EIGHTEENTH ANNUAL REPORT
JOINT CENTER FOR EARTH SYSTEMS TECHNOLOGY

A Cooperative Agreement Between:
University of Maryland, Baltimore County and
NASA Goddard Space Flight Center

July 1, 2012 – June 30, 2013

The Joint Center for Earth Systems Technology

Eighteenth Annual Report
July 1, 2012 – June 30, 2013

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I. EXECUTIVE SUMMARY

This volume is the eighteenth annual report describing the scientific accomplishments and status of the Joint Center for Earth Systems Technology (JCET). This Center 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, all from 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 leverages the collaboration between UMBC faculty and NASA scientists, resulting in an increased effectiveness of university research and teaching. An additional benefit is that the Center 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. At UMBC, JCET is administered through the Office of the Vice President for Research. JCET faculty are currently affiliated with the University's Departments of Physics, Geography and Environmental Systems, Chemistry, Mathematics and Statistics, and Education. JCET's main administrative office is located at the BWTech Research Park at UMBC. JCET also maintains a small administrative office at GSFC. The majority of the JCET faculty and scientific staff are located at GSFC. However, JCET faculty also have offices in the Physics building and Technology Research Center on the UMBC campus. A number of offices are available for GSFC-based faculty who are teaching at UMBC in the Academic Services building on campus.

There are thirty-nine (39) JCET faculty members (listed in Section III.9 Table 1) and fifteen (15) Fellows (listed in Section III.10 Table 2). JCET Fellows may be either NASA civil servants or tenured/tenure-track UMBC faculty. JCET research is also supported by four (4) research analysts (listed in Section III.11 Table 3). Brief biographies of each JCET faculty member are presented in Section III.8. The overall management and administration of JCET is carried out by the administrative staff (listed in Section III.12 Table 4) with oversight by the JCET Advisory Board. The Advisory Board is comprised of both NASA GSFC Civil Servants and UMBC Administration and faculty representatives. JCET welcomed Nader Abuhassan, Associate Research Engineer, Tilak Hewagama, Associate Research Scientist, Jasper Lewis, Post-doctoral Research Associate, Kevin Turpie, Associate Research Scientist, and Glenn Wolfe, Post-doctoral Research Associate to the faculty ranks this year. In addition, John Hall and Hamilton Townsend, both UMBC graduates, joined the scientific support staff as Research Analysts. Tim Berkoff and Shin-Chan Han left JCET to accept Civil Servant positions. Mr. Berkoff is now working at the NASA Langley Research Center and Dr. Han at GSFC.

The body of this report (see Section II) is divided into nine sections aligned 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 reporting year July 1, 2012 to June 30, 2013. Each report includes a description of the research, accomplishments for FY 12-13, and Objectives for FY 13-14. References cited in the reports are listed in Section III.1. Papers that were submitted, in press, or published in the refereed literature by JCET authors are listed in Sections III.2 and III.3. The principal direct contribution of JCET scientists to the Earth Science community is the 88 refereed papers (and 20 others submitted for review), along with 133 conference presentations, technical reports, and non-refereed publications (see Section III.4). Colloquia and seminars are an integral method to share knowledge in the academic and scientific communities. Section III.6 highlights JCET's contributions to these opportunities. In addition to their current research, JCET scientists planned for the future through submission of grant proposals, listed in Section III.7.

JCET scientists also contributed to education at UMBC by teaching and mentoring graduate students in the Departments of Physics, Mathematics/Statistics and Geography and Environmental Systems. The courses they taught this past year are listed in Section III.5. In addition, JCET faculty are mentoring or providing direct supervision for approximately 15 graduate students, and providing research opportunities for a number of additional undergraduate and graduate students from UMBC and other universities. Susan Hoban, Lorraine Remer, Ben Johnson, and Tianle Yuan affiliated with UMBC's Department of Physics during this year.

This year, for the first time, JCET organized a bi-weekly Graduate Student Seminar series. In the Fall, UMBC graduate students funded via JCET gave overview presentations of their research. In the Spring semester, the graduate students discussed highlights of their research utilizing an AGU-style presentation. Dr. Franco Einaudi enhanced the spring seminars by giving a series of lectures on Climate Change and interacting with the students in an open question-and-answer session after each lecture.

After serving as JCET Director for twelve years, Dr. Raymond Hoff continued to serve as the JCET Science Advisor for another two years. Effective July 1, 2013, Dr. Hoff is a JCET Research Professor, working half-time. JCET thanks him for his years of service providing scientific and management leadership. A search is underway for a Director of JCET.

UMBC is proud of this talented and productive group of scientists in JCET.

June 2013

Danita Eichenlaub, Director
Susan Hoban, Associate Director, Academics

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II. TECHNICAL VOLUME

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Earth Sciences Division
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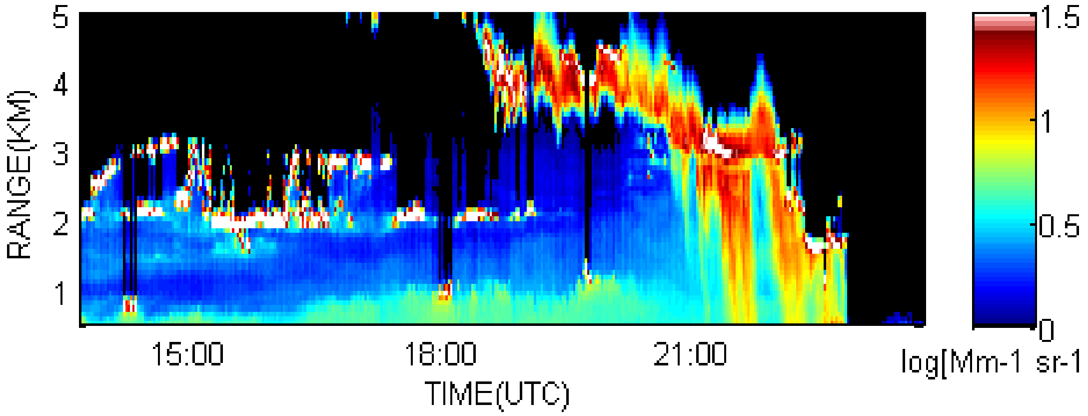
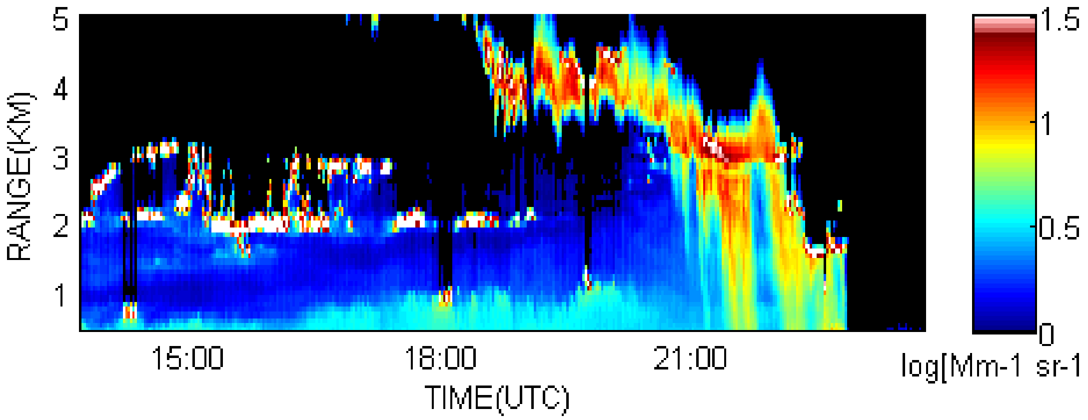
JCET Highlight: Dual Wavelength Precipitation Measurements with Lidar
Investigator: Dr. Simone Lolli





Ground-based lidar measurements taken at NASA Goddard Space Flight Center on May 9, 2012 between 13:40 and 23:59 UTC reveal the structure and phase of precipitation from 0 to 5 km above mean sea level. These graphics show MPLNET (upper) 527 nm and UV-Lidar (lower) 355 nm logarithmic attenuated lidar backscatter data [log(Mm-1 sr-1)] as a function of time for the lower atmosphere. Because two lidar wavelengths were used, it is possible to retrieve the median equivolumetric diameter of the light rain falling during 21:00 to 22:48 UTC. In addition, at 2.9 km above the site after 2200 UTC, it is visible as a lidar dark band that is situated 300m under the melting layer, indicating a cold rain process.

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U.S. Army Corps of Engineers, Institute for Water Resources; Global Change Communication and Assessment (IPA-11-0011)

NASA Grant: Topography Data on Mars: Optimizing its Collection and Application Using Laser Scanning (NNX08AT15G)

Investigator: Mark Bulmer, Associate Research Scientist, JCET

Description of Research

Dr. Bulmer's current collaborations are with U.S. Army Corps of Engineers (USACE), GSFC Cryospheric Sciences Laboratory and the Planetary Geodynamics Laboratory, UMBC Department of Mechanical Engineering, Royal United Services Institute (RUSI), and Roedown Research R^2. Research results have been submitted and accepted for publication in a range of peer reviewed journals. Technical reports related to specific projects and topics have been produced as Geophysical Flow Observatory Open File Reports.

Current research interests include: remote sensing applications to the Earth, terrestrial planets and icy satellites; landslide hazard and risk assessment; emergency management and adaptation strategies; integrating spaceborne, airborne, surface and sub-surface data; configuring Unmanned Aerial Vehicles (fixed wing, rotor, or lighter-than-air) with sensors (cameras), and designing data collection devices. In addition, Dr. Bulmer is involved in resilience and adaptation planning related to natural hazards and disasters and has provided assistance during civil emergencies. Undergraduate classes taught have included Planetary Geology, Natural Hazards and Process Geomorphology. Process Geomorphology was taught at UMBC as a 300 level course in the Department of Geography and Environmental Systems.

Accomplishments in FY 12-13

The final report for the Topography Data on Mars grant was submitted this year. During this grant Dr. Bulmer and his collaborators have built upon earlier work and continued to make advances in identifying the optimal collection parameters, analytical protocols, and supplemental data needed to resolve features on a terrestrial rocky surface. A greater understanding of blocky lava flows has been gained through this research. Consequently, future missions to Mars and other bodies, where topography data has the potential to yield high science return, have been informed by examining natural disasters such as the earthquakes in Haiti and Japan and floods in Pakistan which were utilized as proxies for Mars. This team has provided input and recommendations to the emergency management community regarding the value of obtaining and utilizing topography data at meter to sub meter scales. Further, this research has demonstrated the potential of laser scanning to substantially increase the interpretation of high-resolution imagery. Presentations on topographic data set collection, analysis and dissemination have been given in expert and non-expert academic, government and commercial forums. A variety of reports have been written by Dr. Bulmer and his collaborators, predominantly focused on the utility of topography data.

Dr. Bulmer's work with the Global Change Communication and Assessment program continues to focus on short-term water management decisions in emergency situations and extends it within the context of dealing with climate change and natural variability for reservoir regulation. Hydroclimatic disasters, like floods, make up 40% of natural disasters worldwide. In the USA, numerous recent natural disasters have demonstrated the challenge in providing operational hydrologic information to support short-term water management decisions in emergency situations. Hydrological events cause emergencies at scales from local communities, to whole watersheds and the decisions made in response involve responsible local, state and Federal agencies. The response to a hydroclimatic disaster such as Super-storm Sandy can have international significance and a country or an administration can become defined by the actions taken in the immediate response, recovery and mitigation phases over timescales of days to years. Work by Dr. Bulmer has been included in USACE publications. Presentations related to the need for geo-inputs in civil military operations and responses have been presented at international conferences. Education outreach related to the Maryland Stream Restoration Challenge has been undertaken with Roedown Research R^2, Arlington Echo Outdoor Education Center, the Chesapeake Bay Foundation, and local Maryland schools.

Objectives for FY 13-14

Work for USACE was interrupted by Continuing Resolution 2013 followed by the budget sequestration. When the fiscal position has improved, it is hoped that this work can resume. The effects of the sequester on the NASA ROSES programs of interest to Bulmer remain uncertain and have impacted proposal submissions. Subject to greater understanding of the budgets it is hoped that proposals will be submitted to this program. It is anticipated that submissions to Encyclopedia of Planetary Landforms edited by H. Hargitai and A. Kereszturi will be published by Springer in mid-2013.

NASA Grant: Toward A Better Understanding of The Vertical Structure of Marine Boundary Layer Clouds Using MODIS Observations And Large-Eddy Simulation Models (NNX11AI98G)

Investigators: Hyoun-Myoung Cho, Research Associate, JCET; Zhibo Zhang, Fellow, JCET, Physics, UMBC (PI); Steven Platnick, GSFC (Co-I); Andrew S. Ackerman, NASA GISS (Co-I); Graham Feingold, NOAA ESRL; Toshihisa Matsui, ESSIC UMCP

Description of Research

The goals of this research activity are to understand how various cloud microphysical processes, such as condensation growth, collision-coalescence, and evaporation, influence the three-dimensional microphysical structure of marine boundary layer (MBL) clouds, and thereby affect MODerate resolution Imaging Spectroradiometer (MODIS) effective particle radii (r_e) products. Cho's research focuses on understanding and assessing retrieval uncertainties and inherent limitations of MODIS retrieval algorithms, including 3-D radiative effects as well as the impact of warm rain process on MODIS r_e products.

Accomplishments in FY 12-13

Dr. Cho's primary accomplishments are a systematic assessment of the failure rates of MODIS r_e retrievals at 2.1 and 3.7 µm wavelengths ($r_{e,2.1}$ and $r_{e,3.7}$, respectively). Cho and team found that the MODIS retrieval fails for almost 30% of MBL cloud pixels. Cho eliminated issues in research algorithms that restricted r_e retrievals, allowing the research team to investigate the difference between $r_{e,2.1}$ and $r_{e,3.7}$ failure rates and the dependence of failure rate on clear-sky restoral cloud category. Cho and the team found that $r_{e,2.1}$ retrieval fails more than three times more frequently than $r_{e,3.7}$ retrieval does. It should be also he noted that cloud edge or highly heterogeneous pixels have retrieval failures much more frequently than "good" (homogeneous) pixels.

Objectives for FY 13-14

In the coming year, the team will focus on investigating and understanding the potential mechanisms contributing to the failed MODIS effective radius retrievals for MBL clouds. The team will also assess the potential impacts of failed MODIS effective radius retrievals on aerosol-indirect studies and general circulation model cloud microphysics scheme validation efforts.

CCNY Subcontract: Cooperative Remote Sensing Science and Technology (NOAA-CREST) Center (CCNY Subcontract PN 00006772)

MDE Grant: UMBC Monitoring of Atmospheric Pollution: Vertical Profiling of Baltimore's Lower Troposphere During Nocturnal Low Level Jets, Air Quality Events and Determination of Planetary Boundary Layer With UMBC Lidars (MDE Grant U00P1401314)

Maryland Energy Administration: Measurements of Terrestrial and Offshore Wind Resource over Maryland for Strategic Planning and Development of Offshore Wind Energy Projects (Project Number 0000006436)

Investigators: Rubén Delgado, Faculty Research Assistant, JCET; Raymond Hoff, Science Advisor, JCET, Professor, Physics, UMBC; Timothy A. Berkoff, Assistant Research Engineer, JCET; Simone Lolli, Research Associate, JCET; Christopher Hennigan, Assistant Professor, Chemical, Biochemical, and Environmental Engineering, UMBC; Weidong Zhu, Professor Mechanical Engineering, UMBC; Lynn Sparling, Associate Professor, Physics, UMBC; Belay Demoz, Howard University; Barry Gross, City College of New York; Douglas Martins, Penn State University; Patrick McCormick, Hampton University; Fred Moshary, City College of New York; Christopher Loughner, University of Maryland; Scott Rabenhorst, Post-Doctoral Research Associate, UMBC; Ryan Stauffer, Penn State University; Anne Thompson, Penn State University; Michael Woodman, Maryland Department of the Environment; Andrew Gohn, Maryland Energy Administration

Students: Patricia Sawamura, Daniel Orozco, John Sullivan, Peter Luu, Jared Johnson, Daniel Wesloh, Graham Antoszewski, Farrah Daham, UMBC

Description of Research

Elastic and wind lidar measurements have been conducted to measure the vertical distribution of aerosols and wind over the Baltimore-Washington metro area. The goal of this research is to understand and aid in the assessment of whether exceedances of air pollutants and particulate smaller than 2.5 μm (PM2.5) in the Baltimore-Washington metropolitan area are due to local sources or long-range transport. Active remote sensing lidar measurements support the NOAA CREST Lidar Network (CLN), which monitors air quality in the vertical from multiple locations on the eastern coast of the United States, the North American Global Atmospheric Watch: Aerosol Lidar Observation Network, Nocturnal Low Level Jet (NLLJ) and Maryland offshore wind assessment studies, sponsored by the Maryland Department of the Environment (MDE) and Maryland Energy Administration (MEA).

Accomplishments in FY 12-13

Lidar measurements were made by UMBC's Atmospheric Lidar Group (ALG) and have provided a set of atmospheric profiles of aerosols. Analysts from state and federal agencies query the forecast aerosol vertical distribution of these profiles in near real time and compare them to the inputs of three dimensional forecasts models. The UMBC lidar measurements have been useful for NASA A-train (Aqua, Terra, CALIPSO, etc.) satellite retrieval studies, enabling instrument accuracy assessments and have been compared to various independent active and passive remote sensing instruments for case studies of regional aerosol variability due to long range transport of smoke, dust and pollutants. Results of these studies have determined the relative impact of long-range transport versus local emissions during NLLJ and pollution events over the Baltimore-Washington region.

An electronic mail distribution list continues to be hosted by ALG, cln@lists.umbc.edu, for immediate communication between CREST institutions prior and during air quality events, aiding in the determination and impact of regional and long-range transport of pollutants over a region that extends over the eastern US states and Caribbean.

This year, the team's active remote sensing measurements were augmented with a scanning Doppler wind lidar to characterize offshore winds near Maryland. The system was acquired in June 2013, as part of a Maryland Energy Administration (MEA) sole source grant, for offshore wind resource assessment for the Mid-Atlantic region. The offshore wind resource measurements will provide wind energy stakeholders with a validated database that will reduce uncertainty of wind estimates over Maryland and along its shorelines need for the development and integration of wind energy projects. These research activities will ensure Maryland's contribution to national energy independence plans, as well as environmental stewardship, and a strengthened State economy based on clean renewable energy sources.

Objectives for FY 13-14

The UMBC Planetary Boundary Layer (PBL) algorithm will be used to retrieve PBL heights for the National Weather Service Vaisala's CL31 ceilometers, as part of a proof of concept test bed. This project is a collaboration between UMBC and Howard University. The algorithm development will allow the evaluation of PBL heights retrieved from CL31 ceilometers, installed nationwide at Automated Surface Observing System (ASOS) sites, and to support the National Weather Service's Sterling, Virginia, Field Support Center's scientific efforts.

Validation of scanning Doppler wind lidar profiles with both radar wind profiler and rawinsondes measurements in rural, suburban, coastal and marine environments enables model evaluation of forcings that drive winds in the Mid-Atlantic United States. A seasonal study of near shoreline (0-5 nautical miles, up to 10 km) offshore wind resource and a comparison to a US Department of Energy (DOE) offshore wind resource map for the State of Maryland will be carried out.

NASA Grant: CLARREO Development Guided by Existing Hyperspectral Satellite Knowledge Base (NNX11AG61G)

Investigators: Sergio De Souza-Machado, Assistant Research Professor, JCET, Physics, (Co-I); Vanderlei Martins, Fellow, JCET, Associate Professor, Physics, UMBC; Yuval Ben-Ami, ORAU; L. Larrabee Strow, Fellow, JCET, Research Professor, Physics, UMBC; Andrew Tangborn, Research Associate Professor, JCET; Eric Maddy, NOAA; Xianglei Huang, U. Michigan; Joao Teixeira, JPL

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 instrument has proved to be very stable, and is enabling a high quality 10-year dataset of atmospheric observations to be created. When pieced together with comparable new generation instruments that have recently come online, this should provide scientists with a comprehensive climate-quality data record. Dr. De Souza-Machado with the research team has pioneered the use of probability distribution functions in detecting climate change.

In addition, he is continuing to retrieve large aerosol particle (dust and volcanic ash) information that is contained in AIRS radiances. An ongoing collaboration with NOAA scientist Dr. Eric Maddy, and UMBC scientists Dr. Vanderlei Martins and Dr. Yuval Ben-Ami, is paying dividends by enabling improved operational retrievals in the presence of these aerosols.

Accomplishments in FY 12-13

Ten+ years of AIRS data was analyzed to provide estimates of atmospheric trace gas, temperature and humidity trends. Earlier work with these data was limited to using spectra obtained under clear sky conditions. De Souza-Machado has extended the research to include spectra obtained under all-sky conditions. By limiting the data to angles close to nadir, this reduced the dataset to 5% of available data but radiance trends were obtained from the filtered set and enabled specific channels (namely the 1231 cm-1 window channel) to be used to examine cloud forcing over the 10 year period.

A collaboration by De Souza-Machado with Dr. Vanderlei Martins and Dr. Yuval Ben-Ami has enabled utilization of an Atmospheric Emitted Radiance Interferometer (AERI) on the UMBC campus. Their substantial progress taking measurements from the ground now allows the measurement of aerosol refractive indices in the infrared. These efforts should lead to an improved understanding of dust in the atmosphere.

An additional collaboration with Dr. Eric Maddy of NOAA (Camp Springs) involves using the fast radiative transfer model with scattering designed for use with AIRS data known as the Stand-Alone AIRS Radiative Transfer Algorithm (SARTA-Cloudy) developed at UMBC, to determine radiances in the presence of dust. The aim is to improve AIRS L2 products in the presence of dust. The AIRS project is now exploring an appropriate way to incorporate these efforts in their products.

De Souza-Machado also collaborated with Dr. Xianglei Huang (U. Michigan) who provided code to take Numerical Weather Prediction Fields under cloudy conditions and simulate maximum random overlapping clouds, for comparisons with SARTA scatter code developed at UMBC by De Souza-Machado.

He has also investigated diurnal effects on sea surface temperatures, using codes provided by Dr. Gentemann (Remote Sensing Systems, Santa Rosa, CA), and has written additional processing codes based on advice from Dr. Filipiak (U. Edinburgh, UK).

Objectives for FY 13-14

De Souza-Machado intends to finish looking at 10+ years of AIRS spectral data for assessing climate trends under clear conditions in collaboration with Dr. L. Larrabee Strow and Dr. Andrew Tangborn at UMBC.

Similarly, he will continue to use 10+ years of AIRS spectral data to look for climate trends under cloudy conditions and to use these data to study changes in probability distribution functions as well.

De Souza-Machado also intends to use 10+ years of AIRS data to look for changes in extreme atmospheric events and to develop AIRS L2 retrievals using a cloudy sky Radiative Transfer Algorithm.

In collaboration with Dr. Joao Teixeira (JPL), he also intends to design instruments to improve boundary layer characterization.

NASA Grant: Multiscale Analysis of Tropical Cyclone Hot Tower and Warm Core Interactions Using Field Campaign Observations (NNX09AG03G)

NASA Grant: In Situ Measurement of Meteorological State Variables Using Dropsonde On the NASA DC-8 and Global Hawk During NASA GRIP, and Composite Analysis of a Large Dropsonde Database (NNX09AV79G)

NASA Grant: Hurricane Severe Storm Sentinel (HS3) (NNX11AQ94G)

Investigators: Jeffrey B. Halverson, Fellow, JCET, Associate Professor, Geography and Environmental Systems, UMBC; Scott Braun, Paul Newman, Gerald Heymsfield, GSFC

Students: Janel Thomas, Alexandra St. Pe, UMBC

Description of Research

Halverson studies the dynamics and thermodynamics of severe storms including tropical cyclones, Nor'easters and thunderstorms. His goal is to better understand how these storms develop and evolve in the complex physiographic setting of the Mid-Atlantic Region, and also to assess their socioeconomic impacts.

Accomplishments for FY 12-13

Halverson continued his research as a member of NASA’s Hurricane Science Team. His M.S. graduate student, Ms. Janel Thomas, completed her thesis requirements in Fall 2012 and graduated in May 2013. Her thesis is titled “A Multi-Scale Observational Analysis of Factors Leading to Hurricane Earl’s Rapid Intensification.” In 2012, she presented these results at several professional conferences as well as at a UMBC research symposia. The thesis is being crafted into a journal submission during the summer of 2013.

