a GRACE Earth gravity model. *The European Physical Journal C*, *76*(3), 1–7.

Ciufolini, I., Paolozzi, A., **Pavlis, E. C**., Gabrielli, A., Paris, C., Sindoni, G. (2015). *Improvement Of The Measurement Of Frame-Dragging By The Future Lares 2 Mission* (IAC-15.A2.1.8 ed.). Jerusalem, AIAA: Proceedings of the 66th International Astronautical Congress 2015.

De Souza-Machado, S. G., Tangborn, A. V., Strow, L. L., Sura, P. (2015). Examining infrared radiances for evidence of stochastic forcing. *EGU General Assembly Conference Abstracts* (vol. 17, pp. 14610).

De Souza-Machado, S. G., Strow, L., Tangborn, A. V., Hepplewhite, C., Motteler, H., Schou, P., Buczkowski, S. (2015). Geophysical trends from 12+ years of AIRS radiance trends. *EGU General Assembly Conference Abstracts* (vol. 17, pp. 14647).

Di, Q., Kloog, I., Koutrakis, P., Lyapustin, A., **Wang, Y**., Schwartz, J. (2016). Assessing PM2.5 Exposures with High Spatio-Temporal Resolution across the Continental United States. *Environmental Science & Technology*, *50*(9), 4712–4721.

Dreessen, J., Sullivan, J. S., **Delgado, R**. (2016). Observations and Impacts of Transported Canadian Wildfire Smoke on Ozone and Aerosol Air Quality in the Maryland Region on 9-12 June. *Journal of the Air & Waste Management Association*. ttp://www.tandfonline.com/eprint/QJIV5dcuXrBFRRJRDZrz/full

Fisher, J. A., Jacob, D. J., Travis, K. R., Kim, P. S., Marais, E. A., Chan Miller, C., Yu, K., Zhu, L., Yantosca, R. M., Sulprizio, M. P., Mao, J., Wennberg, P. O., Crounse, J. D., Teng, A. P., Nguyen, T. B., **St. Clair, J. M**., Cohen, R. C., Romer, P., Nault, B. A., Wooldridge, P. J., Jimenez, J. L., Campuzano-Jost, P., Day, D. A., Shepson, P. B., Xiong, F., Blake, D. R., Goldstein, A. H., Misztal, P. K., Hanisco, T. F., **Wolfe, G. M.,** Ryerson, T. B., Wisthaler, A., Mikoviny, T. (2016). Organic nitrate chemistry and its implications for nitrogen budgets in an isoprene- and monoterpene-rich atmosphere: constraints from aircraft (SEAC4RS) and ground-based (SOAS) observations in the Southeast US. *Atmospheric Chemistry and Physics*, *16*, 5969-5991. http://www.atmos-chem-phys-discuss.net/acp-2016-52/

Gamon, J. A., **Huemmrich, K. F**., Stone, R., Tweedie, C. Spatial and temporal variation in primary productivity (NDVI) of coastal Alaskan tundra: Decreased vegetation growth following earlier snowmelt. *Remote Sensing of Environment*, *129*, 144–153.

Gautam, R., Gatebe, C. K., Singh, M. L., **Varnai, T**., Poudyal, R. (in press). Radiative characteristics of clouds embedded in smoke derived from airborne multiangular measurements. *J. Geophys. Res.*.

Herman, J. R., Robert, E., Cede, A., **Abuhassan, N**., Irina, P., G, M. (2015). Comparison of Ozone Retrievals from the Pandora Spectrometer System and Dobson Spectrophotometer in Boulder Colorado. *AMT, 2014-315*, 10.

Hu, W. W., Campuzano-Jost, P., Palm, B. B., Day, D. A., Ortega, A. M., Hayes, P. L., Krechmer, J. E., Chen, Q., Kuwata, M., Liu, Y. J., de Sá, S. S., Martin, S. T., Hu, M., Budisulistiorini, S. H., Riva, M., Surratt, J. D., **St. Clair, J. M.,** Isaacman-Van Wertz, G., Yee, L. D., Goldstein, A. H., Carbone, S., Artaxo, P., de Gouw, J. A., Koss, A., Wisthaler, A., Mikoviny, T., Karl, T., Kaser, L., Jud, W., Hansel, A., Docherty, K. S., Robinson, N. H., Coe, H., Allan, J. D., Canagaratna, M. R., Paulot, F., Jimenez, J. L. (2015). Characterization of a real-time tracer for Isoprene Epoxydiols-derived Secondary Organic Aerosol (IEPOX-SOA) from aerosol mass spectrometer measurements. *Atmospheric Chemistry and Physics*, *15*(8), 11223–11276. www.atmos-chem-phys.net/15/11807/2015/acp-15-11807-2015.html

Kaiser, J., **Wolfe, G. M**., Bohn, B., Broch, S., Fuchs, H., Ganzeveld, L. N., Gomm, S., Haeseler, R., Hofzumahaus, A., Holland, F., Jaeger, J., Li, X., Lohse, I., Lu, K., Prevot, A. S. H., Rohrer, F., Wegener, R., Wolf, R., Mentel, T. F., Kiendler-Scharr, A., Wahner, A., Keutsch, F. N. (2015).

Evidence for an unidentified non-photochemical ground-level source of formaldehyde in the Po Valley with potential implications for ozone production. *ATMOSPHERIC CHEMISTRY AND PHYSICS, 15*(3), 1289-1298.

Kaiser, J., Skog, K. M., Baumann, K., Bertman, S. B., Brown, S. B., Brune, W. H., Crounse, J. D., de Gouw, J. A., Edgerton, E. S., Feiner, P. A., Goldstein, A. H., Koss, A., Misztal, P. K., Nguyen, T. B., Olson, K. F., **St. Clair, J. M**., Teng, A. P., Toma, S., Wennberg, P. O., Wild, R. J., Zhang, L., Keutsch, F. N. (2016). Speciation of OH reactivity above the canopy of an isoprene-dominated forest. *Atmospheric Chemistry and Physics Discussions*, *2016*, 1–20. http://www.atmos-chem-phys-discuss.net/acp-2015-1006/

Kaiser, J., **Wolfe, G. M**., Min, K. E., Brown, S. S., Miller, C. C., Jacob, D. J., deGouw, J. A., Graus, M., Hanisco, T. F., Holloway, J., Peischl, J., Pollack, I. B., Ryerson, T. B., Warneke, C., Washenfelder, R. A., Keutsch, F. N. (2015). Reassessing the ratio of glyoxal to formaldehyde as an indicator of hydrocarbon precursor speciation. *ATMOSPHERIC CHEMISTRY AND PHYSICS, 15*(13), 7571-7583.

Kim, P. S., Jacob, D. J., Fisher, J. A., Travis, K., Yu, K., Zhu, L., Yantosca, R. M., Sulprizio, M. P., Jimenez, J. L., Campuzano-Jost, P., Froyd, K. D., Liao, J., Hair, J. W., Fenn, M. A., Butler, C. F., Wagner, N. L., Gordon, T. D., Welti, A., Wennberg, P. O., Crounse, J. D., **St. Clair, J. M**., Teng, A. P., Millet, D. B., Schwarz, J. P., Markovic, M. Z., Perring, A. E. (2015). Sources, seasonality, and trends of southeast US aerosol: an integrated analysis of surface, aircraft, and satellite observations with the GEOS-Chem chemical transport model. *Atmospheric Chemistry and Physics, 15*(18), 10411–10433. http://www.atmos-chem-phys.net/15/10411/2015/

Kim, S., Kim, S. -Y., Lee, M., Shim, H., **Wolfe, G. M**., Guenther, A. B., He, A., Hong, Y., Han, J. (2015). Impact of isoprene and HONO chemistry on ozone and OVOC formation in asemirural South Korean forest. *ATMOSPHERIC CHEMISTRY AND PHYSICS, 15*(8), 4357-4371.

