FINAL REPORT
THE JOINT CENTER FOR EARTH SYSTEMS TECHNOLOGY

(NNX10AT36A)

A Cooperative Agreement Between:
University of Maryland, Baltimore County and
NASA Goddard Space Flight Center
October 1, 2014 – September 30, 2015

I. Executive Summary

This volume is the twentieth annual report describing the scientific accomplishments and status of the Joint Center for Earth Systems Technology (JCET). This report satisfies the requirement for the Final Report for Cooperative Agreement NNX10AT36A.

JCET was established in 1995 to promote close collaboration between scientists at the University of Maryland, Baltimore County (UMBC) and the NASA Goddard Space Flight Center (GSFC) in areas of common interest related to developing new technologies for environmental remote sensing. The Center's objective is to conduct 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. This research continues to lead to improved understanding of global processes and increased capability to predict global environmental changes. The Center 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 has participated in establishing, funding, and collaborating with JCET. The overall management and administration of JCET is governed by the Executive Board and carried out by an expert administrative staff. The Board Chairman is a civil servant scientist at GSFC. 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 Technology Research Center, and the Academic Services building on the UMBC campus. Most of the JCET scientists work in offices at Goddard.

There are 37 JCET faculty members, who conduct their research amongst nine branches at Goddard and collaborate and teach in six departments at UMBC. JCET faculty are supported at the level of 55% by tasks from Goddard in the Cooperative Agreement, 34% by independent grant funding (e.g., from NSF), and 11% from state funding, which supports, for example, teaching in UMBC departments and proposal writing. JCET faculty teach, collaborate with and/or are affiliated with UMBC's Departments of Physics; Geography and Environmental Systems; Chemistry; Mathematics and Statistics; Chemical, Biochemical and Environmental Engineering; and the Honors College. There are also 16 JCET Fellows, comprising civil servants from NASA and tenured/tenure track UMBC faculty who are deeply involved with research activities at JCET. JCET research is also supported by five research analysts and an Instructional Designer. JCET supports an Associate Director for Academic to coordinate the activities between the academic departments at UMBC and the JCET research faculty. Biographies of each JCET faculty member and associate staff members are included in this report.

In addition to cutting-edge research, JCET faculty members mentor graduate and undergraduate students at UMBC. Through a competitive process, JCET selects a Graduate Fellow each year and supports their 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 semester, the graduate students make a presentation on the progress of their own research. In the Spring semester, each student contributes to a series on a theme that is related to the overall mission of JCET, but may vary from their own narrow slice of the pie. in Spring 2015, the theme of the seminar series was Communicating Climate. The students produced a reading list and a presentation for each topic in the series, resulting in a valuable knowledge base for future uses such as teaching and proposal writing.

More than twenty undergraduate students and two high school students assisted JCET faculty and Fellows in their research during the reporting period. We welcome this talented and productive group of young scientists into JCET. We understand that the future of science in the Nation is dependent on supporting this pipeline.

JCET sponsored an interdisciplinary symposium at UMBC in April 2015 entitled "Communicating Climate." This symposium brought together scientists and communications specialists from state and federal agencies, local universities, as well as faculty from various departments around the UMBC campus, to discuss issues with the changing climate and how to communicate these complex ideas to the public.

The Technical Volume of this report is divided into sections which align with GSFC research areas. Within each section are presented brief accounts of group members' accomplishments, provided by the respective principal investigators supported through a JCET task and/or grant from NASA or other government agencies that was active during the period from October 1, 2014 to September 30, 2015. Each report includes a description of the research, and accomplishments for the reporting period. Following the Technical Volume is supporting material that includes publications, biographies, a complete listing of the JCET faculty and staff, and a list of abbreviations and acronyms.

During this reporting year, the Center proposed and was awarded a new Cooperative Agreement for an additional five years. This final report for Cooperative Agreement NNX10AT36A is opening the door to an exciting and productive future for the Joint Center for Earth Systems Technology.

December 2015

Belay Demoz
Director

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II. Technical Volume

Earth Sciences Division (Code 610)

Task 383: ICESat-2 Mission Education and Outreach Development (Sponsor: Thomas Neumann)

UMBC/JCET: Valerie Casasanto, Program Coordinator

Other: Brian Campbell, Global Science and Technology, Inc.; Kate Ramsayer, Telophase Corporation; Ryan Fitzgibbons and Helen-Nicole Kostis, Universities Space Research Association.

Description of Research

ICESat-2 (Ice, Cloud, and land Elevation Satellite) is a satellite mission to be launched in 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 land and sea ice. To communicate the important science of the mission, an Education and Public Outreach (EPO) program is being developed and implemented. 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 for Oct 2014 - Sep 2015

An array of education and outreach projects were implemented. Casasanto and team initiated and developed a complete redesign of the ICESat-2 public website. 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. Several NASA feature articles were published: one on the telescope during its integration and testing at GSFC (www.nasa.gov/content/goddard/nasa-lining-up-icesat-2-s-laser-catching-telescope); and another feature (with accompanying video-part one of a three-part series) on the laser path (www.nasa.gov/feature/goddard/lasers-path-through-icesat-2). A video feature on the integration and testing and animations of the laser path to the Earth were also produced. ICESat-2 social media was consistently kept current throughout the year.

The EPO 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 Richmond, VA (Oct. 16–18, 2014), the next at the American Geophysical Union (AGU) conference in San Francisco, CA, (Dec. 15-19, 2014), the Odyssey of the Mind Convention in East Lansing, Michigan (May 20-23, 2015), the World Science

Festival in NY, NY (May 27-31, 2015), Earth Day at Union Station, Washington, DC, April 17-22, 2015, NASA Wallops Open House, Wallops, VA (June 27, 2015) and the Summer Watershed Institute Teacher Professional Development Workshop at NASA GSFC (July 6-10, 2015) to name of few.

The highly successful ICESat-2 Pilot collaborative program with the Savannah College of Art and Design (SCAD), and Bowling Green State University (BGSU) was continued and further developed. The program achieved its goals of collaborating with creatively-minded students and their faculty members to come up with unique ideas and prototypes for educational outreach materials such as animations and digital media. Ideas and prototypes that were generated by students were further developed and implemented with the students and faculty such as a short animated film, posters, 3D bookmarks, and banners.

Throughout the reporting period, Casasanto coordinated the education and outreach team and continued development and implementation of EPO goals and milestones.

Mesoscale Atmospheric Processes Laboratory (Code 612)

Task 397: **Data Analysis and instrument development support in research of remote and in situ sensing of atmospheric properties**

Task 398: **Support of GSFC Field Operations: GLOW (Goddard Lidar Observatory for Winds) and TWiLiTE (Tropospheric Wind Lidar Technology Experiment**

JCET/UMBC: Belay B. Demoz, JCET Director/Professor of Physics; Kevin Vermeesch, Research Analyst

NASA: David Whiteman, GSFC; Bruce Gentry, GSFC

Description of Research

The tasks for this research included analysis of data from the NASA-GSFC ALVICE (Atmospheric Laboratory for Validation, Interagency Collaboration and Education) and GLOW (the Goddard Lidar Observatory for Winds) collected during various campaigns across the nation, as well as deployment and operation of these instruments. 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 multiagency, 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 and GLOW 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 for Oct 2014 – Sep 2015

In this task, water vapor time series of Microwave Limb Sounder (MLS) and frost point hygrometer (FPH) for comparisons and trend detection was analyzed and a publication prepared.. The FPH data is from the Earth Systems Research Laboratory in Boulder, CO. As part of this effort, a software was developed to collect, plot, and plot in real-time data from the Vaisala CT12K ceilometer. Several ceilometers were acquired and tested and once they were proved to be in working order, they were shipped to research colleagues at the Higher University of San Andres in La Paz, Bolivia, where they are currently being utilized in a network configuration. In addition, software was developed to collect, plot, and plot in real-time data from Ambient Weather stations. These were also shipped to Bolivia to collect surface weather observations at the locations of the ceilometers. The humidity sensors on the weather stations were compared with high-quality Vaisala and Rotronic humidity sensors to gage their accuracy and response.

Further, monthly balloon launches of the cryogenic frost point hygrometer (CFH) at the Howard campus in Beltsville have begun and proceeding since October 2014 to compare with water vapor measurements taken by instruments on the Suomi National Polar-orbiting Partnership (NPP) satellite.

This task also includes work related to the NOAA Ceilometer network. For this work, software was developed to collect, plot, and plot in real-time data from the Vaisala CL31 and CL51 ceilometers. Data collection began in early 2013 and continues to the present. This data is used to evaluate algorithms for calculating planetary boundary layer (PBL) height and comparing it with PBL heights calculated from radiosondes. As such, a smart algorithm for calculating PBL height using radiosonde data was implemented. Associated with this work, a published volcanic ash detection algorithm was modified and adopted for CALIPSO data to evaluate the ceilometer's ability to detect volcanic ash plumes in their backscatter profiles. JCET members of this task also supported operations for the Plains Elevated Convection at Night (PECAN) field experiment in Kansas (15 May – 15 July 2015). This included deployment of CL31 ceilometers and collection and transmission of their data using cell phone modems and Raspberry Pi computers. Support also includes launching radiosondes and transmission and plotting of their data.

Moreover, a draft paper for publication comparing GLOW wind profiles to Vaisala RS92 sonde profiles was completed and is under internal review. Wind profiles from the NASA/GSFC TWiLiTE instrument aboard the ER-2 flights (Over CONUS) and NASA DC-8 flights (Over Iceland and Greenland) are being analyzed in relation to weather forecast models.

NASA Grant: Hurricanes And Severe Storm Sentinel (NNX11AQ94G)

JCET/UMBC: Jeffrey B. Halverson, Professor, GES/UMBC

NASA: Scott Braun, GSFC; Paul Newman, GSFC

Students: Alexander Martin (Graduate Student, GES/UMBC)

Description of Research

The HS3 science team is a NASA ESS Venture Class Mission in its 4^{th}-5^{th} year. For three years, the NASA Global Hawk unpiloted aircraft have flown over and around Atlantic tropical cyclones, gathering data related to intensity change and storm genesis. Two aircraft were used: An over-storm aircraft equipped to improve understanding of the storm dynamics, and an environmental aircraft, with payloads to measure environmental winds, temperature, moisture, cloud composition and dust aerosol. An important sub-objective was to assess the impact of the dry, stable and dust-laden Saharan Air Layer (SAL) on storm formation. Both aircraft essentially fulfill the role of "virtual satellites" but significantly increase the dwell time over individual storms, compared to conventional piloted aircraft. Summer 2015 marked the third and final year of the field deployment phase. Over a dozen tropical systems ranging from weak depressions through strong category hurricanes were investigated by the HS3 team.

Accomplishments for Oct 2014 - Sep 2015

Halverson and his grad student Alexander Martin worked with the HS3 team to further the objective of better understanding wind, temperature and moisture fields in the inner core region of Atlantic tropical cyclones. The primary dataset is the Advanced Vertical Atmospheric Profiling System (AVAPS) – or dropsonde – on the NASA AV-6 (environmental) Global Hawk.

During August, 2014, the team ran a two-week "dry run" exercise designed to operationalize daily forecast and mission science planning briefings, based on virtual missions of the NASA and NOAA hurricane hunter aircraft. This exercise also tested interagency collaboration and coordination issues which invariably arise in the field. The UMBC HS3 team spend 4 weeks in the field (NASA Wallops, Chincoteague, VA) during September, 2015, for actual deployment of the Global Hawks. Halverson served as forecast team leader and mission scientist, while the graduate student, Alex Martin, participated as a duty forecaster.

In May 2015 the UMBC HS3 team attended a science workshop (San Francisco, CA) to present preliminary analyses of six Atlantic tropical cyclones, from three years of Global Hawk flights. Alex Martin gave the team talk at this meeting. The work illustrated the evolution of inner core temperature and vortex wind structures, obtained by analyzing the dropsonde data in 3D space. Several of the storms were atypical or failed to fully develop into hurricanes, including an example of a cold-core tropical vortex off Africa, a strongly sheared storm that failed to thrive in its tropical environment, and a hybrid storm off the U.S. East Coast undergoing extratropical transition. The centerpiece of the work details the multi-day evolution of a powerful Cat 3 hurricane undergoing rapid intensification, through documentation of changes in the vertical warm core and vortex structure.

Task 348: Improvement of feature detection algorithms within the Micropulse Lidar Network (MPLNET) (Sponsor: Ellsworth J. Welton)

NASA Grant: Understanding Spatiotemporal Variability in Urban Mixed Layer Heights through Observations and Modeling (NNH14CM13C)

UMBC/JCET: Jasper Lewis, Post-Doctoral Research Associate, JCET

NASA: Richard Ferrare, LaRC; Amy Jo Scarino, LaRC; Ellsworth Welton, GSFC

Other: Jennifer Hegarty, AER; John Henderson, AER; Philip DeCola, Sigma Space Corp.; Erica McGrath-Spangler, USRA; Thomas Nehrkorn, AER

Description of Research

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 for Oct 2014 - Sep 2015

The version 3 cloud detection algorithm has been completed and is currently being implemented into operational MPLNET processing. A paper describing the algorithm and demonstrating the efficacy of its retrievals has been submitted for publication and is currently under review. The past year's efforts have also resulted in publications demonstrating the relationship between columnar aerosol optical depth and surface particulate matter, stratospheric injection of volcanic aerosols, and autonomous identification of cirrus clouds from lidar measurements. Processing of the MPLNET sites used during the 2011 DISCOVER-AQ field campaign has been completed and processing of the field-deployed micropulse lidar systems has begun.

Lewis also participated in the submission of two proposals during the past year. The first aims to identify a meridional gradient in cirrus cloud radiative forcing using MPLNET and CALIPSO measurements. The other is intended to engage underrepresented minority and women in NASA research communities at UMBC, Howard University, and Goddard Space Flight Center.

Task 347: UV integration under MPLNET Lidar Network (Sponsor: Ellsworth J. Welton)

JCET/UMBC: Simone Lolli, Assistant Research Scientist

Description of Research

MPLNET (Micro Pulse Lidar NETwork) is in the process of incorporating other Micro Pulse Lidar wavelengths into the network, expanding from the current green wavelength to include others, such as ultraviolet (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 and develop methods 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 for Oct 2014 - Sep 2015

The Fu-Liou_Gu (FLG) radiative transfer code has been modified to assess cirrus cloud and aerosol layer direct, semi-direct and indirect effect on earth-atmosphere radiation budget. MPLNET V3 aerosol and cloud products, with their intrinsic temporal and spatial resolution, can now be ingested into the FLG code to assess their radiative characteristics. A paper has been submitted to Nature, with Lolli as co-author.

The double wavelength algorithm has been tested on COPS measurement campaign data. The raindrop evaporation was assessed and a paper is in progress. Latest findings will be presented with a talk at next AGU meeting.

Collaboration with EARLINET Lidar Network is established during the past year in the frame of ACTRIS project to develop and common algorithms to be applied and tested to both networks in the frame of GALION network of networks project.

Two workshop were given in the frame of 7SEAS project at the Indonesian Met Office BMKG and at USM Penang. The first one, more operational, was focused in teaching ECWMF employees how to use MPLNET and AERONET data for air quality purposes, while at USM Ph.D. and graduate students learned how to write a scientific paper. In past year, the students wrote 4 extended abstracts for European (SPIE) and local Malaysian conferences.

Lolli submitted a proposal as PI during the past year, that aims to identify a meridional gradient in cirrus cloud radiative forcing using MPLNET and CALIPSO measurements.

Task 393: Global Precipitation Measurement Mission Data Access and Applications Training (Sponsor: Dalia Kirschbaum)

Task 395: NASA Applied Remote Sensing Training for Water Resource and Disaster Management (Sponsor: George Huffman)

NASA ASP Sub-contract: Decision Support System to Enhance Source Water Quality Modeling and Monitoring using Remote Sensing Data

JCET/UMBC: Amita Mehta, Assistant Research Professor

Other: Norm Bradley, William Weiss, Benjamin Stanford, Hazen & Sawyer; Benjamin Zaitchik, Johns Hopkins University

Students: Sai Popuri, JCET/Mathematics & Statistics; Amanda Rumsey, NASA-DEVELOP program

Description of Research

Mehta's research during 2014-15 focused on 1) NASA Applied Remote Sensing Training to develop presentations modules and conduct trainings about NASA products from satellites and earth system models useful for water resource and disaster management, 2) conducting a hands-on training for GPM application community, 3) analysis to assess quality of precipitation data from ocean buoys to compare with TRMM/GPM precipitation measurements, and 4) finalizing a USDA-NIFA multi-disciplinary project, with multi-institute team members, involving downscaling of climate model hydrometeorological data for assessing impacts water and crop yields in the Missouri River Basin.

Accomplishments for Oct 2014 – Sep 2015

Mehta, as a part of the Applied Remote Sensing Training (ARSET) program team, 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 four webinars: i) Introduction to NASA Earth Science Data Products, Portals, and Tools (October 2014), ii) Water Quality Monitoring Using Remote Sensing Measurements (November-December 2014), iii) Introduction to Global Precipitation Measurement (GPM) Data and Applications (March 2015), and iv) NASA remote Sensing Observations for Flood Management (June 2015). The webinars were attended by a record number of national and international participants (close to 1,200). Moreover, an in-person training was offered during 19-22 May 2015 on v) Climate Variability, Hydrology, and Flooding at the 2nd GEO-CIEHLYC Water Cycle Capacity Building Workshop in Cartagena, Colombia. All the training material is available freely online (arset.gsfc.nasa.gov). Mehta also conducted an in-person training about an overview of GPM precipitation data and data access case studies on 11 June 2015 as a part of the GPM applications Workshop.

A new project was initiated focusing 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). The precipitation data are collected at every 10-minute interval and span multiple years. These data also include instrumental noise, as they are affected by weather conditions (winds and humidity) near the buoy locations. The objective of this project is to examine data quality to determine how they can be used to validate/inter-compare satellite-based precipitation.

As a part of NASA Energy and Water Cycle Studies program that concluded in 2014, Mehta used TRMM multi-satellite Precipitation Analysis (TMPA) version-7 to diagnose warm season extreme rain events over the USGP. This analysis is now extended over global tropical region.

As a co-investigator of a USDA-NIFA multi-disciplinary, multi-institute project that received a no-cost extension in 2014-15, Mehta, with the help of a graduate student Sai Popuri from UMBC, prepared downscaled surface air temperature and precipitation data from two Coupled Model Inter-comparison Project phase-5 (CMIP-5) climate models

(HadCAM3 and MIROC5) over the Missouri River Basin (MRB). These downscaled data are currently being used by the project team in Soil and Water Assessment Tool (SWAT) to examine climate impacts on water and crop yields in the MRB. Furthermore, Mehta analyzed nutrient levels and water quality in MRB using SWAT and presented results in the SWAT International Workshop in June 2015. The high performance computing portion of this project was included in the Research Experience for Undergraduates (REU) program during summer of 2015 in training a team of four undergraduate students.

Task 325: Global Retrieval of Precipitation and Latent Heating Distributions from Spaceborne Radiometer/Radar Observations (Sponsor: Scott Braun)

NASA Grant: Development and Evaluation of Improved Ice and Mixed-Phase Precipitation Models for GPM Combined Radar-Radiometer Retrieval Algorithm Applications (NNX13AG87G)

NASA Grant: Characterizing Uncertainties in Large-Scale Atmospheric Heating Distributions Derived from TRMM Observations and Reanalysis Datasets (NNX13AC40G)

NASA Grant: Extending Atmospheric Latent Heating Estimates to the Extra-tropics using Satellite Radar-Radiometer Data, High Resolution Regional Model Simulations, and Reanalysis Products (NNX15AH04G)

JCET/UMBC: William Olson, Research Associate Professor

NASA: Michael Bosilovich, GSFC; Wei-Kuo Tao, GSFC

Other: Mircea Grecu, Morgan State University; Kwo-Sen Kuo, University of Maryland, College Park; Benjamin Johnson, Atmospheric and Environmental Research, Inc.; Lin Tian, Morgan State University; Xianan Jiang, University of California Los Angeles; Di Wu, Science Systems and Applications, Inc.

Collaborators: Andrew Heymsfield, National Center for Atmospheric Research; Stephen Munchak, University of Maryland, College Park; Tristan L'Ecuyer, University of Wisconsin; Qunhuei Zhang, Science Applications International Corporation; Guojun Gu, University of Maryland, College Park

Description of Research

The main emphasis of the research is on the calibration of satellite passive microwave and infrared estimates of precipitation and latent heating using coincident, high-resolution estimates from spaceborne radar as a reference. Spaceborne radar methods for estimating precipitation/latent heating vertical structure are being developed and tested for applications to 14 GHz radar (Tropical Rainfall Measuring Mission; TRMM) and 14 + 36 GHz radar (Global Precipitation Measurement mission; GPM) in conjunction with a range of passive microwave radiometer multispectral observations. Regarding precipitation, the specific objectives are to improve the representations of ice and mixed-phase particles in combined radar-radiometer estimation algorithms. The remote sensing of latent heating distributions using spaceborne radar-radiometer data is a related area of study, with implications for understanding the Earth's water and energy cycles.

Accomplishments for Oct 2014 – Sep 2015

The GPM core mission observatory, successfully launched in February 2014, features a spaceborne radar (14 and 36 GHz) and a multichannel passive microwave radiometer (10-183 GHz). Data from these instruments are being used to derive our "best" estimates of precipitation and latent heating vertical profiles, and these profiles, in turn, will be used to cross-calibrate radiometer-only profile estimates from an international fleet of radiometers flying in complementary orbits, and to adjust precipitation estimates from infrared radiometers on geostationary platforms. Prof. Hirohiko Masunaga (Nagoya University) and Dr. Olson co-lead a team that is charged with the continued development and testing of a combined radar-radiometer precipitation/heating algorithm that is applied operationally to the GPM core instrument data.

The GPM radar-radiometer algorithm team performed an evaluation of the first public release of precipitation products from that algorithm, and determined that there were biases of the estimates relative to ground-based, rain gage-calibrated radar rain rates and global precipitation climatologies. The team uncovered a bias in the relative calibration of the 14 and 36 GHz radar observations that led to nonphysical data at lower rain intensities. These biases are under investigation by the GPM radar instrument scientists. The team also made improvements in the radar-radiometer algorithm, introducing a method to enhance the radiometer data to the higher spatial resolution of the radar and a parameterization [Hogan and Battaglia, 2008] for simulating the multiple scattering of radar pulses, to better interpret the GPM data. These changes, as well as others, led to radar-radiometer estimates that were closer to climatology and agreed well with ground radar estimates over ocean surfaces. The updated algorithm will be used to generate the next public release of precipitation products from the GPM mission.

With respect to studies supported by NASA's Precipitation Measurement Missions (PMM) program, the calculation of the microwave absorption and scattering properties of simulated non-spherical snow particles (created by the team of investigators) were completed, and radiative simulations of idealized snow layers were performed. Relative to background thermal emission, simulated "depressions" of upwelling microwave radiances due to scattering by snow particles were much greater for layers of the nonspherical particles relative to layers of the more approximate spherical particles with the same masses. This effect was attributed to the reduced proportion of forward scatter by the non-spherical snow particles, and the impact of nonsphericity was shown to be greatest on radiances at the highest channel frequencies of the GPM radiometer [Kuo et al., 2015]. The properties of the nonspherical ice particles were also shown to be more consistent with simultaneous airborne radar and radiometer observations from field campaigns [Olson et al., 2015]. The scattering properties of simulated nonspherical melting particles were also calculated, and these exhibited greater extinction and backscattering at the onset of melting, relative to those of spherical particles with the same masses and proportions of meltwater [Johnson et al., 2015]. Specific knowledge of the scattering properties of realistic melting, nonspherical particles will have important implications for radar remote sensing of precipitation from GPM.