Halverson’s current M.S. graduate student, Ms. Alexendra St. Pe, developed the core elements of her thesis exploring the relationship between Sahelian dust outbreaks on Atlantic hurricane genesis and their storm intensity change. She is using a rigorous geospatial analysis technique to test correlation between parameters in the large-scale, tropical hurricane environment and the Saharan Air Layer. Her goal is to complete the requirements of the M.S. Thesis during the summer of 2013. The plan is to prepare a journal manuscript during the fall of 2013.

Halverson serves on the science team for the Hurricane and Severe Storm Sentinel (HS3) Venture Class mission. For the second year (2013), the mission will fly two instrumented Global Hawks over the Atlantic from the NASA Wallops Flight Facility to study hurricane structure and dynamics. In 2012, the mission had its first successes by completing numerous, long-duration flights over several Atlantic hurricanes. During the summer of 2013, Halverson will serve as a Mission Scientist and will lead a team of gradute student forecasters. His research emphasis during HS3 will be to explore the process of extratropical transition involving tropical cyclones off the Eastern Seaboard.

Halverson's Ph.D. student, Mr. Aaron Poyer, continues to develop the analytical basis for his Ph.D. research. Poyer is examining the relationship between local thunderstorm formation, precipitation, and atmospheric electrification in the Washington-Baltimore urban corridor. He is utilizing a high-resolution, regional lightning detection array combined with NEXRAD (Next-Generation Radar) and Terminal Doppler Weather Radar data and aerosol optical depth information on the regional air mass. His committee will convene its initial meeting during the summer of 2013.

Halverson and UMBC Geography colleague, Tom Rabenhorst, continued writing chapters for their introductory undergraduate textbook "Severe Storms and Their Environmental Impacts." This continues a four-year contract with Oxford University Press for a total of 20 chapters. Seven chapters have been completed and submitted for peer-review. An eighth chapter is being prepared during the summer of 2013.

Objectives for FY 13-14

Halverson took sabbatical leave from teaching in Fall 2012. He returned to full-time teaching in Spring 2013 and was promoted to Professor in Geography and Environmental Systems. He will teach a new undergraduate course, Natural Hazards, in Fall 2013 and a new graduate-level course, Earth System Science, in Spring 2014. In 2013-2014, his research will continue to focus on the genesis and intensification of severe storms along the East Coast and the Mid-Atlantic region of the United States. He will push the HS3 science team to investigate at least one case of extratropical transition off the Eastern Seaboard during the 2013-2014 timeframe. Ph.D. student Poyer will refine his analytical techniques for a case study of Baltimore-region thunderstorm genesis, and expand the research framework to additional cases. Halverson's M.S. student Amy Bleich is expected to fulfill her M.S. degree requirements during summer-fall 2013, focusing on remote sensing of the Gulf oil spill. Halverson and Rabenhorst expect to author an additional two or three textbook chapters for Oxford by January 1, 2014.

NOAA Grant: Air Quality Proving Ground (AQPG) (NA10NES4280016)

NOAA Grant: GOES-R Air Quality Proving Ground (NA11NES4400009)

NASA Grant: UMBC Participation in Discover AQ (NNX10AR38G)

Investigators: Raymond Hoff, Science Advisor, JCET, Professor, Physics, UMBC; Timothy Berkoff, Assistant Research Engineer, JCET; Amy Huff, Pennsylvania State University; Shobha Kondragunta, NOAA

Students: Patricia Sawamura, Jaime Compton, Daniel Orozco, UMBC

Description of Research

Hoff's research utilizes satellite and ground-based remote sensing techniques to assess air quality. The effort currently involves two projects supported by NOAA and NASA, respectively. In the Geostationary Operational Environmental Satellite R-Series Program (GOES-R) Air Quality Proving Ground (AQPG), Hoff and his team focus on preparing a user community with tools to assess particulate air quality from the GOES-R Advanced Baseline Imager (ABI). In the NASA project, Hoff's team is part of a larger five-year Earth Systems Science Pathfinder mission: Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality (DISCOVER-AQ). This project will determine how best to use satellite-retrieved quantities, such as aerosol optical depth, to determine surface aerosol concentrations. Specifically, UMBC researchers retrieve aerosol extinction profiles using in-situ and remote measurements.

Accomplishments in FY 12-13

In this reporting period, the AQPG focused on a one-day "Day-in-the Life" experiment. Its goal is to generate synthetic ABI data to prepare forecasters for what they will see when the GOES-R mission is launched in 2015. In return, the forecasters provide feedback to the team aimed at improving forecasting day-to-day air quality. Since researchers have no data from a multi-wavelength geostationary sensor prior to the GOES-R launch, Observing Systems Simulation Experiments (or OSSE's) will provide data for the simulation. To do so, NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) and National Centers for Environmental Prediction (NCEP) run the Weather Research and Forecasting (WRF-CHEM) model to simulate day-to-day aerosol loadings. Those results are then fed to the Community Radiative Transfer Model (CRTM) to simulate the on-orbit radiances observed from the GOES-R orbit. These radiances are then fed to the ABI's algorithm to produce the products that will be available in 2015. To simulate real life, the run consists of hourly simulations that are prepared in advance but fed out to a web display at the hour simulated in the OSSE.

Since the OSSE involves simulated data from two models and the GOES-R ABI processor, it is not expected to be highly accurate. WRF-CHEM is known to do poorly in simulating certain aerosol types. And in this initial trial, NOAA NCEP was unable to simulate the radiances in near-real time. A post-hoc analysis of a case, July 4, 2012, was presented to the user group in a workshop setting. The workshop was held on March 14, 2013, at UMBC. However, the user group concluded that the design of the web portal, based on the Integrating satellite Data into Environmental Applications (IDEA) system, is very good. Recommendations made by the user group in 2010-2012 have been implemented to address their needs. The users understand the products therefore the AQPG project met its design goal of familiarizing the user community with GOES-R ABI data.

The DISCOVER-AQ mission operated in the Baltimore-Washington area in 2011 and enables analyses of air quality over urban areas. The UMBC group is continuing its analysis to contribute to papers on Planetary Boundary Layer Height (PBLH), correlation of aerosol optical depth (AOD) and PM2.5, verification of the NASA Langley Research Center (LaRC) High Spectral Resolution Lidar (HSRL) extinction profiles and comparison with the WRF-CMAQ (Community Multi-scale Air Quality) model output, and derivation of aerosol microphysical parameters. These papers are expected to be submitted in 2013 and should also lead to Patricia Sawamura's Ph.D. dissertation.

In 2013, DISCOVER-AQ went to California for the second experiment in the four experiment series. In California, agricultural and biological emissions during the winter season are known to elevate the AOD. The UMBC group deployed in Porterville, California, along with the Nittany Atmospheric Trailer and Integrated Validation Experiment team from Penn State. A micropulse lidar with wide field capability (see write-up by Tim Berkoff) was used with an Aerodyne Cavity Attenuated Phase Shift Particle Extinction Monitor and a UMBC-designed hygroscopic nephelometer. The latter instrument was built by student Daniel Orozco and gave 1/2 hourly sweeps of the extinction of the aerosol in the valley as a function of relative humidity. This novel technique used proportioning valves to mix dry and wet air that was at ambient temperature to remove a nitrate artifact that can occur at elevated temperatures. The results all compare favorably to simpler aerosol hygroscopic growth f(RH) (the increase in the aerosol scattering coefficient with relative humidity) monitors built by NASA LaRC [Ziemba et al., 2013] and revealed that the aerosol in the valley was not as hygroscopic as expected. The reduced aerosol optical depth seen in prior years was not observed but it is likely that residential and agricultural burning (some surreptitious) continues to occur in the area leading to degraded air quality.

Objectives for FY 13-14

In 2013-14, the AQPG will focus on developing new scientific users for both GOES-R and the Visible Infrared Imaging Radiometer Suite (VIIRS) on Suomi NPP (NPOESS Preparatory Project). The latter data is now being fed to IDEA and this will help draw users to the IDEA web site. Another "Day in the Life" experiment is planned for spring 2014. Hoff will participate in the Houston TX, DISCOVER-AQ Experiment. In Houston, UMBC will provide one lidar for profilng the urban boundary layer at the University of Houston's Moody Tower site. Mr. Orozco's hygroscopic system is being transferred to Professor Martin's group for measuring the aerosol phase function in three wavelengths as a function of increasing relative humidity. It is believed that these data will enable predictions of aerosol phase sensitive optical properties for AERONET (AErosol RObotic NETwork) as well as in lidar measurements. Ms. Sawamura is expected to defend her thesis in August 2013 and will be taking up a post-doctoral position at NASA LaRC.

NASA Grant: Validation of the CrIS Sensor Products for Climate Research (NNX11AK78G)

NASA Grant: Hyperspectral Infrared Earth Radiance Time Series (NNX12AG66G)

Task 359: Trace Gas Retrievals using AIRS (Sponsor: Steven Pawson)

Investigators: Breno Imbiriba, Research Associate, JCET; L. Larrabee Strow, Fellow, JCET, Research Professor, Physics, UMBC; Sergio de Souza-Machado, Research Assistant Professor, JCET; Howard Motteler, Contract Researcher, JCET; Andrew Tangborn, Research Associate Professor, JCET; Tilak Hewagama, Associate Research Scientist, JCET; Paul Schou, Research Analyst, JCET

Description of Research

Dr. Imbiriba’s main research focus is on CO_2 retrievals using hyperspectral infrared (IR) sounders as well as atmospheric models with an Optimal Estimation retrieval algorithm. In the previous fiscal year, his research focused on comparing two models, ECMWF Re-Analysis (ERA) from the European Centre for Medium-range Weather Forecasts (ECMWF) and the Modern Era-Retrospective analysis for Research And Applications (MERRA) from NASA’s Global Modeling and Assimilation Office (GMAO), using 10 years of satellite radiance data. Any CO_2 retrieval is very sensitive to the atmospheric model utilized and such comparisons with sounder retrievals serve to test the models. A second focus of the research is to use previously generated CO_2 retrievals dervived from a simple “least squares” inversion method, and to assimilate them into a transport model to look for improvements on surface fluxes.

Accomplishments in FY 12-13

Dr. Imbiriba's main research generates CO_2 retrievals from Atmospheric Infrared Sounder (AIRS) data, specifically its thermal Infrared sounder radiances. These data are used with atmospheric state models for radiative transfer physical retrievals. Those retrievals are very sensitive to the quality of the atmospheric models that is the largest source of uncertainty. Consequently, several models have to be used and compared, and hence Dr. Imbiriba can also use the AIRS retrievals as a gauge for the model quality.

Thermal IR retrievals only observe CO_2 in the middle troposphere, hence a natural way to use the retrieval is together with a global transport and assimilation CO_2 model. This was done in conjunction with the GMAO group, using the Goddard Earth Observing System Model, Version 5 (GEOS-5) model. Imbiriba provided CO_2 retrieved values for the years of 2005 and 2006, using the ECMWF atmospheric model. The assimilation of this data showed a marked reduction of the standard deviation of the modeled CO_2 data at the mid-troposphere pressure levels where the CO_2 is retrieved. Such improvement was not seen with other modeled CO_2 retrievals in the literature [Tangborn, et al. 2013].

Due to the sensitivity of the CO_2 retrieval to variations on the atmospheric model, one can attempt to observe the stability of such models. Imbiriba performed 10 years of CO_2 retrievals for the AIRS instrument using the ECMWF and two reanalysis models, ERA - derived from

ECMWF, and the GMAO's MERRA. Looking at zonal retrieval enables comparisons of the growth rate of CO_2 as calculated from each model which can then be compared with in-situ measurements. This tests the stability of each model, an essential feature in any model used for climate studies. The ECMWF model showed clear discontinuities and appears less suitable for climate studies. The ERA and MERRA models are much more stable, but the retrievals using ERA presented unrealistic features, reminiscent of previous retrievals using the non-reanalysis ECMWF model, whereas the MERRA model allowed for retrievals compatible with in-situ measurements for growth rate - stable and linear.

Objectives for FY 13-14

In the next fiscal year Dr. Imbiriba will implement an optimal estimation CO_2 retrieval in order to reduce retrieval errors and will generate 10 years of AIRS CO_2 retrieved data that will be assimilated into the GEOS-5 product, to study inter-annual CO_2 variabilities. Also the CO_2 retrieval methods will be expanded to use data from two additional IR sounders, the Infrared Atmospheric Sounding Interferometer (IASI) and the Cross-track Infrared Sounder (CrIS), the National Oceanic and Atmospheric Administration's (NOAA) new infrared sounder.

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

Investigators: L. Larrabee Strow, Fellow, JCET, Research Professor, Physics, UMBC; Tilak Hegewama, Associate Research Scientist; JCET; Breno Imbiriba, Research Associate, JCET; Sergio DeSouza-Machado, Research Assistant Professor, JCET, Physics, UMBC; Howard Motteler, Contract Researcher, JCET

Description of Research

The team at UMBC led by Dr. Strow will participate in the pre-launch testing of the JPSS-1 (Joint Polar Satellite System-1) CrIS (Cross-track Infrared Sounder) sounder instrument, supporting CrIS readiness and data reviews, and other technical requirements. The team will analyze CrIS pre-launch test data and determine instrument performance, with a concentration on spectral calibration, the Neon calibration subsystem, and overall end-to-end quality of the instrument interferograms. This will also include studies to support the new high-spectral resolution mode testing and development of CrIS SDR (Sensor Data Records) testbed codes for producing CrIS radiances from interferograms. In particular, Dr. Strow plans to perform testing that will help illuminate existing problems with the Soumi-NPP (National Polar-orbiting Partnership) CrIS sensor, especially systematic differences in the CrIS SDR’s versus interferometer scan direction. This work follows the team’s successful testing and deployment of the CrIS sensor on Soumi-NPP, which was previously performed under the DOD/NOAA/NASA IPO office.

Accomplishments in FY12-13

This task started in January 2013 and the team was very fortunate to have hired Dr. Tilak Hegewama who has over 25 years of experience developing and using astronomical Fourier-transform instruments at NASA/GSFC. Work to date has included modifications to analysis procedures to incorporate the CrIS operation in full-spectral resolution mode, providing higher spectral resolution data in the mid-wave and short-wave bands. This will enable continuation of the NASA Aura TES (Tropospheric Emission Spectrometer) and NASA Terra MOPITT (Measurements of Pollution In The Troposphere) carbon monoxide record for the next 15+ years using the JPSS CrIS instrument. Strow and team have also been working to enable test procedures that allow an in-depth understanding of the behavior of the CrIS FIR (Finite Impulse Response) interferogram filter and it’s phase sensitivity, which is presently causing CrIS SDR radiance records to have a scan-direction bias, especially in the long-wave band.

Objectives for FY 13-14

The team is working toward successful thermal vacuum testing of the CrIS sensor for JPSS-1, including spectral calibration, stability analysis, and producing better models of the CrIS FIR filter behavior.

Task 374: Design, assembly and testing of the GSFC Ozone DIAL Lidar (Sponsor: Thomas McGee)

Investigators: John Sullivan, Graduate Student, JCET, Physics, UMBC; Thomas McGee, Researcher, GSFC; Raymond Hoff, Science Advisor, JCET Professor of Physics, UMBC

Description of Research

Mr. Sullivan and Dr. McGee, with assistance from GSFC contractors, have built a ground based Differential Absorption Lidar (DIAL) system at the NASA Goddard Space Flight Center that will be tested at a Howard University facility near Beltsville, MD. The importance of this project is that current atmospheric satellites cannot peer through the optically thick stratospheric ozone layer to remotely sense tropospheric ozone, which is currently one of the most important greenhouse gases for climate change studies. Additionally, ozone can be formed in the troposphere due to complex interactions with sunlight, NO_x and Volatile Organic Compounds. Ozone has also been shown to mix down from the lower stratosphere and cause high levels of ozone at the Earth's surface. For these reasons, the origination, formation, and amount of ozone in the troposphere are therefore an important variable in atmospheric sciences.

Accomplishments in FY 12-13

As part of the Tropospheric Ozone Lidar Network (TOLNET) funded by NASA Headquarters, the research team has committed to build and operate an ozone DIAL system in Maryland based at GSFC. This system has evolved from a heritage of instruments that have been used in stratospheric research. It will be one of only five such instruments in the US.

Preliminary results taken from the tropospheric ozone DIAL system suggest that there will be enough usable backscatter signal to profile the planetary boundary layer (PBL). Additionally, this system has been constructed for active measurements in a 40' long mobile trailer. Transitioning from a stationary laboratory experiment to a field deployable instrument has taken some time and resources. Additionally, a Thermo Scientific ozone monitor (49i) has been installed in the trailer to yield valuable information about the ozone at the surface.

The DIAL method exploits the difference in signal returned between a strongly absorbing "on" channel and a weakly absorbing "off" channel to obtain the ozone number density. To obtain these data, specific wavelengths (299 nm and 289 nm) Raman cells were manufactured to enhance Stimulated Raman Scattering (SRS) in a Raman-active media. Due to safety precautions, mainly the high pressure of the cells, laser safety and the volatile Hydrogen gas being used, this took longer than expected. At this time, the cells have been completely manufactured and tested, yielding approximately 16 mJ/pulse at 299 nm and 13 mJ/pulse at 289 nm.

Objectives for FY 13-14

Ozone profiles will be generated from measurements taken with the tropospheric ozone DIAL system by the research team. Calibration/validation of ozone lidar profiles will be carried out in conjunction with Howard University ozonesonde launches in Beltsville, MD. Seasonal and diurnal variation of tropospheric ozone will be determined from ozone lidar profiles. Comparison between lidar and satellite derived column measurements will be carried out. Tropospheric column ozone derived from lidar measurements and the Ozone Monitoring Instrument (OMI) sensor on NASA's AURA satellite will be compared to determine how representative satellite observations are with ground-based ozone measurements. This will allow for the quantification of ozone concentrations below the PBL height, where it is well-mixed and would be best represented by ground-based ozone measurements.

The research team will use the instrumentation to acquire summer measurements to study the contrast between strong daytime convection and nighttime conditions, during ozone and PM2.5 exceedance days. Winter measurements will be taken to study the effect of temperature inversions on PM2.5 production enhancements and mixing layer height.

It is expected that in the next JCET reporting period, additional financial support will be received from a grant from the Maryland Department of the Environment through Dr. Ruben Delgado, PI, to provide graduate assistantship support for Mr. Sullivan.

Mesoscale Atmospheric Processes Laboratory (Code 612)

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Task 337: The Micro-Pulse Lidar Network Research and Development (Sponsor: Judd Welton)

Task 336: DISCOVER-AQ Field Campaign and Analysis (Sponsor: Ken Pickering and Jim Crawford)

Task 376: Lunar Photometer (Sponsor: Brent Holben)

Fibertek Inc. STTR Subaward 0581-001-04-80295: New Lidar Laser Configuration for Earth Science Measurements

Investigators: Timothy Berkoff, Assistant Research Engineer, JCET; Raymond Hoff, Science Advisor, JCET, Professor, Physics, UMBC; Ruben Delgado, Research Associate, JCET; Youming Chen, Shantanu Gupta, Fibertek; James Crawford, NASA Langley

Students: Patricia Sawamura, Aasam Tasaddaq, Hasnain Tasaddaq, Daniel Orozco, John Sullivan, UMBC

Description of Research

Mr. Berkoff's research is focused on the development and demonstration of lidar and photometer observational techniques for the characterization of clouds and aerosols for air quality and climate studies. This work benefits NASA's programs such as the Micro-Pulse Lidar Network (MPLNET) and Aerosol Robotic Network (AERONET) that are used as a ground-based compliment to NASA's Earth Observing System (EOS) satellite data and related modeling efforts.

Accomplishments in FY 12-13

UMBC-MPL advanced calibration site: During this reporting period, support for data collection and ongoing studies to support related MPLNET base-line calibrations were accomplished. MPLNET is a world-wide network of ground-based lidars that provide vertical backscatter properties of aerosols and clouds. Activities included the operation of a Wide Field-Of-View (WFOV) receiver at UMBC to help interpret the stability and residual calibration issues that are applied to lidar systems at GSFC. A new version of this system was developed and delivered to GSFC for use as the primary tool for MPLNET calibrations and MPLNET staff were trained on how to use the system.

Lunar Photometry: Ongoing work was carried out to further develop and establish a nighttime Aerosol Optical Depth (AOD) measurement capability using the moon as a light source. The measurement of nighttime AOD is important to understand the full diurnal cycle of aerosols, and is particularly useful at high latitude regions during winter seasons when extended darkness occurs and EOS sensors relying on sunlight cannot be used. A newer version of the photometer was obtained in 2012, calibrated against the AERONET reference integrating sphere, and was used at NOAA's Mauna Loa field site to obtain calibration reference data for Langley. Automated software was developed to operate the instrument by Aasam Tassadaq. The system was then operated at UMBC for a five-month period of time, with all data being processed for atmospheric transmission and provided to AERONET. The nighttime lunar AOD efforts have led to collaborations with NOAA, Izaña Atmospheric Research Center (Meteorological State Agency of Spain), National Institute of Standards and Technology (NIST), United States Geological Survey (USGS), and Université de Sherbrooke (Québec, Canada), where research groups have conducted similar photometer studies based on this approach.

Fibertek HSRL system: During this reporting period, UMBC partnered with Fibertek Inc. for a Small Business Technology Transfer (STTR) Phase II demonstration of a new laser system to obtain atmospheric aerosol measurements based on the High-Spectral Resolution Lidar (HSRL) technique. The main goal of this approach is to develop a ground-based HSRL that will be compatible with MPLNET. Supplementary data was obtained to further evaluate the potential of the system for daytime measurements and stability of the Phase I laser system. During the Phase II effort, optical and mechanical designs were established to allow for the build phase of the prototype instrument. This included the specification of all optical components, and the design trade studies needed to maximize performance of the future system and allow for the opto-mechanical design to proceed.

Discover AQ field campaign and data analysis: Mr. Berkoff participated in NASA's Venture Class project called Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) (James Crawford, PI, Langley Research Center). This field mission occurred in January 2013 in the San Joaquin Valley of California and focused on how EOS satellite data can best be used to provide surface air quality assessments. In this effort, Mr. Berkoff demonstrated the first field deployment of a WFOV receiver for use with an MPL. This experiment provided critical near-surface aerosol information, that MPLs typically have a difficult time reporting correctly. Data for both MPL and WFOV were processed and displayed in near real-time for use by campaign researchers.

Objectives for FY 13-14

In the next year, the three JCET tasks will be discontinued as Mr. Berkoff will be taking up a permanent position with NASA Langley Research Center. The Fibertek sub-award will be completed in the next year with the construction of a fiber-optic laser-based HSRL. Dr. Raymond Hoff will be the Year 2 Principal Investigator on this contract and Hasnain Tasaddaq, a student in the Mechanical Engineering Department, will document the design of the system and provide mechanical interface drawings to the Prime Contractor. The lidar system will be tested at UMBC against the Elastic Lidar Facility (ELF) and Raman lidar systems that have previously been compared to Langley's HSRL airborne system. This will provide confidence that the extinction retrievals from the HSRL are accurate. Comparison with AERONET will be part of the daytime characterization of the HSRL system.

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

Investigator: Jasper Lewis, Post-Doctoral Research Associate, JCET

Description of Research

This research is focused on the development of cloud and boundary layer detection algorithms for the Micropulse Lidar Network (MPLNET). The improved algorithms will be used to develop multiyear climatologies at multiple sites around the globe within the network. Results from this research will improve studies of air quality and climate.

Accomplishments in FY 12-13

A study of boundary layer depths at the Goddard Space Flight Center (GSFC) site in Greenbelt, MD has been conducted using the improved detection algorithm. The results showed the diurnal and seasonal trends in the boundary layer over an eight-year period. The boundary layer depths measured at GSFC compared well with nearby radiosonde observations and modeled retrievals. A manuscript summarizing the boundary layer algorithm and results has been accepted for publication in the Journal of Geophysical Research.

Objectives for FY 13-14

Completion of the boundary layer and cloud detection algorithms is expected in the next year. Both algorithms will be incorporated into the upcoming MPLNET version 3 release and the results will be analyzed for multiple sites in the network. Furthermore, a climatology of daytime cirrus cloud properties will be developed for comparison with the Aerosol Robotic Network (AERONET) cloud screening algorithm to investigate contamination of aerosol measurements by passive instruments.