Kloog, I., Sorek-Hamer, M., Lyapustin, A., Coull, B. A., **Wang, Y**., Just, A. C., Schwartz, J., Broday, D. M. (2015). Estimating daily PM2.5 and PM10 across the complex geo-climate region of Israel using MAIAC satellite-based AOD data. *Atmospheric Environment*, *122*, 409-416.

Kohr, W. Y., Matjafri, M. Z., Lim, H. S., Hee, W. S., **Lolli, S**. (2015). One-year monitoring of the atmosphere over Penang Island using a ground-based lidar. *Proc SPIE 9645*.

Krechmer, J. E., Coggon, M. M., Massoli, P., Nguyen, T. B., Crounse, J. D., Hu, W., Day, D. A., Tyndall, G. S., Henze, D. K., Rivera-Rios, J. C., Nowak, J. B., Kimmel, J. R., Mauldin, III, R. L., Stark, H., Jayne, J. T., Sipilä, M., Junninen, H., **St. Clair, J. M**., Zhang, X., Feiner, P. A., Li Zhang, Miller, D. O., Brune, W. H., Keutsch, F. N., Wennberg, P. O., Seinfeld, J. H., Worsnop, D. R., Jimenez, J. L., Canagaratna, M. R. (2015). Formation of Low Volatility Organic Compounds and Secondary Organic Aerosol from Isoprene Hydroxyhydroperoxide Low-NO Oxidation. *Environmental Science & Technology, 49*(17), 10330-10339. http://dx.doi.org/10.1021/acs.est.5b02031

Kuai, L., Worden, J. R., Campbell, E., Kulawik, S., Li, K. F., Lee, M., Weidner, R. J., Montzka, S. A., Morre, F. L., Berry, J. A., Baker, I., Dennin, S., **Bian, H.,** Bowman, K. W., Liu, J., Yung, Y. L.

(2015). Estimate of carbonyl sulfide tropical oceanic surface fluxes using Aura Tropospheric Emission Spectrometer observations. *J. Geophys. Res., 120*, doi: 10.1002/2015JD023493.

Kuang, W., **Tangborn, A. V.** (2015). Dynamic responses of the Earth's outer core to assimilation of observed geomagnetic secular variation. *Progress in Earth and Planetary Science, 2*(1), 1–17.

Kuo, K.-S., **Olson, W. S**., Johnson, B. T., Grecu, M., Tian, L., Clune, T. L., van Aartsen, B. H., Heymsfield, A. J., Liao, L., Meneghini, R. (2016). The Microwave Radiative Properties of Falling Snow Derived from Nonspherical Ice Particle Models. Part I: An Extensive Database of Simulated Pristine Crystals and Aggregate Particles, and Their Scattering Properties. *Journal of Applied Meteorology and Climatology/American Meteorological Society, 55*, 691-708.

Lacagnina, C., Hasekamp, O. P., **Bian, H.,** Curci, G., Myhre, G., Noije, T. v., Schulz, M., Skeie, R. B., Takemura, T., Zhang, K. (2015). Aerosol single-scattering albedo over the global oceans: Comparing PARASOL retrievals with AERONET, OMI. *J. Geophys. Res., 120*, doi: 10.1002/2015JD023501

Lewis, J. R., Welton, E. J., Campbell, J. R., Haftings, P. C. (2016). MPLNET V3 cloud and planetary boundary layer detection. *EPJ Web of Conferences, 119 (2016) 16011, 119*. dx.doi.org/10.1051/epjconf/201611916011

L'Ecuyer, T. S., Beaudoing, H., Rodell, M., **Olson, W. S**., Lin, B., Kato, S., Clayson, C. A., Wood, E., Clark, E., Adler, R., Huffman, G., Bosilovich, M., Robertson, F., Famiglietti, J. S., Houser, P. R., Chambers, D., Fetzer, E., Gao, S., Gu, G., Hilburn, K., Lettenmaier, D. P., Liu, W. R., Schlosser, C. A., Scheffield, J. (2015). The observed state of global energy balance in the early 21st century. *Journal of Climate/American Meteorological Society, 28*, 8319-8346.

Levy, R. C., Munchak, L. A., Mattoo, S., Patadia, F., **Remer, L. A**., Holz, R. E. (2015). Towards a long-term global aerosol optical depth record: applying a consistent aerosol retrieval algorithm to MODIS and VIIRS-observed reflectance. *Atmos. Meas. Tech., 8*, 4083-4110.

Liao, J., Froyd, K. D., Murphy, D. M., Keutsch, F. N., Yu, G., Wennberg, P. O., **St. Clair, J. M**., Crounse, J. D., Wisthaler, A., Mikoviny, T., Jimenez, J. L., Campuzano-Jost, P., Day, D. A., Hu, W., Ryerson, T. B., Pollack, I. B., Peischl, J., Anderson, B. E., Ziemba, L. D., Blake, D. R., Meinardi, S., Diskin, G. (2015). Airborne measurements of organosulfates over the continental U.S. *Journal of Geophysical Research: Atmospheres, 120*(7), 2990–3005. http://dx.doi.org/10.1002/2014JD022378

Lim, Y. K., Shubert, S. D., Nowicki, S. M., Cullather, R., **Lee, J. N.** (2016). Atmospheric summer teleconnections and Greenland ice sheet surface mass variations: Insights from MERRA-2. *Environmental Research Letters, 11(2)*([10.1088/1748-9326/11/2/024002]).

Liu, X., Zhang, Y., Huey, L. G., Yokelson, R. J., Wang, Y., Jimenez, J. L., Campuzano-Jost, P., Beyersdorf, A. J., Blake, D. R., Choi, Y., **St. Clair, J. M**., Crounse, J. D., Day, D. A., Diskin, G. S., Fried, A., Hall, S. R., Hanisco, T. F., King, L. E., Meinardi, S., Mikoviny, T., Palm, B. B., Peischl, J., Perring, A. E., Pollack, I. B., Ryerson, T. B., Sachse, G., Schwarz, J. P., Simpson, I. J., Tanner, D. J., Thornhill, K. L., Ullmann, K., Weber, R. J., Wennberg, P. O., Wisthaler, A., **Wolfe, G. M**., Ziemba, L. D. (2016). Agricultural fires in the southeastern U.S. during SEAC4RS: Emissions of

trace gases and particles and evolution of ozone, reactive nitrogen, and organic aerosol. *Journal of Geophysical Research: Atmospheres, 121*(12), 7383–7414. http://dx.doi.org/10.1002/2016JD025040

Lolli, S., Lewis, J. R., Welton, E. J., Campbell, J. R., Gu, Y. (2016). Understanding Seasonal Variability in thin Cirrus Clouds from Continuous MPLNET Observations at GSFC in 2012. *EPJ Web of Conferences, 119 (2016) 11004, 119*. dx.doi.org/10.1051/epjconf/201611911004

Lolli, S., Lewis, J. R., Campbell, J. R., Welton, E. J., Gu, Y. (in press). Cirrus cloud radiative characteristics from continuous MPLNET profiling at GSFC in 2012. *Spanish Optical Society*. www.sedoptica.es

Lolli, S., Lewis, J. R., Welton, E. J., Campbell, J. R., Gu, Y. (2016). Understanding Seasonal Variability in thin Cirrus Clouds from Continuous MPLNET Observations at GSFC in 2012. *EPJ Web of Conferences, 119 (2016) 11004, 119*. dx.doi.org/10.1051/epjconf/201611911004