A new study, supported by NASA's Energy and Water cycle Study (NEWS), commenced during 2015. The objective of the study is to extend estimates of latent heat release in precipitating clouds to higher latitude systems using GPM observations of surface rainfall rates and precipitation structure, as well as midlatitude cyclonic storm numerical simulations and reanalysis products. Latent heating is an important component of the Earth's water and energy cycles, and it is also a driver of large-scale vertical motion in the atmosphere. The TRMM mission provided precipitation estimates from 35 ^{o}S – 35 ^{o}N latitudes, while GPM extends that coverage to 65 ^{o}S – 65 ^{o}N. The precipitation structures and dynamics of higher latitude systems are different from those of tropical systems, and so new strategies for estimating heating rates at midlatitudes are needed. So far, an extended, high-resolution simulation of a North Atlantic midlatitude cyclone has been performed to provide a testbed for higher-latitude heating estimation methods. The simulation will be nested to 3-km resolution in order to resolve precipitation and heating structures associated with convective cloud systems.

Task 380: Perform Duty as Project Scientist of Goddard Earth Sciences Data and Information Services Center (DISC) (Sponsor: Steven Kempler)

JCET/UMBC: Chung-Lin Shie, Associate Research Scientist

NASA: Steven Kempler, GSFC; Rahul Ramachandran, MSFC; Dong Wu, GSFC

Other: Suhung Shen, George Mason University; Linette Boisvert, University of Maryland, College Park

Description of Research

Shie has served as Project Scientist of Goddard Earth Sciences DISC since January 2013, providing insight and guidance to Goddard Earth Sciences DISC. The first subject involves a prototype data service development at Goddard Earth Sciences DISC. The primary goal of this in-development service aims to provide the data users with knowledge-based and event-based integrated data package/"bundle data" [Shie, Shen, and Kempler 2014]. Shie has also been invited to collaborate in two other research projects. One of the subjects, involving a study from a two-year project funded by the NASA AIST Program (Ramachandran as PI; Kempler as Co-I; Shie as Collaborator), 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. The other subject, involving a research project (Boisvert as lead-author; Wu and Shie as co-authors), focuses on creating and evaluating estimates of the moisture flux for the entire Arctic Ocean between 2003-2011 using Atmospheric Infrared Sounder (AIRS) Level 3 data products [Boisvert, Wu, and Shie 2015a; 2015b].

Accomplishments for Oct 2014 – Sep 2015

As Project Scientist of Goddard Earth Sciences DISC, Shie has constantly provided inputs such as insights, visions, and suggestions to colleagues (administrators, scientists and engineers) aiming at properly and effectively engaging the data products/services distributed at Goddard Earth Sciences DISC with the current (or/and to develop new) science research applications performed internally (Goddard Earth Sciences DISC) or externally (science communities outside Goddard Earth Sciences DISC). The major objective is to continually improve the overall user and data services at Goddard Earth Sciences DISC. Shie also works closely with the Goddard Earth Sciences DISC Manager (Kempler), coordinating interactions/meetings between Goddard Earth Sciences DISC and its User Working Group (UWG), aiming to bridge together the user community, the data providers, and Goddard Earth Sciences DISC as the data distributor and the service provider. This is for improving the overall user and data services, as well as developing new services or collaborations at DISC. A 1.5-day Goddard Earth Sciences DISC UWG meeting, held every 18 months, was held at Goddard on October 19-20, 2015, following three telecom meetings held in January, April, and August 2015. The recent meeting addressed several important topics, such as "United User Interface"/UUI (the newly developed Web Server at Goddard Earth Sciences DISC), "Federated Giovanni" (a collaborative project with few other NASA data centers), and "Virtual Collection" (an envision and approach for future data service). Moreover, several crucial topics, such as "Web Renovation," "Data Metrics," "Bundle Data," and "Data Quality," have been advocated by Shie and have led to practical improvements and or substantial actions performed at Goddard Earth Sciences DISC accordingly. Shie also helps inviting guest scientists/speakers for giving scientific talks at the Goddard Earth Sciences DISC Weekly Lunch Seminar Series.

The team aims to provide Earth science community with the advanced (i.e., knowledge-based and event-based) "bundle" science datasets, with the eventual goal of further advancing the data service at Goddard Earth Sciences DISC to a "virtual collection" [Shie et al., 2014]. This service framework, when fully established, should be able to effectively provide users with the sophisticatedly integrated "bundle" data package via user-friendly discovery and selecting a system-preset science/event topic (e.g., hurricane, volcano, etc.) based on a still in-development knowledge database. A "Data Recipe" page, related to hurricanes, has been developed at the Goddard Earth Sciences DISC website to prototype the concept. A specific sample hurricane event, such as Hurricane Sandy (Oct 22-31, 2012), is used for the data-retrieval procedure of this data service. With Hurricane Sandy as a user targeted case, a table of related data variables (i.e., precipitation, winds, sea surface temperature, sea level pressure, air temperature, relative humidity, aerosols, soil moisture and surface runoff, trace gases) and the associated URL's directly linked to the respective data products with fine temporal and spatial resolution of various in-house sources, is provided. As such, no duplicates of the original data products would be required/reproduced during such a data-retrieval process.

All the data variables that would be requested by users, such as hurricane track, hurricane intensity, disaster analysis, impacts, etc., can then be readily downloaded through the data search engine, Mirador. Powerful visualization tools, such as Giovanni (online; built in-house), are accessible for users to acquire quick and informative views of the data variables/products (currently Level 3/gridded data). Additional science and event-based topics, such as volcanoes and floods, are currently in development.

The second project by Ramachandran et al. focuses on developing a search tool. This search tool is to be built (an ongoing, two-year project) on semantic technologies, by gathering and screening Earth science metadata assets to create new knowledge discovery pathways in Earth science for the users. Shie has provided science knowledge and expertise, aiding in developing a corpus of scientific keywords and metadata of the use cases for creating the data curation knowledge base.

The third project [Boisvert et al. 2015a; 2015b] involves studies of retrieving and evaluating the moisture flux estimates for the entire Arctic Ocean using 11-year (2003-2013) AIRS Level 3 data products. The moisture flux has been found to play an important role in the Arctic energy budget, the water-vapor feedback and Arctic amplification.

NASA Grant: Synthesis of GPM GV Hydrometeor Datasets for Combined Precipitation Retrieval Algorithms (NNX 13AI86G)

Task 327: Measurements of Hydrometeor Size Distributions during Global Precipitation Measurement (GPM) Field Campaigns (Sponsor: Schwaller)

JCET/UMBC: Ali Tokay, Research Associate Professor

Students: Rigoberto Roche, Florida International University; Jorel Torres, South Dakota School of Mines

Description of Research

The theme of the study is to improve the precipitation measurements under the umbrella of 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. Fourth, steps have been taken to evaluate the existing operational rainfall products that can be used to validate the satellite precipitation products.

Accomplishments for FY 14-15

Tokay was the co-advisor of Dr. Leo Pio Adderio of University of Ferrara, who received his PhD in March 2015. A manuscript on the observations of drop break-up was published in Journal of Atmospheric Sciences [D'Adderio et al., 2015]. The study used disdrometer-based raindrop size distribution measurements and showed that the drop break-up occurs at rain rates higher than 5 mm h^{-1}.

A manuscript has been published to the Journal of Hydrometorology [Tokay et al. 2014a]. This manuscript investigates the spatial variability of rainfall through five-year long rain gauge network (11 sites) observations from the Eastern Shore, Maryland/Virginia. The sub-pixel space variability is one of the key issues of the spaceborne precipitation retrieval algorithms. This study was conducted with a summer intern, Rigoberto Roche, of Florida International University.

A manuscript has been published to the Journal of Hydrometorology [Tokay et al., 2014b]. This manuscript presents the performance of the new version of Parsivel . A comparative field study with impact-type disdrometer, old version of Parsivel, and rain gauges has been conducted.

A manuscript on the pixel-space variability of raindrop size distribution has been conditionally accepted in Journal of Hydrometeorology [Tokay et al., 2015]. This study uses the disdrometer network at NASA Wallops Flight Facility, where the spatial variability of the fifteen different physical parameters was investigated.

A Masters student candidate, Jorel R. Torres of South Dakota School of Mines, was an intern at NASA Goddard Space Flight Center in the Spring of 2015. He worked on the characteristics of falling snow from disdrometer measurements collected during the 2014 winter season at Wallops Flight Facility. The study includes the parametric form of the size distribution, fall velocity, snowfall rate, snow density and reflectivity-based melted snow water equivalent estimation.

A disdrometer and radar-based dataset shows that Hurricane Sandy (2012) had two distinct characteristics. At a given reflectivity, rain rates were lower and mean mass diameters were higher at the early state of the superstorm, where a mid-latitude frontal system was dominant. The rain rates were higher and mass diameters were lower during the latter part of the storm, where more small drops and fewer large drops were observed. The findings of this study were presented during 36th Radar Meteorology Conference.

Climate and Radiation Laboratory (Code 613)

NASA Grant: Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality (NNX10AR41G)

NASA Grant: Improve EPA's AIRNow Air Quality Index Maps with NASA Satellite Data (NNX11AI76G)

Investigators: D. Allen Chu; Associate Research Scientist

NASA: Jim Crawford, LaRC; Ken Pickering, GSFC

Other: Phil Dickerson, EPA

Description of Research

Both projects were focused on airborne and surface aerosol measurements of DISCOVER-AQ to baseline the relationships between AOD and $PM_{2.5}$ in the aerosol environments of Baltimore-Washington Corridor, San Joaquin Valley, and Houston and Denver metropolitan regions in association with meteorological conditions. The baselined relationships are aimed to evaluate $PM_{2.5}$ estimation for satellite remote sensing measurements. Lidar aerosol extinction profiles play the key role in the linear approximation of $PM_{2.5}$. Correlation and linear regression statistics are used to assess the goodness of fit between the observed $PM_{2.5}$ and estimated $PM_{2.5}$ by sunphotometer and satellite aerosol optical depth measurements. The behavior of $PM_{2.5}$ estimation error in association with aerosol retrieval error will be a useful indicator for quantifying the performance of AOD retrieval algorithms of current satellite sensors or serve as requirements for designing future satellite missions in air quality application.

Accomplishments for Oct 2014 - Sep 2015

In addition to the comparative study of DISCOVER-AQ over Baltimore-Washington Corridor (BWC) in July 2011 and San Joaquin Valley (SJV) in January-February 2013, analyses were made in Houston Metropolitan Regions (HMR). The analysis of these results and explanations for the differences were an important component of this task. The linear approximation of normalized AOD vy Have layer height (HLH) that accounts for residual aerosols above the boundary layer outperforms other approximations in estimating surface Particle Matter ($PM_{2.5}$) concentration.

For example, comparison of this two regions reveals that the maximum $PM_{2.5}$ levels are similar (~60-70 g/m^3) in BWC and SJV over the campaign periods, but the maximum Aerosol Optical Depth (AOD) values are quite different. AOD values measured in SJV were 25%-50% lower (<0.3) than those in BWC (<0.6). The characteristics of spatial variability of AOD reflect the deep mixing of aerosols in BWC, shallow mixing in SJV and convective mixing in HMR.

In addition, the regional mean AOD of 0.25, 0.11, and 0.17 were found over the entire campaign periods in BWC, SJV, and HMR, respectively. The regional mean HLH of 0.74 (vs. PBLH ~0.5 km) in SJV depicts a clear contrast to that of 2.21 (vs. PBLH ~1.07 km) in BWC, 2.40 (vs. 0.85 km) in HMR. The larger the difference between HLH and PBLH the larger the aerosol abundance above boundary layer.

Further, the diurnal variation in $PM_{2.5}$ also varies between the two regions. In BWC, the diurnal variability of monthly mean $PM_{2.5}$ is invariant with respect to local solar time, whereas in SJV, the monthly mean $PM_{2.5}$ maximizes at 10 a.m. (morning traffic) and between 18:00 p.m. - 1:00 a.m. local solar time (traffic and residual heating) and in HMR, the monthly mean $PM_{2.5}$ shows maximum values around 5:00-8:00 a.m. (morning traffic) and around 18:00-20:00 p.m. (afternoon traffic).

The research also includes characterizing the effectiveness of the lidars by comparison with measurements from multiple DRAGON sun photometers deployed in the region.

Task 358: Collaboration on SORCE and TSIS (Sponsor: Dong L. Wu)

Task 394: 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 (Sponsor: Sophie Nowicki)

Task 399: Feedbacks, Processes and Impacts of Contemporary Changes in the Arctic (Sponsor: Joel Susskind)

JCET/UMBC: Jae N. Lee, Assistant Research Scientist

NASA: Sophie Nowicki, GSFC; Joel Susskind, GSFC ; Dong L. Wu, GSFC

Description of Research

In task 394, the investigator developed an accurate sounder based multi-decade climate data set using Aqua AIRS and TOVS Pathfinder Path-A products. The task involved studying characteristics of TOVS, AIRS, CERES, and MODIS data products, especially over the overlap period with the TOVS data set, both from the inter-validation perspective and also to identify and help remove biases between AIRS and TOVS products.

In task 358, the investigator analyzed multi-sensor spaced based observations of physical variables and atmospheric tracers in conjunction with the solar irradiance data from SORCE (Solar Radiation and Climate Experiment), TCTE (TIM Calibration Transfer Experiment), and TSIS (Total Solar Irradiance Sensor) to develop appropriate Sun-Earth interaction processes. The primary science objective was to keep developing and validating the solar impact on Earth's climate using a variety of existing satellite observations and model results.

The objectives of task 399 were to provide a more complete documentation of conditions associated with recent melt events, improve our understanding of forcing mechanisms that influence surface conditions on the Greenland Ice Sheet, and identify the impacts of recent, enhanced runoff on Greenland's eustatic contribution and on productivity and circulation in the adjacent ocean.

Accomplishments for Oct 2014 - Sep 2015

For the task 610, the primary accomplishments during this period were focused on the solar rotational variability from space-based observations of solar irradiance. In her recent work with the TSI variation, Lee identified solar rotational variations from SORCE/TIM, ACRIM III, and SOHO/VIRGO Total Solar Irradiance (TSI) observations (Lee et al., 2015) throughout the whole observation periods of each instrument. The rotational variations of TSI from the three independent observations are generally consistent with each other, despite different mean TSI values. Lee characterized the amplitude of TSI 27 day variations in terms of W/m^2 and in percent, during the declining phase, minimum phase, and rising phase of the solar cycle 23-24.

While she was working as a member of the SORCE and TSIS team, she was awarded with an “Outstanding Scientific Support” by NASA climate and radiation laboratory, for SORCE science and of TSIS instrument development for the NASA/NOAA JPSS free-flyer mission. She was also awarded with a “Certificate of Recognition” by NASA and NOAA JPSS Directors, in recognition of her contributions to the successful completion of the JPSS Program’s Key Decision Point-I and Key Decision Point-C milestones.

Lee has been an active reviewer for the Geophysical Research Letters and Journal of Geophysical Research, and a 2015 science team meeting organizer for SORCE.

Lee is continuing a quantitative examination of the significant temporal variability (e.g., 11 year and 27 day period) of spectral solar irradiance (SSI), extending an earlier study of TSI. Lee is continuing an investigation of the stratospheric water vapor composition in the tropical middle atmosphere and its relation to the dynamics and chemistry. Her analysis clarifies the principle roles in temperature anomalies induced by the QBO at the tropopause for upward propagation, and those in mean vertical gradient of water vapor and QBO’s residual vertical velocity for downward propagation [Kawatani et al., 2014].

Under the task 613, Lee is working as a member of the AIRS SRT (sounding radiative transfer) team. As a member of the team, she is participating in the validation of AIRS products. She presented her AIRS work at 2015 NASA Sounder Science Team Meeting, 2015 Sun-Climate Symposium, and 2015 CERES Science Team 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. The spatial and temporal variability of their area mean climatologies are also compared. Analogous research is done using AIRS and MERRA 2 for physical variables, which should shed further light on how global and regional changes in OLR are related to changes in temperature, water vapor, and cloud cover.

Under the task 615, Lee is working on the surface temperature changes and their impact on Greenland Ice Sheet mass loss. She worked on validation of AIRS surface skin and air temperatures in comparison of MODIS ice surface temperature and in-situ measured from the Greenland Climate Network.

Task 321: Retrieval of Cloud and Sea Ice Properties from THOR Lidar Measurements (Sponsors: Robert Cahalan and Alexander Marshak)

JCET/UMBC: Tamás Várnai, Research Associate Professor;

NASA: Alexander Marshak, GSFC and JCET Fellow; Robert F. Cahalan, GSFC and JCET Fellow

Other: Frank Evans, University of Colorado; Charles Gatebe, USRA; Ritesh Gautam, Indian Institute of Technology, Guoyong Wen, Morgan State University; Weidong Yang, USRA

Students: Manoj Kumar, Indian Institute of Technology, Guadalupe Sanchez Hernandez, University of Extremadura

Description of Research

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 work also includes examining the abundance and radiative impact of undetected cloud droplets that occur outside 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 for Oct 2014 – Sep 2015

Várnai and team continued their research on the systematic changes in satellite-based aerosol observations that occur near clouds. They work this issue because several studies found strong systematic changes in clear-sky observations in the vicinity of clouds, and also because the surroundings of clouds cover huge areas, with about half of all clear areas being within five kilometers from clouds.

This year, the team completed the analysis of the question whether systematic near-cloud aerosol changes may be explained by correlations between aerosol properties and regional cloud coverage. For this, the team analyzed aerosol data from two instruments in the NASA A-train satellite constellation: MODIS (Moderate Resolution Imaging Spectroradiometer), and CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization). Data from both instruments showed that correlations between cloudiness and aerosol parameters do indeed contribute to the observed near-cloud increase in aerosol concentration and particle size, but the results also revealed that most of the near-cloud increases are present even if one considers only areas within a narrow range of cloudiness [Yang et al., 2014; Várnai and Marshak, 2015].

In using satellite data to examine the way near-cloud aerosol changes vary with location, season, and scene characteristics, Várnai and team found that the magnitude of cloud-related aerosol changes varies significantly across the globe, and that these changes are typically much stronger in the summer than in the winter. They also found that the cloud-related changes were most pronounced for small aerosol particles. The results also showed that, especially over land, aerosol enhancements are stronger if clouds occur in clusters than if clouds are randomly scattered over an area.

Várnai and team also analyzed multi-angle observations of wildfire smoke plumes in the presence of nearby clouds. In analyzing airborne measurements by the Cloud Absorption Radiometer (CAR), they found that the light scattered by smoke particles varies quite differently with wavelength in the presence of nearby clouds. They also developed an empirical model that, given observations at a few view directions, allows one to estimate the radiation that would be observed from any other direction. This empirical model may prove helpful for combining satellite data obtained from a few different view directions.

The team also continued their work toward improving the accuracy of satellite-based aerosol measurements near clouds. Their specific goal is to enable satellite data interpretation algorithms to consider the impact of 3D radiative processes in which clouds scatter light into nearby clear areas. Considering these 3D processes can prevent researchers from mistakenly attributing the extra brightnesses observed near clouds to elevated concentrations of aerosol particles. This year the team tested and improved the way the 3D correction model accounts for the fact that some cloud-reflected light gets further scattered by aerosol particles floating in nearby clear areas [Wen et al., 2015].

Finally, the team has also continued its efforts toward improving the accuracy of satellite measurements of cloud optical thickness, particle size, and water content. This year, the team explored the spectral dependence of cloud reflection. They found that the air above clouds can significantly weaken the influence of 3D processes. The weakening is especially strong at ultraviolet (UV) wavelengths, where air molecules are especially effective in scattering sunlight. This finding suggests that, at least for some satellite view directions such as backscatter, UV observations can help improve the accuracy of satellite-based cloud measurements [Várnai et al., 2015].

NASA Grant: Evaluate And Constrain Aerosol Indirect Effect In The Trade Cumulus Regime With Nasa Data And Models (NNX13AM19G)

JCET/UMBC: Tianle Yuan, Assistant Research Scientist

NASA: Lazaros Oreopoulos, GSFC

Other: Hongbin Yu, Associate Research Scientist, ESSIC/University of Maryland, College Park

Description of Research

The research goals are to evaluate and constrain NASA GEOS-5 model with available satellite data. Yuan observes dust transport using active satellite data sensors and compare results with modeling work to investigate how dust transport may affect nutrient deposition and biological activity in the Amazon basin. Yuan also uses satellite data to look at aerosol and cloud feedback on multidecadal time scales.

Accomplishments for Oct 2014 - Sept 2015

Three papers were published during this period. Matsui et al. (2014) overviews current and future aerosol science and related projects/missions within the Goddard Space Flight Center. The paper also summarizes recent accomplishments in the AEROCENTER community.

Yu et al. (2015a) demonstrates that dust transported from Sahara desert play a significant role in the nutrient cycle and biological cycle of the Amazon forest. The Amazon River system loses a large amount of nutrients due to river discharge and on long time scales, dust is shown to be essential to replenish this loss.

Yu et al. (2015b) uses space-borne lidar to measure dust transport out of Africa. The advantage of using lidar is its capability to observe vertical structure of dust plumes while previous sensors have to make assumptions about the vertical distribution because only column integrated amount is observable.

NASA Grants: Using MODIS, ASTER, CloudSat and large-eddy-simulations to better understand Marine Boundary Layer Clouds (NNX14AJ25G, NNX15AC77G)

UMBC/JCET**:** Zhibo Zhang, Assistant Professor, UMBC/JCET; Frank Werner, Post-doctoral Research Associate

Description of Research

Zhang's research focuses on the impact of 3D radiative effects on satellite-based remote sensing results of the optical and microphysical properties of liquid-phase clouds. To better understand these effects, high-resolution ASTER reflectances are successively aggregated to larger scales and used as input for radiative transfer simulations. The subsequent deployment of a MODIS-like retrieval algorithm yields cloud properties for each individual spatial resolution and allows for the analysis of 3D-radiative effects in dependence on the observational scale.

Accomplishments for October 2014 – September 2015

Based on a case study of ASTER reflectances observed over subtropical convective water clouds, the CHIMAERA retrieval algorithm developed by G. Wind was incorporated on the UMBC HPCF and jointly improved upon. CHIMAERA now handles variable ASTER cases and yields retrievals with arbitrary spatial resolution.

In a first step the retrieval code was used to generate a case study of truly collocated ASTER and MODIS retrievals. This analysis allowed for a detailed comparison between both instruments and raised questions on the reliability of a subset of MODIS retrieval products. These results were presented during the MODIS Science Team Meeting in May 2015 and are incorporated into a publication, which is soon to be published.

Moreover, by comparing retrieval results from different ASTER resolutions the algorithm provided first results on the scale-dependent changes in cloud cover and retrieved cloud properties. Theoretical frameworks to analyze the impact of aggregation in regard to 3D radiative effects, which were developed in Zhang's group, are currently combined with these finding. This approach promises to yield an improved understanding about 3D radiative effects.

Atmospheric Chemistry and Dynamics Laboratory (Code 614)

NASA Grant: A Modeling Analysis of the Impact of Aerosols from Combustion Sources on Actinic Fluxes and Photolysis Rates Constrained by Aircraft and Satellite Data (NASA NNX11AN72G)

NASA Grant: Integrating carbon monoxide and aerosol retrievals: Improving estimates of aerosol vertical distribution, carbon component & local radiative forcing (NNX11AP62G)

FAA Grant: ACCRI Phase II

Task 350: Modeling of atmospheric aerosols and trace gases (Sponsors: Mian Chin, Jose Rodriguez, and Peter Colarco)

JCET/UMBC: Huisheng Bian, Associate Research Scientist

NASA: Mian Chin, GSFC; Jose Rodriguez, GSFC; Peter Colarco, GSFC

Other: Henry Sirkirk USRA; Chien Wang, MIT; David Edwards, NCAR

Description of Research

Atmospheric aerosols affect air quality and climate. To pursue scientific objectives of improving atmospheric aerosol simulation and understanding their impact, Huisheng Bian contributed to several scientific studies and assessments. The research includes investigating the impact of the aircraft emissions compiled by FAA ACET dataset on surface PM level, updating and upgrading the photolysis module, fastJX, in GMI to study the impact of core-shell aerosol on photochemistry, and integrating carbon monoxide and aerosol distribution from retrievals, aircraft measurements and regional model for air quality study. The research also involves the study of decadal variations of aerosols in the upper troposphere and low stratosphere and feedbacks between air pollution and weather systems in Asia and their connections with climate variability. Bian is leading the AeroCom III nitrate experiment to understand key controlling factors in nitrate formation and diversity among AeroCom models and participating in the HTAP v2 experiment to investigate source-receptor relationship using GEOS-5 GOCART model.