Task 304: Passive And Active Microwave Retrievals Of Frozen And Melting Precipitation Hydrometeors (Sponsor: Gail Skofronick-Jackson)

NASA Grant: Improvements Of Passive And Active Microwave Precipitation Retrieval Algorithms For Mixed-Phase Precipitating Clouds (NNX11AR55G)

Investigators: Benjamin T. Johnson, Assistant Research Scientist, JCET; Gail Skofronick-Jackson, GSFC; William Olson, Associate Research Professor, JCET

Description of Research

Johnson's research has focused primarily on improving multi-sensor microwave (passive and active) retrievals of cold-cloud and mixed phase precipitation. The primary goal is to obtain a higher quality retrieval of precipitation properties such as particle size distribution, particle density, precipitation rate, and particle shape. These improvements can then be implemented in remote sensing algorithms to obtain a more realistic and accurate precipitation retrieval.

Accomplishments in FY 12-13

The primary accomplishments during this reporting period are focused toward precipitation retrieval algorithm development for the upcoming Global Precipitation Measurement (GPM) mission, scheduled for launch in February 2014. The primary focus has been testing and modifying the Goddard Profiling Algorithm (GPROF) to improve snowfall retrieval accuracy. In support of the development of the retrieval algorithm, Johnson has focused on computing the microwave properties of realistically shaped ice and snow hydrometeors, and incorporating this into a database for use in the evolving GPROF retrieval algorithm.

Johnson is also the principal investigator on a proposal to study the microwave scattering properties of melting ice particles, such as snowflakes and aggregates of snowflakes. The primary goal is to be able to accurately simulate satellite-based observations of snowfall and light rain events. During the reporting period, a database of simulated melted particles has been created and is undergoing testing to ensure accuracy.

In addition to his research, Johnson is also a member of the GPM combined radar/radiometer precipitation algorithm development team, and radiometer-only algorithm team. As members of these teams, Johnson is tasked with developing and testing the standard GPM algorithms for passive and combined precipitation retrievals. Johnson is also an active member of the particle size distribution working group, and the land surface working group; both of which operate in support of GPM and other Precipitation Measurement Missions (PMM).

Johnson has also been an active reviewer for the Journal of Applied Meteorology and Climatology (JAMC), Journal of Geophysical Research Atmospheres (JGR-A), and Atmospheric Measurement Techniques (AMT).

Objectives for FY 13-14

Dr. Johnson and his collaborator's primary objective is to develop, test, and validate the GPM-era combined passive microwave/radar called the Global Precipitation Measurement Microwave Imager (GMI) Dual-frequency Precipitation Radar (DPR). Of particular interest will be retrieval algorithms for light rain and snow over both land and ocean to be tested using a variety of existing satellite and ground based observations, new retrieval methods, and field experiment results. Prior to the 2014 launch of the GPM core satellite, the primary objective is to fully test and evaluate the pre-launch databases and algorithm. Following launch, they will update and evaluate the algorithms to reflect the new data sources and any issues with the satellite.

Their intended research direction is towards a working "real-time" post-launch algorithm for GPM which will combine all aspects of the aforementioned research: realistically shaped melting particles, improved retrieval capability, improved forward modeling capability, retrieval over land and ocean of both rain and snowfall, with validation and an estimation of the uncertainties in the retrieved quantities.

Additionally, Dr. Johnson and his collaborators are investigating the relationship between the complex physical properties of ice-phase precipitation particles (including melting particles) and their interaction with active and passive microwave radiation at wavelengths typically employed by remote sensing platforms.

These research topics are expected to continue to generate material suitable for publication and presentation at conferences and seminars.

Task 347: UV Lidar Integration under MPLNET Lidar Network (Sponsor: Judd Welton)

Investigator: Simone Lolli, Assistant Research Scientist, JCET

Description of Research

MPLNET (MicroPulse Lidar NETwork) is incorporating a new UV elastic lidar into the network. The new lidar is manufactured by Leosphere Inc. from France, and is similar to the NASA patented micro pulse lidar currently used in MPLNET. 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 wavelengths. Modified algorithms need to be developed to incorporate the data successfully and are expected to be part of the next data processing system release scheduled for 2013.

Accomplishments in FY 12-13

A field campaign took place in August-September 2012 in South East Asia in the framework of the 7-SEAS (Seven SouthEast Asian Studies) mission, to study the aerosol transport over this key region. The investigator deployed and installed a UV (Ultra Violet) Lidar on a Vasco reseach vessel based in Manila, Philippines. The boat hosted a suite of instruments, and cruised around the Philippines archipelago [Reid et al., 2013] to study aerosol properties and transport. During this campaign, efforts were also made to analyze data taken by an independent UV lidar operated by the Universiti Sans Malaysia, in Penang, Malaysia. In the future, this location will be a permanent MPLNET (MicroPulse Lidar NETwork) observation site. Due to administrative problems, aircraft measurements were not available during the campaign. Data analysis is still going on, in collaboration with the different local institutions in South East Asia: the University of Singapore, the National Indonesian MetOffice and the Universiti Sans Malaysia. The main objective of the research is to better understand the impact of Borneo island biomass burning emissions in boreal summer, with a synergy of satellite observations, model reanalysis and ground based lidar network data.

Three papers are in progress, where statistical techniques such as Principal Component Analysis are applied to lidar data to catch occasional upper air aerosol transport. A stand-alone version of MPLNET algorithm under Matlab is available, and currently used by the Universiti Sans Malaysia group. Lolli was Co-chair at the European Geoscience Union (EGU) in Vienna, Austria in April 2013 of the session Remote Sensing Applications in the Atmospheric and Biogeosciences.

Objectives for FY 13-14

Activities in South-East Asia will intensify during the next fiscal year, where some locations in Borneo will become permanent observation sites in the MPLNET lidar network. The investigator will work closely with local groups to develop tools to analyze the large amount of data to detect sporadic episodes of upper air aerosol transport.

The investigators will also work with MACC-II (Monitoring Atmospheric Composition and Climate) modelers to set-up an automated validation platform on a global scale. For each MPLNET active location, the instrument extinction profile will be compared with aerosol model outputs in near real time.

The new MPL Lidar design has a depolarization channel in the receiver. Progressively, some older instruments will be replaced with the new depolarization MPL lidars. An evaluation and characterization of this new data along with an error assessment will take place in next fiscal year, including validation against a High Spectral Resolution Lidar (HSRL) lidar.

Task 301: Extreme Precipitation Analysis over the US Great Plains (Sponsor: David Starr)

Task 330: Capacity Building Training for Water Resource Management (Sponsor: David Starr)

Task 362: Evaluation of Data Impact Assimilation Runs to Assess the Impact of and Potential Interaction Among Different Sources of Satellite Data in the GEOS-5 and NCEP GDAS/GFS Data Assimilation Systems (Sponsor: Joel Susskind)

USDA/NIFA Grant: Predictability and Prediction of Decadal Climate and its Societal Impacts in the Missouri River Basin with Climate, Hydrology, Crop Yield, Earth System, and Economic Land Use Models

Investigators: Amita V. Mehta, Research Assistant Professor, JCET (Co-I); Vikram M. Mehta, Center for Research on the Changing Earth System (PI); Cody L. Knutson, National Drought Mitigation Center, University of Nebraska; Bruce McCarl, Dept. of Agricultural Economics, Texas A&M University; Norman J. Rosenberg, Center for Research on the Changing Earth System; Raghavan Srinivasan, Dept. of Biological and Agricultural Engineering, Texas A & M University

Description of Research

Mehta's research during 2012-13 focused on: 1) a NASA Applied Remote Sensing Training project to develop presentations about NASA hydrologic products from satellites and earth system models useful for water resource management, and to provide webinars and hands-on training to water resource managers and other end-users; 2) a NASA Energy and Water Cycle Studies (NEWS) project to analyze the atmospheric water cycle over the central United States Great Plains (USGP) from satellite measurements and atmospheric model analysis; and 3) a National Institute for Food and Agriculture (NIFA) - US Department of Agriculture (USDA) project, to develop a statistical technique to downscale surface temperature and rainfall from climate prediction model simulations over the USGP region.

Accomplishments for FY 12-13

Mehta, as a part of the Applied Remote Sensing Training (ARSET) program team, developed several presentations and hands-on training modules focusing on using NASA satellite and atmosphere-land data for monitoring floods and droughts. A webinar series based on flood and drought monitoring was offered in late 2012 for national and international water resources managers (http://water.gsfc.nasa.gov). The webinars were attended by more than 100 participants including county, state, tribal, academic, and private sector representatives from the US as well as various international end-users. In addition, a hands-on training session was conducted at the World Bank in 2013. The purpose of this training was to introduce NASA remote sensing data, particularly rainfall data, and web-based tools available for flood monitoring and prediction to the international water resource managers working with the World Bank. Mehta provided descriptions of web-tools including: 1) Tropical Rainfall Measurement Mission (TRMM) Current heavy Rain, Flood and Landslide estimates (http://trmm.gsfc.nasa.gov/publications_dir/potential_flood_hydro.html); 2) Global Flood

Monitoring System (GFMS) (http://flood.umd.edu); 3) Moderate-resolution Imaging Spectrometer (MODIS) inundation mapping Tool (http://oas.gsfc.nasa.gov/floodmap/); and 4) Global Flood Detection System (GFDS) (http://old.gdacs.org/flooddetection).

As a part of the NASA Energy and Water Cycle Studies program, Mehta has been working on diagnosing, understanding, and modeling of extreme rainfall events over the USGP. Mehta used TRMM multi-satellite Precipitation Analysis (TMPA) version-6 [Huffman et al., 2007, Mehta and Smith 2011] to diagnose warm season extreme rain events over the USGP. During 2012, however, a new and improved version of TMPA became available. Mehta acquired and processed 15-year (1998-2012) data records of TMPA version-7 to update the extreme event analysis over the USGP.

As a co-investigator of a USDA-NIFA multi-disciplinary project, with multi-institute team members, Mehta conducted a detailed comparison of surface air temperature (T) and precipitation (Pr) data from two Coupled Model Inter-comparison Project phase-5 (CMIP-5) climate models (HadCAM3 and MIROC5) with observed, high-resolution (0.125°x0.125° latitude-longitude) data from Maurer et al. [2002]. With assistance from two graduate students from the University of Maryland, Baltimore County, Mr. Andrew Raim and Mr. Sai Popuri, Mehta developed a statistical regression technique to downscale T and Pr from these climate models. Furthermore, the downscaled data were provided to the team members working on Soil and Water Analysis Tool (SWAT). Mehta attended the Science Team meeting of this project hosted by the National Science Foundation (NSF) in July 2012. In addition, Mehta participated in the initial phase of a project assessing the impact of the Atmospheric Infrared Sounder (AIRS) data assimilation into the Goddard Earth Observing System model version 5 (GEOS-5).

Objectives for FY 13-14

Mehta will continue to work on the ARSET capacity building project on water resources and disaster management. Mehta will be involved in planning and developing two webinar series and two hands-on training sessions related to flood and drought monitoring, and river basin management by using remote sensing and model data. Mehta, assisted by a student, will develop modules to teach procedures to incorporate NASA satellite and model data into Geographical Information System (GIS) software. Also, Mehta will assist ARSET team members with training modules related to land cover data. For the USDA-NIFA project, Mehta will continue to provide downscaled T and Pr data for climate variability scenarios based on the CMIP-5 simulations. Moreover, Mehta will participate in analyzing SWAT model simulations of hydrology and crop yield parameters to assess impacts of climate variability over the MRB. Mehta plans to attend a workshop on using SWAT to improve her understanding of the model framework and potential applications. For the NEWS project, Mehta will expand the extreme rain event analysis to global tropical and mid-latitude regions.

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

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: Improved Ice and Mixed-Phase Precipitation Models for Combined Radar-Radiometer Retrieval Algorithm Applications (NNX10AI49G)

NASA Grant: A Combined Satellite Radar-Radiometer Precipitation Algorithm for TRMM and GPM, Based upon Ensemble Filtering (NNX10AJ28G)

NASA Grant: A Long-Term Precipitation Dataset with Uncertainty Information (NNX08AT04A)

Investigators: William Olson, Research Associate Professor, JCET; Mircea Grecu, Morgan State University; Kwo-Sen Kuo, University of Maryland College Park; Benjamin Johnson, Assistant Research Scientist, JCET; Lin Tian, Morgan State University; Xianan Jiang, University of California Los Angeles; Christian Kummerow, Wesley Berg, Colorado State University; Tristan L'Ecuyer, University of Wisconsin; Hirohiko Masunaga, Nagoya University

Collaborators: Andrew Heymsfield, National Center for Atmospheric Research; Stephen Munchak, University of Maryland College Park; Tristan L'Ecuyer, University of Wisconsin; Michael Bosilovich, GSFC; Sara Zhang, Science Applications International Corporation; Guojun Gu, University of Maryland College Park; Wei-Kuo Tao, GSFC

Description of Research

The main emphasis of the research is on the calibration of satellite passive microwave 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 on the Tropical Rainfall Measuring Mission (TRMM) and 14 + 36 GHz radar on the Global Precipitation Measurement mission (GPM) in conjunction with a range of passive microwave radiometer multispectral data. Regarding precipitation, the specific objectives are to improve the representations of ice and mixed-phase particles in combined radar-radiometer algorithms. The remote sensing of latent heating vertical distributions has implications for understanding the Earth's water and energy cycles.

Accomplishments in FY 12-13

The GPM core mission observatory, scheduled to launch in February 2014, will have a spaceborne radar (14 and 36 GHz) and a passive microwave radiometer (10-183 GHz). Data from these instruments will be used to derive "best" estimates of precipitation and latent heating vertical profiles. These profiles will then be used to cross-calibrate radiometer-only profile estimates from an international fleet of radiometers in complementary orbits. Prof. Masunaga and Dr. Olson co-lead a team that will develop and implement a combined radar-radiometer precipitation/heating algorithm to be used operationally by GPM core instruments.

In the past year, the prototype GPM combined radar-radiometer algorithm was updated to make full use of the 14/36 GHz radar and passive microwave channels. Prelaunch testing by Dr. Olson and Dr. Grecu using synthesized data indicated a 50% (30%) reduction in the error standard deviation of instantaneous, 50-km resolution surface rain rate estimates if the 14 GHz radar data are augmented with 36 GHz radar (passive microwave) data, over ocean surfaces. The algorithm was then implemented at Goddard Space Flight Center's Precipitation Processing System (PPS), and passed initial operational processing tests.

Using field data from the Midlatitude Continental Convective Clouds Experiment (MC3E) over northern Oklahoma, a group of investigators including Drs. Olson, Kuo, Grecu, Tian, and Johnson, in collaboration with Dr. Heymsfield, demonstrated that non-spherical ice particle models are required to properly represent scattering properties at the higher frequencies of the GPM Microwave Imager (GMI). Airborne 14 and 36 GHz radar data from the High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) were used to estimate vertical profiles of ice-phase precipitation sizes, which were then input to a forward radiative transfer model to simulate upwelling radiances at 89 and 166 GHz. If spherical ice particle models were used in the procedure, high biases as large as 30-40 K in simulated radiances at 166 GHz relative to those observed by the nadir-viewing Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) instrument were noted. Estimation/simulation using non-spherical ice particle models yielded essentially no bias in simulated upwelling radiances. This finding has important implications for snow estimation from the GPM mission.

Work also began on an error model for radar-radiometer estimates of latent heating from TRMM and GPM, under the NASA Energy and Water cycle Study (NEWS) program. The GPM radar-radiometer algorithm, is now linked with tabulated heating structures derived from model simulations (by Dr. Tao) to estimate latent heating vertical profiles from TRMM.

Objectives for FY 13-14

The GPM combined radar-radiometer precipitation algorithm will undergo further testing, using both TRMM data and synthesized GPM observations, with final delivery in September 2013. Tables representing the properties of non-spherical ice phase precipitation and alternative precipitation particle size distribution descriptions will be implemented. The team will extend the current models of non-spherical aggregate snow particles to melting aggregate particles, and evaluate different particle models using data from the MC3E, GPM Cold-season Precipitation Experiment (GCPEx), and Hydrometeorological Testbed-Southeast field campaigns. A method for operationally gridding footprint scale radar-radiometer estimates of precipitation is also evolving. Studies of uncertainties in latent heating estimates will continue, and a project for modeling the diurnal energy/water cycle of cloud-topped mixed layers in climatological subsidence zones will begin in NEWS.

Task 361: Develop a Simulation of Hurricane Helene from 2006 from NCEP Global Forecast Systems (Sponsor: Scott Braun)

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

NASA Grant: Reprocessing of Goddard Satellite-based Surface Turbulent Fluxes (GSSTF) Data Set for Global Water and Energy Cycle Research (NNX08AP35A)

Investigators: Chung-Lin Shie, Associate Research Scientist, JCET; Scott Braun, Steven Kempler, GSFC; Bob Adler, UMD; Long S. Chiu, GMU

Description of Research

Dr. Shie's research activities consist of two studies and the duties of project scientist. The first study focuses on investigating the impacts of the Saharan Air Layer (SAL) on Atlantic hurricane formation and intensification using numerical simulations, satellite retrievals and sounding observations. In addition, Shie also serves as part-time Project Scientist of the Goddard Earth Sciences Data and Information Services Center (GES DISC) providing insight and guidance to colleagues through his personal research and community collaboration. The last activity, in its final year of a five-year project funded by the NASA MEaSUREs (Making Earth Science Data Records for Use in Research Environments) Program, will resume processing the Reprocessing of Goddard Satellite-based Surface Turbulent Fluxes (GSSTF) product. A refined global (0.25^{o}x0.25^{o}) air-sea turbulent fluxes dataset, i.e, the GSSTF Version 3 (GSST3) from July 1987-December 2008 [Shie et al., 2012a; Shie, 2012a], was completed and distributed via GES DISC in November 2012.

Accomplishments in FY 12-13

The NASA grant-funded project for developing and producing global air-sea turbulent fluxes (GSSTF datasets) originally ended in 2001. It was then successfully revived in May 2008 by Dr. Shie through the MEaSUREs program. The GSSTF2c product was the first product that was extended and distributed and included an improved and upgraded Special Sensor Microwave Imager (SSM/I) V6 brightness temperature (TB). However, Dr. Shie and colleagues had found that TBs trends were impacted by temporal drifting and a decrease of the Earth incidence angle (EIA) of the SSM/I satellites. They subsequently developed an accurate method for removing such EIA dependence from the TB Data in GSSTF2c. Further, by applying an improved algorithm for retrieving surface specific humidity (Qa) directly from TB, the refined GSSTF3 dataset was completed and distributed in November 2012. The temporal trends (% per year during 1988-2008) of the globally averaged Qa and LHF have been reduced from -0.03 and 0.53 in GSSTF2c to -0.007 and 0.48 in GSSTF3, respectively [Shie, 2012a]. There are several other scientific studies using the currently available GSSTF datasets, addressing diverse interests such as ocean flux intercomparison [Shie et al., 2012b; Shie, 2012b; Chiu et al., 2013; Gao et al., 2013], global LHF temporal trend analysis [Shie, 2012a,b; Shie et al., 2012b; Chiu et al., 2012; Gao et al., 2013], and global water and energy budget analysis [Wong et al., 2011]. According to the accumulated monthly metrics recorded by the ESDIS Metrics System (EMS), there have been 383,855 numbers of product (granules) and 2.06 TB data volume of the GSSTF products delivered to 642 distinct users from October 2010 to May 2013.

Dr. Shie's work on Task (#361) focused on studying the influence of the Saharan Air Layer (SAL) on Atlantic hurricane formation and intensification. The SAL has received extensive attention in recent years as a potential negative effect on the formation and development of Atlantic tropical cyclones. In this study, Braun et al. [2013] suggested that the SAL impact on Hurricane Helene appears to be limited to the earliest stages of development; however, the impact is difficult to quantify based on the available observations including a suite of satellite remote sensing data, global meteorological analyses, and airborne data.

For Task 380, Shie started serving as part-time Project Scientist of GES DISC in January 2013. He has actively participated in activities such as the webpage redesign; the community science and technology needs (response to User Working Group's requests); proposal plans and preparations, etc. In an additional collaborative study, the effects of carbonaceous aerosols on climate have been investigated [Hsieh et al., 2013]. The change of SST induced by aerosols has been found to impact climate parameters such as temperature, precipitation, zonal winds, cloud coverage, etc.

Objectives for FY 13-14

The 5-year project for GSSTF production officially ended in May 2013. Shie may seek future funding opportunities for resuming dataset production. The study of SAL's impacts on Atlantic hurricanes may continue even with limited funding. For Task 380, Shie will continue serving as Project Scientist of GES DISC, providing insight and guidance to his GES DISC colleagues for developing and further improving science, and enabling techniques for environmental remote sensing research.

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

NASA Grant: Quantifying Particle Size Distributions in Support of GPM Combined Precipitation Retrieval Algorithms (NNH09ZDA001N-PRECIP)

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

Investigator: Ali Tokay, Research Associate Professor, JCET, Affiliated Associate Professor, GES, UMBC

Students: Rigoberto Roche, Florida International University; J. Duncan Belew, University of North Carolina-Ashville; Elisa Adirosi, University of Rome-Sapienza, Italy; Heidrun Horchen, University of Bonn

Description of Research

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

Accomplishments in FY 12-13

A manuscript has been accepted in the Journal of Atmospheric and Oceanic Technology [Tokay et al., 2013]. The manuscript documents the shortcomings of impact-type, laser-optical, and two-dimensional video disdrometers through collocated six-month long measurements of raindrop size and fall velocity in Northern Alabama. The parametric form of the size distribution, which is determined through surface and airborne measurements, plays an important role in space-borne precipitation retrieval algorithms such as the one from the upcoming Global Precipitation Measurement (GPM) mission.

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

A former visiting doctoral student of Dr. Tokay, Elisa Adirosi of the University of Rome-Sapienza, Italy, presented her findings at the European Geophysical Union (EGU) meeting.

Her study focused on parametric forms of raindrop size distribution using video disdrometer observations. She noticed that the parameters of gamma distribution had noticeable differences between truncated and untruncated fits.

A visiting Master's student, Heidrun Horchen of the University of Bonn, has been working on the parametric form of snow size distribution, fall velocity, snow density, and spatial variability through video disdrometer observations during the GPM cold climate field campaign in Egbert, Canada. She presented her preliminary findings during the EGU meeting in Vienna, Austria.

JCET Summer Intern, J. Duncan Belew of the University of North Carolina-Ashville, has been working on the validation of the National Mosaic & Multi-Sensor Quantitative Precipitation Estimate (NMQ) product using independent gauges from the Southern Delmarva Peninsula where there is no topography and good radar coverage.

A new version of Parsivel became available for testing purposes, and the comparisons with the impact-type disdrometer, the old version of Parsivel, and rain gauges have been conducted. The new version measures the small raindrops more accurately than the old version. A manuscript has been drafted regarding this study.

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 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 less large drops were observed. The findings of this study will be presented during the 36th radar meteorology conference.

The investigator participated in the Iowa Flooding Studies field campaign and processed the GPM Cold Climate Experiment disdrometer and precipitation gauge network database. These activities are related to the tasks.

Objectives for FY 13-14

The investigator is expected to complete ongoing studies and submit two manuscripts to peer-reviewed journals. The recently completed field campaign datasets including Iowa Flooding Studies brought new opportunities to study the variability of rainfall and snowfall within a satellite footprint. The field studies are also an important resource to investigate the microphsyics of rainfall and snowfall. The small-scale variability of rainfall will be further evaluated through a specialized rain gauge network in the mid-Atlantic region. The new network will include dual 25 gauge sites, which will cover a 5 x 5 km array. The gauge network in the Southern Delmarva Peninsula has also expanded to 16 sites. Measurements of raindrop size distribution have been continuously collected at GSFC on the roof of Building 33. Recently, the manufacturer provided a new software package for testing. This site is expected to serve multi-purpose science objectives to the investigator's GSFC colleagues. The investigator will participate in a field campaign in North Carolina during the April-May 2014 timeframe.