Luceri, V., **Pavlis, E**. C., Pace, B., **Kuzmicz-Cieslak, M. H., König, D**., Bianco, G., **Evans, K. D.** (2015). Extending the ILRS Terrestrial Reference Frame Development Contribution to ITRF2014. *EGU General Assembly Conference Abstracts* (vol. 17, pp. 3881). http://iopscience.iop.org/article/10.1088/1748-9326/11/2/024002/meta;jsessionid=BF52A8C499D5E9A772729537A678E8A7.c4.iopscience.cld.iop.org

Lundquist, J., Wilczak, J., Ashton, R., Bianco, L., Brewer, A., Choukulkar, A., Clifton, A., Debnath, M., **Delgado, R.,** Friedrich, K., Gunter, S., Hamidi, A., Valerio, G., Kaushik, A., Kosovic, B., Langan, P., Lass, A., Lavin, J., Lee, Y., McCaffrey, K., Newsom, R., Noone, D., Oncley, S., Quelet, P., Sandberg, S., Schroeder, J., Shaw, W., Sparling, L. C., St. Marin, C., **St. Pe, A.**, Strobach, E., Tay, K., Vanderwende, B., Weickmann, A., Wolfe, D., Worsnop, R. Assessing State-of-the-Art Capabilities for Probing the Atmospheric Boundary Layer : the XPIA Field Campaign. *Bulletin of the American Meteorological Society*.

Maeda, E., Moura, Y., Wagner, F., Hilker, T., Lyapustin, A. I., **Wang, Y**., Chave, J., Mõttus, M., Aragão, L. E. O. C., Shimabukuro, Y. (2016). Consistency of vegetation index seasonality across the Amazon rainforest. *International Journal of Applied Earth Observation and Geoinformation, 52*, 42-53.

Marais, E. A., Jacob, D. J., Jimenez, J. L., Campuzano-Jost, P., Day, D. A., Hu, W., Krechmer, J., Zhu, L., Kim, P. S., Miller, C. C., Fisher, J. A., Travis, K., Yu, K., Hanisco, T. F., **Wolfe, G. M.,** Arkinson, H. L., Pye, H. O. T., Froyd, K. D., Liao, J., McNeill, V. F. (2016). Aqueous-phase mechanism for secondary organic aerosol formation from isoprene: application to the Southeast United States and co-benefit of SO_2 emission controls. *Atmospheric Chemistry and Physics, 16*, 1603-1618.

Matzner, R., Nguyen, P., Brooks, J., Ciufolini, I., Paolozzi, A., **Pavlis, E. C.,** Koenig, R., Ries, J., Gurzadyan, V., Penrose, R., Sindoni, G., Paris, C., Khachatryan, H., Mirzoyan, S. (2016). In Roberto Peron (Ed.), *LARES Satellite Thermal Forces and a Test of General Relativity* (pp. 525-530). IEEE Xplore Digital Library. http://ieeexplore.ieee.org/Xplore/home.jsp

Mayr, H. G., **Lee, J. N.** (2016). Downward Propagating Equatorial Annual Oscillation and QBO Generated Multi-year Oscillations in Stratospheric NCEP Reanalysis Data. *J. Atmos. & Sol. Terr. Physics, 138-139*, 1-8. www.sciencedirect.com/science/article/pii/S1364682615300973

Munchak, S. J., Meneghini, R., Grecu, M., **Olson, W. S**. (2016). A Coupled Emissivity and Surface Backscatter Cross-Section Model for Radar-Radiometer Retrieval of Precipitation over Water Surfaces. *Journal of Atmospheric and Oceanic Technology/American Meteorological Society, 33*, 215-229.

Nicely, J. M., Anderson, D. C., Canty, T. P., Salawitch, R. J., **Wolfe, G. M**., Apel, E. C., Arnold, S. R., Atlas, E. L., Blake, N. J., Bresch, J. F., Campos, T. L., Dickerson, R. R., Duncan, B., Emmons, L. K., Evans, M. J., Fernandez, R. P., Flemming, J., Hall, S. R., Hanisco, T. F., Honomichl, S. B., Hornbrook, R. S., Huijnen, V., Kaser, L., Kinnison, D. E., Lamarque, J.-F., Mao, J., Monks, S. A., Montzka, D. D., Pan, L. L., Riemer, D. D., Saiz-Lopez, A., Steenrod, S. D., Stell, M. H., Tilmes, S., Turquety, S., Ullmann, K., Weinheimer, A. J. (2016). An observationally constrained evaluation of the oxidative capacity in the tropical western Pacific troposphere. *Journal of Geophysical Research: Atmospheres*. http://dx.doi.org/10.1002/2016JD025067

Olson, W. S., Tian, L., Grecu, M., Kuo, K.-S., Johnson, B. T., Heymsfield, A. J., Bansemer, A., Heymsfield, G. M., Wang, J. R., Meneghini, R. (2016). The Microwave Radiative Properties of Falling Snow Derived from Nonspherical Ice Particle Models. Part II: Initial Testing Using Radar, Radiometer and In Situ Observations. *Journal of Applied Meteorology and Climatology/American Meteorological Society, 55*, 709-722.

Orozco, D., Beyersdorf, A., Ziemba, L., Berkoff, T. A., Zhang, Q., **Delgado, R**., Hennigan, C. J., Thornhill, K., Parworth, C., Kim, H., Young, D., **Hoff, R. M.** (2016). Hygroscopicity Measurements of Aerosol Particles in the San Joaquin Valley, CA, Baltimore, MD, and Golden, CO. *Journal of Geophysical Research-Atmospheres, 121*. onlinelibrary.wiley.com/doi/10.1002/2015JD023971/epdf

Paolozzi, A., Paris, C., **Pavlis, E. C**., Sindoni, G., Vendittozzi, C., Ciufolini, I. (2016). Monitoring global climate change using SLR data from LARES and other geodetic satellites. *SPIE Smart Structures and Materials+ Nondestructive Evaluation and Health Monitoring* (pp. 98034N–98034N)

Pan, X., Chin, M., Gautam, R., **Bian, H**., Kim, D., Colarco, P., Diehl, T., Takemura, T., Pozzoli, L., Tsigaridis, K., Bauer, S., Bellouin, N. (2015). A multi-model evaluation of aerosols over South Asia: common problems and possible causes. *Atmos. Chem. Phys., 15*, doi:10.5194/acp-15-5903-2015.

Pan, L. L., Atlas, E. L., Salawitch, R. J., Honomichl, S. B., Bresch, J. F., Randel, W. J., Apel, E. C., Hornbrook, R. S., Weinheimer, A. J., Anderson, D. C., Andrews, S. J., Baidar, S., Beaton, S. P., Campos, T. L., Carpenter, L. J., Chen, D., Dix, B., Donets, V., Hall, S. R., Hanisco, T. F., Homeyer, C. R., Huey, L. G., Jensen, J. B., Kaser, L., Kinnison, D. E., Koenig, T. K., Lamarque, J.-F., Liu, C., Luo, J., Luo, Z. J., Montzka, D. D., Nicely, J. M., Pierce, R. B., Riemer, D. D., Robinson, T., Romashkin, P., Saiz-Lopez, A., Schauffler, S., Shieh, O., Stell, M. H., Ullmann, K., Vaughan, G., Volkamer, R., **Wolfe, G. M.** (2016). The Convective Transport of Active Species in the Tropics (CONTRAST) Experiment. *Bulletin of the American Meteorological Society*. http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-14-00272.1

Pavlis, E. C., Sindoni, G., Paolozzi, A., Ciufolini, I. (2015). Contribution of LARES and geodetic satellites on environmental monitoring. *Environment and Electrical Engineering (EEEIC), 2015 IEEE 15th International Conference on* (pp. 1989–1994).