Accomplishments for Oct 2014 - Sep 2015

Huisheng Bian is a co-I of a newly funded ACMAP project. This project aims to investigate feedbacks between air pollution and weather systems in Asia and their connections with climate variability using an integrated approach of global and regional model simulations. Huisheng Bian has conducted a 14-year (1997-2010) study using a global model GEOS5-GOCART to provide initial and boundary conditions to drive a regional model NEWRF.

Huisheng Bian is a co-I of another ACMAP project that improves the understanding of the impact of aerosols from combustion sources on actinic fluxes. She has implemented an interface in the GMI model that can utilize a new core-shell internal mixture aerosol optical table and mimics the mixing states of aerosols from an otherwise single moment GOCART aerosol model based on projection of mixing and the size-dependent MIT MARC aerosol model. She has provided the results of an experimental run with this work and also a base case run with the GMI original aerosol mass and optical property configuration. In the AURA project that investigates decadal variations of aerosols in the upper troposphere and lower stratosphere, she improved GEOS5-GOCART wet deposition scheme to solve a problem of high-biased modeled BC over remote regions. The improvements include using the GEOS5 internal 3D rain product rate directly in a wet deposition scheme, instead of estimating it based on moisture change and considering snow scavenging. In the FAA ACCRI project that investigates aircraft emission on surface air pollution, mainly ozone and PM2.5, she is in charge of the study of aerosols. She has found that aviation emission can perturb not only the emitted aerosol fields, but also the non-aviation-emitted aerosol fields, such as dust and sea salt, by the change of atmospheric dynamic fields via aerosol-radiation feedback.

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 the AeroCom models and to understand the reasons for the intermodal differences by comparing the 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 participates in the HTAP v2 experiment to investigate source-receptor relationship using GEOS-5 GOCART model. She has finished major experiment simulations and provided the results for a presentation at the HTAP workshop.

Task 343: Volcanic SO_2 Web Pages, (Sponsor: Nickolai A. Krotkov)

JCET/UMBC: Keith D. Evans, Research Analyst

NASA: Nickolai A. Krotlov, GSFC

Description of Research

Evans maintains and expands the Goddard SO_2 web site (so2.gsfc.nasa.gov) posting SO_2 and aerosol images from NASA Aura Ozone Monitoring Instrument (OMI), adding images from new instruments (e.g., NPP/OMPS) and updating heritage (e.g., TOMS) images. Evans ensures continuous timely generation and display of the TOMS and OMI SO_2 images and maintains an archive of the SO_2 maps and images. Evans updates the web site content on a regular basis, continues the long-term record with SO_2 data from NPP/OMPS, and recreates image data as needed.

Accomplishments for Oct 2014 - Sep 2015

The web site currently includes automatic generation of daily OMI and OMPS SO_2 images for volcanic regions. OMPS automatic data processing started in April 2012. Evans wrote software to process SO_2 data from NPP/OMPS instrument. When automatic data processing failed, Evans was able to identify the problem and resolve it quickly.

Evans actively participated in three Working Groups (WG) of the Earth Science Data System Working Group (ESDSWG). Evans contributed to the Geospatial, Airborne and ASCII for Science Data WGs in 2014. Evans participated in the Airborne, ASCII for Science Data and ICARTT WGs in 2015. As Chairman of the ASCII for Science Data Working Group, Evans completed the goals for the 2014 ASCII WG and then started a new ASCII WG for 2015.

Evans received an award for Outstanding Performance Web Development from NASA's Earth Sciences Division/Atmospheres for long-term development of the public Global Sulfur Dioxide web pages.

Task 303: Atmospheric composition, atmospheric radiation, and satellite refurbishment (Sponsors: Jose Rodriquez, Nickolay Krotkov, and Kenneth Pickering)

Sub-Award from Harvard Smithsonian Astrophysical Laboratory: Tropospheric Emissions, Monitoring of pollution (TEMPO) (SV3-83018)

JCET/UMBC: Jay. R. Herman, Senior Research Scientist

Description of Research

The objective of the research is to develop and improve the Pandora spectrometer system to determine ozone and nitrogen dioxide altitude profiles in the atmosphere and validate the results comparing with in -situ balloon instrumentation. Herman corrected a problem with the Pandora optics to enable retrieval of other trace gases such as formaldehyde and bromine oxide. He deployed Pandora at permanent sites to develop long-term records and finished the DISCOVER-AQ campaign analysis for all four campaigns to prepare for the next set of campaigns in Korea (KORUS-AQ).

As Instrument Scientist for EPIC satellite instrument on board the DSCOVR (Deep Space Climate Observatory) satellite, Herman led 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 Harvard Smithsonian sub-award focused on planning for validation for the TEMPO satellite instrument for O3 and NO2 measurements using Pandora spectrometer system. The work employed the developing network of Pandora instruments in the U.S. as well as planned for additional instruments at key locations.

Accomplishments for Oct 2014 - Sep 2015

The Pandora network has been expanded in the U.S. and in other countries. The European Space Agency has adopted the Pandora instrument to validate the upcoming satellites TropOMI and the Sentinel geostationary satellite. They will acquire about 10 instruments per year to be deployed in Europe. Two Pandoras are now active in Canada. In the U.S., the number of permanent sites has expanded to include Boulder, Boston, St. Louis, Huntsville, New York City, Four Corners, Washington DC, and Richmond.

The Pandora optical problem has been solved to permit the detection of additional trace gases.

The Pandora system has now been shown to match the results from standard ozone measuring instruments. The results have been published [Herman et al., 2015]. Six Pandoras have been installed in Korea for use in the 2016 KORUS-AQ campaign. Data is being collected and analyzed from these sites.

A planning meeting for TEMPO was attended where the plans for validation of the TEMPO data were further developed

The DSCOVR spacecraft was successfully launched in February 2015 and reached its orbit in June 2015. Data is now being collected and analyzed. The in-flight calibration process is underway during the commissioning phase. Images of the Earth from the EPIC instrument have been released to the public by the President. A NASA website for the EPIC data has been developed.

Task 323: Management of the Applied Remote Sensing Training Program (ARSET) (Sponsor: Ken Pickering)

Task 360: Coordinate activities with NASA's Air Quality Applied Sciences Teams (AQAST) (Sponsor: Bryan Duncan)

JCET/UMBC: Ana I. Prados, Research Assistant Professor; Amita Mehta, Research Assistant Professor; Brock Blevins, JCET

NASA: Cindy Schmidt, ARC

Other: Pawan Gupta, USRA

Students: David Barbato, UMBC; Kyle Matty, UMBC, and Justin Roberts-Pierel, University of Maryland, College Park

Description of Research

Prados managed the NASA Applied Remote Sensing Training Program (ARSET), which developed online and hands-on courses on the utilization of NASA remote sensing data for water resources, flood monitoring, wildfires, ecological forecasting, and air quality management internationally and in the U.S. The program continued its formal evaluation process via online surveys and to gauge the benefit from their participation in ARSET courses and changes in use of NASA resources. Prados also collaborated with NASA's Air Quality Applied Sciences Team (AQAST).

Accomplishments for Oct 2014 – Sep 2015

For the seventh consecutive year, Dr. Prados managed the NASA Applied Remote Sensing Training Program (Task 323) (arset.gsfc.nasa.gov). The program developed 12 workshops for flood, water resources, air quality, land, and wildfire management. New initiatives during the reporting period included the development of two trainings for wildfire managers, a webinar series dedicated to NASA's Global Precipitation Mission, and the first advanced air quality webinar. The program reached a new record in FY15 by hosting 2163 participants and 734 organizations from 120 countries through online and hands-on workshops.

The ARSET program developed its first webinar series for wildfire applications on March 31-April 28th, 2015. The webinar was designed for land managers at the local, state, and federal levels, non-governmental organizations, international land management agencies, and private sector organizations. There were 278 participants from 178 organizations, 42 countries, and 33 states. Key participant organizations included: the USDA Forest Service (USDA FS), the National Park Service (NPS), the Bureau of Land Management (BLM), the Alaska Fire Science Consortium, the United Nations, and Conservation International. The webinar was a prerequisite for a subsequent hands-on workshop developed as a collaboration between NASA ARSET, Idaho State University's GIS Training and Research Center, and the Idaho Space Grant. The in-person workshop was conducted at Idaho state university, with 41 participants from federal agencies, and state agencies and universities in Idaho and surrounding states.

In May 2015, ARSET developed its first webinar for Conservation Management targeted at non-governmental organizations and federal agencies engaged in conservation management. Through this activity, ARSET engaged 293 participants and 270 organizations in 61 countries and 27 U.S. states. A key accomplishment was enabling NASA to gain visibility of currently-funded Earth Science applications through collaborations with NASA funded PIs who were invited to participate in the webinar as guest speakers and share their research.

The ARSET program was evaluated through the dissemination of project participant surveys prior to and after each training. The results of the surveys were used to assess skills learned and to identify the types management activities that benefited from the ARSET program, and to plan training activities for the next fiscal year.

Prados is a member of the NASA User Working Group (UWG) at the NASA Goddard Earth Science Data and Information Services Center and at the NASA Land, Atmosphere Near real-time Capability for EOS (LANCE). She contributed to both UWGs by using ARSET survey results and input from hundreds of stakeholders to provide direction on NASA datasets and NASA earth science data access capabilities that would be most beneficial to applied science professionals.

Task 313: 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 (Sponsor: Charles Ichoku)

NASA Grant: 13-AURAST13-0033 (Sponsor: Peter R. Colarco)

JCET/UMBC: Adriana Rocha Lima, Post-Doctoral Research Associate

Description of Research

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 for Oct 2014 - Sep 2015

In the initial phase of this research a case study using data from the Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS) campaign and GEOS-5 simulations are been reanalyzed aiming to gain the required familiarity with GEOS-5 variables and with typical modeling tools, such as, age and tracers trajectory analysis. This step is important because similar analysis will be required and applied in the apportionment study of dust sources developed in this study. Additionally, the team has continued efforts to create a database of optical and microphysical properties of dust and volcanic ash in collaboration with the Laboratory of Aerosol, Clouds and Optics (LACO) at UMBC. A paper containing optical and microphysical properties of Saharan dust is in preparation and analysis for the derivation of the spectral imaginary refractive index of several volcanic ashes samples is in progress.

Task 391: In Situ Measurements of Formaldehyde (HCHO) and the Composition of the Lower Atmosphere (Sponsor: Thomas Hanisco)

JCET/UMBC: Jason M. St. Clair, Assistant Research Scientist

Description of Research

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

Accomplishments for Oct 2014 - Sep 2015

Field Work: St. Clair supported the integration of the NASA ISAF (In Situ Airborne Formaldehyde) instruments on two aircraft campaigns, WINTER (Wintertime Investigation of Transport, Emissions, and Reactivity) and SONGNEX (Studying the Atmospheric Effects of Changing Energy Use in the U.S. at the Nexus of Air Quality and Climate Change), as well as the deployment of SONGNEX. WINTER, a NSF-funded project aboard the NCAR C-130, investigated the wintertime atmospheric chemistry along the eastern United States. SONGNEX was a NOAA campaign aboard the NOAA WP-3D and sampled regions of high oil and gas extraction in the Western U.S. to evaluate the air quality impacts of the industry's rapid expansion. The COFFEE instrument was delivered to NASA Ames and a postdoc was trained in its operation, in preparation for test flights and routine weekly flights as part of the AJAX (Alpha Jet Atmospheric eXperiment) payload. St. Clair used the ISAF instrument in a collaborative project at Caltech to evaluate a possible formaldehyde measurement interference. The instrument was subsequently operated by Harvard University and University of Wisconsin students during atmospheric chamber experiments with Caltech.

Data Analysis: Analysis of data collected previously at Caltech was completed, resulting in the publication of a paper in the Journal of Physical Chemistry A on the kinetics and products of hydroxyl radical and ISOPOOH, a major biogenic oxygenated volatile organic carbon species.

Instrument Development: Operation procedures and data processing of the COFFEE instrument were developed over much of FY 14-15, culminating in the delivery of the instrument to NASA Ames. The instrument will, in the future, provide regular profiles over sites in California and provide valuable validation data for upcoming satellite measurements of formaldehyde.

Task 368: In Situ Measurements of Formaldehyde (HCHO) and the Composition of the Lower Atmosphere (Sponsor: Thomas Hanisco)

NASA Grant: Understanding the response of tropospheric chemistry to trends in natural and anthropogenic emissions through in situ and remote observations of formaldehyde (NNX14AP48G)

JCET/UMBC: Glenn M. Wolfe, Assistant Research Scientist

Description of Research

This research utilized in situ measurements of formaldehyde (HCHO) and other gases to study the processes that control the composition of the lower atmosphere. Primary efforts include maintaining and refining sophisticated instrumentation for measurement of HCHO, deployment of these instruments on multiple airborne platforms, and scientific interpretation of the data with a focus on photochemistry and surface-atmosphere interactions. Results from this work improved understanding of fundamental atmospheric chemistry and assisted ongoing efforts to mitigate the impact of anthropogenic activities on air quality and climate.

Accomplishments for Oct 2014 - Sep 2015

Field Work: In the first half of 2015, Wolfe deployed the NASA ISAF (In Situ Airborne Formaldehyde) instrument on two airborne missions. The NSF-sponsored WINTER campaign utilized the NCAR C-130 aircraft to observe atmospheric composition in the eastern U.S. during February and March of 2015. The NOAA-led SONGNEX mission utilized the NOAA WP-3D aircraft to probe the impacts of oil and natural gas extraction (e.g. fracking) on air quality and climate throughout the U.S. during April 2015. ISAF performed well on both missions. For SONGNEX, Wolfe trained a graduate student to run the instrument (M. Thayer, UW Madison). Data analysis for these campaigns is still in the preliminary stage. Expected outcomes include better constraints on direct emissions of HCHO from fossil fuel combustion (WINTER) and natural gas flaring (SONGNEX), both of which are important aspects of the anthropogenic influence on atmospheric composition.

Data Analysis: Wolfe completed the analysis of airborne fluxes discussed in the previous JCET report. Briefly, this analysis provides quantitative, direct information on the rates of key processes like emission, chemical production/loss and deposition for a wide range of gases central to atmospheric chemistry. This effort represents a new frontier in the field of atmospheric chemistry. A manuscript on this work has been accepted for publication in Geophysical Research Letters. Wolfe has also refined an analysis of data collected in 2013 over the southeast U.S., dealing with the relationship between emissions of isoprene (a major reactive hydrocarbon released from vegetation) and the production of HCHO. Satellite-based HCHO retrievals are often used to infer isoprene emissions, and this relationship is a crucial component for accurate calculations. A manuscript on this work has been prepared and will be submitted for publication sometime in 2015.

Model Development: Wolfe maintains a 0-dimensional chemical box model for use by the atmospheric chemistry community. This model was originally developed during Wolfe's graduate work but has since expanded in both utility and popularity. It is used by at least 9 research groups, and at least 1 professor is using it for undergraduate instruction. Wolfe works with these groups on issues related to model setup and troubleshooting and has implemented numerous code upgrades over the last year.

Instrument Development: Wolfe is also involved in a new effort to build a NASA airborne system for direct measurements of surface-atmosphere exchange of greenhouse gases (CH_4 and CO_2). For this mission, the NASA Sherpa aircraft will be equipped with modified commercial off-the-shelf instrumentation and advanced 3-dimensional wind measurements for calculation of eddy covariance fluxes. Work is currently underway to characterize the instrumentation and prepare it for deployment.

Task 357: Making Earth System Data Records for Use in Research Environments (MEASURES), (Sponsor: Nickolai Krotkov)

JCET/UMBC: Leonid Yurganov, Senior Research Scientist; Keith Evans, Research Analyst

NASA: Nickolai Krotkov, GSFC

Other: Simon Carn, Michigan Technological University

Description of Research

Yurganov applies satellite gaseous composition data to problems of air pollution and climatic change. Sulfur dioxide (SO_2) is erupted by volcanoes into the middle and upper atmosphere . It is further converted into aerosol particles. In some cases these particles may reside in the atmosphere for several years. The volcanic aerosol is an important component in the global climate models. A part of the entire MEASURES project that is lead by Dr. Yurganov is development and quantification of the infrared retrieval techniques for SO_2 using radiation data gathered by NASA satellites (Atmospheric InfraRed Sounder(AIRS)/Aqua, Cross-track Infrared Sounder (CrIS)/Suomi).

Accomplishments for Oct 2014 – Sep 2015

The activity during the second half of 2014 focused on development of FORTRAN code that eventually would be incorporated into standard NASA retrieval procedures. In an attempt to include maximum real information about the atmospheric state, Dr. Yurganov used data archived by the Earth Observing System Data and Information System (EOSDIS) and the Global Modeling Initiative (GMI). Profiles of temperature and humidity were taken from Modern-Era Retrospective Analysis For Research And Applications (MERRA) or Goddard Earth Observing System Model (GEOS-5). Surface emissivity data were provided by monthly AIRS Level 3, V6. Daily mean surface skin temperature data were taken from daily AIRS Level 3, V6 files. In a case when monthly AIRS data are unavailable, the emissivity may be used for the same month of the previous year. Three retrieval algorithms for AIRS and one algorithm for OMI gave similar patterns of the plume from this volcano for daytime conditions of 14 February 2014 eruption of the Kelut volcano. To reconcile the available algorithms, a decision on developing FORTRAN codes based on UMBC algorithms has been made. To ensure a better reliability, a development of another code has been proposed. This code written in FORTRAN has been developed in 2014-2015 and the results of calculations were compared with other retrievals. The vertical sensitivity of the AIRS retrieval technique has also been investigated. It was found not to be sensitive below 5 km of altitude because of insufficient spectral resolution and high humidity in the low troposphere.

NASA grant: Long-term Satellite Data Fusion Observations of Arctic Ice Cover and Methane as a Climate Change Feedback (NNX14AR41G)

JCET/UMBC: Leonid Yurganov, Senior Research Scientist

Other: Ira Leifer, Bubbleology Research International (BRI); Robert Chen University of Southern Florida; Frank Muller Karger, University of Southern Florida.

Description of Research

Atmospheric CH_4 has more than doubled during the last century, yet sources remain poorly constrained. Future emissions from the methane sources (e.g., wetlands, termites, etc.) have greater uncertainty, while future emissions from largely unquantified sources - e.g., hydrates, permafrost, geology, remains speculative. The Arctic shelf and slope contain a majority of the organic carbon pool, representing more than 86.5% of the Arctic Ocean sedimentary basin, the "Arctic carbon hyper pool," sequestered under permafrost. Satellite-based CH_4 remote sensing is possible using the thermal infrared (TIR), whose sensitivity primarily lies in the mid- and upper troposphere and is used by satellite-based instruments like AIRS (since 2002) and IASI (since 2007). In this project Yurganov is responsible for preparation, validation, and analysis of all satellite methane data.

Accomplishments for Oct 2014 – Sep 2015

The AIRS and IASI publicly available methane data have been downloaded and analyzed. It was concluded that over a thick ice cover in winter time the vertical temperature contrast is insufficient for a reliable methane retrievals. However, over open water with the Thermal Contrast (ThC) above 10 K methane low tropospheric concentration can be measured. These conditions are typical for the summer-autumn everywhere, and at the Western Arctic Ocean year-round. The satellite retrievals agree with surface measurements at a Spitsbergen coastal observatory: maximum in winter and minimum in summer. After a significant averaging (all seasons from 2010 to 2014) three oceanic source areas have been found: West of Spitsbergen, North of Norway, and West of Novaya Zemlya. A significant methane emission starts at the end of October and proceeds until January (every year) or March (mostly in 2013). According to a preliminary estimate, the Arctic Oceanic methane emission is comparable with emission from the continental Arctic to the North from 60° N (10-50 Tg CH_4 per year).

Cryospheric Sciences Laboratory (Code 615)

Task 373: Climate data record development for surface temperature data for Greenland ice sheet locations (Sponsor: Dorothy Hall)

Task 388: Evaluation of reanalysis data and satellite indicators of melt events over the Greenland ice sheet (Sponsor: Sirpa Häkkinen)

Task 390: Assessment of modeled temperatures over the Greenland ice sheet (Sponsor: Sophie Nowicki)

NASA Grant: Revision and updating of Landsat 7 data users handbook (PI: James Irons) (NNX15AE10G)

JCET/UMBC: Christopher Shuman, Research Associate Professor; Michael Schnaubelt, Research Associate

NASA: Dorothy Hall, GSFC; Sirpa Häkkinen, GSFC; Sophie Nowicki, GSFC; James Irons, GSFC

Other: Richard Cullather, ESSIC/University of Maryland, College Park; Samiah Moustafa, RU-NB; Ted Scambos, NSIDC; Etienne Berthier, LEGOS; Ginger Butcher, SSAI

Description of Research

Shuman continued to work with Drs. Hall and Nowicki at GSFC to study temperature records in central Greenland's 'Summit' Station area. Preliminary discussions have also been made regarding the Dome C location in East Antarctica. Shuman's efforts with Dr. Nowicki have expanded this work more broadly across Greenland including investigations of the MERRA and other reanalysis products. The project with Dr. Häkkinen concluded during the reporting period. Dr. Shuman is also working with Dr. James Irons and Ginger Butcher at GSFC, among others, to revise the out-of-date

Landsat 7 Science Data User's Handbook. This activity has become essential to the joint NASA-USGS program as there have been many changes to Landsat 7's ETM+ sensor since its launch in April 1999. Dr. Shuman continued to collaborate with Dr. Scambos and Dr. Berthier to assess ongoing changes to the Antarctic Peninsula's ice cover. Because of the scale of these changes and the ease of visualizing them, Dr. Shuman has been able to utilize remote sensing imagery to show the ice changes on NASA's hyperwall and also in poster format for events at NASA and UMBC. Such education and outreach activities remain an area of interest both at GSFC and UMBC.

Accomplishments for Oct 2014 – Sep 2015

The past year's efforts generated the content for a paper that quantifies why standard AWS from ice sheet locations may provide inconsistent data for satellite calibration studies. This activity led by Dr. Shuman and supported by former UMBC Graduate Student Michael Schnaubelt was begun with support by Dr. Hall on Task 373 and was later supported by Dr. Nowicki on Task 390. 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, Dr. 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 both the Fall AGU 2014 meeting and also at the NOAA GMAC conference (www.esrl.noaa.gov/gmd/annualconference/) as well as an invited talk at a splinter meeting of researchers working at the Greenland Summit. The initial goal was to use these high-temporal resolution data to assess MODIS IST data being used for a CDR but has expanded to become a valuable reference data set for assessing reanalysis products such as MERRA-2. This effort is currently being developed for a joint publication with Dr. Nowicki and her collaborator here at GSFC, Dr. Cullather. A preliminary version of this material was presented at the EGU meeting in Vienna, Austria. Additional work with Dr. Hall also documented that an AWS at Dome C in East Antarctica was providing unreliable temperature data due to a lack of station maintenance. Supported by Dr. Irons and Ms. Butcher, the handbook revisions have been surprisingly extensive and soon all thirteen chapters will be passed to a NASA-USGS review committee for editing and revision. Once final edits have been made, a new version will then be formatted for online access.