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Climate & Radiation Laboratory
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NASA Grant: Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) (NNX10AR41G)

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

Investigators: D. Allen Chu, Associate Research Scientist, JCET (PI); Jim Crawford, NASA Langley; Ken Pickering, GSFC; Phil Dickerson, EPA

Description of Research

Both projects have used Airborne High Spectral Resolution Lidar (HSRL) aerosol extinction measurements to serve as the baseline study of the relationship between aerosol optical depth (AOD) and particulate matter (PM2.5) while DISCOVER-AQ (Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality) also provides extensive surface networks of sunphotometer and lidar measurements during a series of field campaigns over the continental United States (CONUS). These surface networks are aimed to provide better PM2.5 estimate from satellite remote sensing measurements. Lidar-derived HLH are the key to evaluating PM2.5 estimation using AOD/HLH. The ratio of near-surface and mean PBL extinctions is used as an indicator to classify aerosol vertical distribution. Correlation and linear regression statistics are used to assess the goodness of fit between the baseline and satellite-derived aerosol optical depths on the surface PM2.5 estimate.

Accomplishments in FY 12-13

The Micro Pulse Lidar Network (MPLNET) at GSFC has served as an alternative lidar sensor for assessing PM2.5 estimate in concert with airborne HSRL measurements. The combined MPLNet and AErosol RObotic NETwork (AERONET) measurements are used to estimate PM2.5 given similar aerosol extinction profiles at both GSFC and Beltsville, Maryland sites. Unsurprisingly, the resulting PM2.5 estimate produces similar statistics in comparison to those derived by HSRL. Therefore, the uncertainties of MODIS AOD retrievals applied to the PM2.5 estimation are studied with Distributed Regional Aerosol Gridded Observation Networks (DRAGON) AOD and MPLNet–derived HLH at GSFC instead. These results are compared with those derived by replacing DRAGON AOD with MODIS AOD. For comparison purposes, the researchers employ both 0.1° and 0.25° criteria to collocate MODIS AOD retrievals with DRAGON AOD measurements at Beltsville, Edgewood, and Fair Hill, Maryland. The former corresponds to maximum correlation (~0.98) derived with respect to and the latter is to simulate the range used in MODIS validation. As expected, comparison of MODIS and DRAGON AOD collocated within 0.1° show better correlation (~0.91) as opposed to that by 0.25° (~0.88). The MODIS-estimated PM2.5 at the DRAGON locations can be classified into 4 categories based upon RMSE values. For the total of 38 site locations considered, 12 sites are rated excellent, 15 satisfactory, 1 acceptable, and 8 marginal. The corresponding mean RMSE values of the 4 categories are 1.58, 3.25, 4.45, and 7.79 μg/m3, respectively. The only Type III site (Kent Island) is in the East Shore close to Chesapeake Bay Bridge. Except College Park (at Hyattsville, Maryland) and Wiley Ford (at Western Virginia), all marginal sites (Type IV) sites are situated around the Chesapeake Bay. The large RMSE of Type IV in coastal zone sites are most likely related to overestimated AOD retrievals due to water-contaminated pixels.

Objectives for FY 13-14

The main objectives for the coming year will be focused on expanding a monitoring system using MODIS AOD data, MPLNet aerosol extinction profiles, DRAGON sunphotometer and surface meteorological and PM2.5 data. The three-dimensional data acquired during 2007-2013 will be used to establish the systems. The 2011 and 2013 field campaign data will be used to assess the uncertainties of the systems. The intensive DRAGON sunphotometer network will provide insights of spatial variability of AOD in different parts of CONUS. Multi-resolution satellite AOD data will be used to evaluate the sensitivity to PM2.5 estimation. Uncertainties and biases associated with the estimation will be documented. This program will also be providing near-real time MODIS AOD maps during a DISCOVER-AQ field campaign in Houston in September 2013.

Task 338: Satellite analysis of fire radiative energy release, derivation of Aerosol and Carbon Monoxide (CO) emission rates, and air quality applications (Sponsor: Charles Ichoku)

Investigators: Thishan Dharshana, Graduate Student, UMBC; Raymond Hoff, Science Advisor, JCET, Professor, Physics, UMBC; Charles Ichoku, GSFC

Description of Research

This research is exploring whether emission rates of carbon monoxide (CO) can be determined from measurements of Fire Radiative Power (FRP) derived from satellite data in the same way that aerosol emissions have been currently estimated. Mr. Dharshana's Master's Thesis project examined this research question.

Accomplishments in FY 12-13

Over the course of the last three years, Mr. Dharshana examined the use of Measurements Of Pollution In The Troposphere (MOPITT) satellite data to identify column amounts of carbon monoxide in the atmosphere. Using the local and regional background columns of CO as a baseline, differences from background levels were attributed to fires in the vicinity of the MOPITT measurements. Retrievals of FRP from the MODIS instrument from these fires were aggregated temporally on a fire-by-fire basis and then spatially on a 1º by 1º grid. Correlation plots of CO column versus FRP were made and in some limited cases, some correlation was found (r^2 generally less than 0.7). For many fires, however, little or no correlations existed and considerable effort was expended to examine the reasons for the lack of correlation or poor correlation. The following reasons have been identified (1) instrumental artifacts in the MOPITT product include co-registration errors between ascending and descending orbits; (2) inability of MOPITT to retrieve reliable daytime observations except for the V5 product using NIR plus IR channels over land; (3) low signal to noise between the MOPITT columns and background; (4) inability to discern locally produced CO from CO arriving from other fires via long range transport; and (5) variability of combustion types such as flaming combustion that gives high FRP amounts but low CO emissions and smoldering combustion that gives low FRP amounts but high CO emissions.

This project was not progressing at a satisfactory pace and Mr. Dharshana finished with a Masters of Science Degree in Physics.

Objectives for FY 13-14

This project terminated on June 12, 2013.

Task 311: **Instruments and Methods to Study the Radiative Properties of Aerosol and Cloud Particles (Sponsor: Charles Ichoku)**

Subtasks: **313, 314, 315, 316, 317, 318**

NASA Grant: **Rainbow and Cloud Side Remote Sensing: A Novel Look at Cloud-Aerosol Interaction and its Effect on Cloud Evolution (NNX08AU97H)**

NASA Grant: **Development and Evaluation of Validation Tools by Experimenters (DEVOTE) (NNX10AK56G)**

NASA Grant: **Airborne, Polarized Imaging Nephelometer for Measuring Aerosol Phase Matrix: In Situ Experiments and Comparison to the New Generation of Remote Sensors (NNX11AL61H)**

NASA Grant: **A Statistically Robust Evaluation of the AERONET Retrieval Algorithm (NNX12AH30A)**

NASA Grant: **Deployment of the PACS Imaging Polarimeter and the Polarized Imaging Nephelometer for the Measurement of Cloud and Aerosol Properties during the SEAC4RS and DC3 Campaigns (NNX12AC37G)**

NASA Grant: **Development of Algorithm and Instrumentation for Integration of the PACS Imaging Polarimeter in the ER-2 Aircraft (NNX11AN11G)**

NASA Grant: **Airborne, Polarized Imaging Nephelometer for Measuring Aerosol Phase Matrix: In Situ Experiments and Comparison to the New Generation of Remote Sensors (NNX11AL61H)**

DOE Grant: **Airborne Open Polar/Imaging Nephelometer for Ice Particles in Cirrus Clouds and Aerosols (160790)**

NASA Grant: **Development of the PACS polarimeter system in preparation for the ACE mission (NNX12AR35G)**

NASA Grant: **Support for the detailed aerosol characterization and estimates of direct forcing from combination of Glory-APS, MODIS, CALIPSO and ground-based observations (NNX12AR34G)**

Investigators: J. Vanderlei Martins, Fellow, JCET, Associate Professor, Physics, UMBC; Roberto Fernandez-Borda, Assistant Research Scientist, JCET; Dominik Cieslak, Research Engineer, JCET; John Hall, General Associate, JCET; Oleg Doubovik, General Associate, JCET; Hamilton Townsend, General Associate, JCET

Students: Steven Buczkowski, Gergely Dolgos, Li Zhu, Adriana Rocha Lima, William Espinoza, Ronald Rider, Haotian Sun, UMBC

Description of Research

The optical properties of aerosol particles and their effects on the radiative balance of the atmosphere and on cloud microphysics constitute major uncertainties in determining the anthropogenic impact on Earth's climate and weather. These issues are addressed in this task with a variety of new techniques and methodologies that cover instrument development, laboratory and field measurements from the ground and aircraft, algorithm development, satellite remote sensing, and model calculations.

The impact of aerosol in clouds and precipitation is another very important topic in aerosol research. These tasks address this topic via the study of aerosol microphysical properties and via the measurement of cloud spectral properties using novel instrumentation developed in the team's laboratory. Major efforts in these tasks are also devoted to the development of new ground based, airborne, and satellite techniques to measure aerosol, clouds, and its interactions and consequences. Prototype instruments were built and are being applied to the measurement of cloud properties from the ground and from aircraft, like the PACS (Passive Aerosol and Cloud Suite) polarimeter as part of the Aerosol, Clouds, Ecosystem (ACE) Decadal Survey Mission development and the PI-Neph (Polarized Imaging Nephelometer) instrument.

Accomplishments in FY 12-13

The investigators have continued their efforts on the development of algorithms, instrumentation, and methods for the measurement of aerosol absorption and scattering properties via remote sensing and in situ techniques, on the development and application of instrumentation for the measurement of the effect of aerosols on the vertical profile of cloud effective radii and thermodynamics, and on the development of instrumentation and methods for the measurement of polarized radiances for the retrievals of aerosol and cloud microphysical and thermodynamic properties. The team has also continued the collection and analysis of in situ data from several field campaigns and ground stations. Significant efforts were made towards the development of new remote sensing measurement concepts from aircraft and space. Important efforts were also dedicated to the understanding of the effect of aerosol particles on cloud formation, evolution, and lifetime. The team continued the effort to build and fly the airborne simulator of the PACS polarimeter which is being proposed as part of the ACE Decadal Survey Mission. Vanderlei and team have also continued development of the laboratory setup for the generation and study of aerosol and cloud particles. The team has completed the construction of two PI-Neph instrument systems that flew in the DEVOTE (Development and Evaluation of satellite ValidatiOn Tools by Experimenters) DC3, and DISCOVER AQ (Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality) field campaigns collecting detailed scattering information of aerosol particles.

Specific developments include: construction of automated sampling stations for the collection of aerosol filters, construction and flight test of the PACS airborne multi-angle imaging polarimeter prototype for the ACE Mission proposal, development of algorithms and methods for the measurement of cloud microphysical properties using the polarized cloud-bow, development of dry and wet aerosol generators for the production and measurement of various types of aerosols in the laboratory, development of the PI-Neph instrument for the measurement of the polarized aerosol phase function, development and application of techniques for the measurement of the spectral absorption properties of aerosols from 200-

2500nm, and development of a concept and instrumentation for the measurements of cloud microphysical properties using Pico Satellites.

The team has flown the PACS polarimeter in the NASA ER-2 aircraft during the PODEX (Polarimeter Definition Experiment) mission and is currently analyzing the data to demonstrate the use of multi-angle imaging polarimeters on the retrieval of aerosol and cloud particles. The team will continue the development of new in situ instrumentation for aerosol sampling and for the measurement of aerosol scattering and absorption properties, as well as the development of remote sensing techniques for the measurement of aerosol absorption and direct radiative forcing, and the development of polarization algorithms for the detailed retrieval of aerosol and cloud particles. The team will also continue the development of laboratory techniques for the generation, conditioning and measurement of aerosol and cloud particles, allowing for the study of phase transitions between water and ice, detailed properties of cloud ice particles, and their interaction with several aerosol types including dust, smoke, etc. The team also plans to continue using the PI-Neph instruments for the measurement of aerosol scattering on ground and aircraft experiments.

Objectives for FY 13-14

The team will participate in the NASA SEAC4RS (Studies of Emissions and Atmospheric Composition, Clouds and Climate C oupling by Regional Surveys) mission in 2013 flying the PI-Neph and the RPI (Rainbow Polarimetric Imager) instruments on board the NASA DC8 aircraft. The team will continue the development of new in situ instrumentation for aerosol sampling and for the measurement of aerosol scattering and absorption properties, as well as the development of remote sensing techniques for the measurement of aerosol absorption and direct radiative forcing, and polarization algorithms for the detailed retrieval of aerosol and cloud particles. As part of this effort the team will perform the following: upgrade the PACS polarimeter with the addition of the SWIR telescope; finish the construction and testing of the Open-INeph (Open Imaging Nephelometer) system for the NASA P3 aircraft; and begin the design and construction of the HARP (HyperAngular Rainbow Polarimeter) CubeSat satellite. The team will also continue the development of laboratory techniques for the generation, conditioning and measurement of aerosol and cloud particles, allowing for the detailed characterization of aerosols from different locations worldwide. The team also plans to continue using the PI-Neph, RPI and PACS instruments for the measurement of aerosol scattering on the ground and in aircraft experiments.

NOAA Grant: Integrating VIIRS aerosol products into the Air Quality Proving Ground (NA12NES4400002)[1]

NASA Grant: Assessing contributions of foreign aerosol sources to atmospheric composition, air quality and regional climate impacts in the U.S. using satellite products and models (NNX12AK81G)[2]

NASA Grant: Deployment of the PACS Imaging Polarimeter and the Polarized Imaging Nephelometer for the Measurement of Cloud and Aerosol Properties during the SEAC4RS and DC3 Campaigns (NNX12AC37G)[3]

NASA Grant: Communicating scientific findings concerning aerosols, particulate matter, air quality and radiative effects (NNX12AP60G)[4]

Investigators: Lorraine Remer, Senior Research Scientist, JCET [1,2,4] J. Vanderlei Martins, Associate Professor, JCET and Physics, UMBC[2,3,4], Alexei Lyapustin, GSFC[3]; Sergey Korkin, USRA[3]

Description of Research

The overarching goal of these four projects is to achieve a better understanding of atmospheric aerosols.

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

The specific goal of the NASA project on foreign aerosol sources is to better understand the relative contributions of foreign and domestically-produced aerosols. For example, how much of the particle mass above North America is local and how much originates overseas? Then once here, how much of an air quality concern are these particles? Do they change regional climate or modify local weather? The effort includes developing measurement-based analysis methods to answer these questions, communication of the results, and assessment of the historical context of intercontinental aerosol transport.

The goal of the Passive Aerosol and Cloud Suite (PACS) project, is to participate in field experiments such as Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS), develop and fly innovative remote sensing instruments that measure multi-wavelength, multi-angle polarized reflectance signals from ground or atmosphere targets, to analyze the data, and to publish the results.

The goal of the project of communicating scientific findings is to push specific results to publication for Mian Chin's group at Goddard. In some cases, a senior scientist is needed to find and tell the scientific story produced from the analysis of young scientists.

Accomplishments in FY 12-13

Relative to the NOAA grant within the reporting period, the VIIRS aerosol products were first evaluated and then elevated to 'Beta' status. The team identified that the surface reflectance ratios for the over land retrieval were insufficient and creating a high bias. A revised algorithm was implemented in January. New data was collected, evaluated and the revised product was much improved over its Beta version. Remer and the team argued for elevating the product to 'provisional' status. At the same time, the team completely rewrote the Algorithm Theoretical Basis Document, as well as two papers to peer reviewed journals [Jackson et al., submitted; Liu et al., submitted].

Two important milestones occurred on the NASA project on foreign aerosol sources. First, the Yu et al. [2012a] Science paper was published and generated a lot of publicity. The team worked with the public affairs liaisons at both UMBC and GSFC to get the story out. Interest continued even several months after the initial publication. Second, the same basic team worked to produce a comprehensive review paper on aerosol intercontinental transport. This was published in Atmospheric Research. [Yu et al., 2012b].

The NASA project with the PACS instruments suffered a series of setbacks that prevented the NASA SEAC4RS campaign from taking place in Southeast Asia. NASA then made the decision to deploy in the U.S., and specifically from Houston, TX in FY 13-14.

For the project on communicating science findings, Dr. Remer has engaged with Mian Chin's group at GSFC, specifically to evaluate the relationships, synergy and redundancy of 3 proposed geosynchronous satellites. The team has learned that the coarser resolution Tropospheric Emissions: Monitoring of Pollution (TEMPO) sensor would have reduced capability for aerosol retrievals relative to GEOstationary Coastal and Air Pollution Events (GEO-CAPE) data. Second, the team has evaluated an innovative synthesis that combines the UV capability of TEMPO with the shortwave infrared (SWIR) bands of Geostationary Operational Environmental Satellite R- Series Program (GOES-R) to retrieve aerosol absorption and height, similar to Dr. Remer's previous collaboration [Satheesh et al., 2009].

Objectives for FY 13-14

Following the decision to redeploy the PACS instruments, Dr. Martins, Dr. Remer and their team will deploy the Polarized Imaging Nephelometer and Rainbow Polarimetric Imager instruments on the DC-8 from Houston. Upload is scheduled for July and the systems are on track to meet this schedule. At the same time, a new instrument, the Open I-Neph is being prepared to fly on the P3 aircraft during DISCOVER-AQ, overlapping with the SEAC4RS deployment in Houston.

Dr. Remer will also continue to participate in the evaluation and improvement to the VIIRS aerosol algorithms, to collaboration with Dr. H. Yu in the next stage of the transport study that includes regional modeling and links to local air quality, participate in a leadership capacity with the SEAC4RS deployment in August, and bring the data to publication level by this time next year. The investigator will also work with Dr. Chin and her young scientists to bring at least one and possibly more papers to publication stage.

Task 312: Anthropogenic Effects on Clouds and Precipitation (Sponsor: Charles Ichoku)

Investigators: Ilan Koren, Assistant Research Scientist, JCET; J. Vanderlei Martins, Fellow, JCET, Associate Professor, Physics, UMBC; Lorraine Remer, Senior Research Scientist, JCET

Description of Research

Anthropogenic actions such as aerosol emissions, surface albedo changes, or deforestation are known to affect cloud properties. These effects pose one of the largest uncertainties in the estimation of the anthropogenic contribution to climate change.

The investigators develop new approaches for studying anthropogenic effects on cloud fields and rain, approaching the challenge from both scientific ends: from the process level and from a larger view of a dynamic system. During the last year, the focus was on questions related to cloud invigoration by aerosols. In particular, how does enhanced aerosol loading change the cloud microphysical properties and how do these changes propagate and affect cloud dynamics? The investigators are seeking robust methodologies that use observations and models interactively, which allow them to “peel apart” detailed physical processes. Better understanding of key processes in a detailed manner enable them to formulate the important basic rules that control the field and look for the emergence of the overall effects.

Accomplishments in FY 12-13

The investigator and team expanded the study of how manmade actions change cloud properties and climate balances and further explore theoretical questions related to clouds’ field evolution in time and space in changing environmental conditions. In particular, they further developed analysis related to the investigation of the clouds’ twilight zone: an extensive area in the atmosphere of a gradual transition from clouds to clean atmosphere (droplets to dry aerosol particles). As part of this effort they focused on small clouds that are usually below the detection limit of most remote sensing instruments. Such clouds have a weak optical signature so they are too small to contribute significantly to the detector’s pixel. They developed a new cloud microphysical retrieval that is tuned to be sensitive to such clouds using continuous spectral information in the thermal range [Hirsch et al., 2012]. Furthermore, in a new study they checked the Relative Humidity (RH) effect on absorbing aerosols within cloud fields [Flores et al., 2012].

The investigator and team continue exploring the concept of cloud invigoration by aerosols. As a part of this topic they study trends in the relative dispersion of cloud droplets size distribution as a function of aerosol loading, location in the cloud and stages in the clouds’ lifetime [Tas et al., 2012].

Objectives for FY 13-14

The investigator plans to revisit basic approximations in cloud physics equations and to design a new cloud model tuned to the special case of small clouds with weak updrafts. Such clouds are assumed to be important in their effects on the radiative and thermodynamics budgets of the atmosphere and are ignored in most numerical and observational studies. Furthermore, the investigator plans to continue and expand the application of the systems approach to cloud feedback processes where the goal is to find robust rules that control the whole system as the end result of all the inner processes.

Task 326: Statistical Modeling of Rainfall Data Sets from Ground Based Radar and Rain Gauge Measurements (Sponsor: Matthew Schwaller)

Investigators: Prasun K. Kundu, Research Associate Professor, JCET, Physics and Mathematics, UMBC; Mathew R. Schwaller, GSFC

Student: James E. Travis, Mathematics and Statistics, UMBC

Description of Research

There are four major goals of the research performed under this task: 1) developing mathematical models of rainfall statistics that quantify the natural space-time variability of rain; 2) applying these models to describe statistical behavior of precipitation data sets from a variety of sources including satellite and ground based radar and rain gauge measurements including the upcoming Global Precipitation Measurement (GPM) Mission; 3) development of statistical techniques for validation of ground radar observations of rain against rain gauge observations at the GPM Ground Validation (GV) sites including one being set up at the Wallops Flight Facility in Virginia; and 4) inter-comparison of satellite and ground observations of rain from GPM.

Accomplishments for FY 12-13

With Mr. James Travis, recipient of the JCET Graduate Student Fellowship for Academic Year 2012-13 and a Ph.D. candidate at the Department of Mathematics and Statistics, UMBC, the team has formulated a comprehensive statistical model of area- and time-averaged precipitation from co-located radar and rain gauge measurements at a GV site. A new statistical model based on a linear stochastic differential equation of fractional order for the point rain rate field has been introduced to describe the second moment statistics of space- and/or time-averaged rainfall data. It improves upon a previous model of Bell and Kundu [1996] and Kundu and Bell [2003] that was originally devised to primarily describe the statistics of radar rainfall observations. The new model yields a unified theoretical description the second moment statistics of precipitation data over a much larger range of length and time scales that encompass both radar and gauge measurements. The model has been successfully applied to rainfall data from the Tropical Rainfall Measuring Mission (TRMM) ground validation sites at Melbourne, Florida and Kwajalein Atoll, Republic of Marshall Islands in the Pacific Ocean. The parameters of the model are estimated from the space-time covariance statistics of area-averaged rain rate from the Melbourne and Kwajalein radars (TRMM standard product 2A-53). The model predictions for the covariance statistics of time-averaged point rain rate are then computed and tested against the measured statistics from a network of rain gauges located within the radar field of view (TRMM standard product 2A-56). A full-length paper on the model is now in the final stages of peer review in Journal of Geophysical Research – Atmospheres [Kundu and Travis 2013].

A practical goal of the above work on the statistical rainfall model is to quantify the statistical difference between radar and gauge observations of rain at the same spatial location over a period of time [Bell and Kundu 2003] and thus help calibrate the radar using the gauge observations as reference. A statistical method of inter-comparison between rain rates estimated from a specific gauge and the corresponding radar pixel based on the spectral model has been developed and is being tested using the TRMM ground validation data sets in collaboration with David Marks from SSAI and GSFC who is an expert in the observational aspects of both data sets. A paper on the subject is in preparation for publication. The work constitutes the topic of Mr. Travis' Ph.D. Dissertation.

Objectives for FY 13-14

In the coming year, the immediate goals are: 1) to apply the new fractional stochastic dynamics model of rain to various radar-gauge inter-comparison scenarios relevant for GPM validation as the Wallops data becomes available; 2) examine spatial statistics of TRMM PR (Precipitation Radar) derived rain data and test the model predictions with regard to the multiscaling behavior; and finally 3) pursue the problem of obtaining a parameterized model of the probability distribution of area-averaged rain rate [Kundu and Siddani, 2007, 2011] and the joint distribution as a function of time lag in terms of a suitably chosen copula using existing ground radar data from the validation sites.

Task 322: Collaboration on Solar Forcing of Climate Change (Sponsor: Robert Cahalan)

Task 358: Observational Study of Solar Variability Impacts on the Troposphere, Stratosphere and Mesosphere (Sponsor: Dong L. Wu)

Investigators: Jae N. Lee, Assistant Research Scientist, JCET; Dong L. Wu, GSFC; Alexander Ruzmaikin, JPL/Caltech; Jiansong Zhou, USRA

Description of Research

The research has focused primarily on analyzing 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) to develop appropriate Sun-Earth interaction processes.

Accomplishments in FY 12-13

Under NASA's Living With a Star Program, the primary accomplishments during this period are focused on impacts of the solar spectral variability on mesospheric carbon monoxide and water vapor obtained in MLS (Microwave Limb Sounder) observations and WACCM global climate models.