Pavlis, E. C., Ciufolini, I., Paolozzi, A., Paris, C., Sindoni, G. (2015). Quality assessment of LARES satellite ranging data: LARES contribution for improving the terrestrial reference frame. *Metrology for Aerospace (MetroAeroSpace), 2015 IEEE* (pp. 1–5).

Pavlis, E. C., Paolozzi, A., Ciufolini, I., Paris, C., Sindoni, G., Gabrielli, A. (2015). Use of LARES Satellite Data for Earth Science. In E. Carrera, M. Cinefra, A. Pagani, M. Petrolo and E. Zappino (Ed.), *23rd Conference of the Italian Association of Aeronautics and Astronautics AIDAA2015*. Torino, AIDAA:. www.aidaa2015.it

Pearlman, M. R., Ma, C., Noll, C., **Pavlis, E. C**., Schuh, H., Schoene, T., Barzaghi, R., Kenyon, S. (2015). The GGOS Bureau of Networks and Observations and an Update on the Space Geodesy Networks. *EGU General Assembly Conference Abstracts* (vol. 17, pp. 7420).

Reid, J., Lagrosas, N., Jonsson, H., Reid, E., Atwood, A., Boyd, T., **Lolli, S.,** Oo, M., Perry, K., Salinas, S., Sessions, W., Zhao, Y. (2016). Aerosol meteorology and Philippine receptor observations of Maritime Continent aerosol emissions for the 2012 7SEAS southwest monsoon intensive study. *Atmos. Chem. Phys. Discuss.*. 10.5194/acp-2016-214

Rodell, M., Beaudoing, H. K., L'Ecuyer, T. S., **Olson, W. S.,** Famiglietti, J. S., Houser, P. R., Adler, R., Bosilovich, M. G., Clayson, C. A., Chambers, D., Clark, E., Fetzer, E. J., Gao, X., Gu, G., Hilburn, K., Huffman, G. J., Lettenmaier, D. P., Liu, W. T., Robertson, F. R., Schlosser, C. A., Sheffield, J., Wood, E. F. (2015). The observed state of the water cycle in the early 21st century. *Journal of Climate/American Meteorological Society, 28*, 8289-8318.

Samarasinha, N., Mueller, B. E. A., Knight, M. M., Farnham, T. L., Briol, J., Brosch, N., Caruso, J., Gao, X., Gomez, E., Lister, T.,Hergenrother, C., **Hoban, S., Prouty, R.,** Holloway, M., Howes, N., Guido, E., Hui, M., Jones, J. H., Penland, T. B., Thomas, S. R., Wyrosdick, J., Kiselev, N., Ivanova, A. V., Kaye, T. G., Kikwaya Eluo, J.-B., Lau, B. P.S., Lin, Z-Y., Luis Martin, J., Moskvitin, A. S., Nicolini, M., Ottum, B. D., Pruzenski, C., Vogel, D.C., Kellett, L., Rapson, V., Schmid, J., Doyle, B., Dimino, F., Carlino, S., Safonova, M., Murthy, J., Sutaria, F., Schleicher, D. G., Snodgrass, C., Tezcan, C. T., & Yorukoglu, O., Trowbridge, D., Whitmer, D., and Ye, Q-Z. (2015). Results from the worldwide coma morphology campaign for comet ISON (C/2012 S1). *Planetary And Space Science*, doi:10.1016/j.pss.2015.10.006

Scambos, T. A., **Shuman, C. A.** (2016). Comment on "Mass gains of the Antarctic ice sheet exceed losses" by H. J. Zwally and others. *Journal of Glaciology*, *FirstView*, 1–5. http://journals.cambridge.org/article_S0022143016000599!!!

Schwantes, R. H., Teng, A. P., Nguyen, T. B., Coggon, M. M., Crounse, J. D., **St. Clair, J. M**., Zhang, X., Schilling, K. A., Seinfeld, J. H., Wennberg, P. O. (2015). Isoprene NO3 Oxidation Products from the RO2 + HO2 Pathway. *The Journal of Physical Chemistry A, 119*(40), 10158-10171. http://dx.doi.org/10.1021/acs.jpca.5b06355

Sindoni, G., **Pavlis, E. C.** (2015). LARES mission operations. *Aerospace Conference, 2015 IEEE* (pp. 1–10).

Sindoni, G., Pavlis, E. C., Paolozzi, A., Paris, C., Ciufolini, I. (2015). Orbital predictions for the LARES satellite mission: The International Space Time Analysis Research Center (ISTARC). *Metrology for Aerospace (MetroAeroSpace), 2015 IEEE* (pp. 66–70).

Sindoni, G., Paris, C., Vendittozzi, C., **Pavlis, E. C**., Ciufolini, I., Paolozzi, A. (2015). The Contribution of LARES to Global Climate Change Studies With Geodetic Satellites. *ASME 2015 Conference on Smart Materials, Adaptive Structures and Intelligent Systems* (pp. V002T04A010–V002T04A010).

St. Clair, J. M., Rivera-Rios, J. C., Crounse, J. D., Praske, E., Kim, M. J., **Wolfe, G. M**., Keutsch, F. N., Wennberg, P. O., Hanisco, T. F. (2016). Investigation of a potential HCHO measurement artifact from ISOPOOH. *Atmospheric Measurement Techniques Discussions*.

St. Clair, J. M., Rivera-Rios, J. C., Crounse, J. D., Knap, H. C., Bates, K. H., Teng, A. P., Jørgensen, S., Kjaergaard, H. G., Keutsch, F. N., Wennberg, P. O. (2015). Kinetics and Products of the Reaction of the First-Generation Isoprene Hydroxy Hydroperoxide (ISOPOOH) with OH. *The Journal of Physical Chemistry A, 0*(0), null. http://dx.doi.org/10.1021/acs.jpca.5b06532

St. Clair, J. M., Rivera-Rios, J. C., Crounse, J. D., Praske, E., Kim, M. J., **Wolfe, G. M**., Keutsch, F. N., Wennberg, P. O., Hanisco, T. F. (2016). Investigation of a potential HCHO measurement artifact from ISOPOOH. *Atmospheric Measurement Techniques Discussions*.

Su, J., Felton, M., Lei, L., McCormick, M. Patrick, **Delgado, R., St. Pé, A.** (2016). Lidar Remote Sensing of Cloud Formation Caused by Low-Level Jets. *Journal of Geophysical Research-Atmospheres, 121*, 8. onlinelibrary.wiley.com/doi/10.1002/2015JD024590/epdf

Tao, W.-K., Takayabu, Y. N., Lang, S., **Olson, W. S**., Shige, S., Hou, A., Jiang, X., Lau, W., Krishnamurti, T., Waliser, D., Zhang, C., Johnson, R., Houze, R., Cielsielski, P., Grecu, M., Hagos, S., Kakar, R., Nakamura, N., Braun, S., Oki, R., Bhardwaj, A. (2016). TRMM latent heating retrieval and comparison with field campaigns and large-scale analyses. *AMS Meteorological Monographs - Multi-scale Convection-Coupled Systems in the Tropics*. Boston, MA: American Meteorological Society.