Shuman was also engaged on other activities at GSFC. In addition to those above, he assisted a visiting Ph.D candidate, Samiah Moustafa, with some data analysis that helped lead to the publication of a paper 'Multi-modal albedo distributions in the ablation area of the southwestern Greenland Ice Sheet' [Moustafa et al., 2015]. Shuman continued his collaboration with Drs. Scambos and Berthier to help publish an additional paper in a multi-year research series. Their latest effort updated and expanded assessments of ice area and ice mass losses from the Antarctic Peninsula during 2001-2011 [Scambos et al., 2014]. This paper, 'Detailed ice loss pattern in the northern Antarctic Peninsula: widespread decline driven by ice front retreats' is now published. Another paper on an adjacent ice shelf remnant is now in review and a presentation is planned at Fall AGU.

Ocean Ecology Laboratory (Code 616)

Task 370: Suomi-NPP Science Team Ocean Color Science (Sponsor: Carlos Del Castillo)

NASA Grant: Extension of the MODIS Ocean Color Time-Series to S-NPP/VIIRS: Marine Remote Sensing Reflectance and Derived Products (NNH13ZDA001N)

Task 382: HyspIRI Aquatic Studies Group (Sponsor: Betsy Middleton)

Task 389: JPSS/VIIRS Prelaunch Instrument Performance Analysis (Sponsor: Jim Butler)

JCET/UMBC: Kevin Turpie, Research Associate Professor

Description of Research

Remote sensing of the ocean biosphere on global and synoptic scales provides vital information for research applications such as large-scale modeling biogeochemical cycles and their response to climate change. Kevin Turpie leads research efforts in evaluation of ocean color remote sensing for the Suomi National Polar-orbiting Partnership (S-NPP) Visible Infrared Imaging Radiometer Suite (VIIRS). He is a subject matter expert for the testing program for the next VIIRS instrument aboard the J1 spacecraft, part of the Joint Partnership Satellite System (JPSS) mission. He is also the founding chair of the Hyperspectral and Infrared Imager (HyspIRI) Aquatic Studies Group (ASG), overseeing the development of coastal and in-land water aquatic remote sensing and is a member of the HyspIRI Science Study Group. Turpie continued work with the GSFC Coastal Interdisciplinary Science Task Group.

Accomplishments for Oct 2014 – Sep 2015

A new S-NPP science team was selected and funding began early in the fiscal year. Turpie was part of the Goddard ocean color team, contributing data quality analysis, calibration, and played the role of liaison to NOAA. The year began with the publication of a paper by Eplee, Turpie et al. in Applied Optics, which demonstrated unprecedented accuracy in the calibration of S-NPP VIIRS, with uncertainties of only a couple tenths of a percent. This improved calibration was possible in part by the reduction or removal of various autocorrelated artifacts in the calibration time series. Turpie re-evaluated the calibration trend uncertainty, which were nearly halved as a result. He also quantified the extrapolation uncertainty for extending the calibration trend into the forward processing stream for the first time, suggesting new protocols for how far such extensions can be trusted and under what conditions. Turpie introduced an analytical method to assess the propagation of uncertainty from instrument artifacts and other error sources to derived remote sensing data products for ocean observations. Collaborative work continued to be coordinated with the VIIRS Calibration Support Team (VCST) and findings were shared with related NOAA teams.

Turpie contributed to requirements and testing discussions for the JPSS VIIRS instruments, including participating in meetings of the Data Analysis Working Group during ambient testing of J1 VIIRS. Turpie was provided analysis and recommendations regarding anomalies observed in the polarization response characterization of the instrument. In particular, he employed optics model results to quantify variation in the sensor spectral response as a function of polarization state of input light. He was an observer at the Raytheon laboratory where the NIST SIRCUS laser was used to verify and further characterize this phenomenon. Evaluation of how changing spectral response effects VIIRS Earth measurements were included in a publication providing a narrative of the polarization testing.

Turpie continued to work with the HyspIRI project management, including the HyspIRI Steering Committee; the Science Study Group (SSG); and he continued to chair the ASG. The ASG is an internationally-scoped organization of over seventy researchers and scientists chartered to collect and synthesize input from the hyperspectral aquatic community and literature to define an aquatic hyperspectral data product suite for HyspIRI. At the beginning of 2015, the ASG form an Executive Community to help plan and steer activities of the ASG. The ASG organized two panel discussions at Ocean Optic XXII in October of 2014, continued the community dialogue at the 3rd Annual HyspIRI Aquatic Forum in June 2015, and coordinated a joint hyperspectral breakout session at the International Ocean Color Science meeting in June 2015. These community discussions focused on the potential and challenges of hyperspectral remote sensing in coastal and inland waters. The aquatic community contributed an equal portion to land oriented paper to a special issue of Remote Sensing of Environment on HyspIRI, including Turpie's survey paper on applications of HyspIRI technology to wetlands.

Biospheric Sciences Laboratory (Code 618)

Task 306: **Spectral Reflectance and Fluorescence Indicators of Ecosystem Physiology, Scientific Support for NASA's Earth Observing 1 (EO-1) Mission and Hyperspectral Infrared Imager (HyspIRI) Mission Concept (Sponsor: Elizabeth Middleton)**

JCET/UMBC: Petya Campbell, Research Associate Professor; K. Fred Huemmrich, Research Associate Professor

NASA: Elizabeth Middleton, GSFC

Other: Q. Zhang, USRA; L. Corp, Sigma Space Corp.; Y-B. Cheng, ERT

Description of Research

This research was conducted in support of future missions (e.g., Hyperspectral Infrared Imager (HyspIRI), Pre Aerosol-Cloud-Ecosystem (PACE), EnMAP, FLEX) by providing optimal remote sensing strategies and a critical modeling tool for monitoring ecosystem stress (i.e., down-regulation of GEP) and a better understanding of the role of canopy structure in defining ecosystem carbon uptake. It is relevant to NASA's program on plant functional types and physiology, and supports research to justify missions currently under development by several agencies, including NASA and the European Space Agency.

Spectral Bio-Indicators of Ecosystem Physiology, using Surface Reflectance and Fluorescence

Measuring, monitoring, and modeling the carbon dynamics of our terrestrial ecosystems is a critical goal of NASA. Significant effort has been devoted to developing remote sensing (RS) techniques for monitoring plant stress and photosynthetic status and it is recognized that these processes can most efficiently be achieved at a regional and global level from space-borne platforms. However, the majority of conventional RS approaches, using reflectance measurements are not sensitive to the rapid changes in plant photosynthetic status associated with common environmental stressors, such as diurnal fluxes in radiation, heat, and water. Most reflectance derived vegetation products have no direct link to photosynthetic functioning beyond their sensitivity to changes in canopy structure and pigment concentration. Plants commonly absorb more solar radiation than can be used for photosynthesis and excess energy is expelled in the form of fluorescence (Fs), and/or is dissipated through non-photochemical quenching (NPQ). Consequently, Fs and NPQ provide sensitive indicators of photosynthetic function. In this task, high spectral resolution reflectance data is obtained for vegetation over a range of functional types, species, phenology, and stress conditions and evaluated to establish spectral algorithms that perform rigorously describing vegetation diversity, photosynthetic function and efficiency. These relationships are developed both through empirical studies and physically-based models.

Support for the Earth Observing 1 (EO-1) Mission Science Office

This effort provides science support for the EO-1 Mission Science Office. Science support activities include: i) developing new EO-1 science demonstration products, as well as prototype products for the Hyperspectral Infrared Imager (HyspIRI); ii) conducting terrestrial calibration studies, and participating in international cal/val activities and organizations; iii) providing technical interface for the scientific user community, including the NASA HyspIRI mission concept team; and iv) examining approaches for future instruments for sustainable land imaging (SLI). This work supports the collection and use of EO-1 imagery by helping to identify sites to be imaged, evaluating atmospheric correction algorithms for surface reflectance, developing time series of images of vicarious calibration sites to evaluate instrument stability, and predicting and monitoring effects of changes in overpass time.

The science support activities include finding new uses for EO-1 data, developing and testing approaches for the use of hyperspectral imagery and taking advantage of EO-1 ability to collect multitemporal observations of sites located in a number of different ecosystem types. This effort focuses on the detection of ecosystem stress, determining productivity, and describing vegetation types and biodiversity. The task also examines how hyperspectral data can be convolved to broader multispectral bands to simulate observations from multispectral instruments, such as the Operational Land Imager (OLI) on Landsat 8, and to test the effects of broader bands on algorithms for retrieving biophysical variables.

Developed as a technology demonstration mission, EO-1 has evolved into a global sampling and enabling mission within the NASA Earth Science Program. The EO-1 satellite contains two operating passive Earth observing instruments with high spatial resolution (30 m): Hyperion and the Advanced Land Imager (ALI). Hyperion, is a full-spectrum (400-2500 μm) imaging spectrometer with 10 nm spectral resolution. ALI was the prototype for the Operational Land Imager (OLI) on Landsat-8 (i.e., Landsat Data Continuity Mission, LDCM), with a 10 m panchromatic (Pan) band and push broom multispectral (MS) sensor with radiometric properties that exceed those of the Landsat-7 Enhanced Thematic Mapper Plus (ETM+) instrument. EO-1 has been collecting data for over 14 years, well beyond its planned original mission. Over that time it has acquired a unique globally distributed sampling of hyperspectral imagery, with imagery continuing to be collected.

Hyperspectral Infrared Imager (HyspIRI) Project Support

The Hyperspectral Infrared Imager (HyspIRI) is a Tier 2 priority mission recommended in the 2007 National Research Council Decadal Survey. HyspIRI is in the pre-formulation development phase with no official assigned launch date. HyspIRI includes two instruments: an imaging spectrometer measuring from the visible to short-wave infrared (VSWIR: 380 nm - 2500 nm) and a multispectral thermal (TIR) imager measuring from 3 to 12 μm. The instruments have a spatial resolution of 60 m at nadir with revisits of 19 days and 5 days for the VSWIR and TIR respectively. There will also be an Intelligent Payload Module (IPM) on board that will enable on-board processing and direct broadcast of some data. Among the uses of HyspIRI data will be to support studies in the Carbon Cycle and Ecosystem focus areas.

The use of simultaneously acquired surface reflectance and emissivity data enables the evaluation of a number of ecological parameters (e.g., canopy water, pigment content and photosynthetic function) that can be used to detect stress responses and improved species characterization and separation. These synergistic applications of optical spectroscopy and thermal emissivity satellite data are of importance for the development of improved and more effective operational natural resources monitoring system, including vegetation, soil, water and natural disaster assessments, for providing understanding of ecosystem function and sustainability, and sound predictions regarding the effects of climate change. A key activity is to perform studies to develop and test algorithms that demonstrate uses of HyspIRI data to meet mission goals.

Accomplishments for Oct 2014 – Sep 2015

Support for the Earth Observing 1 (EO-1) Mission Science Office

Campbell and collaborators conducted comparisons of current data products, generated by multiple systems. For multiple ecosystems was assembled Hyperion reflectance and contemporaneous flux and environmental data provided by AmeriFlux collaborators, from tower sites representing a range of ecosystems. High performance of candidate spectral bio-indicators and continuous spectral parameters were evaluated for remote sensing application at ecosystem scales at the AmeriFlux a sites, using statistical approaches and radiative transfer modeling tools.

Hyperspectral Infrared Imager (HyspIRI) Project Support

Campbell completed the AVIRIS and MASTER data processing and analysis and established that the use of simultaneously acquired surface reflectance and emissivity data enables the simultaneous evaluation of a number of ecological parameters (e.g., canopy water, pigment content and photosynthetic function). Such analyses are required for assessing the effects of urban expansion on ecosystem function, diversity and local climate. The study established strong relationship between vegetation reflective and thermal properties, which provides strong potential for improved species characterization and separation. The 60m HyspIRI-like data provides a powerful capability for the assessment of vegetation function and the detection of stress, and the combination of high spectral resolution optical and thermal infrared imagery of the proposed HyspIRI mission provides a much more powerful capability for ecosystem analysis and monitoring than is presently possible using the current satellite systems. The synergistic applications of optical spectroscopy and thermal emissivity satellite data are of importance for the development of improved and more effective operational natural resources monitoring system, including vegetation, soil, water and natural disaster assessments, for providing understanding of ecosystem function and sustainability, and sound predictions regarding the effects of climate change.

The GSFC team conducted HyspIRI Scientific Symposia. Campbell contributed in the organization, led discussion groups and presented her research.

Task 320: Joint development of algorithm and analytic techniques from a variety of data sources (Sponsor: Jeff Masek)

JCET/UMBC: Forrest G. Hall, Senior Research Scientist

Description of Research

The Investigator collaborated with GSFC and university scientists (Oregon State and University of Lethbridge, Alberta Canada) to develop processing approaches permitting the use of MODIS TERRA, AQUA and Landsat data to investigate changing vegetation cover in the Amazon and in the Canadian boreal forests.

Accomplishments during Oct 2014 - Sep 2015

Dr. Hall co-authored one paper in *Remote Sensing of Environment*, one in *Environmental Research Letters* and one in the *Canadian Journal of Remote Sensing*. The Investigator wrote a proposal as PI to participate with Dr. Jeff Masek in NASAs ABoVE arctic investigation. Together with Dr. Scott Goetz (WHRC), Dr. Hall organized and lead a workshop at the Goddard Space Flight Center in October 2014 to address the challenge of advanced planning for the NASA Earth Science Division. The workshop involved 50 scientists from institutions and agencies including NASA, USGS, USFS, NSF, NOAA and DOE engaged in terrestrial ecology, carbon cycle, land use and land cover change, and biodiversity (TECLUB) research. Dr. Hall co-authored, with Dr. Goetz, a summary that was submitted to the NRC Decadal Survey that was based on a more extensive report (cce.nasa.gov/cce/pdfs/TECLUB_Final_Report.pdf). Dr. Hall also attended NASA's Hyspiri workshop at GSFC.

Dr. Hall delivered invited popular lectures on climate change and quantum theory to Howard County Executive Council, the Montgomery College Scholars and the Johns Hopkins Odyssey program. Hall delivered an invited paper to the Canadian Remote Sensing Symposium held in St. John's Newfoundland. Dr. Hall taught Physics 335, Atmospheric Physics and Chemistry, in UMBC's Physics Department.

Task 305: NASA Earth Observing-1 (EO-1) Mission, Scientific support for Hyperion data analysis and product development and NASA HyspIRI Mission, Scientific support for HyspIRI mission planning (Sponsor: Elizabeth Middleton)

NASA Grant: Defining a MODIS Light Use Efficiency Product (NNX14AJ65G)

JCET/UMBC: K. Fred Huemmrich, Research Associate Professor; Petya Campbell, Research Associate Professor

NASA: Elizabeth Middleton, GSFC

Other: Q. Zhang, USRA; L. Corp, SSAI; D.R. Landis, GST; Jiangfeng Wei, U. Texas Austin

Description of Research

The focus of the first part of this project is to develop and evaluate approaches for using satellite-based imaging spectroscopy to answer NASA Earth Science and Applications questions. The EO-1 mission carries the Hyperion imaging spectrometer, which has been collecting data since 2000 and acquiring over 80,000 images in that time. HyspIRI (Hyperspectral Infrared Imager) is a proposed NASA mission to fly an imaging spectrometer and multispectral thermal imager. Research focuses on the use of hyperspectral imagery of landscapes to determine biophysical characteristics of vegetation, and to link those characteristics to carbon fluxes, plant growth, biodiversity, and disturbances. Hyperspectral and narrow-band multispectral data can detect changes in apparent leaf spectral reflectance due to biochemical status or fluorescence associated with plant stress. Combining reflectance data with in situ measurements of carbon flux provides opportunities to link vegetation photosynthetic rates to spectral reflectances. Leaf level measurements are used in models merging canopy reflectance with photosynthesis models to examine relationships between spectral reflectance and carbon, water, and energy fluxes. These relationships are also explored at a canopy level using canopy-level reflectance measurements combined with ecosystem carbon flux measurements from flux towers and extended to wider scales using aircraft and Hyperion data. This understanding provides the basis for algorithm development for HyspIRI.

The focus of the second part of this research is to retrieve the fraction of photosynthetically active radiation absorbed by chlorophyll (fAPARchl) from available spaceborne observations (e.g., Terra/MODIS and Aqua/MODIS, Landsat, and EO-1 Hyperion) for quantifying both spatial variation and temporal dynamics of chlorophyll content for the continental US. fAPARchl is a key limiting factor in determining ecosystem gross primary production (GPP). Time series of geospatial datasets of fAPARchl and derived GPP for the continental US region will be derived from MODIS data as 8-day composites at 1000-m spatial resolution for 2000 – 2011. The fAPARchl product from MODIS will be integrated into the most recent version of the Community Land Model (CLM) to improve the model's simulation of surface fluxes reducing uncertainties due to ecosystem feedbacks.

The goal of the grant-funded study is to develop a measurement of ecosystem Light Use Efficiency (LUE) based on MODIS surface reflectance products through an analysis of MODIS reflectances, including both land and ocean bands, with LUEs calculated from data from the global network of eddy covariance flux towers. From these datasets the effects of a number of factors are to be evaluated, including: the best choice for spectral bands, effects of view/solar angles, cloud screening and quality evaluation approaches, variations in relationships for different vegetation types along with approaches for stratifying landscape for applying these relationships, and the effects of spatial heterogeneity. The goal of this study is to develop an understanding of these factors, organize the information into a usable algorithm, and describe its accuracy. The merger of the global flux network with global MODIS observations makes possible observations of a variety of vegetation types under a wide range of environmental conditions leading to the information needed to derive a robust algorithm that will be described in an Algorithm Technical Basis Document (ATBD).

Accomplishments for Oct 2014 – Sep 2015

For the first part of this project, the focus was to examine vegetation spectral reflectance changes associated with stress in a detailed manner, field experiments were conducted where measurements of leaf level spectral reflectance and fluorescence along with leaf photosynthesis were made in conjunction with measurements of whole canopy reflectance, fluorescence, and carbon exchange. This fieldwork was performed in a cornfield in collaboration with Department of Agriculture scientists. A tower-mounted automated spectrometer measures diurnal and seasonal changes in canopy-level spectral reflectance, surface temperature, and fluorescence. This automated system is a prototype for future systems for calibration and validation of HyspIRI and other proposed missions, such as the European Space Agency (ESA) Fluorescence Explorer (FLEX) mission. Results find short-term changes in apparent spectral reflectance are associated with photosynthetic down-regulation and the reduction of carbon uptake by the plants. Results were presented at the Fall American Geophysical Union meeting, the Ameriflux annual meeting, and the North American Carbon Program meeting.

Hyperion imagery was matched with ecosystem carbon flux data from the global network of eddy covariance towers representing a variety of different globally-distributed vegetation types. Spectra were compared with ecosystem respiration, productivity, and Light Use Efficiency (LUE) calculated from the flux tower data. The best spectral vegetation index (SVI) for LUE, out of 107 tested, was based on spectral derivatives (R^2=0.5). Going beyond traditional SVI, data mining approaches were applied to this diverse dataset to provide insights into other productive approaches. Partial Least Squares Regression (PLSR) utilizes all of the spectral information, trained using randomly selected subsets, and applied to the rest of the data produce R^2 values over 0.7 for LUE. A second analysis using data sampled throughout the entire growing season indicate PLSR can also describe seasonal change in different vegetation types. Further analysis is required as the regression equations do not transfer between these two datasets.

For the second part of this project, analysis was conducted using the photochemical reflectance index (PRI) from MODIS, relating it to ecosystem light use efficiency, a variable linked with GPP, as measured by flux towers. PRI is related to fAPARchl.

For the grant-funded study, software was developed to extract MODIS surface reflectance data for both land and ocean bands, which are now available from the Collection 6 reprocessing, for areas around given locations. MODIS data have been extracted for 18 different flux tower sites, these data were merged with carbon, water, and energy fluxes, along with meteorology data, from the flux towers. These data have been analyzed to evaluate the use of band combinations and spectral indices to determine optimum approaches to retrieve ecosystem GPP.

A Chlorophyll-Carotenoid Index (CCI), using a combination of land and ocean bands from MODIS, has been developed that, in particular, detects seasonal changes in evergreen forests that are difficult to observe using traditional vegetation indices. CCI has been shown to be related to chlorophyll to carotenoid ratios in evergreen needles as well as being related to needle-level photosynthesis. These results appear to carry over to evergreen needle-leaf forests as well.

Huemmrich made a presentation on the use of MODIS data to determine ecosystem GPP to the MODIS science team and presented a poster on the topic at the NASA Joint Earth Science Meeting.

CASIS Grant: Hyperspectral Remote Sensing of Terrestrial Ecosystem (GA-2014-142)

JCET/UMBC: K. Fred Huemmrich, Research Associate Professor; Petya Campbell, Research Associate Professor

Description of Research

This study is working toward developing approaches using continuous high spectral resolution imaging from the Hyperspectral Imager for Coastal Ocean (HICO) to determine carbon fluxes and light use efficiency for different terrestrial vegetation types under varying environmental conditions. This study utilizes spectral approaches to directly measure biochemical changes in vegetation reflectance associated with photosynthetic downregulation, leaf nutrient status, and leaf pigment content. Vegetation stress responses govern the dynamics in carbon dioxide fluxes as directly measured by eddy covariance techniques at flux tower sites on the ground. Vegetation function also varies throughout a day following diurnal changes of light, temperature, and humidity and controls carbon exchange between ecosystems and the atmosphere. Other than the International Space Station (ISS), no orbital system is currently capable of delivering consistent high spectral resolution observations of a number of sites at different times of day, uniquely providing the ability to assess both seasonal and diurnal responses for a variety of terrestrial ecosystem types.

Accomplishments for Oct 2014 – Sep 2015

Huemmrich identified study sites, focusing on a grassland site in Lethbridge, Alberta and acquired 17 usable HICO images of the site collected in different times of the growing season over three years. The images were atmospherically corrected to surface reflectance and matched with carbon flux data from the eddy covariance flux tower at the site. Multiple approaches using a number of different spectral bands were found to successfully estimate GPP at the time of the ISS overpasses. Some HICO observations were made at different times of the day and collected over a period of a few days. These data allowed a comparison between the observed diurnal change in GPP and an estimated diurnal change estimated from HICO.

Huemmrich presented posters on the results at the ISS Research and Development meeting and the HyspIRI Science and Applications Workshop.

Task 363: A Comprehensive Operational and Science Evaluation of Algorithm MAIAC for the MODIS Land Processing (Sponsor: Alexei Lyapustin)

JCET/UMBC: Yujie Wang, Associate Research Scientist, JCET;

NASA: Alexei Lyapustin, GSFC

Description of Research

The main objective of Wang's research consists of four areas: operational performance of the Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm; adapting the MAIAC algorithm for GOES-R related risk reduction activities; conducting MODIS/VIIRS calibration-validation analysis for surface reflectance products; and 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 priori constraints are approximate, and limit the accuracy and/or applicability of the current operational aerosol/atmospheric correction algorithms. On the contrary, The MAIAC algorithm is an algorithm for simultaneous retrieval of the aerosol optical thickness and surface bidirectional reflectance from MODIS. It uses the time series of gridded geolocated and calibrated L1B MODIS measurements, and an image-based rather than pixel-based processing. If we take into account the facts that the surface changes much slower than measurement frequency and the AOT varies over rather large scale, the number of measurements will be more than the number of unknowns, which becomes a solvable problem. The new algorithm is generic and works over vegetated regions of the Earth as well as over bright deserts. The aerosol retrievals are performed at high 1 km resolution, which is a highly requested product in different science and application disciplines, such as Air Quality/Urban Pollution. MAIAC has an advanced cloud mask (CM) and an internal dynamic land-water-snow classification that helps the algorithm to flexibly choose a processing path in changing conditions.

Accomplishments for Oct 2014 – Sep 2015

Wang worked on MAIAC algorithm improvement, tested large scale areas with various land surface types and aerosol features over North America, South America, Europe, and part of Africa, Asia regions. The results were used for aerosol mode improvements, also distributed to user communities and used in air quality, ecosystem studies.

MAIAC algorithm is close to operational stage for global data production. Dr. Wang has successfully transplanted MAIAC research code into operational code, so it can run in MODIS Adaptive Processing System (MODAPS) for regular production. In addition, Dr. Wang also implemented ancillary data processing code so it can be ingested into MAIAC. All these codes have been successfully tested in MODAPS.