As a science PI of NASA's Living With a Star program, Lee is continuing a quantitative examination of the significant temporal variability (e.g, 11 year and 27 day period) of atmospheric CO, ozone, water vapor and temperature, extending an earlier study of Lee et al. [2008; 2009a,b; 2011]. Lee investigated the variability of the mesospheric Carbon Monoxide (CO) composition in the polar middle atmosphere and its relation to the total solar irradiance and integrated spectral irradiance in the far ultra violet region. She finds that an increased solar insolation led to more abundant CO amounts, because of more CO production from photolysis of carbon dioxide in the upper mesosphere and thermosphere [Lee et al., 2013; Ruzmaikin et al., 2013]. In her recent publication, she shows that CO amount can change ~300% for the 1 % change of solar irradiance and a small change of solar forcing can drive significant impacts on earth's atmospheric composition.

Under Task 322, Lee is working as a member of the Polar Free Flyer TSIS (Total Solar Irradiance Sensor). As a member of the team, she is participating in the progress of TSIS and TCTE (TIM Calibration Transfer Experiment) missions.

Lee has been an active reviewer for the *Geophysical Research Letters* and *Journal of Geophysical Research* and 2012 and 2014 science team meeting organizer for SORCE.

Objectives for FY 13-14

Lee's primary objective is to keep developing and validating the solar impact on Earth's climate using a variety of existing satellite observations and model results. Additionally, she is investigating the modes of the solar spectral variability, which will combine all aspects of the solar variability from the solar spectral observations and models. Lee will continue to collaborate with Juan Fontenla (NorthWest Research Associates Inc.), who performed a series of WACCM (Whole Atmosphere Community Climate Model) experiments.

Lee and the TSIS team will be working on the launch of TSIS instruments towards the data continuity of the Total Solar Irradiance (TSI) and Spectral Solar Irradiance (SSI). One additional objective has recently been added to fill the data gap of TSI records. The new objective is to modify the existing TIM (Total Solar Irradiance Monitor) from SORCE and to fly the TCTE (TIM Calibration Transfer Experiment) instrument and launch it in STP Sat3 in 2013, which can be used as a TSI data gap filler between the SORCE and TSIS.

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

Investigators: Tamás Várnai, Research Associate Professor, JCET, Physics, UMBC; Alexander Marshak, Fellow, JCET, GSFC; Robert F. Cahalan, Fellow, JCET, GSFC; Frank Evans, University of Colorado; Charles Gatebe, USRA; Guoyong Wen, Morgan State University; Weidong Yang, USRA

Description of Research

The research focuses on four main areas. First, it examines the systematic changes in aerosol properties that occur near clouds. This includes characterizing the way these changes are dependent upon season, location, and scene properties, as well as understanding their causes and estimating their radiative impacts. 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 also developing a correction method that allows satellite data interpretation algorithms to consider the impact of 3D radiative processes. Third, it uses radiative simulations to explore the capabilities of estimating forest canopy properties from airborne measurements taken at multiple view directions. Fourth, the research uses spaceborne lidar data to examine the changes in Saharan dust particles as they are transported across the Atlantic Ocean.

Accomplishments in FY 12-13

This year Várnai and team continued their research on the systematic changes in satellite observations near clouds. The work this year focused mainly on estimating the contributions of various factors to the near-cloud changes observed from satellites. The various contributions were estimated by combining data from the MODIS (MODerate resolution Imaging Spectroradiometer) and CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) instruments with 3D Monte Carlo radiative transfer simulations and simulations of instrument blurring. The results [Várnai et al., 2013] revealed that near-cloud changes in particle populations cause about two thirds of the solar reflectance changes observed by the MODIS instrument. These particle changes include both the increased presence of undetected cloud particles and aerosol particle changes such as swelling in the humid air that surrounds clouds. Much of the remaining third of near-cloud reflectance enhancements is caused by 3D radiative processes, for example by clouds scattering extra sunlight into nearby clear areas. Instrument blurring was also found to be significant within a kilometer or so from clouds, but much less so farther away. By analyzing a yearlong global dataset of co-located MODIS and CALIOP lidar data, the team found that near-cloud particle changes are weaker in regions where aerosols are less prone to swelling and occur well above clouds. This is the case, for example, for high-altitude desert dust west of the Sahara and east of China.

Várnai also analyzed high-resolution aerosol data provided in the MODIS ocean color product. The results indicated that optical thickness increases substantially near clouds; on average it is 45% higher within 5 km from clouds than beyond 5 km. This increase was accompanied by a roughly comparable increase in particle size. Theoretical simulations indicated that the 45% increase in optical depth can change instantaneous direct aerosol radiative forcing by up to 7 W/m2, and that the radiative impact is significantly larger if observed near-cloud changes are attributed to aerosols as opposed to undetected cloud particles.

The team also further developed a correction method to consider 3D radiative enhancements near clouds in satellite retrievals of aerosol properties. This year's main development was to incorporate the effects of surface reflection into the correction. This effect is especially important at longer wavelengths.

With his colleagues, Várnai also explored the potential for estimating tree height based on solar reflectance measurements taken from multiple view directions. He used three-dimensional simulations to understand the way solar reflectance measurements are affected by canopy properties such as tree height or the amount of leaves. Initial results suggest that while canopy height cannot be estimated directly from multi-view measurements alone, these measurements can extend the spatial coverage of lidar-based tree height data that is often available only along a narrow swath below an airplane or satellite.

Finally, Várnai and team examined the way particle shape changes within Saharan dust plumes as they are transported across the Atlantic Ocean. By analyzing lidar depolarization data from the CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) satellite, they found that particle populations become increasingly spherical as dust moves westward. Also, particles of different shapes become vertically separated during westward transport, as spherical particles fall faster due to their smaller air resistance [Yang et al., 2013]. Finally, Várnai made several minor improvements to the website for the I3RC (Intercomparison of 3-dimensional Radiation Codes) project, especially to the first online calculator for 3D radiation simulations.

Objectives for FY 13-14

Next year the team plans to further explore near-cloud changes in particle populations and radiation fields. This will include the contributions of undetected cloud particles and aerosols by using MODIS observations at longer wavelengths. The work will also include refining the methodologies of estimating 3D radiative enhancements through Monte Carlo simulations, for example by incorporating the effects of surface reflection. The team also plans to analyze in more detail the way near-cloud changes depend on time, location, and scene properties, and to expand the analysis to areas over land. Várnai will also use radiation simulations to better understand the capabilities of airborne canopy height measurements that use multi-view solar reflectance observations. Finally, he plans to further improve the I3RC website, most notably to enhance the capabilities of the new online 3D radiative transfer calculator.

Task 319: CALIPSO-CloudSat (Sponsor: Lazaros Oraiopoulos)

Investigators: Tianle Yuan, Assistant Research Scientist, JCET; Lazaros Oraiopoulos, GSFC

Description of Research

Yuan's research is in the area of aerosol-cloud-climate interactions. This is among the least well understood aspects of climate change. Yuan's effort along with that of his collaborators and colleagues is targeted at reducing the uncertainties surrounding the interactions among aerosols, clouds, and climate. Specifically, his current research deals with how aerosols change deep and shallow convective cloud properties as well as the consequences of these changes as determined using modeling and observational tools.

Accomplishments in FY 12-13

The team published two journal papers, one in the Journal of Geophysical Research-Atmospheres (JGRD) and one in Science, during this fiscal year. The JGRD paper [Yuan et al., 2012] demonstrated that aerosols can affect tropospheric ozone production through changing lightning production of deep convective clouds. The team shows that lightning activity around the globe is not a purely natural process. Rather, human activity has changed the concentration of aerosol particles, which in turn modifies cloud microphysics and thus lightning activity of deep convective clouds. This research documented strong evidence that aerosols increase lightning flashes at a rate of 20-40 times as a function of increasing aerosol optical depth. Using satellite data, the study showed that NO_2 increases as a result of the increasing lightning flashes. Because the study region generally lacks enough NO_2 to produce enough tropospheric ozone, this increase in lightning leads to substantial increase in tropospheric ozone. Implementation of this link into a chemical transport model showed that due to the aerosol changes, tropospheric ozone has substantially increased, especially in low latitude regions. These results will also lead to new research areas that will include lightning-wild fire activity, aerosol-climate-chemistry interactions and tropospheric ozone change.

The paper in Science [Yu et al., 2012a] showed that imported aerosols over the US account for about half of the total aerosol loading. This study documented that these aerosols come to the United States at a high altitude with the majority in the form of dust from both Asia and Africa. This is a surprising result and has major implications for both science and policy research.

Objectives for FY 13-14

Yuan will continue to work on the issue of aerosol-deep convective cloud interactions. A comprehensive study that investigates the impact of aerosols on ice particle size and their freezing temperature will be finalized this year. This study also investigates how aerosols may change cloud-top ice particle sizes. Furthermore, it studies the variation of aerosol effects as a function of aerosol type. With collaborators, Yuan is also contributing to two manuscripts based on the statistics of deep convective cloud particle sizes and their macrophysics as well as their thermodynamic control. In addition, the researchers are documenting how aerosols affect the overall size of deep convective clouds and why this happens with both modeling and observational tools. The team is currently revising a manuscript [Yuan and Oreopoulos, 2013] that looks at a global cloud overlap and assesses its importance for the Earth's radiation and low cloud evolution.

Task 333: Investigation of Polarimetric Remote Sensing of Cloud Particle Microphysics (Sponsor: Steven Platnick)

Subtask 365: Analysis of MODIS Cloud Data Records and Polarimeter Remote Sensing Information Content

Investigators: Zhibo Zhang, Fellow, JCET, Assistant Professor, Physics, UMBC; Jerome Riedi, University of Lille; Steven Platnick, Fellow, JCET, GSFC

Student: Daniel Miller, UMBC

Description of Research

The objective of Task 333 is to investigate the sensitivity of polarimetric cloud reflection measurements to cloud particle microphysics.

Accomplishments FY 12-13

During the second year of this project, the GSFC/UMBC team has made the following progress: The team's long-time collaborator Dr. Jerome Riedi, has helped to collocate one year (2007) of multi-angle polarization measurements from the POLarization and Directionality of the Earth's Reflectances (POLDER) instrument with other A-Train sensors, including Moderate Resolution Imaging Spectroradiometer (MODIS), the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), and CloudSat. The team is using this collocated dataset to investigate the optical and microphysical properties of supercooled and mixed-phase clouds, and has achieved some preliminary results.

The team computed an extensive Look-Up-Table (LUT) of cloud total and polarized reflectances (i.e., I, Q, U, V) based on MODIS (Collection 6) cloud microphysical properties. The team is validating this LUT by comparing the total cloud reflectances with the MODIS operational LUT.

Leveraging another NASA project, the team has developed a Large-Eddy-Simulation (LES) polarimeter data simulator. This simulator derives multi-angular polarimetric cloud reflection observations from cloud fields generated by a LES model developed by Andrew Ackerman. The team is using this simulator to study the differences between polarization-based (e.g., POLDER) and spectrally-based (e.g., MODIS) assessments in terms their sensitivity to cloud vertical structure and horizontal heterogeneity.

The team also studied the polarimetric characteristics of nine cloud types using collocated POLDER and MODIS data. Cloudy pixels in collocated data are classified into nine groups according to their cloud top pressure and cloud optical thickness (both from MODIS) on the basis of the International Satellite Cloud Climatology Project (ISCCP) cloud classification scheme. Then, the polarized cloud reflectance as a function of scattering angle is derived from the collocated POLDER observation. Three low cloud types (Cumulus, Stratocumulus and Stratus) show conspicuous rainbow features around 142° scattering angle indicating they are mainly liquid-phase, whereas the three high cloud types (Cirrus, Cirrostratus and

Deep Convective) have dramatically different polarized reflectance values. This is because these clouds mainly consist of non-spherical ice particles. Interestingly, the three midlevel cloud types (Altocumulus, Altostratus and Nimbostratus) have both liquid-phase (i.e., rainbow) and ice-phase features indicated by enhanced polarized reflectance around 60°~80° in the team's data.

As shown in Riedi et al. [2007], polarimetric cloud reflectance data can be used to derive cloud top thermodynamic phase. The advantage of polarimetric-based cloud phase retrieval is that it is independent of cloud top temperature and therefore can be used as independent reference in the study of the temperature dependence of cloud phase transitions. In the light of previous studies, the team continues to investigate how the angular pattern of POLDER polarimetric cloud reflectances vary with Cloud Top Temperatures (CTT) derived from MODIS. Ongoing analyses show that when CTT is between 0 ~ −15 °C, POLDER polarimetric cloud reflectance data show a clear rainbow pattern suggesting clouds in this temperature range are mostly supercooled. When CTT is below −35 °C, POLDER polarimetric cloud reflectance shows a clear ice-phase pattern. The team finds it very interesting that the rainbow pattern can exist in clouds with CTT as low as −25 ~ −35 °C, suggesting that supercooled water can exist at fairly low temperatures in some cloud formations.

Objectives for FY 13-14

While the future of this research direction is uncertain, there are a number of near term objectives for this team. Zhang and his collaborators will continue to develop numerical algorithms to retrieve cloud droplet effective radius and variance from multi-angle polarization cloud reflectance. In addition, they will implement bin microphysics in our polarized radiative transfer model and simulate polarized cloud reflectance from LES. Dr. Zhang and his collaborators will investigate the impacts of cloud vertical structure and horizontal variability on polarization-based cloud microphysics retrievals. And finally, related to his work on subtask 365, Daniel Miller will publish his first journal paper.

Atmospheric Chemistry & Dynamics Laboratory (Code 614)

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NASA Grant: Global modeling of nitrate and ammonium at present day and the year 2050: Implications for atmospheric radiation, chemistry, and ecosystems (NNX10AK61G)

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 (NNX11AN72G)

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

Tasks 350, 356: Modeling of atmospheric aerosols and trace gases (Sponsors: Mian Chin, Jose Rodriguez, and Peter Colarco)

Investigators: Huisheng Bian, Associate Research Scientist, JCET; Mian Chin, Jose Rodriguez, Peter Colarco, GSFC; Chien Wang, MIT; David Edwards, NCAR; Hongbin Yu, ESSIC-UMCP

Description of Research

Atmospheric aerosol and gas tracers affect air quality and climate. Huisheng Bian contributed to the investigation of atmospheric tracers, especially aerosol component nitrate and the greenhouse gas CH_4, in the flowing areas: (1) investigating the impact of aerosol nitrate on air quality in the present day as well as in future climate change scenarios and publishing the results in five papers; (2) revising the long-term global greenhouse gas CH_4 simulation for an international Atmospheric Tracer Transport Model Intercomparison Project (TransCom-CH4) and contributing the results to three papers; (3) updating and upgrading the photolysis algorithm module, Fast-JX, in NASA's Global Modeling Initiative (GMI) and assisting the study of improving Fast-JX by better representing the impact of combustion aerosols on actinic fluxes and photolysis rates; and (4) analyzing the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) aircraft measurement for the study of integrating carbon monoxide and aerosol retrievals and the study of source attribution to the Western Arctic.

Accomplishments in FY 12-13

Huisheng Bian led the development of new capabilities in GMI that can simulate key aerosol components such as nitrate and ammonium using a thermodynamic equilibrium model that partitions semi-volatile HNO_3 into both a gas phase and an aerosol phase. During fiscal year 12-13, Bian and her team conducted a series of sensitivity experiments to investigate the impact of emissions and meteorology variables on atmospheric nitrate abundance and radiative forcing. They applied their results in multiple scientific studies including domestic and foreign aerosols to US [Yu et al., 2012a]; aerosol-lighting-O_3 [Yuan et al., 2012]; and three Aerosol Comparisons between Observations and Models (AeroCom) II papers for aerosol direct radiative forcings [Myhre et al., 2013; Samset et al., 2013; Stier et al., 2013]. They also reported their results by seminars and conferences.

Huisheng Bian also led a group effort of CH4 study in Goddard using the NASA PCM-CSM Transition Model (PCTM) by participating an international activity, Transcom-CH4, which is a multi-model assessment of global long-term CH4 distribution during 1990-2007. During this fiscal year, she not only revised the Goddard PCTM results but also corrected errors conducted by the leading author in an Atmospheric Chemistry and Physics discussion (ACPD) paper for the impact of transport model errors on global and regional CH4 emissions estimated by inverse modeling. She also collaborated on two TransCom-CH4 papers that investigated CH4 vertical convection [Belikov et al., 2013; Satio et al., 2013].

Bian also updated and upgraded the Fast-JX algorithm, the photolysis scheme that is used by GMI and Goddard Chemistry Climate Model (GEOSCCM) for atmospheric photochemical calculation. The work represents a major upgrade in terms of the new model framework for the cloud and aerosol processing. She is also involved in a NASA project led by C. Wang to use the Aerosol Simulation Program (ASP). This simulation program was constrained by in situ observations of aerosol size, composition, and mixing state from ARCTAS and Intercontinental Chemical Transport Experiment - Phase B (INTEX-B), and led to updated optical property lookup tables for aerosols from combustion sources for use in Fast-JX. She not only served as a consultant for the group in the GMI model simulation, but also compiled various emission data sets for the study.

Huisheng Bian analyzed the ARCTAS aircraft measurements of the vertical profiles of CO and various aerosol components and summarized the correlation between CO and aerosols under various different atmospheric conditions. The work aims to support assessing how well the combination of Measurements Of Pollution In The Troposphere (MOPITT) CO and Moderate-resolution Imaging Spectroradiometer (MODIS) aerosol optical depth (AOD) improves estimates of aerosol vertical distribution, carbon component and local radiative forcing. This is one of the objectives proposed by an on-going NASA project led by D. Edwards. Using the ARCTAS measurements combined with a Goddard Earth Observing System Model, Version 5 (GEOS-5) simulation, she studied pollution sources in the Western Arctic [Bian et al., 2013].

Objectives for FY 13-14

Bian and her team will continue working on the study of nitrate and its impact on atmospheric chemistry and Earth's radiation field during the coming fiscal year. They will wrap up the study and submit a paper detailing a comprehensive nitrate study using GMI. Huisheng Bian will also continue contributing to the two on-going NASA projects that are integrating carbon monoxide and aerosol retrievals. This work should improve photolysis calculations by investigating the impact of aerosols from combustion sources on actinic fluxes and photolysis rates constrained by aircraft and satellite data.

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

NASA Grant: Eastern Mediterranean Altimeter Calibration Network - E-MACNET (Continuation of DYNMSLAC and GAVDOS) (NNX08AR50G)

NASA Grant: Space Geodetic Networks Data Analysis (NNX11AI44G)

Investigators: Keith Evans, Research Analyst, JCET; Nickolai A. Krotkov, GSFC; Erricos Pavlis, GEST, UMBC

Description of Research

The research includes maintaining and expanding the GSFC SO_2 web site (http://so2.gsfc.nasa.gov) posting SO_2 and Aerosol images from the NASA Aura Ozone Monitoring Instrument (OMI), adding images from new instruments such as Suomi National Polar-orbiting Partnership's (NPP) Ozone Mapping and Profiler Suite (OMPS), and updating heritage Total Ozone Mapping Spectrometer (TOMS) images. This also continuous timely generation and display of the TOMS and OMI SO_2 images and maintaining the archive of the SO_2 maps and images. Web site content is updated on a regular basis.

The research team also continued the long-term record with SO_2 data from NPP/OMPS, obtaining long-term records from GPS, ILRS and NASA satellite data. These long-term records using satellite data will allow changes in the Earth climate system to become visible. The team also performs processing of long-term processing of Global Positioning System (GPS), International Laser Ranging Service (ILRS) and Ocean Surface Topography Mission (OSTM)/Jason-2 data.

Accomplishments in FY 12-13

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. Mr. Evans finished writing software to process SO_2 data from the NPP/OMPS instrument. When automatic data processing failed, he was able to identify the problem and resolve it quickly.

Mr. Evans also retrieves GPS data from terrestrial sites and processes the data through GAMIT (GPS analysis software) on a regular basis to obtain station positions and velocities, especially for new ground stations created by Dr. Pavlis. Mr. Evans is responsible for running ILRS combination solutions on a daily and weekly basis and debugging bad runs. Data from JASON-1 and JASON-2 satellites is acquired to update a database used for deriving SLAs (Sea-Level Anomalies). These tasks are ongoing with the goals of adding to the time-series in order to study the variability of these and other parameters, and also for satellite altimeter calibration. Mr. Evans also assisted with the presentation and publication of the results. Further, Mr. Evans took responsibility for collecting, processing, and plotting data for these tasks from employees who transitioned during the year.

Objectives for FY 13-14

Mr. Evans plans to add SO_2 trajectory modeling capability to the NASA SO_2 site and to become involved with the Earth Science Data System Working Group (ESDSWG). Mr. Evans will continue to assist other team members with data program generation as well as processing GPS data through GAMIT, ILRS and Jason-2 data. These data will continue to be added to the earlier records. The data will be calibrated and compared to other data, such as tide gauge data to further the development of the Space Geodesy Project as required.

Task 302: **Development of Active and Passive Sensors for Remote Sensing Applications (Sponsor: William Heaps)**

Task 372 **Calibration, remote sensing - development of novel linearity setup for testing of optical detectors using high-brightness light emitting diodes and an integrating sphere (James Butler)**

Task 371 **Precision Sub-sampling System for Mars Surface Missions – development of PSS Raman and microscopy optical interface (William B. Brinckerhoff)**

Investigators: Elena Georgieva, Research Associate Professor, JCET; William Heaps, Elizabeth Middleton, GSFC; Petya K.E. Campbell, Research Assistant Professor, JCET; W.B. Brinckerhoff, GSFC; Wen Huang, SSAI; P.R. Mahaffy, GSFC; Xiang Li, CREST, UMBC; Amy McAdam, GSFC; Joel McCorkel, GSFC; James Butler, GSFC

Description of Research

The first task (302) is focused on the development of passive and active sensors for remote sensing determination of various atmospheric trace gases. The active sensor work is focused on the development of a unique airborne LIght Detection And Ranging (LIDAR) system for measuring carbon dioxide changes in the lower atmosphere using as a detector a Fabry-Perot interferometer (FPI) and a charge-coupled device (CCD) camera. Testing of the LIDAR system was done February-March 2013 on NASA DC-8 airplane. For the second task (372), Georgieva is developing a Novel Linearity Tester dedicated for measurement and characterization of detector’s linearity with high speed and precision in the spectral range from UV to IR, and traceable to a NIST calibrated detector. For task 371 Georgieva was using Raman spectroscopy as a nondestructive technique for remote sensing of planetary surfaces to demonstrate the ability of a PSS (Precision Sub-sampling System) breadboard to analyze minerals at fine spatial scales. The long-term goal is for the breadboard to become operational and used in the future for planetary research. For notable aspects of the above research, she has presented results of her work at national and international conferences.

Accomplishments in FY 12-13

Georgieva completed her work on the setup and testing of the novel spectrally broadband imaging lidar for the ASCENDS (Active Sensing of CO_2 Emissions over Nights, Days, and Seasons) mission. This improved sensor is capable of dealing with the atmospherically-induced variations in CO_2 absorption in Earth’s atmosphere [NASA, 2010]. The detector used in the new version is an XS-1.7-320 camera unit from Xenics Infrared solutions combined with an uncooled InGaAs (indium, gallium, arsenic) detector array. The lidar has a potential to operate from a variety of platforms. Custom software was developed in addition to the graphical user basic interface X-Control provided by the company to help save and process the data. The technique and setup can be used to measure other trace gases in the atmosphere [Georgieva et al., 2008] with minimal changes of the Fabry-Perot etalon

[Hernandez, 1986; Vaughann, 1989] and the associated prefilter. The whole system was flown on NASA DC-8 airplane near Palmdale, CA.

For her calibration work, Georgieva built a novel linearity tester dedicated to the measurement and characterization of the detector's linearity with both high speed and precision. This enabled assessment of detector performance across the spectral range from UV to IR, and the results are traceable to a National Institute of Standards and Technology (NIST) calibrated detector. She identified the components for the setup, performed design studies and completed the breadboard. A model of the system in TracePro and SolidWorks is under development. Tests will be done next year when the trap detectors from NIST become available. High-speed optical detectors that are sensitive in the UV-near-IR wavelength region have application in global 3D mapping, spectrally resolved forcing and response of climate system, atmospheric gas measurements, and multi-frequency lidars; GSFC needs to develop capabilities to test in-house all detectors for space applications, be able to compare results to NIST's established standards, and also to enable detector array scaling.