Thébault, E., Finlay, C. C., Beggan, C. D., Alken, P., Aubert, J., Barrois, O., Bertrand, F., Bondar, T., Boness, A., Brocco, L., Canet, E., Chambodut, A., Chulliat, A., Coisson, P., Civet, F., Du, A., Fournier, A., Fratter, I., Gillet, N., Hamilton, B., Hamoudi, M., Hulot, G., Jager, T., Korte, M., Kuang, W., Lalanne, X., Langlais, B., Léger, J.-M., Lesur, V., Lowes, F. J., Macmillan, S., Mandea, M., Manoj, C., Maus, S., Olsen, N., Petrov, V., Ridley, V., Rother, M., Sabaka, T. J., Saturnino, D., Schachtschneider, R., Sirol, O., **Tangborn, A. V**., Thomson, A., Tøffner-Clausen, L., Vigneron, P., Wardinski, I., Zvereva, T. (2015). International Geomagnetic Reference Field: the 12th generation. *Earth, Planets and Space, 67*(1), 1–19. http://dx.doi.org/10.1186/s40623-015-0228-9

Tokay, A., D'Adderio, L. P., Wolff, D. B., Petersen, W. A. (in press). A field study of pixel-space variability of raindrop size distribution. *Journal of Hydrometeorology*.

Travis, K. R., Jacob, D. J., Fisher, J. A., Kim, P. S., Marais, E. A., Zhu, L., Yu, K., Miller, C. C., Yantosca, R. M., Sulprizio, M. P., Thompson, A. M., Wennberg, P. O., Crounse, J. D., **St. Clair, J. M**., Cohen, R. C., Laugher, J. L., Dibb, J. E., Hall, S. R., Ullmann, K., **Wolfe, G. M.**, Pollack, I. B., Peischl, J., Neuman, J. A., Zhou, X. (2016). NOx emissions, isoprene oxidation pathways, vertical mixing, and implications for surface ozone in the Southeast United States. *Atmospheric Chemistry and Physics Discussions*, 1-32.

Turpie, K. R., Allen, D. W., Ackelson, S., Bell, T., Dierssen, H., Cavanaugh, K., Fisher, J. B., Goodman, J., Guild, L., Hochberg, E., Klemas, V. V., Lavender, S., Lee, C., Muller-Karger, F., Ortiz, J. D., Palacios, S., Thompson, D. R., Zimmerman, R. (2015). *New need to understand changing coastal and inland aquatic ecosystem services* (pp. 11). Decadal Survey for Earth Science and Applications from Space - Request for Information. doi:10.13140/RG.2.1.5162.6007

Warneke, C., Trainer, M., de Gouw, J. A., Parrish, D. D., Fahey, D. W., Ravishankara, A. R., Middlebrook, A. M., Brock, C. A., Roberts, J. M., Brown, S. S., Neuman, J. A., Lerner, B. M., Lack, D., Law, D., Huebler, G., Pollack, I., Sjostedt, S., Ryerson, T. B., Gilman, J. B., Liao, J., Holloway, J., Peischl, J., Nowak, J. B., Aikin, K., Min, K. E., Washenfelder, R. A., Graus, M. G., Richardson, M., Markovic, M. Z., Wagner, N. L., Welti, A., Veres, P. R., Edwards, P., Schwarz, J. P., Gordon, T., Dube, W. P., McKeen, S., Brioude, J., Ahmadov, R., Bougiatioti, A., Lin, J., Nenes, A., **Wolfe, G. M**., Hanisco, T. F., Lee, B. H., Lopez-Hilfiker, F. D., Thornton, J. A., Keutsch, F. N., Kaiser, J., Mao, J., Hatch, C. (2016). Instrumentation and Measurement Strategy for the NOAA SENEX Aircraft Campaign as Part of the Southeast Atmosphere Study 2013. *Atmos. Meas. Tech. Discuss., 2016*, 1-39. http://www.atmos-meas-tech-discuss.net/amt-2015-388/

Werner, F., Zhang, Z., Hyoun-Myoung, C. (2016). A framework based on 2-D Taylor expansion for quantifying the impacts of sub-pixel reflectance variance and covariance on cloud optical thickness and effective radius retrievals based on the bi-spectral method (vol. 121). *J. Geophys. Res. Atmos*.

Werner, F. (2016). Spectral optical layer properties of cirrus from collocated airborne measurements – a feasibility study (vol. 15, pp. 19045-19077). *Atmos. Chem. Phys. Discuss.*.

Werner, F. (2016) and CoAuthors. ML-CIRRUS-The airborne experiment on natural cirrus and contrail cirrus with the high-altitude long-range research aircraft HALO. *Bulletin of the American Meteorological Society*. http://dx.doi.org/10.1175/BAMS-D-15-00213.1

Werner, F. (2016). *The ACRIDICON–CHUVA campaign: Studying tropical deep convective clouds and precipitation over Amazonia using the new German research aircraft HALO* (pp. 63).

Yu, H., Chin, M., Yuan, T., **Bian, H**., **Remer, L.,** Prospero, J. M., Omar, A., Winker, D., Yang, Y., Zhang, Y., **Zhang, Z**., Zhao, C. (2015). The fertilizing role of African dust in the Amazon rainforest: A first multiyear assessment based on data from Cloud-Aerosol Lidar and Infrared Path finder Satellite Observations. *Geophys. Res. Lett., 42*, doi:10.1002/2015GL063040.

Wolfe, G. M., Kaiser, J., Hanisco, T. F., Keutsch, F. N., de Gouw, J. A., Gilman, J. B., Graus, M., Hatch, C. D., Holloway, J., Horowitz, L. W., Lee, B. H., Lerner, B. M., Lopez-Hilifiker, F., Mao, J., Marvin, M. R., Peischl, J., Pollack, I. B., Roberts, J. M., Ryerson, T. B., Thornton, J. A., Veres, P.

R., Warneke, C. (2016). Formaldehyde production from isoprene oxidation across NOx regimes. *Atmospheric Chemistry and Physics, 16*, 2597-2610.

Wolfe, G. M., Hanisco, T. F., Arkinson, H. L., Bui, T. P., Crounse, J. D., Dean-Day, J., Goldstein, A., Guenther, A., Hall, S. R., Huey, G., Jacob, D. J., Karl, T., Kim, P. S., Liu, X., Marvin, M. R., Mikoviny, T., Misztal, P. K., Nguyen, T. B., Peischl, J., Pollack, I., Ryerson, T., **St Clair, J. M**., Teng, A., Travis, K. R., Ullmann, K., Wennberg, P. O., Wisthaler, A. (2015). Quantifying sources and sinks of reactive gases in the lower atmosphere using airborne flux observations. *Geophysical Research Letters, 42*, 8231-8240.

Wolfe, G. M., Marvin, M. M., Roberts, S. J., Travis, K. R., Liao, J. (2016). The Framework for 0-D Atmospheric Modeling (F0AM) v3.1. *Geosci. Model Dev. Discuss., 2016*, 1-21. http://www.geosci-model-dev-discuss.net/gmd-2016-175/

Yu, H., Chin, M., Yuan, T., **Bian, H.**, Prospero, J. M., Omar, A., Remer, L. A., Winker, D. L., Yang, Y., Zhang, Y., Zhang, Z., Zhao, C. (2015). Quantification of trans-Atlantic dust transport from seven-year (2007-2013) record of CALIPSO lidar measurements. *Rems. Sens. Environ., 159*, 232-249.

Yu, H., Chin, M., Yuan, T., Bian, H., Remer, L. A., Prospero, J. M., Omar, A., Winker, D. L., Yang, Y., Zhang, Y., **Zhang, Z**., Zhao, C. (2015). The fertilizing role of African dust in the Amazon rainforest: A first multiyear assessment based on data from Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations. *Geophys. Res. Lett., 42*(1984-1991).