In order to further improve the performance of MAIAC code, Wang implemented parallel MAIAC code using Message Passing Interface (MPI). This code dramatically improved the efficiency of MAIAC code. The test results show that in the NASA NCCS supercomputer environment, the processing time for North American region has dropped from two weeks to three days.

Wang also adapted the 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, which is an important part of GOES-R project.

Heliophysics & Solar System Divisions (Codes 670--690)

NASA Grant: Understanding Near-Equator Geomagnetic Spots via Data Assimilation (NNX12AP31G)

NASA Grant: Climate studies using AIRS, radiative transfer and spectroscopy (NNX14AK58G)

NASA Grant: Improvements to AIRS Forward Modeling (NNX14AK57G)

JCET/UMBC: Andrew Tangborn, Research Associate Professor; Sergio DeSouza-Machado, Research Assistant Professor; Larrabee Strow, Research Professor

NASA: Weijia Kuang, GSFC

Description of Research

Research was carried out in two basic areas of Earth sciences: geomagnetism and satellite observations of the atmosphere using the Atmospheric Infrared Sounder (AIRS), supported by three NASA grants. The work on geomagnetism involved the development and application of geomagnetic data assimilation methods to study the source and evolution of the Earth's magnetic field. The work on AIRS observations encompassed technical improvements to the radiative transfer model (RTM) and use of the observations to study climate variability.

Accomplishments for Oct 2014 - Sep 2015

Development work on the geomagnetic data assimilation system (MoSST-DAS) continued during the past year. The team is currently using the system to help understand the uncertainty in geomagnetic field models, which are used as observational inputs into the data assimilation system. For example, the sensitivity of modern day geomagnetic forecasts are studied by perturbing observations hundreds of years in the past. In this way, the team intends to learn more about the accuracy of early era geomagnetic observations and field models. The time rate of change of the geomagnetic field (called the secular variation or SV) can be used as an observational constraint.

Work on AIRS observations is divided into improvements to the Stand Alone Radiative Transfer Algorithm (SARTA) and applications to climate studies. The former involves applying SARTA to high accuracy sonde data, combined with analysis fields from the European Center for Medium Range Forecasts (ECMWF) to calculate top of the atmosphere radiances that can be compared with AIRS observations. This is being used to improve the parameterizations in the SARTA model. The climate variability study uses AIRS observations over a 13 year period to study climate extremes in terms of the radiance measurements. The team makes use of the fact that different AIRS channels are sensitive to a wide variety of atmospheric properties and different levels of the atmosphere. In this way, information on climate extremes may be extracted, including how they are changing in time.

Office of Education (Code 160)

Task 378: NASA's Beginning Engineering, Science and Technology (BEST): Educator Professional Development (EPD) (Sponsor: Dean Kern)

Subcontract: Howard County Public Library System (HCLS) (from IMLS Grant: HiTech: The Road to a STEM Career)

Subcontract: Johns Hopkins University, Center for Talented Youth (CTY)

JCET/UMBC**:** Susan Hoban, Senior Research Scientist; Laurie Cook; Instructional Designer; Catherine Kruchten, Instructional Designer; Michelle Graf, GEST

Other: Angela Brade, HCLS; Gary Brandt, Northwest Indian College

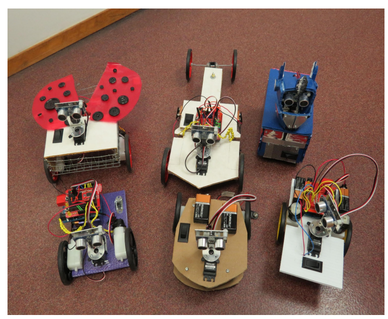
Students: Matthew Koert, Alexis O'Malley, Julio Roman, James Warshaw (UMBC Undergraduate Students)

Description of Research

The JCET STEM team provides professional development for educators and curriculum support resources with a space exploration theme for engineering clubs for elementary and middle school students and for robotics clubs for high school students. The NASA's BEST Students project involves research, development and application of educational technologies to communicate NASA science and engineering concepts to educators and students. The HiTech: The Road to a STEM Career project involves writing curriculum and delivering STEM content to learners in the Howard County Library System's HiTech program. The Center for Talented Youth project involves delivery of STEM content to youth and their parents.

Accomplishments for Oct 2014 – Sep 2015

UMBC hosted a variety of BEST activities, ranging from Telescope Open House at UMBC to Professional Development workshops for educators to student-oriented programs, such as CTY. Through 25 different events, over 365 educators, 530 students, and 180 parents were involved in activities promoting STEM education and increasing the awareness of NASA's mission.



NASA BEST:
Robotics at Northwest Indian College

Top left: Instructor (Michelle Graf/GEST) demonstrates components to NWIC Students.

Top right: Robots designed and built by NWIC Students.

Lower right: NWIC Student posing with robot in progress.

On campus at UMBC

CCNY Subcontract 49173-B: Cooperative Remote Sensing Science and Technology (NOAA-CREST) Center.

Hampton University Subcontract N0. 17-001: Lidar observations of land-marine boundary layer/UMBC Monitoring of Atmospheric Pollution in Coastal Locations.

Maryland Department of the Environment Grant U00P4400079: UMBC Monitoring of Atmospheric Pollution: Vertical Profiling of Baltimore's Lower Troposphere for Air Quality Applications.

Maryland Energy Administration MOU# 2013-06-513S1: Measurements of Terrestrial and Offshore Wind Resource over Maryland for Strategic Planning and Development of Offshore Wind Energy Projects

DOE-National Renewable Energy Laboratory Subcontract NO. AFA-5-52030-01: Remote Sensing Profiling of Winds and Temperature during XPIA.

JCET/UMBC: Rubén Delgado, Assistant Research Scientist; Belay Demoz, Physics Professor and JCET Director; Raymond Hoff, Physics Emeritus Professor

Students: Farrah Daham, Undergraduate Student; Julio Roman, Undergraduate Student Christian Sias, Undergraduate Student; Shelbi Tippet, Undergraduate Student; Daniel Wesloh, Undergraduate Student; Brian Carroll, Graduate Student; Daniel Orozco, Graduate Student; Glorianne Rivera, Undergraduate Student; John Sullivan, Graduate Student; Alexandra St. Pé, Graduate Student.

Description of Research

Elastic and wind lidar measurements are conducted to measure the vertical distribution of aerosols and wind over the Baltimore-Washington metro area to understand and aid in the assessment of whether exceedances of air pollutants and particulate smaller than 2.5 microns ($PM_{2.5}$) are occurring in the Mid-Atlantic United States, and to determine the impact of weather regimes in their seasonal variability. Active remote sensing lidar measurements support the NOAA CREST Lidar Network (CLN), the North American Global Atmospheric Watch: Aerosol Lidar Observation Network, and air quality studies. Doppler wind lidar measurements are geared to enhance knowledge of Mid-Atlantic meteorological control (stability, wind shear, turbulence) impact on seasonal and diurnal variations in wind regimes (thus potential turbine power generation), wind farm layout strategies (minimizing energy loss), Doppler wind lidar retrievals of turbine's wake effect (measurements & modeling), validation/improvements of Numerical Weather Prediction and weather industry's model output (reducing uncertainty), and land/marine boundary layer dynamics.

Accomplishments for Oct 2014 - Sep 2015

Lidar measurements carried out at UMBC allow confirmation in real time the presence of aloft layers of particle pollution that may descend into the planetary boundary layer (PBL). The lidar determination of height-dependent extinction profile and aerosol optical depth (AOD) in the atmosphere allows quantification of aerosol concentrations within the planetary boundary layer (PBL), presumably where it is well-mixed and would be best represented by ground-based $PM_{2.5}$ measurements. Observations have also allowed the team to establish when the surface air quality in Baltimore may be impacted by long-range transport particle pollution (e.g., smoke from Canadian and Alaska forest fires) and how it may impact local $PM_{2.5}$ concentrations. Lidar observations have been highlighted in UMBC's daily diary of U.S. air quality, the Smog Blog (alg.umbc.edu/usaq).

Lidar observations at UMBC support the CREST Lidar Network (CLN) activities, which contribute to NOAA's "Weather Ready Nation" goal and addresses the following objectives within this goal: 1) healthy people and communities through improved air and water quality, and 2) reduced loss of life, property, and disruption from high-impact events. One of the key goals of the NOAA-CREST program is to create an education and outreach strategic plan aligned with NOAA's Education Strategic Goals of (1) Environmental Literacy and (2) Workforce Development. The goal of CREST Education, therefore, is to recruit, train, and educate students from K-20 in NOAA-related STEM fields of Remote Sensing Sciences, Engineering and Technology. The education and outreach component/activities by UMBC NOAA-CREST are a conduit to introduce and involve K-20 students in Earth Science research topics that fall within NOAA's "Weather Ready Nation" goals and increase STEM training. Students in this program won best oral and poster presentations in conferences such as the American Meteorological Society, American Wind Energy Association, NOAA Office of Education 7th Biennial Education Partnership Program Symposium, and the NOAA/NESDIS Cooperative Research Program (CoRP)11th Annual Student Science Symposium for their remote science technology research in air quality and wind energy.

UMBC participated in the U.S. Department of Energy Atmosphere to Electrons (A2e) program Planetary Boundary Layer Instrumentation Assessment (XPIA) field study in Erie, Colorado. The field campaign goals consisted of characterization of sampling error for vertical velocity statistics, sensitivity analysis of Doppler wind lidar systems, inter-comparison of various Doppler retrieval techniques, characterization of spatial representativeness error for separation distances up to 3 km, and validation of turbulence analysis techniques with Doppler wind lidars. As part of this campaign, UMBC deployed a Doppler wind lidar, a microwave temperature profiler, and a sounding system to obtain wind, thermal and moisture profiles for better understanding of stability conditions and moisture flux.

NASA Grant: Climate studies using AIRS, radiative transfer and spectroscopy updates (NNX14AK58G)

JCET/UMBC: Sergio DeSouza-Machado, Research Assistant Professor

Description of Research

NASA's Atmospheric Infrared Sounder (AIRS) has been operational since September 2002. Orbiting 16 times a day on the Aqua platform, this new generation instrument has proved to be very stable, and is now beginning to provide an opportunity to study a high quality 13+ year dataset of atmospheric observations. Of particular interest is how the cloud forcing has been changing over the years, which would be a measure of the cloud feedback. When pieced together with comparable new generation instruments that have recently come online, this should provide scientists with a comprehensive climate quality data record. In addition the dataset will help develop new models that could more accurately predict atmospheric variability.

Accomplishments for Oct 2014 - Sep 2015

The team extended and continued to analyze 12+ years of AIRS data to provide estimates of atmospheric trace gas, temperature and humidity trends. Work has been done under both clear and all-sky conditions. The data was filtered by limiting the angles to close to nadir, which reduces the dataset to less than 5% of available data. Radiance trends were obtained from the filtered set, from which specific channels were chosen (namely the 1231 cm-1 window channel) to look at cloud forcing. A large effort has gone into characterizing the TwoSlab cloud representation in the fast infrared scattering radiative transfer code, which reduces the multilevel cloud profiles in Numerical Weather Prediction models to two slab clouds. This collaborative work was done with researchers at NASA-Langley, University of Michigan and NASA-Jet Propulsion Laboratory. The code was also used to demonstrate the possibility of doing Single Footprint Retrievals of hyper-spectral radiance spectra.

In-situ sonde measurements were gathered in preparation for evaluating future spectral updates needed for AIRS and other hyperspectral infrared missions.

Dr. Philip Sura met informally in the spring, to discuss potential work involving stochastic data analysis.

An ongoing collaboration with NASA-JPL involves using the Fast Radiative Transfer Model with Scattering (SARTA-Cloudy) developed at UMBC, to analyze AIRS radiances in the presence of dust. The aim is to improve AIRS L2 products in the presence of dust. The work has been extended to include detecting and mitigation of SO2 released during volcanic events.

Much of the above work was presented at the December 2014 AGU Fall Meeting and the April 2015 EGU Meeting (Vienna, Austria).

NASA Grant: UMBC Participation in Discover-AQ (NNX10AR38G)

JCET/UMBC: Raymond Hoff, Emeritus Professor, Physics; Rubén Delgado, Assistant Research Scientist; Chris Hennigan, Assistant Professor, UMBC Civil and Environmental Engineering

Students: Daniel Orozco, Graduate Student; Interns: Jennifer Izumi, Jared Johnson, Chemical and Environmental Engineering.

Description of Research

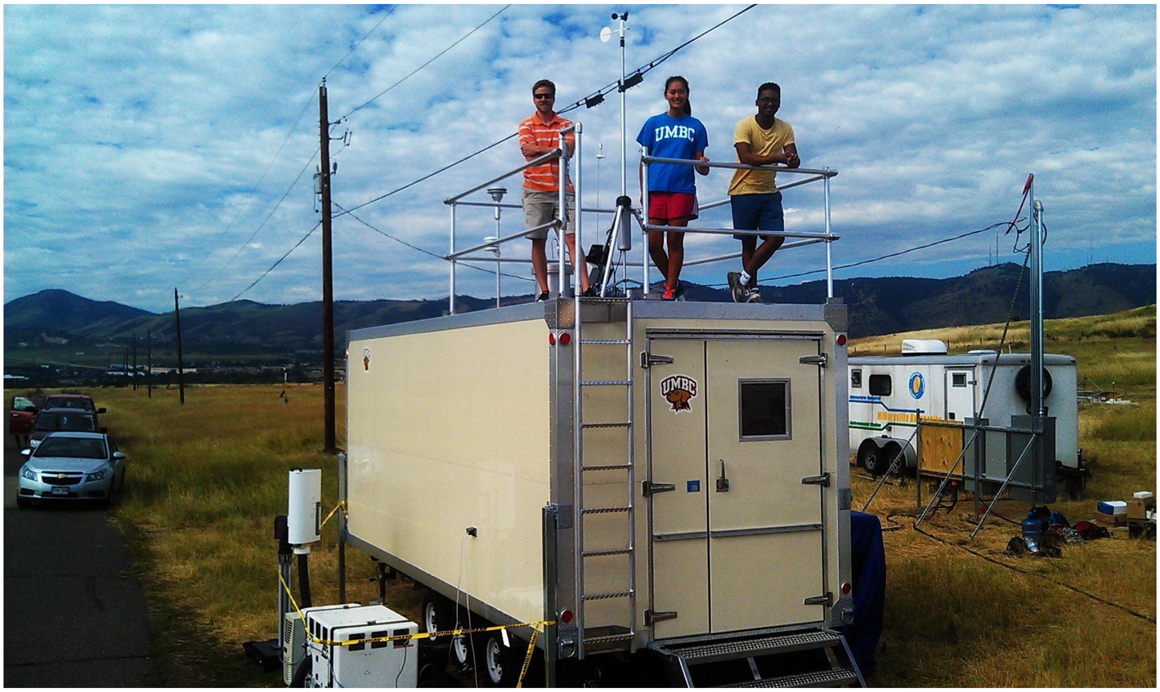
The correlation of column measurements of aerosols as seen from NASA and NOAA satellites with ground based measurements of aerosol light scattering and aerosol mass is a challenging problem, but one which must be assessed in order to advance the utility of those satellite observations. DISCOVER-AQ is a five year "mission" in the Earth Venture series designed to address this issue. UMBC co-investigates on this project providing observations of aerosol profiles and surface measurements which are relevant to the optical measurements of these aerosols from ground and spaceborne instruments.

Accomplishments for Oct 2014 – Sep 2015

Hoff, Delgado and Hennigan participated in the fourth and final Discover-AQ deployment in Golden, Colorado. UMBC contributed a mobile laboratory to the project. The mobile laboratory contained two lidars, a micropulse lidar and the Leosphere ALS-450 355nm lidar. Mr. Orozco contributed a hygroscopic measurement system which measured the degree of hydration of aerosols from 30-80+% RH. In addition, Mr. Orozco's system employed the PI-NEPH from Dr. Martins' laboratory. This is one of the first field deployments that looked both at the overall increase in light scattering at aerosols become hydrated and, at the same time, measured the angular scattering properties of these aerosols as they grow. The combination is sensitive not only to aerosol size but also aerosol morphology and indices of refraction.

To make further sense of these measurements, Dr. Chris Hennigan of the Civil and Environmental Engineering (CEE) Department joined the JCET/Physics team to make measurements of the mass of elemental and total carbon aerosol and to speciate those aerosols with a Particle in Liquid Sampler (PILS). Two students, Jennifer Izumi and Jared Johnson, supported the CEE measurements.

One month of measurements were made at the National Energy Research Laboratory's Table Mountain facility in Golden, Colorado. While the overall aerosol mass in the region was relatively low (the lowest of all the DISCOVER-AQ deployments), the types of aerosols (mostly organic in nature) were unique to the project. These results have given a spectrum of aerosol behavior across the U.S. from Baltimore, Houston, Porterville, California and finally Colorado. Mr. Orozco has led the effort to publish a synthesis paper on the DISCOVER-AQ mission and this paper is currently in review in JGRD.



Above: The UMBC Research Trailer on Table Mountain in Golden Colorado. The UMBC Leosphere lidar is shown outside the trailer on the left. On the trailer (left to right) are Dr. Chris Hennigan, Ms. Jennifer Izumi and Mr. Jared Johnson of the UMBC Civil and Environmental Engineering Department.

Task 381: CrIS Flight Model 2 Thermal Vacuum Analysis (Sponsor: James Gleason)

Task 392: NASA CrIS Level 1B and VIRS level 1 Algorithm and Software Development (Sponsor: James Gleason)

JCET/UMBC: L. Larrabee Strow, Research Professor; Howard Motteler, Research Professor; Steven Buczkowski, Research Analyst; Christopher Hepplewhite, Associate Research SCientist; Sergio de-Souza Machado, Research Assistant Professor

Description of Research

The Cross-track Infrared Sounder (CrIS) is a hyperspectral infrared satellite interferometric radiometer series that started operation in early 2012. CrIS is a follow-on to the AIRS instrument on EOS-AQUA, and represents NOAA's first series of operational hyperspectral weather sounders. The JCET investigators work with NASA/GSFC and the hardware vendor, Exelis, to test and understand the performance of the second and third CrIS instruments. The investigators support the JPSS-1 and JPSS-2 testing, especially with regard to the scientific integrity of the measured interferograms and radiances derived from those interferograms. In particular, investigators analyze pre-flight data relevant to the spectral calibration of the instrument, especially the correction for the rather large off-axis interferograms.

The University of Maryland Baltimore County (UMBC) Atmospheric Spectroscopy Laboratory (ASL) and the University of Wisconsin (UW) Space Science and Engineering Center (SSEC) and) are supporting NASA climate research by providing a climate quality Level 1B (geolocation and calibration) algorithm and long-term measurement record for CrIS. The investigators 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. The investigators provide samples of CrIS Level 1B data for the Suomi-NPP science team in advance of production for validation by the science team. The investigators provide long-term monitoring and validation of the CrIS Level 1B data record and long-term maintenance and refinement of the Level 1B software. The investigators provide a CrIS radiative transfer algorithm and code for use by the L1b and L2 NPP Science Teams.

Accomplishments for October 2014 - September 2015

CrIS Flight Model 2 (FM2) underwent pre-flight thermal vacuum testing during the fall of 2014. UMBC performed the spectral calibration of Neon lamp in FM2 and the exact location of the CrIS FM2 three detector focal planes relative to the interferometer axis using the thermal vacuum test data, which consisted of a series of gas cell transmittance measurements. These data are used to correct the measured spectra for self-apodization due to the off-axis locations of most detectors. These corrections are nominally 500 ppm (fractional frequency) and need to be accurate to 1-2 ppm in order for CrIS to retain the required radiometric accuracy. The results were extremely good, and the investigators are confident that the pre-launch spectral calibration is good to 1-2 ppm for all 27 CrIS detectors. The vendor made gas cell measurements with the following gases: CO_2, NH_3, CH_4, and CO. Investigators found (as predicted) that the NH_3 spectroscopy is not known well enough for CrIS spectral calibration. In addition, the analysis of the CO_2 spectra showed that our knowledge of the spectral line shapes of CO_2 in the strong 667 cm-1 Q-branch (important for stratospheric temperature sounding) is still insufficient to model the data due to rotational line-mixing.

An improved L1b calibration for CrIS was derived that reduces the sinc spectral ringing in the original vendor L1b algorithm and that tracks the CrIS metrology laser wavelength continuously, unlike the operational algorithm. Using the UMBC HPC (High Performance Computing) center resources, investigators were able re-process the full 3-year record of CrIS several times to test these new L1b algorithms. Unlike the NOAA operational algorithms, these L1b results allowed investigators to track the accuracy of the CrIS Neon spectral calibration lamp, which was determined to change by less than 1 ppm over the first three years, an extremely good result and important for deriving climate-quality radiance benchmarks with CrIS. Sample data has been provided to the NASA CrIS L2 retrieval algorithm team in concert with our Univ. Wisconsin partners.

The investigators also evaluated the stability of the CrIS sensor using the above 3-year L1b data set re-processed at UMBC. This was done by subsetting from the full data stream clear, ocean scenes at night. These were averaged on a daily basis, giving a 365 days/year times 3 years long time series for each of the 1305 CrIS spectral channels. Investigators then derived the linear rate of change of each channel radiance, producing a spectrum of the linear change in d(radiance)/d(time). An optimal estimation retrieval for d(temperature profile)/dt, d(water profile)/dt, d(CO_2)/dt etc provided the linear rate of change of the relevant geophysical variables we can observe. These were compared to in-situ measurements for CO_2 and CH_4. CO_2 is very well mixed and very well measured, providing an accurate comparison to our measurements from the CrIS radiance rate spectra. The retrieved CO_2 rate over the first three years of CrIS operation was 2.35 ppm./year, compared to the in-situ rate of 2.25 ppm/year (NOAA/ESRL). This difference of 0.1 ppm/year translates into a CrIS radiometric stability of 0.005K/year plus/minus 0.001K/year. This is a fantastic result and gives the investigators confidence that the CrIS sensor will be able to provide climate-quality data if sufficient overlap of the CrIS sensors takes place while in orbit.

NASA Grant: Water Cloud Depolarization – Multiple Scattering Relation: A Novel Technique for Spaceborne Lidar Retrievals of Above-Cloud Aerosol Optical Depth (ACAOD) (NNX15AB94G)

JCET/UMBC: Pengwang Zhai, Assistant Professor, Physics/JCET

Description of Research

Zhai implements the retrieval algorithms for water cloud droplet sizes and variances using available RSP data and then deriving lidar ratio of water clouds (Sc).

Accomplishments for Oct 2014 - Sep 2015

Zhai compiled test datasets that include collocated RSP and HSRL data measuring water cloud properties. Several water-cloud scenes have been identified, which include RSP and HSRL measurements acquired during the AZORES and PODEX field campaigns.

An algorithm has been developed to read in the RSP data and re-organize them into measurements for the same water cloud pixels using an assigned cloud height. The cloud height can be determined by two ways: one is from the HSRL lidar backscatter measurements; the other is to adjust the cloud height through a trial and error procedure to best reconstructed false color images.