For her third task, Georgieva used Raman spectroscopy as a nondestructive technique for remote sensing of planetary surfaces. She was able to demonstrate the ability of the Precision Sub-sampling System (PSS) breadboard to analyze minerals at fine spatial scales. She hopes that this concept will be used in the future as part of the planetary exploration analytical toolbox. Raman spectroscopy is most often used for mineralogical and organic/biological analysis. This spectroscopic technique, depending on molecule's vibrations in reaction to the light, can provide information on the nature of the molecules, their spatial arrangement and relative concentrations. Georgieva used a Inspector Raman from DeltNu during field tests in Laramie, WY, USA. This portable instrument is equipped with a 785 nm diode laser for excitation, and has a wavenumber range of 200-2000 cm-1. The image is also viewed in real-time with a color video camera. Different mineralogical samples were identified. One of the advantages of Raman is that we were able to study different layers from the minerals and identify microbial communities in some of the samples.

Objectives for FY 13-14:

Georgieva will continue to do research of Mars analog samples using an X-ray D8 DaVinci Diffractometer from Bruker. This effort will advance our measurements and characterization of mineral peak shapes and help identify phases with higher resolution. The diffraction pattern for every phase is as unique as a fingerprint and phases with the same chemical composition can have drastically different x-ray diffraction patterns. One of the goals of the Mars Science Laboratory rover instruments is to characterize the geology and investigate the planetary processes that influence habitability.

Georgieva will continue with her calibration work on the linearity tester as well as using the NIST Spectral irradiance and radiance responsivity calibrations using uniform sources (SIRCUS) Transfer radiometer cross-calibration output. The goal is to transfer the NIST calibration to GSFC detectors.

Task 303a: DISCOVER-AQ (NNH09ZDA001N-EV1) (Sponsor: Kenneth Pickering)

NASA Grant: DISCOVER-AQ (NNH09ZDA001N-EV1)

Task 303b: DSCOVR Satellite Project (Sponsor: Albert Vernacchio)

Task 303c MEaSUREs Reflectivity Project (NNH06ZDA001N-MEASURES) (Sponsor: Jose Rodriguez)

Task 303d: Atmospheric Composition: Upper Atmospheric (NNH12ZDA001N-UACO) (Sponsor: Nickolay A. Krotkov)

Investigator: Jay R. Herman, Senior Research Scientist, JCET

Description of Research

For Task 303a, Herman conducted ground-based deployment of the Pandora spectrometer system and related support during a coordinated aircraft campaign for air quality studies that was part of Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ).

For Task 303b, Herman used results from laboratory measurements taken by the Scripps Earth Polychromatic Imaging Camera (Scripps-EPIC) 10-channel spectroradiometer to characterize the instrument's performance in terms of calibration, detector flat fielding, stray-light correction, and to then devise in-flight calibration techniques. This effort is in support of the Deep Space Climate Observatory (DSCOVR, formerly known as Triana) that is scheduled for launch in December 2014 to the Earth's Lagrange-1 point.

For Task 303c, Herman combined the data from 33 years of the seven operating Solar Backscatter Ultraviolet radiometer (SBUV) satellites to produce a uniformly calibrated long-term data record of scene reflectivity for the NASA Making Earth System Data Records for Use in Research Environments (MEaSUREs) program.

Task 303d enabled Herman to determine atmospheric altitude profiles of NO_2 and O_3 from principal plane sky scans using the Pandora spectrometer system.

Accomplishments in FY 12-13

For Task 303a, Herman participated in two major field campaigns and analyzed data for trace gas amounts as 12 sites in Maryland and then in Central Valley (near Fresno), California. The Pandora instruments measured the geographic distribution of NO_2 and O_3 in comparison with aircraft flights overhead. The results of the ozone measurements were published.

Herman's efforts through Task 303b has led to the development of a complex stray light correction algorithm, written software to run the algorithm, and then ported the software to the GSFC super computer. Optimizing the code reduced running time from 40 hours on a standard LINUX machine to several minutes on the multi-processor supercomputer. Herman has also derived test algorithms for the basic science products that will verify the delivery of DSCOVR's on orbit of calibrated geolocated radiances.

Herman completed the Task 303c effort in FY 13 and submitted the data to the Goddard Earth Sciences Data and Information Services Center (GES DISC) for general distribution. The investigator also determined long-term changes in cloud plus aerosol amount and estimated the climate impact of these changes. The results have recently been published.

Algorithms were developed through Task 303d that successfully compute the altitude profiles of NO_2 and O_3 concentrations. This project started in May 2013.

Objectives for FY 13-14

Two more campaigns are planned in support of DISCOVER-AQ through Task 303a. One campaign will be in Houston Texas starting in September 2013 and the other will be in Boulder Colorado starting in June 2014. As in the other campaigns, the Pandora spectrometer data will be analyzed with respect to aircraft measurements and incorporated into regional models to quantify air quality.

Herman will continue work on Task 303b to perform optical modeling of the Scripps-EPIC instrument to improve the stray light correction and calibration over what can be accomplished with just the laboratory measurements alone.

There are no objectives for the coming fiscal year as Task 303c has been completed.

Herman intends to improve the algorithms created through Task 303d and will apply the results to the Pandora spectrometer data.

Task 377: Deployment, Optimization and Maintenance of the Pandora Spectrometer Systems in support of NASA's DISCOVER-AQ project. (Sponsor: Ken Pickering)

Investigators: Nader Abuhassan, Associate Research Engineer, JCET; Jay Herman, Senior Research Scientist, JCET; Alexander Cede, USRA; Matthew Kowalewski, USRA

Description of Research

Ground-based measurements combined with satellite and airborne observations, have played a major role in improving our knowledge of the impacts of trace gases and aerosols on local pollution episodes and its effects on air quality and human health. Near-surface pollution is one of the most challenging problems for earth observations from space. Tropospheric nitrogen dioxide (NO_2), as an example, has a high diurnal variability influenced by both natural and anthropogenic emissions. Fossil fuel combustion is a major source of NO_2, and high NO_2 concentrations are usually confined to areas with high industrial activities. Pandora spectrometer instrument will be used in the evaluation of total column amounts of NO_2, O_3 and other key trace gases from the ground.

Accomplishments in FY 12-13

In support of the second deployment of NASA's Earth Venture-1, Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ), 15 Pandora spectrometer instruments were deployed in California's San Joaquin Valley to retrieve the temporal and spatial variability of NO_2, O_3 and other key trace gases. Vertical profiles were also measured at these field sites.

Objectives for FY 13-14:

The third DISCOVER-AQ campaign will take place in Houston, Texas during the month of September 2013. Our Team is in the process of realizing multiple optical and electrical upgrades to all the instruments. Once the pre-field calibration is completed and calibration data evaluated, the team will start the deployment of the 15 Pandora Spectrometers.

Our team will assist the scientific community in the data processing and analysis, however the DISCOVER-AQ project still has two more years and our team will provide all necessary support for the fourth field campaign in Colorado, scheduled in the spring of 2014.

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

Task 360: Creating an Objective "Air Quality Applied Sciences Team (AQAST) Recommendations for AQ Satellite Missions" Document to Guide AQ Mission Planning. (Sponsor: Bryan Duncan)

NASA Grant: Building Capacity for Project Evaluation via NASA and ESIP Participation in the Environmental Evaluators Network Annual Conference (NNX11AR66G)

NASA Grant: Beautiful Earth: Learning Science In a New and Engaging Way (NNX11AH30G)

Investigators: Ana I. Prados, Research Assistant Professor, JCET; Amita Mehta, Research Assistant Professor, JCET; Valerie Casasanto, Program Coordinator, JCET; Tom Painter and Chris Mattmann, NASA/JPL; Cindy Schmidt, NASA/Ames; Richard Kleidman, Pawan Gupta, and Jaquie Witte, NASA/SSAI; Yang Liu, Emory University; Bryan Duncan, NASA/GSFC; Kenji Williams, Remedy Arts; Ronan Hallowell, Remedy Arts

Students: David Barbato, UMBC; Ali Hoy, Maria Stenborg, University of Maryland, College Park

Description of Research

The investigator's research centers around providing online and hands-on courses on the utilization of NASA remote sensing data for water resources, disaster, and air quality management internationally and in the U.S.

Accomplishments in FY 12-13

For the fifth consecutive year, Dr. Prados managed the NASA Applied Remote Sensing Training Program (ARSET), Task 323. Prados developed online and hands-on courses on the utilization of NASA remote sensing data for water resources, disaster and air quality management internationally and in the U.S. New courses built capacity for flood and drought monitoring. Prados also collaborated with NASA's Air Quality Applied Sciences Team (AQAST), using ARSET end-user feedback and interviews with NASA scientists to develop a recommendations document for future AQAST activities.

ARSET expanded its online courses and nearly doubled the number of online and in-person participants from 166 in 2011 to 350 in 2012. Overall, ARSET conducted a total of 6 online and in-person courses. Four courses were on air quality (http://airquality.gsfc.nasa.gov) and two were on water resources, covering uses of flooding tools and precipitation products (http://water.gsfc.nasa.gov) [Prados, 2012].

The program offered its first advanced-level course online in 2012, addressing special topics in air quality remote sensing. A five-week course in July and August 2012 covered a step-by-step methodology for using aerosol and carbon monoxide observations from MODIS and Aqua/ AIRS to analyze air pollution due to fires. The course focus was the 2012 summer season wildfires in Colorado, Utah, and Montana and their effect on receptor sites in Iowa and Illinois. More than 50 individuals from 29 different government agencies, universities, and organizations participated in the course. It had attendees from six past ARSET in-person courses, including the Lake Michigan Air Directors Consortium (LADCO), the Desert Research Institute (DRI), and the California Air Resources Board.

During a five-week online training in November 2012, ARSET reached 65 end users from across the world on applications of Earth observations to flooding, hydrologic modeling, and droughts. It was the first online ARSET course for water resources managers. The course included participants from Belize, Jamaica, Bolivia, East Africa, the Hindu Kush–Himalayan region and NOAA. Case studies covered uses of decision support tools and data sets in the United States, South America, East Africa, and Southeast Asia [Prados, 2013a]. In January 2013 the program offered its second online course for water resources managers, focused on the application of NASA snow products in the western US.

Prados also coordinated and chaired a workshop for Earth Science professionals on how to use logic models to develop winning proposals and for program evaluation (Grant NNX11AR66G) [Prados, 2013b]. Prados (and PI Bryan Duncan) developed a "Recommendations for NASA's Air Quality Sciences Team Activities" (Task 360), which also presented the results of interviews with NASA personnel who are involved in mission planning and/or satellite data product development, and EPA employees who are familiar with satellite data. These interviews showed that a) upper management at agencies such as EPA are not convinced of the utility of NASA data and b) most NASA scientists involved in algorithm development or mission planning do not interact with the applied end-user community. Based on these interviews, the report provided recommendations for AQAST activities that can improve the use of satellite data for AQ applications. Prados also chaired a session at the AQAST meeting in June 2013 [Prados, 2013b]. On the Beautiful Earth Program, Prados strategized and prepared for an upcoming teacher training session to take place in Syracuse, NY in August 2013.

Objectives for FY 13-14

In addition to air quality and water courses, the ARSET program (managed by Prados) will focus on courses for disaster applications, especially tools for flood potential monitoring. ARSET also plans to offer courses on the application of NASA snow products to water resources management in the western United States, and to develop training modules on land products. The ARSET program will also develop a trainer's manual, which will provide guidance on ways to communicate Earth science research within a capacity building framework. Prados will also conduct remote sensing teacher trainings for the Beautiful Earth project.

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

Investigator: Glenn Wolfe, Research Associate, JCET

Description of Research

This research utilizes in situ measurements of formaldehyde (HCHO) to study the processes that control the composition of the lower atmosphere. Primary efforts include 1) maintaining and refining sophisticated instrumentation for measurement of HCHO, 2) deployment of this instrument on multiple airborne platforms, and 3) scientific interpretation of the data with a focus on photochemistry and gas-aerosol interactions. Results from this work will improve our understanding of fundamental atmospheric chemistry and assist ongoing efforts to mitigate the impact of anthropogenic activities on air quality and climate.

Accomplishments in FY 12-13

The NASA In Situ Airborne Formaldehyde (ISAF) instrument is a state-of-the-science tool for measuring the concentration of HCHO down to parts-per-trillion mixing ratios. It is compact, lightweight (~60 kg), low power, and built to withstand the harsh environmental conditions typical of many research platforms. Arguably, it is the best research-grade HCHO instrument currently available.

Several improvements to ISAF have been made over the last year. One key upgrade is the incorporation of computer-controlled optical mounts, allowing for alignment of the laser system without opening the enclosure. This makes the instrument both easier and safer to operate. A new pumping system and power unit were also designed for deployment on NASA and NOAA WP-3D aircraft, extending ISAF's multi-platform capabilities. Furthermore, an exhaustive series of laboratory tests were carried out to calibrate the instrument and identify potential sources of error and uncertainty. These efforts, combined with substantive improvements to data analysis software, will ensure the continued fidelity of future measurements.

Much progress has also been made towards construction of a second instrument (tentatively named ISAF Jr.). This instrument is nearly identical to ISAF (Sr.) but with enhancements to mechanical and laser components. This system will be operational by August 2013.

Field Work: ISAF is participating in two airborne field campaigns during the Summer of 2013. The first of these, the Southeast Nexus (SENEX) experiment, is a collaborative effort with the Keutsch group at the University of Wisconsin, Madison and the Atmospheric Chemistry Division of the National Oceanographic and Atmospheric Administration (NOAA). The goal of SENEX is to study the interactions between natural and anthropogenic emissions at the nexus of climate change and air quality. As of this writing, ISAF is currently deployed and collecting data aboard the NOAA WP-3D aircraft. The second campaign, dubbed Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS), is a NASA-led intensive campaign with a broad set of objectives that encompass the primary meteorological and chemical processes impacting the North

American troposphere. This campaign will take place onboard the NASA DC-8 from August to October 2013.

As this research started in October 2012, little data is yet available for scientific analysis; however, some steps have been taken in anticipation of successful field campaigns. Particular attention has been paid to improving two numerical box models developed by Wolfe prior to arriving at JCET [Wolfe and Thornton, 2011; Kim et al., 2013]. These models provide a powerful framework for testing our understanding of chemical and physical processes in the atmosphere. Key improvements include updated parameterizations and revised computer code that is simultaneously more efficient, more flexible and more user-friendly. It is Wolfe's goal to provide these modeling tools to the broader scientific community, and several collaborations are currently under pursuit in this vain. These models have also been used to analyze observations from previous NASA campaigns (particularly DC-3) and may be employed in future collaborations with the Dickerson group at UMCP. Wolfe has also assisted in the advising of a graduate student (Heather Arkinson) from the Dickerson group.

Objectives for FY 13-14

Efforts in the coming year will focus mainly on interpretation of data from the SENEX and SEAC4RS field campaigns. Wolfe's work will involve chemical box modeling and observational analyses, along with publication of results. Also, collaborations will be pursued for 1) validation of satellite-based HCHO retrievals and 2) global model-assisted inversions of HCHO measurements to improve biogenic emission inventories and model photochemistry. Refinements in ISAF methodology will also continue, with the end-goal of simplifying instrument operation to the push of a single button.

Task 352: Use of NASA MODIS AOD Product for Evaluation of EPA's CMAQ Model (Sponsor: Ken Pickering)

Task 357: Develop Forward Radiative Transfer Model for Simulating SO_2 Absorption Effect in the Thermal IR Band. (Sponsor: Nickolai A. Krotkov)

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

Description of Research

Dr. Yurganov's research is connected with the application of satellite gaseous composition data relative to problems of air pollution and climatic change. Enhanced nitrogen dioxide (NO_2) concentrations are observed in urban areas and are connected with power plants and transport sources. Sulfur dioxide (SO_2) is also an anthropogenic pollutant, and, at the same time, is an important component in global climate models.

Accomplishments in FY 12-13

Activities under Task 352 leveraged on accomplishments of the previous year. The simulations of NO_2 on a monthly basis from January 2006 to December 2006 for the US between 70 W and 105 W were compared with experimental data of the NASA OMI/Aura instrument. OMI, a nadir-viewing UV/Visible spectrometer aboard the Aura satellite, has been collecting data since October, 2004 with a nominal ground footprint of 13×24 km at nadir. Global daily coverage gives an opportunity to compare version 2 standard product tropospheric column NO_2 product with the Community Multiscale Air Quality model (CMAQ). OMI NO_2 data depends on the first guess (a priori) profile, which is taken as monthly mean GMI calculations with a resolution of 2 x 2.5 degrees. In the team's comparisons, OMI data were adjusted to replace GMI as a priori with CMAQ as a priori. This adjustment significantly improves agreement, as expected. Typical correlation coefficients between CMAQ and OMI data are between 0.85 and 0.91 on a monthly basis. Slopes of linear regression line (CMAQ vs. OMI) are between 1.0 and 1.4 (CMAQ>OMI), depending on the season. Another set of calculations by the (Weather Research and Forecasting) WRF model, developed at GSFC for July 2011 was evaluated the same way. The general conclusions are similar, i.e, overestimation of NO_2 columns by the model, but magnitudes of this effect are larger than for the case of CMAQ. The reasons for this discrepancy are analyzed by the team of Dr. Pickering. Task 352 has been completed. Dr. Pickering, PI of the project, plans to extend the task for the 2013-2014 time frame.

For Task 357, a Matlab-based code developed at UMBC by Scott Hannon et al. allows for the retrieval of SO_2 from volcanoes during day and night using AIRS data with equal accuracy. A priori information on the height of the volcano plume is necessary for a retrieval. A proposal for re-processing of all available OMI SO_2 data has been approved for funding by NASA. A significant set of data for evaluation of accuracy of these retrievals has been analyzed during the reporting period and compared with retrievals using other instruments and codes (Fred Prata's codes of the Norwegian Institute for Air Research, AIRS, OMI, IASI instruments). It was found that OMI retrievals are more accurate than AIRS data in the tropical areas in cases of significant concentrations of volcanic SO_2 in the boundary layer. On the other hand, AIRS has many advantages over the OMI data at high latitudes. The area of interest is usually observed by the polar orbiting instruments several times a day. NRT GSFC SO_2 retrievals have been evaluated as well. Accuracy of these retrievals is lower than the UMBC retrievals, but tracking of SO_2 plumes from volcanoes may be performed very well. The UMBC code is now being modified to be compatible with FORTRAN codes. An evaluation of existing FORTRAN compilers has been done. The preliminary test FORTRAN program is written.

Objectives for FY 13-14

Task 352 is planned to be re-activated in the next fiscal year. Satellite data on the atmospheric gaseous and particulate composition are planned to be used for evaluation of atmospheric models.

Task 357 will be funded from the The Making Earth System Data Records for Use in Research Environments (MEaSUREs) program. Dr. Yurganov will be responsible for the development of a FORTRAN-based code for retrievals of SO_2 from AIRS radiation data and a modification of this code for IASI data. Volcanic eruptions since 2002 (AIRS) and 2007 (IASI) will be investigated and estimates of total SO_2 mass emitted by these volcanoes will be supplied to NASA. Two proposals to NASA on the analysis of satellite methane data for the Arctic has been submitted. Decisions are expected by the end of 2013.

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Cryospheric Sciences Laboratory
(Code 615)

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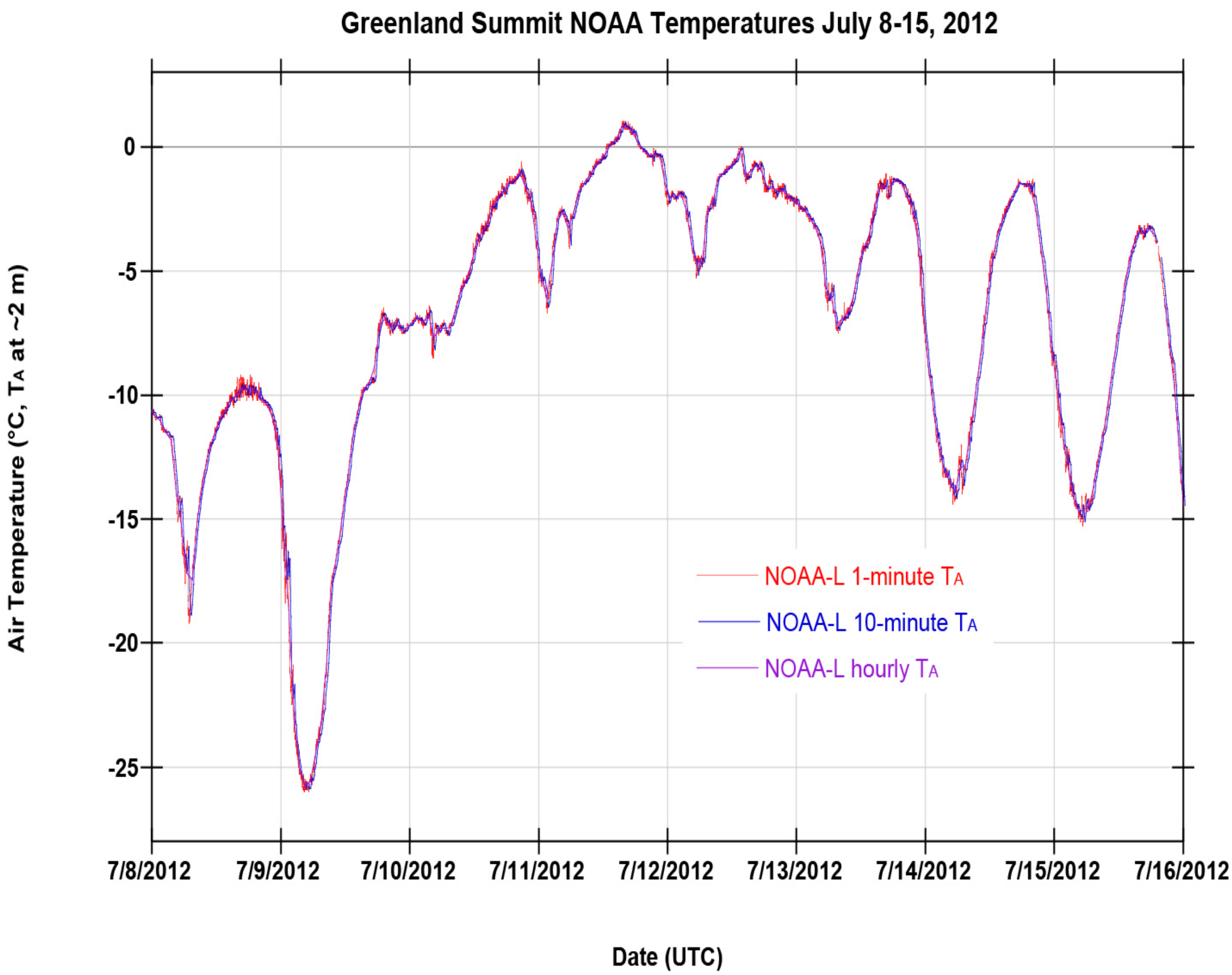
JCET Highlight: Monitoring the July 2012 Melt Event at Greenland's Summit

Investigator: Dr. Christopher Shuman



The plot shows temperature variations at Summit Station, Greenland (>3200 m or about 10,500 ft in elevation) during the major July 2012 ice sheet melt event observed by multiple satellites. Data from the NOAA Logan sensor at 2 m above the snow surface are shown with one and ten minute and one hour average air temperatures and document the approximately 6.5 hour long melt event on July 11th as well as the surprising warmth on adjacent days at that elevation.

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

Investigator: Valerie Casasanto, Program Coordinator, JCET

Description of Research

The development and implementation of Education and Public Outreach (EPO) efforts are required as part of the upcoming ICESat-2 (Ice, Cloud, and land Elevation Satellite) Mission to be launched in 2016. ICESat-2 will use precision lasers to measure the height of the Earth from Space and provide a 3-D view of the Earth's elevation. 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.

Accomplishments in FY 12-13

Casasanto performed planning and implementation of ICESat-2 mission education and outreach efforts for FY13, and began planning for FY14. Due to the budget sequestration, a process of waivers was implemented. Casasanto and team submitted waivers to the NASA Headquarters Office of Education for projects to be implemented in FY13 including: university collaboration for students to develop educational outreach materials, and the development of ICESat-2 travelling museum exhibits.