Yurganov, L., Leifer, I., Lund Myhre, C. (2016). Seasonal and interannual variability of atmospheric methane over Arctic Ocean from satellite data. *CPRSES, 13*(2), 107-119. jr.rse.cosmos.ru/?lang=eng

Yurganov, L., Leifer, I. (2016). Abnormal concentrations of atmospheric methane over the Sea of Okhotsk during 2015/2016 winter. *CPRSES, 13*(3), 231-234. jr.rse.cosmos.ru/?lang=eng

Yurganov, L., Leifer, I. (2016). Estimates of methane emission rates from some Arctic and sub-Arctic areas, based on orbital interferometer IASI data. *CPRSES, 13*(2), 173-183. jr.rse.cosmos.ru/?lang=eng

Yurganov, L. (2016). In АНО «Редакция журнала «Наука и жизнь» (Ed.), *Satellites are measuring methane in the Arctic* (8th ed.). Moscow: Nauka i Zhizn. www.nkj.ru/

Zhu, L., Jacob, D. J., Kim, P. S., Fisher, J. A., Yu, K., Travis, K. R., Mickley, L. J., Yantosca, R. M., Sulprizio, M. P., De Smedt, I., Gonzalez Abad, G., Chance, K., Li, C., Ferrare, R., Fried, A., Hair, J. W., Hanisco, T. F., Richter, D., Scarino, A. J., Walega, J., Weibring, P., **Wolfe, G. M.** (2016). Observing atmospheric formaldehyde (HCHO) from space: validation and intercomparison of six retrievals from four satellites (OMI, GOME2A, GOME2B, OMPS) with SEAC^{4}RS aircraft observations over the Southeast US. *Atmospheric Chemistry and Physics Discussions*, 1-24.

D. Proposals & Status

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
Reconstruction of Antarctic Climate History by Remote Sensing of Ice Sheet Subsurface Temperatures	NSF	Aksoy, Mustafa		Pending
Towards the improvement of chemical lateral boundary conditions for the National Air Quality Forecasting Capability	NOAA	Bian, Huisheng		Awarded
Global marine organic aerosol and DMS: Emissions, distributions, and climate impacts via aerosol-cloud-radiation interaction	NASA	Bian, Huisheng		Pending
The effect of atmospheric aerosols and clouds on Amazon forest productivity	NASA	Bian, Huisheng		Pending
Improving accuracy and resolvability of PM2.5 estimation with NASA remote sensing and assimilation data for public health assessment	NASA	Chu, Allen	Wang, Yujie	Declined
Investigation of Low-Level Jet wind Evolution using molecular and aerosol 3D Doppler LIDAR systems.	NASA	Demoz, Belay		Declined
In Support of NOAA's commitment to the Global Climate Observing System (GCOS) Reference Upper Air Network (GRAUN)	UMD/ ESSIC/ CICS (NOAA)	Demoz, Belay	Vermeesch, Kevin	Pending
Investigate and validate the effectiveness of the Vaisala CL31 ceilometer algorithm at selected sites across the U.S. for the Automated Surface Observing System (ASOS) program product improvement	UMD/ ESSIC/ CICS (NOAA)	Demoz, Belay		Pending

Upper Atmosphere Long-Term Monitoring and Aircraft Campaign Support of Ozone, NO2, and other Atmospheric Trace Gas at Multiple Sites using the Pandora Spectrometer Instrument Network	NASA	Herman, Jay	Abuhassan, Nader	Pending
Radiometric Calibration of the DSCOVR-EPIC Satellite Spectrometer with Data from Multiple NASA and non-NASA Satellites	NASA	Herman, Jay		Pending
Combining plant functional responses from hyperspectral imagery with ecosystem models to improve estimates of carbon balance in savanna ecosystems	NASA	Huemmrich, Karl F.	Campbell, Petya	Pending
Causes and consequences of arctic greening: the importance of plant functional types and surface hydrology	NASA	Huemmrich, Karl F.	Campbell, Petya	Pending
Comprehensive Modeling of the Nucleus Rotational State and the Coma Morphology and Lightcurve Variability of Comet 1P/Halley	Lowell Obs'y (NASA)		Hoban, Susan	Selected
Something to CHEW On (Climate, Health, Ecosystems, Weather)	USM	Hoban, Susan	St. Pé, Alex	Pending
Development and applications of the HARP imaging polarimeter in preparation for the ACE mission	GSFC	Martins, Vanderlei	Remer, Lorraine; Zhai, Pengwang	Awarded
Retrievals of Aerosol and Cloud Droplet Microphysical Properties with the Hyper-Angular Rainbow Polarimeter (HARP)	NASA	Martins, Vanderlei		Awarded
Optical and Chemical Properties of Volcanic Ash to Support Remote Sensing and Modeling for Earth Science	NASA	Martins, Vanderlei		Declined

Applications				
Compact Visible to Shortwave Infrared Hybrid Imaging Sensor (HIS) for Landsat Imagers	NASA	Martins, Vanderlei	Remer, Lorraine; Borda, Roberto Fernandez	Pending
Integration and Testing of Improved Ice and Mixed-Phase Precipitation Models for GPM Combined Radar-Radiometer Retrieval Algorithm Applications	NASA	Olson, Bill	Johnson, Ben	Awarded
Improving Forward Radiative Simulations of Satellite Observations Affected by Ice-Phase Precipitation for Earth System Model/Assimilation Systems	NASA	Olson, Bill		Pending
SGP Network Architecture and Geodetic Data Combination (SNAGDAC) for an improved development, maintenance and distribution of the ITRF	NASA	Pavlis, Erricos	Kuzmicz-Cieslak, Magda; Konig, Daniel; Evans, Keith	Pending
Satellite Investigation and model representation of the diurnal signature in aerosol-cloud processes	NASA	Remer, Lorraine	Martins, Vanderlei	Pending
Diurnal signatures in aerosol-cloud processes as viewed by geostationary sensors	NASA	Remer, Lorraine	Martins, Vanderlei	Pending
Full Spectral Resolution Fast Radiative Transfer Modules For CrIS	NOAA	Strow, Larrabee		Awarded
Calibration and Validation of the CrIS Operational Sensor	NOAA	Strow, Larrabee	Heppelwhite, Christopher	Pending
An Homogenous Infrared Hyperspectral Radiance and Level 3 Climate Record Combining NASA AIRS, JPSS CrIS, and EUMETSAT IASI	NASA	Strow, Larrabee	Hepplewhite, Christopher	Pending

Establishing the Sun and the Moon as Primary Absolute Standards for Interconsistent Calibration of Earth-viewing Satellite Sensors	NASA	Turpie, Kevin		Pending
Modeling, analysis and prediction of the dust-climate	NASA	Yuan, Tianle		Pending
Cells in the field of clouds: discovery in NASA data by citizens	NASA	Yuan, Tianle		Pending
Validation of the Line-by-Line Radiative transfer Modeling Task	JPL	Zhai, Pengwang		Awarded
An Innovative Atmospheric Correction Scheme Ocean Observations Using Combined Active and Passive Measurements	NGIA	Zhai, Pengwang	Demoz, Belay	Pending
Development of a Test-Bed on the Basis of NASA A-Train Satellite Cloud Measurements for Evaluating and Improving the CFMIP-COSP	NASA	Zhang, Zhibo		Pending
Improved understanding of vertical mixing in the lower atmospheric boundary layer in the presence of wind turbines via numerical simulations and measurements	Univ. of DE (NSF)		Delgado, Ruben	Awarded
Validation of GPM Precipitation Retrieval Algorithms across the Precipitation Continuum	NASA		Tokay, Ali	Awarded
From Arboreal to Benthic Communities: the ABCs of Land to Ocean Biodiversity Observations	NC State (NASA)		Turpie, Kevin	Awarded
Cloud scavenging of aerosols in the NASA GEOS-5 model: Physically based parameterizations, uncertainties, and impact on aerosol direct and indirect effects	NIA/ LaRC (NASA)		Bian, Huisheng	Pending