Based on the reconstructed RSP measurement, Zhai built a water cloud polarized reflectance Look-Up-Table (LUT) at 865 nm in order to perform cloud microphysical property retrievals. The theory is based on fitting the polarized reflectance using the Mie theory in the rainbow region [Breon and Doutriaux-Boucher, 2005]. To fit the RSP measurements, the following matrix is constructed:

$$\begin{pmatrix} R_q(\theta_1) \\ R_q(\theta_2) \\ \vdots \\ R_q(\theta_n) \end{pmatrix} = \Sigma \cdot \begin{pmatrix} A \\ B \\ C \end{pmatrix}, \tag{1a}$$

$$\Sigma = \begin{pmatrix} P_{12}(\mu_1) & \mu_1^2 & 1 \\ P_{12}(\mu_2) & \mu_2^2 & 1 \\ \vdots & \vdots & \vdots \\ P_{12}(\mu_n) & \mu_n^2 & 1 \end{pmatrix} \tag{1b}$$

where $R_q = \pi Q/\mu_s F_0$ is the polarized reflectance in the scattering plane; $\mu_s = \cos(\theta_s)$, θ_s is the solar zenith angle; P_{12} is the 12 element of the Mie scattering matrix; $\mu_i = \cos(\Theta_i)$, and $\Theta_i, i = 1, \dots, n$ is the scattering angle; A, B, and C are the fitting parameters. To minimize the difference between the left and right hand sides of Eq. (1), we use the singular value decomposition of the matrix:

$$\Sigma = \mathbf{U} \cdot \mathbf{W} \cdot \mathbf{V}^T \tag{2}$$

$$(A, B, C)^T = V \cdot \left[diag\left(\frac{1}{W_i}\right)\right] \cdot (U^T \cdot \mathrm{R}_q) \tag{3}$$

where the superscript T stands for transpose. This singular value decomposition is repeated for every effective radius and variance in the look-up table and the set of values with minimal difference between measurement and fits are preserved as the successful retrieval.

The LUT searching algorithm is applied to the PODEX and AZORES field campaign data to obtain the effective radius and variance. The retrieved data has been delivered to NASA Langley research center for further analysis with collocated Lidar data.

In summary, the team has developed a look-up table and a searching algorithm to fit the polarized reflectance of the RSP measurement at 865 nm. The searching algorithm has been applied to the PODEX and AZORES field campaign water cloud measurements data. The retrieved effective radius and variance were delivered to NASA Langley Research Center for further analysis with collocated Lidar measurements.

III. Supporting Information

References

Boisvert, L. N., D. L. Wu, and C.-L. Shie (2015a), Increasing evaporation amounts seen in the Arctic between 2003-2013 from AIRS data, *J. Geophys. Res. Atmos.*, 120, 6865-6881, doi:10.1002/2015JD023258.

Boisvert, L. N., D. Wu, and C.-L. Shie (2015b), Moisture flux increases seen in the Arctic between 2003-2013. Abstract EGU2015-3996, *EGU General Assembly 2015*, Vienna, Austria.

Bourles, B., R. Lumpkin, M. J. McPhaden, F. Hernandez F. Hernandez, P. Nobre, E. Campos, L. Yu, S. Planton, A. Busalacchi, A. D. Moura, J. Servain, Jacques, and J. Trotte (2008), The PIRATA program: History, accomplishments, and future directions, *Bull Amer Meteorol Soc.*, 89, 1111-1125.

Breon, F.M. and M. Doutriaux-Boucher (2005), A comparison of cloud droplet radii measured from space, *IEEE Trans. On Geosc. And Remote Sensing*, 43, 1796-1805.

DeSouza-Machado, S.,L. Strow, E. Maddy, O. Torres, G. Thomas, D. Grainger, D. and A. Robinson (2015), A novel retrieval of daytime atmospheric dust and volcanic ash heights through a synergy of AIRS infrared radiances and MODIS L2 optical depths, *AMTD*, 8, 443-485.

Hogan, R. J., and A. Battaglia (2008), Fast Lidar and Radar Multiple-Scattering Models: Part 2: Wide-Angle Scattering Using the Time-Dependent Two-Stream Approximation, *J. Atmos. Sci.,* 65, 3636-3651.

Johnson, B. T., W. S. Olson, and G. Skofronick-Jackson (2015), The Microwave Properties of Simulated Melting Precipitation Particles: Sensitivity to Initial Melting, *Atmos. Meas. Tech*., submitted.

Kawatani, Y., J. N. Lee, and K. Hamilton (2014), Interannual variations of stratospheric water vapor in MLS observation and climate model simulation, *J. Atm. Science*, 71, 4072–4085.

Kuo, K.-S., W. S. Olson, B. T. Johnson, M. Grecu, L. Tian, T. L. Clune, B. H.van Aartsen, A. J. Heymsfield, L. Liao, and R. Meneghini (2015), 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, *J. Appl. Meteor. and Climatol.*, submitted.

Lee, Jae N., R. F. Cahalan, and D. L. Wu (2015), The 27 Day Rotational Variations in Total Solar Irradiance Observations: from SORCE/TIM, ACRIM III, and SOHO/VIRGO, *J. of Atmospheric and Solar-Terrestrial Physics,* 132, 64-73.

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

McPhaden, M. J., G. Meyers, K. Ando, Y. Masumoto, V. S. N. Murty, M. Ravichandran, F. Syamsudin, J. J. Vialard, L. Yu, and W. Yu (2009), RAMA The Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction, *Bull Amer Metorol Soc.*, 90, 459-480.

McPhaden, M. J, A. J. Busalacchi, R. Cheney, J. R. Dongu, K. S. Gage, D. Halpern, M. Ji, P. Julian, P, G. Meyers, G. T. Mitchum, P. P. Niiler, J. Picaut, R. W. Reynolds, N. Smith, and K. Takeuchi (1998), The tropical ocean global atmosphere observing system: A decade of progress, *J. Geophys Res.*, 103, 14169-14240.

Moustafa, S.E., A.K. Rennermalm, L.C. Smith, M.A. Miller, J.R. Mioduszewski, L.S. Koenig, M. Hom, and C.A. Shuman (2015). Multi-modal albedo distributions in the ablation area of the southwestern Greenland Ice Sheet, *The Cryosphere,* 9, 905-923, doi:10.5194/tc-9-905-2015.

Olson, W. S., L. Tian, M. Grecu, K.-S. Kuo, L. Tian, B. T. Johnson, A. J. Heymsfield, A. Bansemer, G. M. Heymsfield, and R. Meneghini (2015), The Microwave Radiative Properties of Falling Snow Derived from Nonspherical Ice Particle Models. Part II: Initial Testing Using Radar, Radiometer and In Situ Observations, *J. Appl. Meteor. and Climatol.*, submitted.

Scambos, T.A., E. Berthier, T. Haran, C.A. Shuman, A.J. Cook, S.R.M. Ligtenberg, and J. Bohlander (2014). Detailed ice loss pattern in the northern Antarctic Peninsula: widespread decline driven by ice front retreats, *The Cryosphere*, 8, 2135-2145, doi: 10.5194/tc-8-2135-2014.

Shie, C.-L., S. Shen, and S. Kempler (2014), Advanced Science/Event-based Data Service Framework at GES DISC, *2014 AGU Fall Meeting*, 15-19 December 2014, San Francisco, CA.

Várnai, T. and A. Marshak (2015). Effect of cloud fraction on near-cloud aerosol behavior in the MODIS atmospheric correction ocean color product. *Remote Sensing*, 7, 5283-5299.

Várnai, T., A. Marshak, and G. Sanchez-Hernandez (2015), 3D radiative effects in satellite remote sensing of clouds at high latitudes, *26th International Union of*

Geodesy and Geophysics General Assembly, Prague, Czech Republic, June 22-July 2.

Wen, G., A. Marshak, K. F. Evans, T. Várnai, and R. Levy (2015), Assessing the two-layer model for estimating 3D cloud induced clear sky reflectance enhancement using LES/SHDOM simulated radiances, *American Geophysical Union Joint Assembly, Montreal*, Canada, May 3-7.

Yang, W., A. Marshak, T. Várnai, and R. Wood (2014), CALIPSO observations of near-cloud aerosol properties as a function of cloud fraction. *Geophys. Res. Lett.,* 41, doi:10.1002/2014GL061896.

Peer-Reviewed Publications

Abuhassan, Nader (Associate Research Engineer)

Journal Article, Academic Journal
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.

Bian, Huisheng (Associate Research Scientist)

Journal Article, Professional Journal
Yu, H., Chin, M., Bian, H., Yuan, T., Prospero, J. M., Omar, A. H., Remer, L. A., Winker, D. M., Yang, Y., Zhang, Y., Zhang, Z. (2015). Quantification of Trans-Atlantic Dust Transport from Seven-year (2007-2013) record of CALIPSON Lidar Measurements. *Remote Sensing of Environment, 159*, 232-249. http://www.sciencedirect.com/science/article/pii/S0034425714005021

Journal Article, Professional Journal
Veselovskii, I., Whiteman, D. N., Korenskiy, M., Suvorina, A., Kolgotin, A., Lyapustin, A., Wang, Y., Chin, M., Bian, H., Kucsera, T. L., Perez-Ramirez, D., Holben, B. (2015). Characterization of forest fire smoke event near Washington, DC in summer 2013 with multi-wavelength lidar. *Atmos. Chem. Phys., 15*, 1647-1660. www.atmos-chem-phys.net/15/1647/2015/

Journal Article, Professional Journal
Jiao, C., Flanner, M., Balkanski, Y., Bauer, S. E., Bellouin, N., Berntsen, T. K., Bian, H., Carslaw, K. S., Chin, M., De Luca, N., Diehl, T., Ghan, S. J., Iversen, T., Kirkervag, A., Koch, D., Liu, X., Mann, G. W., Penner, J. E., Pitari, G., Schulz, M., Seland, O., Skeie, R. B., Steenrod, S. D., Stier, P., Takemura, T., Tsigaridis, K., van Noije, T., Yun, Y., Zhang, K. (2014). An

AeroCom assessment of black carbon in Arctic snow and sea ice. *Atmos. Chem. Phys., 14*.

Journal Article, Professional Journal
Anenberg, S. C., Jason, J., Yu, H., Chin, M., Schulz, M., Bergmann, D., Bian, H., Diehl, T., Fiore, A., Hess, P., Marmer, E., Montanaro, V., Park, R., Shindell, D., Takemura, T., Dentener, F. (2014). Impacts of intercontinental transport of anthropogenic fine particulate matter on human mortality. *Air Qual. Atmos. Health, doi:10.1007/s11869-014-024809*.

Journal Article, Professional Journal
Samset, B. H., Myhre, G., Herber, A., Kondo, Y., Li, S.-M, Moteki, N., Koike, M., Oshima, N., Schwanz, J. P., Balkanski, Y., Bauer, S. E., Bellouin, N., Berstsen, T. K., Bian, H., Chin, M., Diehl, T., Easter, R. C., Ghan, S. J., Iversen, T., Kirkevag, A., Lamarque, J.-F, Lin, G., Liu, X., Penner, J. E., Schultz, M., Seland, O., Skeie, R. B., Stier, P., Takemura, T., Ksigaridis, K., Zhang, K. (2014). Modelled black carbon radiative forcing and atmospheric lifetime in AeroCom Phase II constrained by aircraft observations. *Atmos. Chem. Phys., 14*, 12465-12477.

Journal Article, Professional Journal
Chin, M., Diehl, T., Tan, Q., Prospero, J. M., Kahn, R. A., Remer, L. A., Yu, H., Sayer, A. M., Bian, H., Geogdzhayev, I. V., Holben, B. N., Howell, S. G., Huebert, B. J., Hsu, N. C., Kim, D., Kucsera, T. L., Levy, R., Mishchenko, M. I., Pan, X., Quinn, P. K., Schuster, G. L., Streets, D. G., Strode, S. A., Torres, O., Zhao, X.-P (2014). Multi-decadal aerosol variations from 1980 to 2009: a perspective from observations and a global model. *Atmos. Chem. Phys., 14*.

Journal Article, Professional Journal
Tsigaridis, K., Daskalakis, N., Kanakidou, M., Adams, P. J., Artaxo, P., Bahadur, R., Balkanski, Y., Bauer, S. E., Bellouin, N., Benedetti, A., Bergman, T., Berntsen, T. K., Beukes, J. P., Bian, H., Carslaw, K. S., Chin, M., Curci, G., Diehl, T., Easter, R. C., Ghan, S., Gong, S. L., Hodzic, A., Hoyle, C. R., Iversen, T., Jathar, S., Jimenez, J. L., Kaiser, J. W., Kirkevag, A., Koch, D., Kokkola, H., Lee, Y. H., Lin, G., Liu, X., Luo, G., Ma, X., Mann, G. W., Mihalopoulos, N., Morcrette, J.-J, Muller, J.-F, Myhre, G., Myriokefalitakis, S., Ng, N. L., O'Donnell, D., Penner, J. E., Pozzoli, L., Pringle, K. J., Russell, M. M., Shultz, M., Scare, J., Seland, O., Shindell, D. T., Sillman, S., Skeie, R. B., Spracklen, D., Stavrakou, T., Steenrod, S. D., Takemura, T., Titta, P., Tilmes, S., Tost, H., van Noije, T., van Zyl, P. G., von Salzen, K., Yu, F., Wang, Z., Wang, Z., Zaveri, R. A., Zhang, H., Zhang, K., Zhang, Q., Zhang, X. (2014). The AeroCom evaluation and intercomparison of organic aerosol in global models. *Atmos. Chem. Phys., 14*, 10845-10895.

Campbell, Petya K. E. (Associate Research Scientist)

Journal Article, Academic Journal

Lagomassino, D., Price, R. M., Whitman, D., Campbell, P. K. (2014). Estimating major ion and nutrient concentrations in mangrove estuaries in Everglades National Park using leaf and satellite reflectance. *Remote Sensing of Environment*(154), 202-218.

Journal Article, Academic Journal

van der Tol, C., Berry, J. A., Campbell, P. K., Rascher, U. (2014). Steady state leaf chlorophyll fluorescence yield is related to the rate and the relative light saturation of photosynthesis. *AGU Journal of Geophysical Research: Biogeosciences, DOI: 0.1002/2014JG002713, 119*. http://onlinelibrary.wiley.com/enhanced/doi/10.1002/2014JG002713/

Cho, Hyoun-Myoung (Research Associate)

Book, Chapter in Scholarly Book-New

Zhang, Z., Platnick, S., Ackerman, A. S., Cho, H.-M. (2015). Spectral dependence of MODIS cloud droplet effective radius retrievals for marine boundary layer clouds. *Light Scattering Review IX*. link.springer.com/chapter/10.1007%2F978-3-642-37985-7_4

Chu, Ding-Chong (Associate Research Scientist)

Journal Article, Academic Journal

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*, 338 - 349.

Delgado, Ruben (Assistant Research Scientist)

Journal Article, Academic Journal

Orozco, D., Delgado, R., Wesloh, D., Powers, R. J., Hoff, R. M. (2015). Aerosol particulate matter in the Baltimore metropolitan area: temporal variation over a six-year period. *Journal of the Air & Waste Management Association, 65* (9), 1050-61.

Hall, Forrest G. (Senior Research Scientist)

Journal Article, Academic Journal

Hilker, T., Lyapustin, A., Tucker, C. J., Hall, F. G., Myneni, R., Wang, Y., Bi, J., Moura, Y. M. d., Sellers, P. J. (2014). Vegetation dynamics and rainfall sensitivity of the Amazon. *Proceedings of the National Academy of Sciences*, DOI: 10.1073/pnas.1404870111.

Herman, Jay R. (Senior Research Scientist)

Journal Article, Academic Journal
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.

Journal Article, Academic Journal
Flynn, C., Pickering, K., Crawford, J., Lansal, L., Krotkov, N., Herman, J. R. (2014). Relationship between column-density and surface mixing ratio: Statistical analysis of O3 and NO2 data from the July 2011 Maryland DISCOVER-AQ mission. *Atmospheric Environment, 92*, 429-441.

Journal Article, Academic Journal
Hansell, R. A., Tsay, S.-C., Pantina, P., Lewis, J. R., Ji, Q., Herman, J. R. (2014). Spectral Derivative Analysis of Solar Spectroradiometric Measurements: Theoretical Basis. *Journal of Geophysical Research: Atmospheres*, n/a–n/a. http://dx.doi.org/10.1002/2013JD021423

Hoban, Susan M. (Senior Research Scientist)

Journal Article, Academic Journal
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

Hoff, Raymond M. (Emeritus)

Journal Article, Academic Journal
Orozco, D., R. Delgado, D. Wesloh, R. J. Powers[3], and R. Hoff. (2015). Origins Of Aerosol Particulate Matter In The Baltimore Metropolitan Area: Temporal Variation Over A Six Year Period. *Air Waste Manage. Assoc.*, UAWM-2015-0048.R2

Journal Article, Academic Journal
Sullivan, J. T., McGee, T. J., Sumnicht, G. K., Twigg, L. W., Hoff, R. M. (2014). A mobile differential absorption lidar to measure sub-hourly fluctuation of tropospheric ozone profiles in the Baltimore-Washington, DC region. *Atmospheric Measurement Techniques, 7*(10), 3529-3548.

Journal Article, Academic Journal
Sawamura, P., Mueller, D., Hoff, R. M., Hostetler, C. A., Ferrare, R. A., Hair, J. W., Rogers, R. R., Anderson, B. E., Ziemba, L. D., Beyersdorf, A. J., Thornhill, K. L., Winstead, E. L., Holben, B. N. (2014). Aerosol optical and microphysical retrievals from a hybrid multiwavelength lidar data set - DISCOVER-AQ 2011. *Atmospheric Measurement Techniques, 7*(9), 3095-3112.

Huemmrich, Karl F. (Research Associate Professor)

Journal Article, Academic Journal
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.

Journal Article, Academic Journal
Joiner, J., Yoshida, Y., Vasilkov, A. P., Schaefer, K., Jung, M., Guanter, L., Zhang, Y., Garrity, S., Middleton, E. M., Huemmrich, K. F., Gu, L., Marchesini, L. B. (2014). The seasonal cycle of satellite chlorophyll fluorescence observations and its relationship to vegetation phenology and ecosystem atmosphere carbon exchange. *Remote Sensing of Environment, 152*, 375-391.

Lee, Jae Nyung (Assistant Research Scientist)

Journal Article, Academic Journal
Lee, J. N., Cahalan, R. F. (2015). The 27-Day Rotational Variations in Total Solar Irradiance Observations: from SORCE/TIM, ACRIM III, and SOHO/VIRGO ." Journal of Atmospheric and Solar-Terrestrial Physics. *J. of Atmospheric and Terrestrial Physics, 132 (2015)*, 64-73. dx.doi.org/10.1016/j.jastp.2015.07.001

Lewis, Jasper R. (Research Associate)

Journal Article, Academic Journal
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

Journal Article, Academic Journal
Fromm, M., Kablick, G., Nedoluha, G., Carboni, E., Grainger, R., Campbell, J., Lewis, J. R. (2014). Correcting the record of volcanic stratospheric

aerosol impact: Nabro and Sarychev Peak. *Journal of Geophysical Research: Atmospheres, 119*(17), 10–343.

Journal Article, Academic Journal
Campbell, JR, Vaughan, M., Oo, M., Holz, R., Lewis, J. R., Welton, E. (2014). Distinguishing cirrus cloud presence in autonomous lidar measurements. *Atmospheric Measurement Techniques Discussions, 7*(7), 7207–7243.

Journal Article, Academic Journal
Hansell, R. A., Tsay, S.-C., Pantina, P., Lewis, J. R., Ji, Q., Herman, J. R. (2014). Spectral Derivative Analysis of Solar Spectroradiometric Measurements: Theoretical Basis. *Journal of Geophysical Research: Atmospheres*, n/a–n/a. http://dx.doi.org/10.1002/2013JD021423

Lolli, Simone (Assistant Research Scientist)

Journal Article, Academic Journal
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

Journal Article, Academic Journal
Lolli, S., Di Girolamo, P. (2015). Principal Component Analysis Approach to Evaluate Instrument Performances in Developing a Cost-Effective Reliable Instrument Network for Atmospheric Measurements. *Journal of Atmospheric and Oceanic Technology, 32*(9), 1642-1649.

Journal Article, Academic Journal
Eck, T. F., Holben, B. N., Reid, J. S., Ferrare, R. A., Hostetler, C. A., Crumeyrolle, S. N., Berkoff, T. A., Weltoin, E. J., Lolli, S., Lyapustin, A., Wang, Y., Schafer, J. S., Giles, D. M., Anderson, B. E., Thornhill, K. L., Pickering, K. E., Loughner, C. P., Smirnov, A., Sinyuk, A. (2014). Observations of Rapid Aerosol Optical Depth Enhancements in the Vicinity of Polluted Cumulus Clouds. *ACP, 14*(21), 11633-11656.

Conference Proceeding
Lolli, S., Welton, E. J., Campbell, J. R., Eloranta, E., Holben, B. N., Chew, B.N., Salinas, S. V. (2014). High Spectral Resolution Lidar and MPLNET Micro Pulse Lidar aerosol optical property retrieval intercomparison during the 2012 7-SEAS field campaign at Singapore (pp. 92460C-92460C-6). *International Society for Optics and Photonics*.

Conference Proceeding
Lolli, S., Welton, E. J., Benedetti, A., Jones, L., Suttie, M., Wang, S.H. (2014). MPLNET lidar data assimilation in the ECMWF MACC-II Aerosol system: evaluation of model performances at NCU lidar station (vol. 9246, pp. 92460I-92460I-5). *International Society for Optics and Photonics*.

Conference Proceeding
Hee, W., Kohr, W., Tan, F., Lim, H., Matjafri, M., Lolli, S. (2014). Tropospheric Raman Lidar measurements of the vertical aerosol backscattering with range-dependent Lidar ratio in Penang Island, Malaysia during the dry season (vol. 9246, pp. 92460Q-92460Q-10). *International Society for Optics and Photonics*.

Mehta, Amita V. (Research Assistant Professor)

Journal Article, Professional Journal
Casella, D., Panegrossi, G., Sano, P., Dietrich, S., Mugnai, A., Smith, E., Tripoli, G., Formenton, M., Doi Paola, F., Leung, W.-Y., Mehta, A. V. (in press). Transitioning from CRD to CDRD in Bayesian Retrieval of Rainfall from Satellite Passive Microwave Measurements: Part 2. Overcoming Database Profile Selection Ambiguity by Consideration of Meteorological Control on Microphysics. *IEEE Transaction on Geosciences and Remote Sensing MicroRad 2012 Special Issue*.

Journal Article, Professional Journal
Smith, E., Leung, W. Y. Hester, Elsner, J., Mehta, A. V., Tripoli, G., Casella, D., Dietrich, S., Mugnai, A., G. P., Sano, P. (in press). Transitioning from CRD to CDRD in Bayesian retrieval of rainfall from satellite passive microwave measurements: Part 3. Identification of optimal meteorological tags. *Natural Hazards and Earth System Sciences: Special Issue on Plinius 13*.

Peer-reviewed Book Chapter Published as a Conference Proceeding
Popuri, S. K., Neerchal, N. k., Mehta, A. V. (in press). *Comparison of linear and Tobit modeling of downscaled daily precipitation over Missouri River Basin using MIROC5*. Springer.

Olson, William S. (Research Associate Professor)

Journal Article, Academic Journal
Johnson, B. T., Olson, W. S., Skofronick-Jackson, G. (2015). The microwave properties of simulated melting precipitation particles: Sensitivity to initial melting. *Atmospheric Measurement Techniques* (8) 6, 5615-5649,doi: 10.5194/amtd-8-5615-2015.

Journal Article, Professional Journal
Sun, W., L'Ecuyer, T. S., Olson, W. S., Jiang, X., Fetzer, E. J. (2014). Local balance and variability of atmospheric heat budget over oceans: Observation and reanalysis-based estimates. *Journal of Climate/American Meteorological Society, 27*, 893-913.

Journal Article, Professional Journal

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. (in press). The observed state of global energy balance in the early 21st century. *Journal of Climate/American Meteorological Society*.

Journal Article, Professional Journal
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. (in press). The observed state of the water cycle in the early 21st century. *Journal of Climate/American Meteorological Society*.

Monograph
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. (in press). 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.

Journal Article, Professional Journal
Jiang, X., Kubar, T. L., Wong, S., Olson, W. S., Waliser, D. E. (2014). Modulation of marine low clouds associated with the tropical intraseasonal variability over the eastern Pacific. *Journal of Climate/American Meteorological Society, 27*, 5560-5574.