Casasanto initiated the social media sites for the mission including Facebook and Twitter and has regularly posted news items to the sites. Casasanto coordinated the education and outreach team, and developed team structure, goals, and milestones.

In addition, Casasanto organized the filming of mission experts for a series of education video clips (NASA E-clips), and provided inputs to optimize videos.

Objectives for FY 13-14

Casasanto will complete ICESat-2's FY13 activities and continue planning FY14 initiatives. She will implement the university partnership and work with students to develop outreach materials. Casasanto will lead the development of ICESat-2's website. She will organize ICESat-2's participation in NASA and related events.

Casasanto will continue to develop and oversee the ICESat-2 education and outreach initiatives and interface with team members on a regular basis.

Task 341: IceBridge, ICESat–1/2 calibration validation assessment (Sponsor: Thorsten Markus)

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

Task 375: Surface deformation of icy moons: Insights from Earth analogs and modeling (Sponsor: Jeanne Sauber-Rosenberg)

NASA Grant: Using Refined ICESat-1 Altimetry to Investigate the Limits of Change Detection on the East Antarctic Plateau: Analysis of Megadune Migration and Other Signatures of Heterogeneous Accumulation, (NH09ZDA001N)

Investigators: Christopher Shuman, Associate Research Scientist, JCET (PI); Thorsten Markus, Fellow, JCET, GSFC; Thomas Neumann, Philip Dabney, Dorothy Hall, Scott Luthcke, David Harding, Jeanne Sauber-Rosenberg, Compton Tucker, GSFC; Kelly Brunt, Morgan State University; Ted Scambos, NSIDC; Etienne Berthier, LEGOS; Mark Fahnestock, UAF; Michelle Hofton, UMD Geography; Winnie Humberson, Wyle Information Systems

Student: Michael Schnaubelt, UMBC

Description of Research

Dr. Shuman is currently working with Dr. Markus and Dr. Neumann at GSFC, among others, to enable calibration and validation of the planned Ice, Cloud, and land Elevation Satellite 2 (ICESat-2, launch planned in mid-2016). He continues efforts to refine ICESat-1 elevation data as well. He is also working with Dr. Hall at GSFC to calibrate temperature records in central Greenland's 'Summit' Station area. Dr. Shuman continues to collaborate with Dr. Scambos and Dr. Berthier on the dramatic ongoing changes to the Antarctic Peninsula's ice cover. Because of the scale of these changes as well as the ease of visualizing them, Dr. Shuman has been able to utilize multiple types of remote sensing imagery to show the area's ice changes on NASA's hyperwall.
http://www.flickr.com/photos/eospso/sets/72157633379483874/

Accomplishments in FY 12-13

The past year saw a considerable amount of research activity related to Greenland ice sheet surface melt on July 11-12, 2012. A NASA press release stated that ~97% of the ice sheet surface had melt water on it and further anomalous warmth was observed later in July. An ongoing activity led by Dr. Shuman and UMBC Graduate Student Michael Schnaubelt (supported by Dr. Hall, Task 373 "Climate data record development for surface temperature data for Greenland ice sheet locations", and UMBC) was extracting and reprocessing data from NOAA Earth System Research Laboratory's Temporary Atmospheric Watch Observatory (TAWO) sensors installed at Greenland's Summit Station. Because of those unique climate data sets, they were able to rapidly and accurately illustrate the magnitude and duration of the unusual melt events more than 3200 m high on the Greenland ice sheet (http://jcet.umbc.edu/news-2/?id=18072). In addition, Shuman and Schnaubelt contributed to other online material detailing the anomalous warmth in 2012 as well as multiple publications and presentations. http://www.climatewatch.noaa.gov/article/2012/summer-weighing-heavily-on-greenland-ice-sheet

Dr. Shuman was also engaged on other tasks at GSFC. For Task 341 "ICESat-1/2 calibration validation assessment", Dr. Shuman worked closely with Dr. Brunt and Mr. Dabney on both pre- and post-launch planning for engineering, modeling, and field activities to ensure calibration and validation of the ICESat-2 satellite laser altimeter. Part of the challenge is that ICESat-2 is a fundamentally different measurement approach (photon-counting lidar) as opposed to ICESat-1 (analog waveform lidar) among other differences. There is recognition that not all the biases in the ICESat-1 time series have been resolved in the last data release. Finally, as part of the NASA Chief Scientist's first Science Innovation Fund (SIF) program that was designed to catalyze scientific research across NASA, Dr. Shuman contributed to Task 375 "Surface Deformation of Icy Moons: Insights from Earth Analogs and Modeling".

In addition to these activities, Dr. 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 continuing ice area and ice mass losses from the Antarctic Peninsula during 2001-2011 [Berthier et al., 2012]. On a related note, Dr. Shuman has provided guidance and editing to a related NASA Earth Observatory post, "Thinning at Hektoria and Green Glaciers" and converted that material into visualizations documenting ice area and elevation changes over the past decade. See http://earthobservatory.nasa.gov/IOTD/view.php?id=79493 and http://jcet.umbc.edu/news-2/?id=22375

Objectives for FY 13-14

Obtaining continuing research funding from Research Opportunities in Space and Earth Sciences (ROSES) proposals is clearly the highest priority for the coming year. Shuman's goals and Objectives for FY 13-14 include: to help publish the broader Antarctic Peninsula study of glacier and mass changes; to finalize a study of a large area of megadunes showing no interpretable elevation changes from ICESat-1 data; to assess revised G-C corrected ICESat-1 data from other ice sheet sites for residual received energy bias correction; to support the ICESat-2 science team; and to contribute to teaching at UMBC; to continue mentoring UMBC Graduate Student Michael Schnaubelt; and to complete the team's assessment of temperature records from central Greenland as well as available MODIS ice surface temperature (IST) data derived by Dr. Hall's research team.

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Ocean Ecology Laboratory
(Code 616)

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

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

NASA Grant: Constructive Assessment of VIIRS Ocean Color Data Quality Toward NASA Climate Data Record Continuity (NNH10ZDA001N)

NASA Grant: VIIRS Sea Surface Temperature Retrievals (NNH10ZDA001N)

NASA Grant: Assessing Ecosystem Diversity and Urban Boundaries using Surface Reflectance and Emissivity at Various Spectral Scales (NNX10AE66G)

Investigators: Kevin R. Turpie, Associate Research Scientist, JCET; Chuck McClain, Bryan Franz, GSFC; Peter Minnett, University of Miami, RSMAS; Robert Evans, University of Miami, RSMAS

Description of Research

Ocean color remote sensing is the only method to monitor and observe the global ocean's biosphere with a passive sensor. This provides vital information for research applications such as modeling biogeochemical cycles and their response to climate change. Dr. Turpie led related research using the Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS). He was an unfunded co-investigator for the retrieval of Sea Surface Temperature (SST) using the VIIRS sensor. He is also the founding chair of the Hyperspectral and Infrared Imager (HyspIRI) Aquatic Studies Group, overseeing the definition and development of coastal and in-land water aquatic remote sensing for this mission and a member of the HyspIRI Science Study Group.

Accomplishments for FY 12 - 13:

As Suomi NPP Ocean Discipline Lead, Turpie was responsible for being cognizant of the activities of investigators contributing to the ocean science component of the mission; serving as liaison with team members and NASA management; and coordinating collaborative efforts towards the discipline objectives for evaluating SST and ocean color data products. Turpie provided input to the SST data quality assessment report and coordinated his evaluation of the ocean color data products with the rest of the team, which was written into a separate white paper. For the ocean color assessment, the team members had two primary goals: 1) to evaluate the NOAA ocean color Environmental Data Record (EDR) for compatibility with the established NASA ocean color data record and 2) to determine if VIIRS could support development of new algorithms.

After working for years before launch on instrument characterization, Turpie collaborated with the Ocean Biology Processing Group (OBPG) to assess the calibration of the sensor and to identify artifacts and correct them. OBPG generated an ocean color data product from the VIIRS data, based on NASA-selected algorithms, to compare to the operational NOAA data product. Turpie lead the evaluation of the resulting data products. He worked with the NPP science team in their evaluation of new algorithms, including those generating data products that were previously supported for the Sea-viewing Wide Field of view Sensor (SeaWiFS) and the MODerate resolution Imaging Spectroradiometer (MODIS), but not operationally for NPP. These included the diffuse attenuation coefficient (K_d), particulate inorganic carbon (PIC), and photosynthetically available radiation (PAR).

Turpie compared matched satellite and *in situ* data for radiometric parameters and found good agreement between the satellite and surface truth. The VIIRS surface radiometry for both the EDR and NASA evaluation products showed good agreement with *in situ* data from fixed stations of the AErosol RObotic NETwork – Ocean Color (AERONET-OC). However, the regional time series analysis identified that, while the NASA evaluation data products were in remarkable agreement with heritage data products, the NOAA operational data products were indicating values for chlorophyll *a* concentration that exceeded any previous NASA data. Further analysis revealed that this was due to poor calibration in the NOAA products during the first year, especially the lack of a vicarious calibration step.

Work with the HyspIRI Science Study Group (SSG) enabled Dr. Turpie to focus on remote sensing of coastal and inland water ecosystems. With support from NASA HQ, he formed the HyspIRI Aquatic Studies Group (HASG) to collect and synthesize input to define an aquatic data product suite. Turpie performed a literature search to develop an initial aquatic data product list for HyspIRI. He organized two teleconferences enabling dozens of scientists to discuss these products. He compiled and presented the HASG findings at the HyspIRI Science Workshop in Washington, D.C. in October of 2012. He subsequently formed a subgroup of writers to refine ideas and to develop a more detailed argument for and prioritization of the candidate products. The draft of the white paper was presented and discussed at a special session on Aquatic Studies at the HyspIRI Science Symposium at GSFC last May.

Objectives for FY 13-14

The work for the NNH10ZDA001N award will conclude early next calendar year. In the remaining months of the evaluation effort, two pursuits will be undertaken. First, additional in situ data will be available for analysis, especially High Performance Liquid Chromatography (HPLC) chlorophyll *a* concentration data. Previously, only ten matched data pairs were available. Second, the calibration of the VIIRS sensor has been improved over the past several months and so the OBPG will reprocess the satellite data. The reprocessed data will be evaluated against *in situ* data and Dr. Turpie expects they will yield a more stable and longer regional time series for analysis. An update to the assessment report will be submitted to NASA HQ and publications on the capability of VIIRS for ocean color and SST will then be submitted to peer-review journals. Turpie will continue to lead the HASG HyspIRI Aquatic Data Product white paper and he expects that publications will result. The white paper section for water-column retrievals has already been selected for publication as a high-light paper in a special issue of Remote Sensing on the remote sensing of phytoplankton.

Biospheric Sciences Laboratory
(Code 618)

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Task 306: NASA Terrestrial Ecosystems, Spectral Bio-Indicators of Ecosystem (Sponsor: Elizabeth Middleton)

Investigators: Petya K.E. Campbell, Research Assistant Professor, JCET; Elizabeth Middleton, GSFC

Description of Research

With this research, high spectral resolution reflectance data obtained for vegetation over a range of functional types, species, phenology, and stress conditions is evaluated to establish which spectral algorithms perform rigorously with respect to correlation to photosynthetic function and efficiency. The team will supplement existing datasets with focused field measurements necessary for model parameters using Earth Observing-1 Mission (EO-1) Hyperion satellite imagery. From the combined in-situ information (including spectral, structural, flux, and micro-meteorological data) and remote sensing (spectral, structural) data, the team will determine how the carbon uptake/efficiency is affected by the partitioning of the canopy into functionally different sunlit and shaded foliage fractions, as expressed with the Photochemical Reflectance Index (PRI) and other stress indices including solar-induced chlorophyll fluorescence (SIF), as well as chlorophyll-related spectral indices.

This EO1-Hyperion data inter-calibration and analysis effort is designed to compare existing and suggest new land cover products, addressing vegetation type and function. This effort was initiated in the spring of 2007 and will use the only available space borne spectrometer (EO-1 Hyperion) to contribute toward the comparisons of current data products, generated by multiple and frequently disparate systems. Datasets and comparisons will be produced for core Earth Observing System (EOS) sites and would be made available for use in calibrating long term data records needed for understanding climate dynamics and change. The development of new products assessing vegetation physiology would contribute toward the two missions recommended in the NRC Decadal Survey: HyspIRI (Hyperspectral/IR Imagery) and GEO-CAPE (Geostationary Coastal and Air Pollution Events) missions.

Accomplishments for FY 12-13

In the past year, Dr. Campbell completed the processing and analysis of AVIRIS (Airborne Visible and Infrared Imaging Spectrometer) and MASTER (MODIS/ASTER Airborne Simulator; MODIS, MODerate resolution Imaging Spectroradiometer; ASTER, Advanced Spaceborne Thermal Emission and Reflection radiometer) images and associated other data. This enabled spectral algorithm development, presentations on these results and a draft publication. Dr. Campbell's goals included: Detection of early vegetation stress based on bio-physiological, fluorescence and spectral optical reflectance remote sensing, using field, airborne and spaceborne spectral radiometers. Such analyses are required for assessing the effects of urban expansion on ecosystem function, diversity and local climate. Satellite data are crucial 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 reliable predictions regarding the effects of climate change.

In addition, Dr. Campbell contributed toward the comparisons of current data products, generated by multiple and frequently disparate systems. Reflectance data having contemporaneous photosynthetic data is being assembled in concert with flux and environmental data provided by AmeriFlux collaborators, from tower sites representing a range of ecosystems. High performance of candidate spectral bio-indices are being evaluated for remote sensing application at ecosystem scales at the AmeriFlux and intensive sites using several radiative transfer modeling tools and atmospheric correction modules. The best performing spectral bio-indices will be applied to available hyperspectral remote sensing data over selected test sites and the data would be made available for use in calibrating the long-term data records that are required for understanding climate dynamics and change.

Objectives for FY 13-14

Specific goals for 2013-14 include: data analysis and product generation in support of future satellite missions; developing new demonstration Level 2 science products, as prototypes for HyspIRI; assistance in the collection/generation of an EO-1 archive of research Level 0, Level 1 and 2 data; Hyperion seasonal and yearly composites over cal/val sites and targeted vegetative sites; and providing scientific support for the user community including the HyspIRI team.

In addition, Dr. Campbell was also advising two undergraduate students and one graduate student. The graduate student is anticipated to complete graduate studies in the fall of 2013 and is currently working on a peer-reviewed publication describing the research activities.

BU Subcontract: Synergistic Study for Lidar and Passive Optical Remote (GC202505 NGA)

NASA Grant: Multi-Sensor Retrieval of Vegetation 3-D Structure and Biomass using Physically-Base Algorithms (NNX11AF92G)

Task 320: Algorithm and Analytic Techniques via Various Sources (Sponsor: Jon Ranson)

Investigator: Forrest G. Hall, Senior Research Scientist, JCET (PI); Thomas Hilker, Oregon State; Compton Tucker, Alexi Lyapustin, GSFC

Description of Research

Hall's research in FY2012 involved five activities: (1) PI on a 3rd of 3 year radar/optical satellite project (BioPhys) to combine radar and passive optical satellite data for biophysical parameter estimation; (2) Development of a new satellite concept for direct measures of light use efficiency and gross primary production; (3) Formulating and presenting an Earth Ventures (EV) concept 'Rapid Arctic Methane Pulse' (RAMP) to investigate the response of Arctic permafrost regions to rapid warming and increasing precipitation, and how this response will contribute to future climate change. RAMP will adopt a multi-scale strategies pioneered in FIFE (the First ISLSCP Field Experiment with ISLSCP = International Satellite Land Surface Climatology Project), Boreal Ecosystem-Atmosphere Study (BOREAS), and other NASA studies and will use past and current in-situ, airborne, and satellite measurements of surface and subsurface characteristics to scale these to the circumpolar Pan Arctic using the terrestrial ecosystem model (TEM) and the Goddard Earth Observing System Model, Version 5 (GEOS-5) general circulation and climate mode; (4) Utilizing the spectrometer techniques developed in the past 4 years to achieve first-time ever, direct quantification of evapotranspiration and respiration; and (5) Collaborate with Dr. Alexi Lyapustin to employ improved Moderate Resolution Imaging Spectroradiometer (MODIS) cloud screening techniques to explore vegetation trends in the tropics.

Accomplishments in FY 12-13

Dr. Hall applied and was accepted to serve on a new NASA study, the Arctic-Boreal Vulnerability Experiment that plans to study surface atmosphere carbon exchange in Alaska. He also published or contributed to three peer-reviewed papers, all related to the funded research described above. In addition, he initiated an Arctic EV proposal that was reviewed and accepted by the GSFC line of business organization for full proposal development support. The submission due date for the 5-year $30M EV proposal RAMP should be in the latter part of calendar year (CY) 2013 with a funding decision in mid-CY 2014. RAMP will acquire field, aircraft and satellite data in the years 2015, 2016 and 2017, and conclude at the end of 2018 following a year of data analysis. Dr. Hall also wrote and submitted three proposals for follow-on research in response to different NASA Announcements of Opportunity with collaborators Dr. Hilker of Oregon State, Dr. Tucker and Dr. Lyapustin of GSFC.

Relative to Task 320, together with Dr. Hall's Co-Is, the team developed a combined optical-radar model for retrieving the biophysical parameters from forested ecosystems. The model has been evaluated in Howland Forest in Maine. A paper entitled "Retrieval of Forest Biophysical Parameters Using Physically-Based Algorithms," has been submitted for publication in Remote Sensing Letters. In this work, optical reflectance model and radar backscatter models were used to create a look up table by simulation of multi-spectral reflectance at LANDSAT bands and radar backscattering coefficients and the height of scattering phase center in L-band from the forest stands generated by a forest growth model. As a first step, a simulated data set was used to test the look up table method. The results showed that optical reflectance, radar backscatter and interferometric SAR signature have their own advantage in deriving different parameters, and combined use of these data improved the estimation results. In the next step of the team's study, real data, such as LANDSAT data, ALOS PALSAR data will be used in look-up table inversion.

Objectives for FY 13–14

Wrap up the research on the Multi-Sensor Retrieval BioPhys project, continue to develop the Earth Ventures proposal (RAMP), and other work in support of GSFC management.

Task 305: **Spectral Bio-Indicators of Ecosystem Photosynthetic Efficiency and NASA Earth Observing - 1 (EO-1) Mission, Scientific support for Hyperion data analysis and product development (Sponsor: Elizabeth Middleton)**

Investigators: K.F. Huemmrich, Research Assistant Professor, JCET; Elizabeth Middleton, GSFC (PI); Petya K.E. Campbell, Research Assistant Professor, JCET; Y.B. Cheng, ERT; Q. Zhang, USRA; C. Daughtry, USDA/ARS; G. Parker, Smithsonian Environmental Research Center; L. Corp, Sigma Space Corporation

Description of Research

The focus of this research is to develop methods of using hyperspectral remote sensing observations of landscapes to determine biophysical characteristics of vegetation, and to link those characteristics to carbon fluxes, plant growth, biodiversity, and disturbance. 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 observations from the Earth Observing-1 (EO-1), Aqua, and Terra satellites.

Accomplishments in FY 12-13

Studies using ground- and satellite-based observations for a number of different ecosystem types are being performed to study the use of narrow spectral bands to detect plant stress and relate that to ecosystem carbon exchange. The satellite approach uses data from the Hyperion imaging spectrometer on EO-1 and narrow MODerate resolution Imaging Spectroradiometer (MODIS) spectral bands intended for ocean studies over land. Our work has shown that indices using a number of different spectral bands are related to ecosystem light use efficiency, the rate of carbon dioxide taken up by plants for photosynthesis per unit of light absorbed by the canopy. This work has been done for a number of globally-distributed sites with different vegetation types, where carbon fluxes between the ecosystem and atmosphere were measured.

To further examine vegetation spectral reflectance changes associated with stress in a more detailed manner, field experiments were conducted where measurements of leaf level reflectance and carbon exchange were made in conjunction with measurements of whole canopy reflectance and carbon exchange. This fieldwork was performed in a cornfield in conjunction with Department of Agriculture scientists. Hyperspectral reflectance data were collected at multiple times diurnally in a cornfield and compared with carbon fluxes measured in the same field. Preliminary results indicate that short-term changes in apparent spectral reflectance are associated with photosynthetic down-regulation and the reduction of carbon uptake by the plants.

In particular, Dr. Huemmrich combined field measurements of tundra vegetation reflectance and carbon flux to identify optical-functional tundra plant types, such as lichens, mosses, and vascular plants. The relationships developed from the field measurements were used to map regional patterns of the coverage of these plant types for an area around Barrow, Alaska using Hyperion imagery and relating the vegetation patterns with carbon fluxes.

Dr. Huemmrich was also chair of the NASA Terrestrial Ecology Field Campaigns Working Group. As chair, he lead evaluation panels of scoping studies for two prospective NASA field campaigns and organized recommendations for programmatic changes to increase the productivity of existing field activities. Dr. Huemmrich served on the Pelagic and Coastal Ecosystem (PACE) science definition team (SDT), attended three team meetings and wrote sections of the SDT report. He served on NASA proposal review panel. He organized and chaired a session on Remote Sensing of Terrestrial Carbon Fluxes at the Fall American Geophysical Union meeting.

Dr. Huemmrich is presently on the committee of a PhD student in the Forestry Department at Virginia Tech. He was also on the committee of a Masters student at the University of Idaho.

Objectives for FY 13-14

Dr. Huemmrich will continue the work on remote sensing of plant stress. His goal is to publish an analysis using MODIS and Hyperion data to detect light use efficiency for multiple vegetation types, leading to the development of a model for ecosystem carbon uptake driven only by satellite data. He will also create models of vegetation canopy radiative transfer dynamically linked to leaf level photosynthesis and stress response. Such a model will provide a physical link between the leaf- and canopy-level observations. Further, Dr. Huemmrich will examine the use of narrow spectral band data to detect chlorophyll fluorescence, its relation to carbon fluxes and work with combining thermal and spectral data to determine ecosystem water and energy fluxes along with carbon flux. Finally, he will continue to work on monitoring high latitude ecosystem change, to examine the use of high temporal frequency reflectance data in describing vegetation seasonality and temporal patterns of carbon flux and to support airborne campaigns to collect fluorescence, thermal, and spectral reflectance data for monitoring vegetation stress and carbon fluxes.

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

Investigators: Yujie Wang, Associate Research Scientist, JCET; Alexei Lyapustin, GSFC

Description of Research

The main objective of Dr. Wang's research consists of three areas: 1) Operational performance of the Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm; 2) Adapting the MAIAC algorithm for GOES-R related risk reduction activities; and 3) Conducting MODIS/VIIRS calibration-validation analysis for surface reflectance products

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/albedo without empirical assumptions typical of current operational algorithms [Lyapustin et.al, 2012b, 2011a, 2011b]. 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 [Lyapustin et.al, 2012a] that helps the algorithm to flexibly choose a processing path in changing conditions.

As a validation effort, Dr. Wang, in collaboration with Dr. Lyapustin, also developed an AERONET-based Surface Reflectance Validation Network (ASRVN) [Wang et. al, 2011]. ASRVN is an operational processing system that receives MODIS TERRA and AQUA data from MODAPS and MISR data, from NASA Langley for AERONET locations, and AERONET aerosol and water vapor data. Then it performs an accurate automated atmospheric correction creating individual sensor records of surface bidirectional reflectance. Spectral surface BRF and albedo are primary ASRVN products generated in gridded format at resolution of 1 km for the areas of 50x50 km for over 100 AERONET stations globally. ASRVN is used as a main tool for the validation of MAIAC results. In addition, it has also been recently extended to compare with NPP VIIRS products.

Accomplishments in FY 12-13

In FY12-13, Dr. Wang has mainly focused on:

1) MAIAC operational code development

The MAIAC research code has been converted to an operational code. The operational code uses standard HDF4 files as input/output format. For the operational run, a check point mechanism has been implemented to allow the code run under interrupt/resume mode. The code has been delivered to the MODIS operation team and is under testing. In addition, a series analysis tools are developed to analyze MAIAC data, including MAIAC browse image tool, MAIAC sub-setting tool, MAIAC geolocation tool and MAIAC time series analysis tool.

2) Large scale test of MAIAC algorithm

The MAIAC algorithm was tested for continental level run. Dr. Wang has successfully performed MAIAC test run over the full Amazon basin area for both MODIS Terra (13 years) and Aqua (11 years) data. The full set of MAIAC output (such as surface reflectance, aerosol optical depth, surface BRDF model parameters and soon on) is staged and distributed for public evaluation. The MAIAC algorithm was also tested over the continental US area. These data have been used for air quality [Chudnovsky et. al, 2013] and ecosystem studies [Hilker et. al, 2012].