NOAA Educational Partnership Cooperative Science Center Solicitation for the Center: Earth System Sciences and Remote Sensing Technologies	CUNY (NOAA)		Delgado, Ruben	Pending
NOAA Cooperative Science Center in Atmospheric Sciences and Meteorology at Howard University	Howard Univ. (NOAA)		Demoz, Belay	Pending
Implementing an automated upper air monitoring for temperature, moisture profiles, and aerosol mixing layer height in the Washington, DC – Baltimore, MD region.	Howard Univ. (NOAA)		Demoz, Belay	Pending
Consortium for Training of Underrepresented STEM Professionals (CTUSP)	FAMU (NSF)		Demoz, Belay; Hoban, Susan	Pending
GRASP: Geodetic Reference Antenna in Space	NASA		Pavlis, Ericcos	Pending
Geodetic System Ties Using a CubeSat Constellation	GSFC		Pavlis, Erricos; Kuzmicz-Cieslak, Magda; Koenig, Daniel; Evans, Keith	Pending
The transport and impact of light absorbing aerosols on Himalayan glaciers	NASA		Remer, Lorraine	Pending
A Satellite-based Global Ocean Evaporation Product (including Polar Regions)	NASA		Shie, Chung-Lin	Pending
Phenology Imaging Spectrometer for Coastal Ecology Studies (PISCES)	NASA		Turpie, Kevin	Pending
A Compressive Line Sensing Hyperspectral Imaging System	DoN/ ONR		Zhai, Pengwang	Pending

E. Biographies

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

Steven Buczkowski, Research Analyst, holds a MS in Physics from West Virginia University and an M.S. in Atmospheric Physics from the University of Maryland, Baltimore County (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.

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 analyses 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.

Ding-Chong (Allen) Chu, Associate Research Scientist, holds a PhD in Atmospheric Sciences from Georgia Institute of Technology. Dr. Chu has 26 years experience in satellite remote sensing, radiative transfer modeling and statistical analysis on atmospheric measurements. He has been involved in UARS ISAMS and EOS MODIS satellite missions since 1988. He served as a PI in multiple NASA field campaigns between 2004 and 2010. His recent involvement in NASA DISCOVER-AQ airborne missions targets column AOD with surface PM2.5 for air quality application over the US.

Dr. Chu's research focus includes 1) radiative transfer modeling with line-by-line and band models on satellite sensor development, 2) retrieval methodology development of ozone and aerosols, 3) application of satellite data to air quality and public health, 4) atmospheric radiative forcing, and 5) aerosol-cloud interaction.

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 University of Maryland Baltimore county and the current Director of the Joint Center for Earth Systems Technology (JCET: http://jcet.umbc.edu). 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 PI's 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 (http://www.earthzine.org/) 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 H_2O 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.

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 Plank 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 State, 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).

Forrest Hall, Senior Research Scientist, holds a PhD in Physics from the University of Houston. Dr. Hall specializes in global change research using earth-observing satellites. He has served as Project Manager on three major field campaigns in the US and Canada (COVER, FIFE and BOREAS). Dr. Hall's research focuses on the development of physically based algorithms for the remote sensing of vegetation condition, structure and function and the modeling of surface carbon, water and energy exchange. He has authored more than 75 scientific papers. Dr. Hall's current research interests focus on terrestrial vegetation including photosynthesis, vegetation structure, terrestrial ecosystem-Atmosphere carbon, water and energy exchange, and ecology.

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 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 develops curriculum for professional development of educators for classroom use and informal education venues. Dr. Hoban specializes in integrating hands-on activities with data collection and analysis to develop the habits-of-mind of STEM. Curriculum modules include, but are not limited to rocketry, environmental education, astronomy & astrobiology, computer modeling, STEM music, and robotics for learners of all ages. Dr. Hoban is currently also working on using analytics for cyber security.

Dr. Hoban serves on the STEM Advisory Board for Anne Arundel County Public Schools. 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, an Honors College Fellow and the Associate Director for Academics for the UMBC Joint Center for Earth Systems Technology. Dr. Hoban also teaches in the

Department of Astronomy at the University of Maryland, College Park. Dr. Hoban's research interests include the effectiveness of various pedagogical models on teacher preparation and student outcomes, composition and evolution of comets, and cybersecurity.

Raymond Hoff, Emeritus professor, holds a PhD in Physics from Simon Fraser University. Dr. Hoff has 39 years of experience in atmospheric research. His research interests are in the optical properties of aerosols and gases in the atmosphere. Dr. Hoff has been central in formulating major research programs on Raman, differential absorption, airborne and spaceborne lidar, volcanic emissions, and atmospheric transport of toxic chemicals to the Great Lakes, atmospheric visibility, Arctic Haze, and dispersion of pollutants. He has led or participated in over 20 major field experiments.

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 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.

Catherine Kruchten, Instructional Designer**,** holds a B.S. in Mathematics from Massachusetts Institute of Technology, MAT from The George Washington University, Museum Education, MLA in Liberal Arts and Ed.D. School of Education (expected 2016) from Johns Hopkins University. Catherine supports STEM educational programming for students and educators as

part of the NASA's BEST Students project. Before coming to UMBC, she was the Informal Educator for the Visitor Center at NASA's Goddard Space Flight Center, where she was charged with creating and implementing STEM engagement in out-of-school programs and supporting informal educator professional development. While an undergraduate at MIT, she earned her teaching license for secondary level mathematics before bridging her classroom experiences to informal education. Ms. Kruchten has developed educational programming, research, and evaluation for several museums, including the Smithsonian Institution, the Capitol Visitor Center, the Museum of Science in Boston, the Newseum, and the International Spy Museum.Kruchten's research interests focus on informal learning, particularly in STEM. She is seeking to understand how to better engage underrepresented students (e.g., girls) with STEM content and how informal education environments can support such learning. Ms. Kruchten is also interested in how formal and informal education complement each other, and how informal learning reaches beyond just engagement of students and promotes broader and deeper content understanding. Having developed experience as a practitioner of informal education, she is currently translating her practical experience into doctoral research in informal education.

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. Lee's research interests include observation of total and spectral solar irradiance, analysis of solar irradiance variability, and its impact on earth's climate. She uses numerical models of the sun and earth's atmosphere as well as remote sensing observations to investigate solar activities, climate variability and their interconnections. Besides this, she also 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, Research Associate, 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.

Simone Lolli, Assistant Research Scientist, holds a PhD in Physics from Ecole Polytrechnique. Simone Lolli is affiliated with NASA MPLNET lidar network science team. The network is operative since 1999, with more than 20 lidar instruments, deployed worldwide, from Arctic and Antarctic regions to tropical and equatorial zones. Simone Lolli principal research interests are to assess the impact on air quality and radiative transfer of natural and anthropogenic aerosol particles and their interaction and effects on clouds ,precipitations and climate change, focusing especially in South-East Asia, a wild and remote region, important source of smoke due to natural and anthropogenic biomass burning, during the dry season. This research is part of 7-SEAS NASA mission (7_seas.gsfc.nasa.gov), established to quantitatively characterize aerosol-

meteorological interactions in tropical to sub-tropical environments. A Fellow of American and European Geoscience Union, he has published more than 20 peer-reviewed papers and 100 conference proceedings. Dr. Lolli's main research interests are to quantify the impact on climate change and air quality of the natural and anthropogenic aerosol particle emissions, especially their interaction with clouds and precipitation formation.