Prados, Ana I. (Research Assistant Professor)

Journal Article, Academic Journal
Rose, R., Byler, D., Eastman, R., Fleishman, E., Geller, G., Goetz, S., Guild, L., Hamilton, H., Hansen, M., Headley, R., Hewson, J., Horning, N., Kaplin, B., Laporte, N., Leidner, A., Leimgruber, P., Morisette, J., Musinsky, J., Pintea, L., Prados, A., Radeloff, V., Rowen, M., Saatchi, S., Schill, S., Tabor, K., Turner, W., Vodacek, A., vogelmann, J., Wegmann, M., Wilkie, D., Wilson, C. (2014). Ten Ways Remote Sensing Can Contribute to Conservation. *Conservation Biology*. onlinelibrary.wiley.com/doi/10.1111/cobi.12397/full

Journal Article, Academic Journal
Duncan, B., Prados, A. (2014). Satellite data of atmospheric pollution for U.S. air quality applications: Examples of applications, summary of data end-user resources, answers to FAQs, and common mistakes to avoid. *Atmospheric Environment, 94*, 647-662. \

Rabenhorst, Scott D. (Research Associate)

Journal Article, Professional Journal
Rabenhorst, S. D., Whiteman, D. N., Zhang, D.-L., Demoz, B. B. (2014). A case study of Mid-Atlantic nocturnal boundary layer events during WAVES 2006. *Journal of Applied Meteorology and Climatology, 53*(11), 2627-2648.

Remer, Lorraine A. (Research Professor)

Journal Article, Professional Journal
Livingston, J. M., Redemann, J., Shinozuka, Y., Johnson, R., Russell, P. B., Zhang, Q., Mattoo, S., Remer, L. A., Levy, R., Munchak, L., Ramachandran, S. (2014). Comparison of MODIS 3 km and 10 km resolution aerosol optical depth retrievals over land with airborne sunphotometer measurements during ARCTAS summer 2008. *Atmospheric Chemistry and Physics, 14*, 2015-2038.

Journal Article, Professional Journal
Colarco, P. R., Kahn, R. A., Remer, L. A., Levy, R. C. (2014). Impact of satellite viewing-swath width on global and regional aerosol optical thickness statistics and trends. *Atmospheric Measurement Techniques, 7*, 2313-2335.

Journal Article, Professional Journal
Chin, M., Diehl, T., Tan, Q., Prospero, J. M., Kahn, R. A., Remer, L. A., Yu, H., Sayer, A. M., Bian, H., Geogdzhavev, I. V., e. a. (2014). Multi-decadal aerosol variations from 1980 to 2009: observations and a global model. *Atmospheric Chemistry and Physics, 14*, 3657-3690.

Journal Article, Professional Journal
Wollner, U., Koren, I., Altaratz, O., Remer, L. A. (2014). On the signature of the cirrus twilight zone. *Environmental Research Letters, 9*, 094010.

Journal Article, Professional Journal
Rocha-Lima, A., Martins, J. V., Remer, L. A., Krotkov, N. A., Tabacniks, M. H., Ben-Ani, Y., Artaxo, P. (2014). Optical, microphysical and compositional properties of the Eyjafjallajoku volcanic ash. *Atmospheric Chemistry and Physics, 14*, 10649-10661.

Journal Article, Professional Journal
Altaratz, O., Koren, I., Remer, L. A., Hirsh, E. (2014). Review: Cloud invigoration by aerosols – Coupling between microphysics and dynamics. *Atmospheric Research, 140-141*, 38-60.

Journal Article, Professional Journal
Liu, H., Remer, L. A., Huang, J., Huang, H.-C., Kondragunta, S., Laszlo, I., Oo, M., Jackson, J. M. (2014). Validation of Suomi-NPP VIIRS Aerosol

Optical Thickness. *Journal of Geophysical Research - Atmospheres, 119*, 3942-3962.

Journal Article, Academic Journal
Rocha-Lima, A., Martins, J. V., Remer, L. A., Krotvov, N. A., Tabacniks, M. H., Ben-Ami, Y., Artaxo, P. (2014). Optical, microphysical and compositional properties of the Eyjafjallajökull volcanic ash. *Atmospheric Chemistry and Physics, 14*, 10649-10661. www.atmos-chem-phys.net/14/10649/2014/acp-14-10649-2014.html

Shie, Chung-Lin (Associate Research Scientist)

Journal Article, Academic Journal
Boisvert, L., Wu, D., Shie, C.-l. (2015). Increasing evaporation amounts seen in the Arctic between 2003-2013 from AIRS data. *J. Geophys. Res. Atmospheres, 120*(14), 6865–6881. doi:10.1002/2015JD023258

Shuman, Christopher A. (Research Associate Professor)

Journal Article, Academic Journal
Shuman, C. A. (2015). Multi-modal albedo distributions in the ablation area of the southwestern Greenland Ice Sheet. *The Cryosphere, 9*, 905-923.

Journal Article, Academic Journal
Scambos, T., Berthier, E., Haran, T., Shuman, C. A., Cook, A., Ligtenberg, S., Bohlander, J. (2014). Detailed ice loss pattern in the northern Antarctic Peninsula: widespread decline driven by ice front retreats. *The Cryosphere, 8*, 2135-2145.

St. Clair, Jason M. (Assistant Research Scientist)

Journal Article, Academic Journal
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. doi: 10.1002/2014JD022378

Journal Article, Academic Journal
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.

Journal Article, Academic Journal
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. doi:10.1021/acs.est.5b02031

Journal Article, Academic Journal
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. doi:10.1021/acs.jpca.5b06355

Journal Article, Academic Journal
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,*doi:10.1021/acs.jpca.5b06532

Journal Article, Academic Journal
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.

Journal Article, Academic Journal
Nguyen, T. B., Crounse, J. D., Teng, A. P., St. Clair, J. M., Paulot, F., Wolfe, G. M., Wennberg, P. O. (2015). Rapid deposition of oxidized biogenic compounds to a temperate forest. *Proceedings of the National Academy of Sciences of the United States of America, 112*(5), E392-E401.

Journal Article, Academic Journal
Rivera-Rios, J. C., Nguyen, T. B., Crounse, J. D., Jud, W., St. Clair, J. M., Mikoviny, T., Gilman, J. B., Lerner, B. M., Kaiser, J. B., de Gouw, J.,

Wisthaler, A., Hansel, A., Wennberg, P. O., Seinfeld, J. H., Keutsch, F. N. (2014). Conversion of hydroperoxides to carbonyls in field and laboratory instrumentation: Observational bias in diagnosing pristine versus anthropogenically controlled atmospheric chemistry. *Geophysical Research Letters, 41*(23), 8645-8651.

Journal Article, Academic Journal
Gentner, D. R., Ford, T. B., Guha, A., Boulanger, K., Brioude, J., Angevine, W. M., de Gouw, J. A., Warneke, C., Gilman, J. B., Ryerson, T. B., Peischl, J., Meinardi, S., Blake, D. R., Atlas, E., Lonneman, W. A., Kleindienst, T. E., Beaver, M. R., St. Clair, J. M., Wennberg, P. O., VandenBoer, T. C., Markovic, M. Z., Murphy, J. G., Harley, R. A., Goldstein, A. H. (2014). Emissions of organic carbon and methane from petroleum and dairy operations in California's San Joaquin Valley. *Atmospheric Chemistry and Physics, 14*(10), 4955-4978.

Journal Article, Academic Journal
Pusede, S. E., Gentner, D. R., Wooldridge, P. J., Browne, E. C., Rollins, A. W., Min, K. -E., Russell, A. R., Thomas, J., Zhang, L., Brune, W. H., Henry, S. B., DiGangi, J. P., Keutsch, F. N., Harrold, S. A., Thornton, J. A., Beaver, M. R., St. Clair, J. M., Wennberg, P. O., Sanders, J., Ren, X., VandenBoer, T. C., Markovic, M. Z., Guha, A., Weber, R., Goldstein, A. H., Cohen, R. C. (2014). On the temperature dependence of organic reactivity, nitrogen oxides, ozone production, and the impact of emission controls in San Joaquin Valley, California. *Atmospheric Chemistry and Physics, 14*(7), 3373-3395.

Journal Article, Academic Journal
Nguyen, T. B., Crounse, J. D., Schwantes, R. H., Teng, A. P., Bates, K. H., Zhang, X., St. Clair, J. M., Brune, W. H., Tyndall, G. S., Keutsch, F. N., Seinfeld, J. H., Wennberg, P. O. (2014). Overview of the Focused Isoprene eXperiment at the California Institute of Technology (FIXCIT): mechanistic chamber studies on the oxidation of biogenic compounds. *Atmospheric Chemistry and Physics, 14*(24), 13531-13549.

Journal Article, Academic Journal
St. Clair, J. M., Spencer, K. M., Beaver, M. R., Crounse, J. D., Paulot, F., Wennberg, P. O. (2014). Quantification of hydroxyacetone and glycolaldehyde using chemical ionization mass spectrometry. *Atmospheric Chemistry and Physics, 14*(8), 4251-4262.

Journal Article, Academic Journal
Barth, M., Cantrell, C. A., Brune, W. H., Rutledge, S. A., Crawford, J. H., Huntrieser, H., Carey, L. D., MacGorman, D., Weisman, M., Pickering, K. E., Bruning, E., Anderson, B. E., Apel, E., Biggerstaff, M., Campos, T., Campuzano-Jost, P., Cohen, R. C., Crounse, J. D., Day, D. A., Diskin, G. S., Flocke, F., Fried, A., Garland, C., Heikes, B., Honomichl, S., Hornbrook, R., Huey, L. G., Jimenez, J. L., Lang, T., Lichtenstern, M., Mikoviny, T., Nault, B. A., O'Sullivan, D., Pan, L., Peischl, J., Pollack, I., Richter, D., Ryerson, T., Schlager, H., St. Clair, J. M., Walega, J., Weibring, P., Weinheimer, A., Wennberg, P. O., Wisthaler, A.,

Wooldridge, P., Ziegler, C. (2014). The Deep Convective Clouds and Chemistry (DC3) Field Campaign. *Bulletin of the American Meteorological Society, 96*, 1281–1309. journals.ametsoc.org/doi/abs/10.1175/BAMS-D-13-00290.1

Tangborn, Andrew V. (Research Associate Professor)

Journal Article, Academic Journal
Tangborn, A. V., Kuang, W. (2015). Geodynamo model and error parameter estimation using geomagnetic data assimilation. *Geophysical Journal International, 200*, 664-675.

Tokay, Ali (Research Associate Professor)

Journal Article, Academic Journal
Gatlin, P. N., Thurai, M., Bringi, V. N., Petersen, W., Wolff, D., Tokay, A., Carey, L., Wingo, M. (in press). Searching for large drops: A global summary of two-dimensional video disdrometer observations. *Journal of Applied Meteorology and Climatology*.

Journal Article, Academic Journal
Liao, L., Meneghini, R., Tokay, A. (2014). Uncertainties of GPM DPR rain estimate caused by DSD parameterization. *Journal of Applied Meteorology and Climatology, 53*(11), 2524-2537.

Journal Article, Academic Journal
Skofronick-Jackson, G., 1.-a., Tokay, A. (in press). Global Precipitation Measurement Cold Season Precipitation Experiment (GCPEx): For Measurement Sake Let it Snow. *Bulletin of American Meteorological Society*.

Journal Article, Academic Journal
Giangrande, S., Curtis, S., Theisen, A., Tokay, A. (2014). Precipitation Estimation from the ARM distributed radar network during the MC3E campaign. *Journal of Applied Meteorology and Climatology, 53*(9), 2130-2147.

Journal Article, Academic Journal
Machado, L. A., 1.-a., Tokay, A. (2014). The Chuva Project: How does convection vary across Brazil? *Bulletin of American Meteorological Society, 95*(9), 1365-1380.

Turpie, Kevin R. (Research Associate Professor)

Technical Report
Turpie, K. R., Abelev, A., Babin, M., Bachmann, C., Bell, T., Devred, E., Forget, M.-H., Goodman, J., Hochberg, E., Hu, C., Kelly, M., Klemas, V.

V., Lee, Z., Moisan, T., Moses, W., Philpot, W., Toro-Farmer, G., Jo, H.-Y., Yu, Q., Byrd, K., Guild, L., Brando, V., Dekker, A., Muller-Karger, F., Palacios, S. (2015). In Kevin R. Turpie (Ed.), *Coastal and Inland Aquatic Data Products for the Hyperspectral Infrared Imager (HyspIRI)* (pp. ca 109). Goddard Space Flight Center, Greenbelt, MD: NASA White Paper.

Várnai, Tamás (Research Associate Professor)

Journal Article, Academic Journal
Várnai, T., Marshak, A. (2015). Effect of cloud fraction on near-cloud aerosol behavior in the MODIS atmospheric correction ocean color product. *Remote Sensing, 7*, 5283-5299.

Journal Article, Academic Journal
Yang, W., Marshak, A., Várnai, T., Wood, R. (2014). CALIPSO observations of near-cloud aerosol properties as a function of cloud fraction. *Geophys. Res. Lett., 41*, 9150-9157.

Wolfe, Glenn M. (Assistant Research Scientist)

Journal Article, Academic Journal
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.*

Journal Article, Academic Journal
de Gouw, J. A., McKeen, S. A., Aikin, K. C., Brock, C. A., Brown, S. S., Gilman, J. B., Graus, M., Hanisco, T., Holloway, J. S., Kaiser, J., Keutsch, F. N., Lerner, B. M., Liao, J., Markovic, M. Z., Middlebrook, A. M., Min, K. -E., Neuman, J. A., Nowak, J. B., Peischl, J., Pollack, I. B., Roberts, J. M., Ryerson, T. B., Trainer, M., Veres, P. R., Warneke, C., Welti, A., Wolfe, G. M. (2015). Airborne measurements of the atmospheric emissions from a fuel ethanol refinery. *Journal of Geophysical Research-Atmospheres*, 120(9), 4385-4397.

Journal Article, Academic Journal
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.

Journal Article, Academic Journal
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.

Journal Article, Academic Journal
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 a semi-rural South Korean forest. *Atmospheric Chemistry and Physics*, 15(8), 4357-4371.

Journal Article, Academic Journal
Nguyen, T. B., Crounse, J. D., Teng, A. P., St. Clair, J. M., Paulot, F., Wolfe, G. M., Wennberg, P. O. (2015). Rapid deposition of oxidized biogenic compounds to a temperate forest. *Proceedings of the National Academy of Sciences of the United States of America, 112*(5), E392-E401.

Journal Article, Academic Journal
Riedel, T. P., Wolfe, G. M., Danas, K. T., Gilman, J. B., Kuster, W. C., Bon, D. M., Vlasenko, A., Li, S.-M., Williams, E. J., Lerner, B. M., Veres, P. R., Roberts, J. M., Holloway, J. S., Lefer, B., Brown, S. S., Thornton, J. A. (2014). An MCM modeling study of nitryl chloride (ClNO2) impacts on oxidation, ozone production and nitrogen oxide partitioning in polluted continental outflow. *Atmospheric Chemistry and Physics, 14*, 3789-3800.

Journal Article, Academic Journal
Saylor, R. D., Wolfe, G. M., Meyers, T. P., Hicks, B. B. (2014). A corrected formulation of the Multilayer Model (MLM) for inferring gaseous dry deposition to vegetated surfaces. *Atmospheric Environment, 92*(0), 141 - 145.

Journal Article, Academic Journal
Ortega, J., Turnipseed, A., Guenther, A. B., Karl, T. G., Day, D. A., Gochis, D., Huffman, J. A., Prenni, A. J., Levin, E. J. T., Kreidenweis, S. M., DeMott, P. J., Tobo, Y., Patton, E. G., Hodzic, A., Cui, Y., Harley, P. C., Hornbrook, R. H., Apel, E. C., Monson, R. K., Eller, A. S. D., Greenberg, J. P., Barth, M., Campuzano-Jost, P., Palm, B. B., Jimenez, J. L., Aiken, A. C., Dubey, M. K., Geron, C., Offenberg, J., Ryan, M. G., Fornwalt, P. J., Pryor, S. C., Keutsch, F. N., DiGangi, J. P., Chan, A. W. H., Goldstein, A. H., Wolfe, G. M., Kim, S., Kaser, L., Schnitzhofer, R., Hansel, A., Cantrell, C. A., Mauldin, III, R. L., Smith, J. N. (2014). Overview of the Manitou Experimental Forest Observatory: site description and selected science results from 2008 - 2013. *Atmospheric Chemistry and Physics, 14*, 6345-6367.

Journal Article, Academic Journal
Wolfe, G. M., Cantrell, C., Kim, S., Mauldin, III, R. L., Karl, T., Harley, P., Turnipseed, A., Zheng, W., Flocke, F., Apel, E. C., Hornbrook, R. S., Hall, S. R., Ullmann, K., Henry, S. B., DiGangi, J. P., Boyle, E. S., Kaser, L., Schnitzhofer, R., Hansel, A., Graus, M., Nakashima, Y., Kajii, Y.,

Guenther, A., Keutsch, F. N. (2014). Missing peroxy radical sources within a summertime ponderosa pine forest. *Atmospheric Chemistry and Physics, 14*, 4715-4732.

Publications Submitted for Review

Cho, Hyoun-Myoung (Research Associate)

Journal Article, Academic Journal (Submitted)
Cho, H.-M., Zhang, Z., Meyer, K., Lebsock, M., Platnick, S., Ackmerman, A. S., Girolamo, L. D., Labonnote, L. C., Cornet, C., Riedi, J., Holz, R. Frequency and causes of failed MODIS cloud property retrievals for liquid phase clouds over global oceans. *Journal of Geophysical Research - Atmospheres*.

DeSouza-Machado, Sergio G. (Research Assistant Professor)

Journal Article, Professional Journal (Submitted)
De Souza-Machado, S. G., Strow, L. L., Maddy, E., Torres, O., Thomas, G., Grainger, R., Robinson, A. A novel retrieval of daytime atmospheric dust and volcanic ash heights through a synergy of AIRS infrared radiances and MODIS L2 optical depths. *Atmospheric Measurements and Techniques Discussion, 8*, 443-485.

Hoff, Raymond M. (Emeritus)

Journal Article, Professional Journal (Submitted)
Orozco, D., L. Ziemba, A. Beyersdorf, T. Berkoff, Q. Zhang, R. Delgado, C. Hennigan, K.L. Thornhill, and R. M. Hoff, 2015. Hygroscopic Measurements of Aerosol Particles in the San Joaquin Valley, CA, Baltimore, MD, and Golden, CO, *J. Geophys. Res. D*

Journal Article, Professional Journal (Submitted)
Pusede, S.E., K. C. Duffey, A. A. Shusterman, A. Saleh, J. L. Laughner , P. J. Wooldridge, Q. Zhang, C. L. Parworth, H. Kim, S. L. Capps, L. C. Valin, A. Fried, J. Walega, J. B. Nowak, T. A. Berkoff, R. M. Hoff, A. J. Beyersdorf, J. Olson, J. H. Crawford, R. C. Cohen, 2015. Trends in the chemistry of inorganic nitrate production in the most aerosol-polluted location in the U.S., *ACP*

Olson, William S. (Research Associate Professor)

Journal Article, Professional Journal (Submitted)

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. 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*.

Journal Article, Professional Journal (Submitted)
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. 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*.

Journal Article, Professional Journal (Submitted)
Munchak, S. J., Meneghini, R., Grecu, M., Olson, W. S. 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*.

Journal Article, Academic Journal (Submitted)
Johnson, B. T., Olson, W. S., Skofronick-Jackson, G. The microwave properties of simulated melting precipitation particles: Sensitivity to initial melting. *Atmospheric Measurement Techniques/European Geosciences Union*.

Tangborn, Andrew (Research Associate Professor)

Journal Article, Academic Journal (Submitted)
Kuang, W. and A. Tangborn, Dynamic responses of the Earth's outer core to assimilation of observed geomagnetic secular variation, submitted to Progress in Earth and Planetary Science, 2015.

Várnai, Tamás (Research Associate Professor)

Journal Article, Academic Journal (Submitted)
Wen, G., Marshak, A., Evans, F., Varnai, T., Levy, R. Assessing the two-layer model for correcting sky reflectance enhancement near clouds using LES/SHDOM simulated radiances. *J. Geophys. Res.*.

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.

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.

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.

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 ConvectionAt 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.

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's experience brings the excitement of STEM to educators and students alike. Her passion is to provide high-quality STEM learning opportunities to girls and underserved minority students. 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, an Honors College Fellow and the Associate Director for Academics for the UMBC Joint Center for Earth Systems Technology. She is the Principal Investigator on the NASA's BEST (Beginning Engineering, Science and Technology) project. Dr. Hoban's research interests include the effectiveness of various pedagogical models on teacher preparation and student outcomes, and comparisons among aerosols in the Earth's atmosphere, refractory material in the Solar System and dust in the Universe.

Raymond Hoff, Emeritus, holds a PhD in Physics from Simon Fraser University, Physics. 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, 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.

Benjamin Johnson, Research Assistant Professor, holds a PhD in Atmospheric Sciences from the University of Wisconsin, Madison. He is a member of the Global Precipitation Measurement (GPM) mission science team, and is the instrument scientist for the Conically Scanning Microwave Imaging Radiometer (CoSMIR).

Dr. Johnson's research interests cover the entire scope of remote sensing of precipitating clouds. Specifically, he uses passive and active microwave remote sensing techniques for precipitation measurement using ground, aircraft, and satellite-based observations. To better understand the underlying physical properties, Dr. Johnson uses a variety of simulations of the radiative-physical relationships for complex ice and mixed-phase precipitation particles. As a validation approach for satellite-based observations, Dr. Johnson has served as mission scientist in a number of NASA field experiments, which employ a vast array of ground- and aircraft-based observations of precipitation. It is anticipated that these experiments will lead to improved precipitation measurement on a global basis, eventually resulting in more accurate weather and climate forecasts.

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.

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.

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 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.

Scott Rabenhorst, Research Associate, holds a PhD in Atmospheric & Oceanic Science from the University of Maryland, College Park. Dr. Rabenhorst has extensive experience using WRF to simulate various mesoscale and boundary layer phenomenon. He has participated in several multi-agency fields campaigns collecting in-situ and remotely sensed observations used for model validation.

Dr. Rabenhorst's research interests are in mesoscale meteorology and boundary layer phenomenon, such as the evolution of the nocturnal boundary layer, low-level jets, downslope winds, sea breezes, frontal passages, convective forecasting, and poor air quality events, particularly within the Mid-Atlantic region. In addition to numerical modeling, he has experience working with Elastic, Raman and Doppler lidar systems, radiosondes, radar wind profiler data, radiometers, and several other conventional and air quality sensors which can be synergistically used to investigate the evolution of finescale meteorological features. Additionally, Dr. Rabenhorst has used data assimilation in observing system simulation experiments (OSSE) to investigate the impact of including research-grade atmospheric profiling measurements to improve numerical weather forecasts.

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.

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.

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.

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.