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 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 received his B.S. in Meteorology from the Pennsylvania State University in 2005, his M.S. in Atmospheric Science from the State University of New York, University at Albany in 2008, and his PhD in Atmospheric Science from Rutgers University in 2012. Until March 2016, Dr. Nicholls was a NASA Postdoctoral Program Fellow and he current serves as a post-doctoral researcher at JCET. He has authored several peer-reviewed journal papers which have focused primarily upon numerical weather/climate prediction models and space-based observation studies. Dr. Nicholls' research interests are far and wide-ranging. Topics of interest include large scale numerical modeling (COAWST, WRF) at weather and climatological time scales; synoptic and mesoscale meteorology (mid-latitude cyclones, regional/continental scale circulations), and applications of observational (ground, air, and space) data to investigate meteorological phenomenon (*e.g.,* Saharan Heat Low, moisture transport, precipitation processes, dust-precipitation interactions).

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 precipitation/heating in numerical weather prediction forecasts. Since joining NASA in 1994, he has continued these studies using data from the Tropical Rainfall Measuring Mission and Global Precipitation Measurement mission satellites. He leads a team that continues to develop a method for estimating precipitation profiles and latent heating from a combination of radar and passive microwave radiometer observations from the TRMM and GPM satellites.

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 convective systems, stratocumulus modeling, the earth's 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 of 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.

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 advices 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 [NASA funded project of MEaSUREs]. Dr. Shie has also investigated the potential influence of SAL dust on intensity of tropical cyclone and hurricane/typhoon using multi-sensors data and modeled simulations (applying the WRF model) [NASA funded projects of EOS; NAMMA; TCSP]. He has also applied the cloud-resolving model (GCE): studying the radiative-convective system (clouds) and its interaction with large-scale environment; producing numerical vertical heating profiles and improving the satellite latent heating profile retrieval [NASA funded projects of NEWS; TRMM]. Dr. Shie, as the project scientist of GES DISC (the data center at Goddard) since January 2013, has recently extended his interests into the "Data Science" field focusing on better understanding 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. Previously, he has authored or co-authored research papers on ice elevation changes and glacier mass losses using altimetry in combination with other remote sensing in the Antarctica Peninsula, on the accuracy of the first ICESat mission's data over Antarctica's large subglacial lakes. He has also worked on composite temperature records derived from automatic weather stations (AWS), passive microwave data from SMMR and SSM/I and IR data from AVHRR satellite sensors. In addition, Dr. Shuman has successfully matched those records through stratigraphic correlation with stable isotope temperature proxy profiles in shallow snow layers. He has worked extensively in Greenland (7 deployments) and Antarctica (6 field deployments plus more recent Operation Ice Bridge flights from Punta Arenas, Chile). He began his cryospheric career helping to date the 3054 m long Greenland Ice Sheet Project 2's (GISP2) deep ice core in 1992. He was the longest serving member of the Polar DAAC Advisory Group (PoDAG) and also served on the Center for Remote Sensing of Ice Sheets (CReSIS) advisory board and is also on the Executive Committee of the Cryospheric Focus Group of AGU.

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) science teams, and a Co-Investigator on EUMETSAT's IASI sounder on the new METOP platform.

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), 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 Agency's 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.

Igor Veselovsky, Associate Research Scientist, 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.

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.

Kevin Vermeesch, holds a M.S. in Atmospheric Science from Purdue University in 2007. He joined JCET in 2015, but since 2008 has worked on analysis of ALVICE, GLOW, and TWiLiTE lidar data at the NASA Goddard Space Flight Center and the Howard University Beltsville Research Campus (HUBRC). The analysis includes data processing and comparison of wind and water vapor data from lidar, radiosonde, and satellite. Kevin participated in the Plains Elevated Convection At Night (PECAN) field campaign (May - July 2015) to deploy ceilometers to collect and transmit data and provide operational support launching weather balloons. Since October 2014 and continuing to the present, he has overseen monthly launches of the cryogenic frostpoint hygrometer (CFH) from the HUBRC to acquire high-quality water vapor data in the upper troposphere and lower stratosphere to compare with satellite and lidar observations. Kevin is working with partners from the National Weather Service to assess the operational reporting of Automated Surface Observing System (ASOS) ceilometer backscatter and planetary boundary layer (PBL) height (derived from the backscatter) and the benefits of having such products available operationally nationwide.

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, Assistant Research Scientist, 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, Research Associate, 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 change. He uses the vast amount of satellite data together with other sources of observations to tackle a range of issues. He also employs models with a hierarchy of complexity to model observational results. Dr. Yuan also has 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.

E. Acronyms and Abbreviations

AIRS, Atmospheric Infrared Sounder
AIST, Advanced Information Systems Technology
AJAX, Alpha Jet Atmospheric eXperiment
ALVICE, Atmospheric Laboratory for Validation, Interagency Collaboration and Education
AOT, Alignment Optical Telescope
AToM, Atmospheric Tomography Mission
AVHRR, Advanced Very High Resolution Radiometer
BRF, Band Rejection Filter
CAFE, Compact Airborne Formaldehyde Experiment
CALIOP, Cloud-Aerosol Lidar with Orthogonal Polarization
CALIPSO, Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
CARAFE, Carbon Atmospheric Flux Experiment
CEOS, Committee on Earth Observation Satellites
CM-SAF, Climate Monitoring Satellite Application Facility
CMIP6, Coupled Model Intercomparison Project Phase 6
COFFEE, Compact Formaldehyde Fluorescence Experiment
CSESP, Citizen Science for Earth Systems Program
DAAC, Distributed Active Archive Center
DISCOVER-AQ, Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality
EOS, NASA Earth Observatory
ESDIS, Earth Science Data and Information System
ESIP, Earth Science Information Partners
EUMETSAT, European Organisation for the Exploitation of Meteorological Satellites
GES DISC, Goddard Earth Sciences Data and Information Services Center
GCOS, Global Climate Observation Site
GHRC, Global Hydrology Resource Center
GLI, Global Imager
GLOW, Goddard Lidar Observatory for Wind
GOES, Geostationary Operational Environmental Series
GRUAN, GCOS Reference Upper-Air Network
HUBRC, Howard University Beltsville Research Campus
ISAF, In Situ Airborne Formaldehyde
ISOPOOH, Isoprene Oxidation Product
IQC, Information Quality Cluster
JPL, Jet Propulsion Laboratory
KORUS-AQ, KORean-U.S. Air Quality
MAIAC, Multiangle Implementation of Atmospheric Correction
MODAPS, MODIS Adaptive Processing System

MODIS, Moderate Resolution Imaging Spectroradiometer
NDOA, NASA Data for Operation and Assessment
NPP, National Polar-orbiting Partnership
PECAN, Plains Elevated Convection at Night
PODEX, Polarimeter Definition Experiment
POLDER, Polarization and Directionality of the Earth's Reflectances
PROPHET, Program for Research on Oxidants: PHotochemistry, Emissions, and Transport
SDSM, Solar Diffuser Stability Monitor
SEAC4RS, Studies of Emissions, Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys
SeaWiFS, Sea-viewing Wide Field-of-view Sensor
SENEX, Southeast Nexus
SEUS, Southeast United States
SEVIRI, Spinning Enhanced Visible and Infrared Imager
SONGNEX, Shale Oil and Natural Gas Nexus
SSA, Single Scattering Albedo
UWG, User Working Group
VIIRS, Visible Infrared Imaging Radiometer S
WINTER, Wintertime Investigation of Transport, Emissions, and Reactivity