Table 1: Courses Taught

Course Number	Title	Semesters
HONR 300	Robots in Society	Fall 2014
GES 311	Weather and Climate	Fall 2014
MATH 221	Intro to Linear Algebra	Fall 2014
PHYS 112	Basics Physics II	Fall 2014
PHYS 450	Independent Study - Robotics	Fall 2014
PHYS 622	Atmospheric Physics II	Spring 2015

Table 2: Proposals Submitted by JCET Members

Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
21st century mass balance rates and projections of surface melt of land-terminating glaciers in Southwest Greenland	Columbia University (NASA)		Shuman, Christopher	Not Awarded
3D Radiative transport study	Aerodyne	Várnai, Tamás		Not Awarded
A Consistent Aerosol Data Record from MODIS and VIIRS	NASA	Remer, Lorraine		Awarded
A Modeling Analysis of the Impacts of Particulate Pollution on Tropospheric Chemistry in Past Decades Constrained by Surface	MIT (NASA)		Bian, Huisheng	Awarded

Measurement and Satellite Data				
A Near-Global Exploration of Aerosol-Convection-Lightning Interactions and Their Impacts with NASA Data and Models	NASA	Yuan, Tianle	Bian, Huisheng	Not Awarded
Adaptation to Decadal Climate Variability for Sustainable Water, Food, and Energy Security in the Missouri and Nile River Basins: A Regional Study Integrating Earth System Data, and Hydrologic, Agricultural, Land Use, and Economic Models	NSF		Mehta, Amita	Not Awarded
Aerosol absorption retrievals from base-line OCI observations: Risk reduction for atmospheric correction of the PACE mission	NASA	Remer, Lorraine		Awarded
Aerosol Optical and Physical Properties Measured from the Polarized Imaging Nephelometer	NASA	Martins, Vanderlei	Remer, Lorraine	Not Awarded
An Error Model for Describing the Uncertainties in Satellite Estimates of Precipitation and Latent Heating	NASA	Olson, William		Not Awarded
Applying Aircraft and satellite measurements in evaluation and improvement of photolysis model for photochemistry simulation in GEOSCCM	NASA	Bian, Huisheng		Not Awarded
ASTEC CubeSat - Demonstration of the next generation of passive measurements of aerosol and cloud microphysics from space	NASA	Martins, Vanderlei		Not Awarded
Bowie State University and National Education Partners (BNEP): STEM Advances Professional Learning for Educators (STAPLE) “Teaching and Preparing K-20 Students for the Future”	Bowie State University (NSF)		Hoban, Susan	Not Awarded
Changes in forest land cover extent, function and productivity in Central Europe: a prototype assessment of their driving factors, and their impacts on climate and society	NASA	Campbell, Petya		Not Awarded
Characterizing Lidar Backscattering Profiles and MERRA Reanalysis for Aerosol-Cloud and Air Quality Related Studies	NASA	Chu, Allen		Not Awarded
Climate Trends Using Hyperspectral Infrared Satellite Sounders	NASA	Strow, Larrabee	DeSouza-Machado, Sergio; Tangborn, Andrew	Not Awarded
Cloud Aerosol Interaction Measurements in 3D (CLAIM-3D)	NASA	Martins, Vanderlei		Pending
Collaborative Proposal: Full Scale Development, HiTech: The Road to A STEM Career	NSF	Hoban, Susan		Not Awarded
Community Engagement: STEM DiRBE (Distributed Robotics Build Event)	Anne Arundel County Public Schools (NSF)		Hoban, Susan	Not Awarded
Community Health using Air Quality Surveillance System (CHASS)	University of Miami NIH		Chu, Allen	Not Awarded
Comprehensive Modeling of the Nucleus Rotational State and the Coma Morphology and Lightcurve Variability of Comet 1P/Halley	NASA (Lowell Observatory)		Hoban, Susan	Pending
Continuity of the AIRS/AMSU cloud products for Suomi NPP	JPL (NASA)		Strow, Larrabee	Awarded

Core Flow estimates using assimilation of geomagnetic secular variation	NSF	Tangborn, Andrew		Not Awarded
Decision Support System (DSS) to Enhance Source Water Quality Modeling and Monitoring using Remote Sensing Data	Benjamin, Stanford, & Sawyer (NASA)		Mehta, Amita	Awarded
Detailed characterization of the optical properties of carbonaceous aerosols	NASA	Martins, Vanderlei		Not Awarded
Development and Analysis of a Decade-long Product of Dust Amount Imported to North America Using NASA Satelite Measurements and Model Simulations	NASA (UMD)		Yuan, Tianle Remer, Lorraine	Not Awarded
Development of a Laboratory Based Data Base of Aerosol Optical Properties	NASA	Martins, Vanderlei	Borda, Roberto	Not Awarded
Development, operation and algorithms of the HARPP instrument for the PACE mission.	NASA JPL	Martins, Vanderlei		Pending
Earth Photosynthesis Imaging Constellation	Oregon State U (NASA)		Hall, Forrest	Not Awarded
Enhancing CALIPSO's Capability of Measuring Above-Cloud Absorbing Aerosols and Assessing Aerosol Long-Range Transport and Radiative Effects Through an A-Train Integration	NASA		Zhang, Zhibo	Awarded
Estimation of Arctic Atmospheric and Surface Albedo Changes from MISR and MODIS Multi-angle Measurements	NASA GSFC		Várnai, Tamás	Pending
Evaluation of NCAR CAM5 simulated MBL cloud properties using a combination of satellite and surface observations	DOE	Zhang, Zhibo		Awarded
Evaluation of Rain DSD and Snow PSD Models for Advancement of DPR Retrieval Algorithms	NASA WFF		Tokay, Ali	Pending
Exploitation of large scale national and international ground validation datasets	NASA (UMD)		Tokay, Ali	Pending
Exploiting Suomi NPP OMPS nadir mapper observations for the retrieval of NO2 columns and free-tropospheric NO2 mixing ratios	GSFC (NASA)		Herman, Jay	Not Awarded
Farmland and Agriculture Remote	NASA		Huemmrich, K.F.	Not Awarded
Fate and Influences of African Dust and Smoke in the Amazon Basin During the Wet Season: An Integrated Analysis of GoAmazon Observations and WRF-Chem Simulations	DOE (Dessert Research Institute)		Yuan, Tianle	Not Awarded
Generation of Advanced VIIRS Land-Atmosphere Product Suite with Algorithm MAIAC	GSFC (NASA)		Wang, Yujie	Awarded
Hourly global Aerosol Index and aerosol particle properties using EPIC observations	NASA/GSFC	Remer, Lorraine		Awarded
Identifying a Meridional Gradient of Daytime Cirrus Cloud Radiative Forcing In the Summer Hemisphere from A-Train Measurements	NASA	Lolli, Simone		Pending
Identifying sources of ionospheric variability from above and below	University of Texas, Dallas (NASA)		Lee, Jae N.	Not Awarded
Improved understanding and modeling of Nox emissions and distributions, using observations	NASA	Herman, Jay		Not Awarded

from multiple airborne campaigns, surface-based networks and OMI satellite data				
Improving and exploiting global satellite hyperspectral measurements for ecosystem assessment and modeling	NASA		Huemmrich, K.F.	Awarded
Improving GPM Precipitation Algorithms Using Knowledge of Precipitation Processes Derived from Satellite and Ground Observations	NASA	Johnson, Benjamin		Pending
Integrated observational and modeling study of the influence of above-cloud aerosols on the nighttime cloud microphysics and precipitations in Southeast Atlantic	NASA	Zhang, Zhibo		Pending
Integrating NASA Earth Observations into EPA's Worldwide AirNow Program to Improve Public Health	NASA	Chu, Allen		Not Awarded
Integration and Testing of Improved Ice and Mixed-Phase Precipitation Models for GPM Combined Radar-Radiometer Retrieval Algorithm Applications	NASA	Olson, William		Pending
Interpreting and Utilizing MPL Net Data: A Combined Measurement and Modeling Study	Atmospheric and Environmental Research (NASA)		Lewis, Jasper	Not Awarded
Investigation of Arctic Atmospheric and Surface Albedo Changes with MISR, MODIS and GEOS-5 Model	NASA	Várnai, Tamás		Not Awarded
Linking Changes in Aerosol Loading to Changes in Cloud Properties Over Time	GSFC (NASA)		Remer, Lorraine	Awarded
NASA Early Opportunities Program for Underrepresented Minorities in Earth and Space Sciences	NASA (Howard University)		Hoban, Susan	Selected
NASA Earth Science and Engineering (NESE) Graduate Program for Underrepresented Minorities and Women	NASA (UMBC)		Hoban, Susan	Pending
NASA Inspires Native American Students (NINAS)	NASA (Northwest Indian College)		Hoban, Susan	Pending
NASA Makes SENSE for Upper Level Undergraduates (Starting Early with NASA SciencE!)	NASA (UMBC)		Hoban, Susan	Not Awarded
NASA Question, Explore, Discover!	NASA (UMBC)		Hoban, Susan	Not Awarded
NASA Snow Modeling Airborne Spring Snowmelt Experiment (SnowMass)	USRA (NASA)		Várnai, Tamás	Awarded
New angular distribution models for satellite estimation of direct radiative forcing by wildfire aerosols	USRA (NASA)		Várnai, Tamás	Not Awarded
Observational Characterization of Extreme Precipitation Events over Global Tropical and Midlatitude regions	NASA	Mehta, Amita		Pending
Ocean Color and Chlorophyll Trend Uncertainty for the Suomi National Polar-Orbit Partnership (NPP) Mission	NASA	Turpie, Kevin		Not Awarded

Quantifying contributions of variability in stratospheric mean transport and mixing and its connection to STE using Aura observations	GSFC (NASA)		Lee, Jae N.	Awarded
Quantifying the sources of day-to-day ionospheric variability	NASA GSFC		Lee, Jae N.	Not Awarded
Regional methane surface fluxes inverted from GOSAT radiances	UMD (NASA)		Bian, Huisheng	Not Awarded
Respiratory health effects of air quality regulations in Delhi	University of Miami (NSF)		Chu, Allen	Pending
Retrieval Studies in Support of Cloud Property Products From the Pace Ocean Color Imager	GSFC (NASA)		Zhang, Zhibo	Awarded
Satellite and sub-orbit observations to improve boundary layer ammonia and PM2.5 mixing ratios associated with agricultural emission and its effects on climate and air quality	NCSU (NASA)		Bian, Huisheng	Not Awarded
Single-footprint retrievals of atmospheric properties from CrIS	JPL (NASA)		Strow, Larrabee	Awarded
SMAP - GPM Synergy: Multichannel Passive and Active Microwave Remote Sensing of the Land Surface During Precipitation Events	NASA	Johnson, Benjamin		Pending
SNPP VIRS Aerosol Product Calibration and Validation Activities	NOAA	Remer, Lorraine		Awarded
Solar Rotational Modulations of Spectral Irradiance and Correlations with the Variability of Total Solar Irradiance	NASA	Lee, Jae N.		Not Awarded
Support for a polarimeter concept for the ACE mission	JPL (NASA)	Martins, Vanderlei		Awarded
Synergistic use of CALIOP data for understanding cloud-related variations in aerosol properties and aerosol radiative effects	NASA GSFC		Várnai, Tamás	Pending
The Effects of Atmospheric Composition on UTLS Structure and Stratosphere-Troposphere Exchange	GSFC (NASA)		Bian, Huisheng	Not Awarded
The sensitivity of marine boundary layer cloud retrievals and derived products to spatial resolution: an integrated study using (e)MAS and other field campaign data, satellites, and 3-D radiative transfer	USRA (NASA)		Zhang, Zhibo	Awarded
Time Series Approach for Ocean Color and Aerosol Retrievals Over Coastal and Turbid Waters	GSFC (NASA)		Wang, Yujie	Awarded
Towards Improved Understanding and Modeling of the Madden_Julian Oscillation Using GPM/TRMM Rainfall Estimates	NASA (UCLA)		Olson, William	Pending
Transition of GIFS-IIP Prototype to Science Campaign-Ready Airborne Chlorophyll Fluorescence Instrument (ACFI)	NASA		Huemmrich, K.F.	Not Awarded
Understanding the response of tropospheric chemistry to trends in natural and anthropogenic emissions through in situ and remote observations of formaldehyde	NASA	Wolfe, Glen		Awarded
Using Collocated GMI-DPR Observations to Study Frozen Particle Microphysical Processes above the Melting Layer and the Relationships with Precipitation Down Below	NASA (USRA)		Johnson, Benjamin	Pending

Using MAIAC and NU-WRF High-Resolution Products along with Field Measurements to Study Aerosol Distribution in association with Particle Pollution During KORUS-AQ	NASA	Chu, Allen		Not Awarded
Utilizing Aerosol Vertical Profile Observations and MERRA Reanalysis data for Air Quality and Aerosol-Cloud Interaction Studies	NASA	Chu, Allen	Yuan, Tianle	Not Awarded
Validation of GPM Precipitation Retrieval Algorithms across the Precipitation Continuum	NASA GSFC		Tokay, Ali	Pending
A Novel Data Fusion Methodology Using Measurements from Multiple Satellite Sensors	UMD (NASA)		Tangborn, Andrew	Not Awarded
Next Generation UAV Based Spectral Systems for Environmental Monitoring	NASA	Campbell, Petya		Awarded
Establishing the Sun and the Moon as Primary Absolute Standard Celestial Satellite Sensor Calibration Targets	NASA		Turpie, Kevin	Not Awarded
Use of Laboratory and Long-Path High Resolution Echelle Grating Spectroscopy of HCHO, NO2, O2:O2, and BrO to Resolve the “Aliasing” Problem in Satellite and Ground-Based Atmospheric Retrievals	NASA	Herman, Jay		Not Awarded
Comparative Metagenomics Between Psychrophilic Microorganisms Found in Surface and Subterranean Ice Formations	NASA		Shuman, Christopher	Not Awarded
Space Geodetic Networks Data Analysis	NASA	Pavlis, Erricos		Awarded
Improved understanding of vertical mixing in the lower atmospheric boundary layer in the presence of wind turbines via numerical simulations and measurements	NSF (U of Delaware)		Delgado, Ruben	Not Awarded
Water Cloud Depolarization- Multiple Scattering Relation: A Novel Technique for Spaceborne Lidar Retrievals of Above Cloud Aerosol Optical Depth (ACAO)	NASA	Zhai, Penwang		Awarded
PECAN: Ground Based Lidar and MicroWave Radiometer Profiling of the Thermodynamic and Dynamic Structure of the Nocturnal Boundary at FP2	NSF	Demoz, Belay		Awarded
Investigate and validate the effectiveness of the CL31 ceilometer algorithm at selected sites across the U.S., as developed from the Proof of Concept (CL31 Test Sites Evaluation (Phase 2)	NOAA(CUNY)	Demoz, Belay		Awarded
Atmospheric Correction Algorithm Development Using both Active and Passive Sensor Data	NASA	Zhai, Penwang		Not Awarded
Hampton University Center for Atmospheric Research and Education (CARE)	NASA (Hampton U)	Delgado, Ruben		Awarded
High Temporal Resolution Multi-sensor Land Cover Chlorophyll and LAI Products for Global Assessment of Changes in Vegetation Cover, Function and Productivity	NASA	Campbell, Petya		Not Awarded
Understanding the global morphology of the geomagnetic field using data assimilation.	NSF	Tangborn, Andrew		Not Awarded
Center for Research and Education in Human-Earth Interaction	NASA (Bowie State)		Casasanto, Valerie	Not Awarded

Remote Sensing Profiling of Winds and Temperature during XPIA	NREL	Delgado, Ruben		Awarded
Vulnerability of arctic-boreal vegetation to changes in climate	NASA (Oregon State)		Hall, Forrest	Not Awarded
Growing season length and carbon balance of boreal and arctic ecosystems	NASA (U of Nebraska)		Huemmrich, K.F.	Pending
Causes and consequences of arctic greening: the importance of plant functional types and surface hydrology	NASA	Huemmrich, K.F.		Not Awarded
Experiment Design Support for ABoVE Permafrost and Carbon Biogeochemistry Studies	NASA	Hall, Forrest		Not Awarded
NASA Earth Science Education Collaborative Network.	NASA		Casasanto, Valerie	Awarded
Hyperspectral Cubesat Constellation	NASA		Huemmrich, K.F.	Not Awarded
21st Century Mass Balance Rates and Projections of Surface Melt of Land	NASA (LDEO)		Shuman, Christopher	Not Awarded
Understanding rapid geomagnetic secular variation via data assimilation	NASA		Tangborn, Andrew	Pending
Improved understanding of vertical mixing in the lower atmospheric boundary layer in the presence of wind turbines via numerical simulations and measurements	NSF (U of Delaware)		Delgado, Ruben	Pending
Emissions and Chemistry of Formaldehyde in Biomass Burning Plumes	NOAA	Wolfe, Glen		Pending
Combined geodetic data analysis for improved development, maintenance and distribution of the ITRF	NASA	Pavlis, Erricos		Pending

Table 3: JCET Faculty (as of September 30, 2015)

Faculty Member	Title	Affiliation
Nader Abuhassan	Associate Research Engineer	Research faculty
William Barnes	Senior Research Scientist	Research faculty
Huisheng Bian	Associate Research Scientist	Research faculty
Roberto Borda	Assistant Research Scientist	Research faculty
Petya Campbell	Research Associate Professor	GES
Ding-Chong (Allen) Chu	Associate Research Scientist	Research faculty

Dominik Cieslak	Research Engineer	Research faculty
Sergio de Souza-Machado	Research Assistant Professor	Physics
Ruben Delgado	Assistant Research Scientist	Research faculty
Forrest Hall	Senior Research Scientist	Physics
Christopher Hepplewhite	Associate Research Scientist	Research faculty
Jay Herman	Senior Research Scientist	Research faculty
Susan Hoban	Senior Research Scientist	Physics
Fred Huemmrich	Research Associate Professor	GES
Leonid Iourganov	Senior Research Scientist	Research faculty
Daniel Koenig	Post-doctoral Research Associate	Research faculty
Magdalena Kuzmicz-Cieslak	Faculty Research Assistant	Research faculty
Jae Nyung Lee	Assistant Research Scientist	Research faculty
Jasper Lewis	Post-doctoral Research Associate	Research faculty
Simone Lolli	Assistant Research Scientist	Research faculty
Amita Mehta	Research Assistant Professor	GES
William Olson	Research Associate Professor	Physics
Erricos Pavlis	Associate Research Scientist	Research faculty
Ana Prados	Research Assistant Professor	Chemistry
Scott Rabenhorst	Post-doctoral Research Associate	Leave of Absence
Adriana Rocha Lima	Post-doctoral Research Associate	Research faculty
Chung-Lin Shie	Associate Research Scientist	Research faculty
Christopher Shuman	Research Associate Professor	GES
Jason St. Clair	Assistant Research Scientist	Research faculty

Andrew Tangborn	Research Associate Professor	Math
Ali Tokay	Research Associate Professor	GES
Kevin Turpie	Research Associate Professor	GES
Tianle Yuan	Research Associate	Physics
Tamas Varnai	Research Associate Professor	Physics
Yujie Wang	Associate Research Scientist	Research faculty
Frank Werner	Research Assistant	Research faculty
Glenn Wolfe	Assistant Research Scientist	Research faculty

Table 4: JCET Fellows (as of September 30, 2015)

Name	**Affiliation**
Robert Cahalan	NASA GSFC
Shin-Chan Han	NASA GSFC
Mr. Ernest Hilsenrath	NASA GSFC (retired)
Weijia Kuang	NASA GSFC
Thorsten Markus	NASA GSFC
Alexander Marshak	NASA GSFC
Vanderlei Martins	Physics
Harvey Melfi	Emeritus
Lazaros Oreopoulos	NASA GSFC
Steven Platnick	NASA GSFC
Lynn Sparling	Physics
David Starr	NASA GSFC
L. Larrabee Strow	Physics
David Whiteman	NASA GSFC

Pengwang Zhai	Physics
Zhibo Zhang	Physics
*Alexandra St. Pé (Graduate Fellow, Academic Year 2014-15)	Geography & Environmental Systems

Table 5: JCET Associate Staff (as of September 30, 2015)

Name	Title
Steven Buczkowski	Research Analyst
Keith Evans	Research Analyst
John Hall	Research Analyst
Catherine Kruchten	Instructional Designer
Townsend Hamilton	Research Analyst
Kevin Vermeesh	Research Analyst

Table 6: JCET Administrative Staff (as of September 30, 2015)

Name	Title
Valerie Casasanto	Program Coordinator
Mary Dawson	Business Manager
Belay Demoz	Director
Danita Eichenlaub	Administrative Director
Susan Hoban	Associate Director, Academics
Cathy Manalansan	Administrative Assistant II
Kevin Mooney	Accountant I
Margo Young	Business Manager

Acronyms and Abbreviations

3D	three-dimensional
ACRIM	Active Cavity Radiometer Irradiance Monitor
AGU	American Geophysical Union
AIRS	Atmospheric Infrared Sounder
AIST	Advanced Information Systems Technology
	AJAX Alpha Jet Atmospheric eXperiment
AOD	Aerosol Optical Depth
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AToM	Atmospheric Tomography Mission
AWS	Automatic Weather Station
BRF	Bidirectional Reflectance Factors
BWC	Baltimore-Washington Corridor
CAFE	Compact Airborne Formaldehyde Experiment
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarization
CAR	Cloud Absorption Radiometer
	CDR Climate Data Record
CH_4	Methane
	CHIMAERA Cross-platform HIgh resolution Multi–instrument AtmosphEric Retrieval Algorithms
CO_2	Carbon dioxide
COFFEE	Compact Formaldehyde Fluorescence Experiment
CrIS	Cross-track Infrared Sounder
DISC	Data Information Service Center
	DISCOVER-AQ Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality
DRAGON	Distributed Regional Aerosol Gridded Observation Networks
EGU	European Geosciences Union
ESRL	Earth System Research Laboratory
ESSIC	Earth System Science Interdisciplinary Center
ETM+	Enhanced Thematic Mapper Plus
FLG	Fu-Liou-Gu
GES	Geography & Environmental Systems
GLI	Global Imager
GMAC	Global Monitoring Annual Conference
GMU	George Mason University
GRL	Geophysical Research Letters
GSFC	Goddard Space Flight Center
	HASG HyspIRI Aquatic Studies Group
	HCHO Formaldehyde
HLH	Haze Layer Height
HMR	Houston Metropolitan Region
HPCF	High Performance Computing Facility
HSRL	High Spectral Resolution Lidar
HyspIRI	Hyperspectral Infrared Imager
IASI	Infrared Atmospheric Sounding Interferometer
ISAF	In Situ Airborne Formaldehyde
IST	Ice Surface Temperature

J1	First JPSS spacecraft, due to launch in late 2016 to 2017
J2	Second JPSS spacecraft, due to launch five years after J1
JCET	Joint Center for Earth Systems Technology
JPSS	Joint Partnership Satellite System
JPL	Jet Propulsion Laboratory
KORUS-AQ	KORean-U.S. Air Quality
LEGOS	Laboratoire d'Etudes en Géophysique et Océanograhie Spatiales
MAIAC	Multi-Angle Implementation of Atmospheric Correction
MEaSUREs	Making Earth System Data Records for Use in Research Environments
MERRA	Modern-Era Retrospective Analysis For Research And Applications
MGH	Maximum Gradient Height
MIROC GCM	Model for Interdisciplinary Research on Climate Global Circulation Model
MLS	Microwave Limb Sounder
MODIS	Moderate Resolution Imaging Spectroradiometer
MPLNET	Micropulse Lidar Network
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NSIDC	National Snow and Ice Data Center
OBPG	Ocean Biology Processing Group
OMI	Ozone Monitoring Instrument
PBLH	Planetary Boundary Layer Height
PC	Polarization Correction
$PM_{2.5}$	Particulate Matter with Aerodynamic Diameter Less Than 2.5 μm
QBO	Quasi-Biennial Oscillation
RMSE	Root-mean-square error
ROSES	Research Opportunities in Space and Earth Sciences
RU-NB	Rutgers University-New Brunswick
S-NPP	Suomi National Polar-orbiting Partnership
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SOHO	Solar and Heliospheric Observatory
SONGNEX	Studying the Atmospheric Effects of Changing Energy Use in the U.S. at the Nexus of Air Quality and Climate Change
SORCE	Solar Radiation and Climate Experiment
SJV	San Joaquin Valley
SR	surface reflectance
SSAI	Science Systems and Applications, Inc.
SSG	Science Study Group
TAWO	Temporary Atmospheric Watch Observatory
TRMM	Tropical Rainfall Measuring Mission
UMBC	University of Maryland, Baltimore County
UMD	University of Maryland, College Park
URL	Uniform Resource Locator
USGS	United States Geological Survey
USM	Universiti Sans Malaysia
UV	ultraviolet
UWG	User Working Group
VCST	VIIRS Calibration Support Team
VIIRS	Visible/Infrared Imaging Radiometer Suite
VIRGO	Variability of IRradiance and Gravity Oscillations Sun PhotoMeter
WINTER	Wintertime Investigation of Transport Emissions and Reactivity