3) MODIS-VIIRS calibration –validation analysis for surface reflectance products

The ASRVN system was adapted for VIIRS data to test VIIRS surface reflectance products. Dr. Wang conducted APU (Accuracy, Precision and Uncertainty) analysis of VIIRS SR for a number of AERONET sites. Negative bias in visible bands of VIIRS SR has been found which means that the VIIRS SR algorithm underestimates surface reflectance. The bias is spectrally dependent, generally being largest in the blue band and reducing with wavelength.

Dr. Wang also performed comparisons among VIIRS surface reflectance (SR), MODIS SR (MOD09), and MAIAC SR generated from VIIRS and MODIS. To conduct this 4-way comparison, all the data were gridded/resampled into similar grid cells and then aggregated into 3x3km^2 resolution. Since MODIS and VIIRS have difference sun-view geometry, all the VIIRS and MODIS SR products were also normalized to nadir view and SZA = 45 degree (called BRFn), using BRDF parameters retrieved from MAIAC VIIRS/MODIS process, separately. The results show that both MODIS SR and VIIRS SR have negative bias in visible bands compared to MAIAC, especially in the Blue band. The negative bias in the VIIRS SR is higher than MODIS SR.

Objectives for FY 13-14

During the next fiscal year, Dr. Wang will continue to work on the MAIAC operational code development and perform comprehensive large scale MAIAC testing over North American and European areas. In addition, Dr. Wang will also continue the MODIS-VIIRS calibration-validation analysis for new and improved VIIRS surface reflectance.

Heliophysics & Solar System Divisions
(Codes 670-690)

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NSF Grant: Collaborative Research: CSEDI Variational Approaches to Geomagnetic Data Assimilation (EAR-0757880)

NASA Grant: Understanding Near-Equator Geomagnetic Spots via data assimilation (NNX12AP31G)

NASA Grant: Validation of the CrIS - Hyperspectral Infrared Earth Radiance Time Series (NNX12AG66G)

NASA Grant: Validation of the CrIS Sensor Products for Climate Research (NNX11AK78G)

NASA Grant: Calibration and Validation of the CrIS Sensor (NA11NES4400001)

Task 308: Carbon Cycle Data Assimilation (Sponsor: Steven Pawson)

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

Investigators: Andrew Tangborn, Research Associate Professor, JCET, Mathematics, UMBC; Weijia Kuang, Fellow, JCET, GSFC; Gary Egbert, Oregon State University, L. Larrabee Strow, Fellow, JCET, Research Professor, Physics, UMBC

Description of Research

Research is carried out in the field of data assimilation with applications in Earth's core research (geodynamo) and carbon cycle science.

The geomagnetic data assimilation research group, funded by both NSF and NASA, is a collaborative project involving scientists and graduate students from UMBC, Goddard Space Flight Center, Oregon State University and Harvard University. The team has been employing techniques traditionally used in Numerical Weather Prediction (NWP) with the goals of predicting future changes to the Earth's magnetic field, and gaining better estimates of the fluid motion inside the Earth's core. Carbon cycle data assimilation, funded by NASA through the physics department at UMBC (PI-Strow), is concerned with producing new carbon dioxide (CO_2) retrieval products from NASA satellites assimilating them into the GEOS-5 constituent assimilation system. The team is also developing techniques for using long term measurements from the Atmospheric Infrared Sounder (AIRS) to quantify changes in the earth's atmosphere over the past 10 years.

Accomplishments in FY 12-13

Atmospheric research is centered on extracting information from hyperspectral instruments measuring properties of the Earth's atmosphere. The team particularly focuses on the AIRS instrument, which has been operational for more than 10 years, providing a wealth of information about changes to the atmosphere. Part of this work involves assimilating CO_2 retrievals into a global assimilation system to evaluate both the quality of the data, and it's impact on a global constituent model. The team has completed assimilation runs using AIRS CO_2 retrievals in the 15μ wavebands for the years 2005-2006, showing that these observations can improve global estimation of CO_2 at all levels of the atmosphere. The team has also assimilated CO_2 retrievals from the Greenhouse Gas Observing Satellite (GOSAT) for a 9 month period in 2010. This work showed how lower tropospheric sensitivity of the near-infrared sounder increases the ability of a global model to predict surface layer CO_2, and how it could be used in conjunction with the AIRS retrievals to improve the estimation of the entire tropospheric CO_2 profile.

The geomagnetic data assimilation work continues to improve the ability to forecast future changes to the geomagnetic field, and to improve estimates to the dynamics of the Earth's core. The assimilation algorithm has been rewritten so that it can now make use of Observation–Forecast (O-F) statistics to improve the error estimates for the covariance matrix. The team has begun to include more realistic observation errors, which generally increase back in time. The system now also has greater flexibility to handle a wide range of forecast error correlation length scales, which should improve the magnetic field deeper within the outer core.

Objectives for FY 13-14

The team plans to expand collaboration in geomagnetic data assimilation towards the goal of building an ensemble-hybrid system. The team has completed an NSF proposal and, if funded, this will provide the major new direction for this research.

Atmospheric research using radiances from AIRS will continue with an expanded retrieval period (2010-2013), and these carbon dioxide observations will be assimilated into GEOS-5 along with GOSAT measurements. Also, the team plans to carry out retrievals on the rates of changes to a number of atmospheric properties (trace gases, humidity, surface temperature) for the past 10 years in order to extract a climate signal from this long satellite record.

Office of Education
(Code 160)

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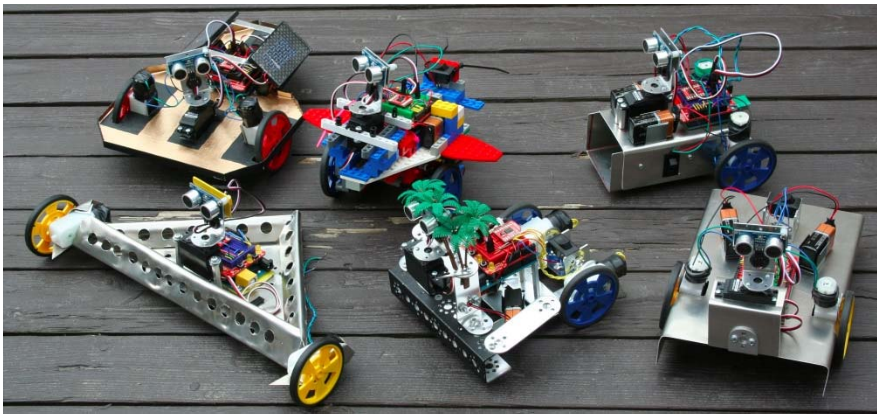
JCET Highlight: GSFC "I'm an Engineer" Afterschool Program
Investigator: Dr. Susan Hoban



NASA's BEST (Beginning Engineering, Science and Technology) Students program provides professional development to educators on the teaching of STEM through robotics. Group photo from April 2013 NBS robotics training with teachers and students from Seattle Public Schools. (Photos courtesy of NASA.) For more information, visit: www.nasa.gov/audience/foreducators/best/

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NASA Grant: NASA's BEST Students - Dissemination and Expansion to other Centers (NNX11AI16G)

Anne Arundel County Public Schools Subcontract: NASA Earth and Space (contract 10-116)

Task 378: NASA's BEST Activities (Sponsor: Carmel Conaty)

Subtask 379: NASA's BEST Students Professional Development and Coordination of NBS Submissions to the NASA Office of Education Performance Management System

Investigators: Susan Hoban, Senior Research Scientist, JCET; Laurie Cook, Michelle Graf, Anuradha Koratkar, GEST; Catherine Kruchten, Paragon/GSFC; Carmel Conaty, GSFC; Russ Billings, DFRC; Nancy Hall, GRC; Susan Currie, MFSC; John Boffenmyer, SSC; Maureen McMahon, AACPS

Description of Research

The UMBC-GSFC NASA's Beginning Engineering, Science and Technology (BEST) Students (NBS) team designs and delivers engineering education professional development for K-12 educators. The NASA's BEST Activity Guides, in three volumes for grades K-2, 3-5 and 6-8, is in use both locally and nationally. For example, the Anne Arundel County Public Schools offer after school clubs in over 20 schools reaching more than 400 students annually. The Los Angeles Unified School District, second largest in the nation with 700,000 students, has adopted the NASA's BEST Activity Guides in their acclaimed afterschool program, "Beyond the Bell." The team's unique combination of educators and STEM professionals enables the production of high-quality STEM materials and effective professional development.

The UMBC NASA Earth and Space team develops course materials for a high school-level course in Earth and Space Science. This course is designed in a problem-based format, where the students set out to answer science questions using data from NASA and other sources. The course is in a hybrid format, with most of the material being online. Periodic online visits from scientists punctuate the course, providing access to professional researchers for the students to ask questions and get general guidance in the overall research process. The UMBC team is preparing to provide professional development to high school educators on the course content and associated pedagogy.

Accomplishments in FY 13-14

In response to the need expressed nationally and by NASA for engineers, the NASA's BEST Students project was launched in 2008. The goal of the project is to promote Science, Technology, Engineering and Mathematics (STEM) education with an emphasis on engineering, using a NASA-unique focus, in elementary and secondary learning venues, in the formal classroom and in informal learning environments. The goal is achieved through the development and deployment of STEM curriculum support resources, particularly through the delivery of professional development for educators and facilitators on the fundamental concepts addressed in the curriculum support materials.

In 2012, the NBS team provided professional development and student experiential learning opportunities aligned with NASA's education objectives to strengthen the nation's future workforce, attract and retain students in STEM disciplines, and engage Americans in NASA's mission. To date, the NBS team has directly impacted over 7,500 students, teachers, and education outreach audiences nationwide. In 2012, the team introduced 1,283 educators; 2,002 students; and 294 outreach participants to NASA's BEST activities and multi-media resources. Many of these participants were educators who returned to their home organizations and are currently disseminating the activities and resources to their peers. Thus, the reported number of educators and students reached directly by the NBS team is, in fact, a lower limit on the use of activities and resources across the nation.

A major focus of 2012 was on partnerships to leverage NASA's investment. The ongoing partnership with Anne Arundel County Schools in Maryland remains strong, as does the relationship with the Catalyst STEM Schools within the District of Columbia. Growing is the partnership with the Los Angeles Unified School District.

In the out-of-school time arena, the Goddard Visitor Center implemented two afterschool series based on the NASA's BEST Activity Guides. Each series fills to capacity, advertised only on the Goddard Visitor Center website. A new relationship with the Maryland Out of School Time Network has yielded access to groups such as the YMCA.

Not surprisingly, educators and facilitators who use the NASA's BEST Activity Guides have come back to us clamoring for more. To address this strong response from the target audience, we have begun a second set of activities based on NASA's Technology Demonstration Missions. To expand and leverage the program, an article was written and published in "The Classroom Astronomer," detailing the advantages of using NBS to teach STEM to younger students. [Hoban, 2013].

For the NASA Earth and Space program, all 6 modules (3 Earth Science and 3 Space Science) were completed this year. The entire collection of modules was transferred to the Anne Arundel County Public Schools sharepoint site.

Objectives for FY 13-14

Looking forward, the NASA BEST Students team will place emphasis on providing educator professional development to support underserved minorities and girls in NASA-unique, STEM education pursuits. Additional targets for 2013-14 are informal education networks across the nation. With the strong emphasis on inquiry and engineering in the Next Generation Science Standards, the NASA's BEST Students curriculum support resources and the professional development provided for these resources position NASA as a leader in STEM content and pedagogical strategies using engineering as the focus. A final major push will be to duplicate the stunningly successful "I'm an Engineer!" after school program currently running at the Goddard Visitor Center at UMBC's campus to support the homeschooling community.

For the NASA Earth and Space program, this final, partial year will be used to develop a roadmap for educators and provide professional development as requested by Anne Arundel County Public Schools.

III. SUPPORTING INFORMATION

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III.3 Publications Submitted for Review

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III.4 Conference Presentations, Non-reviewed Publications and Technical Reports

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Prados, A.I. (2012), Connecting NASA Science to Policy Through Capacity Building: ARSET Program, invited talk, The International Research Institute for Climate and Society, Columbia University, 3 August.

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Prados, A.I. (2013), Grant writer's Goldmine: how to use logic models to develop winning proposals, Session Chair and Workshop Coordinator, Earth Science Information Partners Annual Winter Meeting, 10 January.

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Prados, A.I., and Bryan B. Duncan (2013), Lightning Talk Session for Air Quality Management Agencies, Organizers and Co-chairs, Air Quality Applied Science Team 5th Biennial Meeting, University of Maryland, College Park, 4-6 June.

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Turpie, K.R., B. Balch, B.A. Franz, R. Frouin, W. Gregg, C.R. McClain, C. Rousseaux, D. Siegel, and M. Wang (2013), NASA science team assessment of S-NPP VIIRS ocean color products, Presentation at the International Ocean Color Science Meeting, Darmstadt, Germany. 8 May.

Turpie, K.R., B. Balch, R. Frouin, W. Gregg, C.R. McClain, D. Siegel, and M. Wang (2013), Suomi National Polar-orbiting Partnership (NPP) Science Team Ocean Science Discipline Review Presentation, Presentation at the Suomi NPP Science Team Meeting, Greenbelt, MD. 23 January.

Turpie, K.R., B.A Franz, C.R. McClain, W.D. Robinson, R.E. Eplee Jr, G. Meister, G.F. Fireman, F.S. Patt, and R.A. Barnes (2012), Suomi NPP VIIRS ocean color data product early mission assessment, in Earth Observing Systems XVII J.J. Butler, X Xiong, and X. Gu, eds, Proceeding of the SPIE, 8510, 85101I, San Diego, California, 12-16 August.

Turpie, K.R., M. Babin, T. Bell, M-H. Forget, J. Goodman, E. Hochberg, Y.H. Jo, C. Hu, M. Kelly, V.V. Klemas, Z.P. Lee, T. Moisan, W. Moses, and G. Toro-Farmer (2013), HyspIRI Aquatic Studies Group (ASG) aquatic data products white paper and community discussion. Presentation at the HyspIRI Science Symposium, Greenbelt, Maryland, 29 May.

Venero-Vélez, I., D. Orozco, R. Delgado, and R.M. Hoff (2012), Characterization of Particle Pollution during 2011 DISCOVER-AQ campaign by means of Sun-photometer, Nephelometer, Lidar and Particulate Matter measurements at UMBC presented at UMBC's Fifteen Annual Summer Undergraduate Research Fest (SURF), University of Maryland, Baltimore County, Baltimore, Maryland, August.

Wilson, E.L., E.M Georgieva, and H.R Melroy (2012), Miniaturized Hollow-Waveguide Gas Correlation Radiometer (GCR) for Trace Gas Detection in the Martian Atmosphere, International Workshop on Instrumentation for Planetary Missions, NASA/GSFC, 10-14 October.

Wolfe, G.M., C. Cantrell, S. Kim, R.L. Mauldin III, T. Karl, Harley, A.Turnipseed, W. Zheng, F. Flocke, E. C. Apel, R. S. Hornbrook, S.R. Hall, K. Ullmann, S.B. Henry, J.P. DiGangi, E.S. Boyle, L. Kaser, R. Schnitzhofer, A. Hansel, M. Graus, Y. Nakashima, Y. Kajii, A.Guenther, and F.N. Keutsch (2012), Peroxy Radical Chemistry and Partitioning under a Ponderosa Pine Canopy, AGU Fall Meeting, San Francisco, California, 3-7 December.

Wong, S., T. L'Ecuyer, W.S. Olson, and E. Fetzer (2012), Local Balance of Heat Budget in the Atmosphere over the Oceans, 2012 AGU Fall Meeting, San Francisco, California, 7 December.

Woods, L., D. Orozco, R. Delgado, and R.M. Hoff (2012), Contribution of Relative Humidity on Light Scattering of Aerosols presented at UMBC's Fifteen Annual Summer Undergraduate Research Fest (SURF), University of Maryland, Baltimore County, Baltimore, Maryland, August.

Yurganov, L., K.E. Pickering, E. J. Bucsela, N. A. Krotkov, L. N. Lamsal, R. W. Pinder, and W. H. Swartz (2012), Nitrogen Dioxide Over US in 2006: OMI Measurements in Comparison With CMAQ Model, AGU Fall Meeting, San Francisco, California, 4-8 December.

Yurganov, L., X. Xiong, S. and C. Wofsy. (2012), Atmospheric Methane over the Arctic Ocean: Satellite Data, AGU Fall Meeting, San Francisco, California, 4-8 December.

Zhang, H., R.M. Hoff, S. Kondragunta, I. Laszlo, and A. Lyapustin (2012), Aerosol Optical Depth (AOD) Retrieval using GOES-East and GOES-West Reflected Radiances over the Western United States, Paper A23J-05, American Geophysical Union Fall Meeting, San Francisco, California, 3-7 December.

Zhang, Z., H.M. Cho, S. Platnick, and M. Lebsock (2012), A regime-by-regime analysis of the microphysical properties and warm rain characteristics of marine-boundary-layer clouds using collocated CloudSat and MODIS data, presented at AGU 2012 Fall Meeting, San Francisco, 3-7 December.

Zhang, Z., H.M. Cho, S. Platnick, and M. Lebsock (2012), A regime-by-regime analysis of the microphysical properties and warm rain characteristics of marine-boundary-layer clouds using collocated CloudSat and MODIS data, presented at AGU 2012 Fall Meeting, San Francisco, 3-7 December.

Zhu, L., J.V. Martins, and H. J. V, Yu (2012), Improved flux and aerosol forcing calculation using the MODIS enhanced vegetation albedo, International Radiation Committee, Internacional Radiation Symposium Berlinm, Germany, 6 August.

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III.5 Courses Taught

Geography and Environment Systems (GES) 302: Arctic Geography

The course is designed to provide students with a comprehensive understanding of Arctic geography, including the physical, biological, and cultural characteristics of the region. (Taught by K. F. Huemmrich, Fall 2012).

GES 311: Weather and Climate

This class covers fundamentals of meteorology including atmospheric radiation, cloud microphysics, weather analysis and severe weather, global circulation and global climate. The student's grade was based on four tests, and four homework sets. The daily weather briefing is presented at the beginning of each class period. The class notes, homework material, past tests are available through class web page, http://userpages.umbc.edu/~tokay. There were 40 students on the roster for this class. (Taught by A. Mehta, Fall 2012 and Spring 2013).

GES 415: Climate Change

This course deals with the question of climate change and variability. Topics covered include changes in climate in different time scales (geologic, historic and the present), environmental evidence of climate change, factors controlling climate variations, and the use of computer models in reconstructing past climates and predicting climate changes. (Taught by J. Halverson, Spring 2013).

HONR 300: Robots in Society

Robots are becoming an increasingly ubiquitous part of modern society, though ideas about robots date back to at least the era of DaVinci. The objective of this course is to introduce students to concepts related to the use of robots in society. The course delves into technical, ethical, legal and creative ideas surrounding the increasing role of robots in our lives. Students build an extremely simple robot to help them understand some of the realities of robotics and dispel certain misconceptions about how robots make decisions and act on those decisions. (Taught by S. Hoban, Fall 2012).

Physics 335: Introduction to Atmospheric Physics and Chemistry

This course covers the composition and structure of the atmosphere, radiation and energy balance, and global warming. (Taught by L. Remer, Spring 2013).

Physics 721: Atmospheric Radiation

This is a graduate level course introducing the student to formal radiative transfer theory, which is simplified quickly for application to Earth's atmosphere. The physical processes, which contribute to absorption and scattering in the Earth's atmosphere, are examined. Topics include molecular absorption via vibration-rotation transitions and spectral line formation in homogeneous atmospheres. Raleigh and Mie scattering theory are covered, as well as their application to radiative transfer in clouds and aerosol-laden atmospheres. The importance of radiative transfer to the heat balance of the Earth and implications for weather and climate will be examined. If time permits, various parameterizations and approximation schemes for atmospheric radiative transfer will be developed. (Taught by T. Várnai and S. De Souza-Machado, Fall 2012).

Physics 722: Remote Sensing of the Earth's Atmosphere

Techniques for the passive and active remote sensing of the state and composition of the Earth's atmosphere. Fundamentals of radiative transfer as applied to remote sensing. Introduction to measuring radiation and designing passive and active instruments; theoretical background and algorithmic considerations for the passive and active sensing of aerosol and cloud properties; atmospheric profiles of temperature, humidity and trace gas concentration; and the state and composition of the Earth's surface. (Taught V. Martins, Fall 2012).

Physics 799: M.Sc. Research (Student: Jaime Compton)

(Taught by R. Hoff, Fall 2012)

Physics 898: Pre-Candidacy Doctoral Research (Students: John Sullivan, Daniel Orozco, Thishan Dharshana)

(Taught by R. Hoff, Fall 2012, Spring 2013)

Physics 899: Doctoral Research (Student: Patricia Sawamura)

(Taught by R. Hoff, Fall 2012, Spring 2013)

III.6 Colloquia and Seminars

Bulmer, M.H. (2012), Gregory C. Leptoukh Online Giovanni Workshop, *NASA Goddard Space Flight Center, NASA Goddard Earth Sciences Data and Information Services Center*, Greenbelt, MD, 25-27 September.

Bulmer, M.H. (2012), Working with ATVI: Progress and Planning to Build Technical Capacity in Afghanistan, *Mott MacDonald Inc.*, Arlington, Virginia, December 17-18.

Bulmer, M.H. (2013), An Eye in the Sky: New Frontiers in Open Spatial Data for Development, *The World Bank*, Washington, D.C., 14 February.

Bulmer, M.H. (2013), Comparative Climatology Symposium. *NASA HQ*, Washington, D.C., 7 May.

Bulmer, M.H. (2013), National Conference on Science, Policy and the Environment: Disasters and Environment Science, Preparedness and Resilience, *Ronald Reagan Building and International Trade Center*, Washington, D.C., 15-17 January.

Bulmer, M.H. (2013), U.S. Drought Management and Monitoring. Michael Hayes, National Drought Mitigation Center, *The World Bank*, Washington, D.C., 3 April.

Hoban, S. (2013), Engineering Careers, Invited speaker, TED Talk, *Maryland Out-of-School Time 3rd Annual Statewide Conference*, Annapolis, Maryland, 3 March.

Johnson, B.T. (2013), Microwave Remote Sensing of Precipitation, Challenges and Progress, *NASA Goddard Space Flight Center Young Scientist Forum*, Greenbelt, MD, 17 June.

Johnson, B.T. (2013), The Microwave Response to Ice-Phase Precipitation, Applications for Satellite Remote Sensing, *UMBC, Department of Physics*, Baltimore, Maryland, 13 March.

Johnson, B.T., et al. (2012), Rain and Snowfall Retrievals for the Global Precipitation Measurement Mission, Progress and Challenges, *NASA Goddard Space Flight Center Climate and Radiation Laboratory Seminar*, Greenbelt, Maryland, 19 September.

Lewis, J.R., E.J. Welton, and A.M. Molod (2012), *Validation of GEOS-5* boundary layer heights using improved MPLNET retrievals, *UMBC Seminar*, Baltimore, MD, 2 November.

Lima, A.R. (2013), Oral presentation, *PhD Committee meeting*, *UMBC*, Baltimore, MD, 3 May.

Lolli, S. and the MPLNET team (2013), Drizzle drop size estimation method in the frame of UV-Lidar MPLNET integration, *GSFC Lab Meeting*, Greenbelt, MD, January.

Mehta, A.V. (2012), Case Studies of Floods and Droughts, *GSFC Seminar*, Greenbelt, MD, 6 December.

Mehta, A.V. (2012), Introduction to NASA DATA: Rain, Temperature, Humidity, and Wind, *GSFC*, Greenbelt, MD, 13 November.

Mehta, A.V. (2012), Introduction to Remote Sensing Data for Flood and Drought Monitoring, *GSFC*, Greenbelt, MD, 6 November.

Mehta, A.V. (2012), Overview of Web-based Tools for NASA Data Access and Imaging, *GSFC*, Greenbelt, MD, 20 November.

Mehta, A.V. (2013), Introduction to Remote Sensing Data for Flood Monitoring, *The World Bank*, Washington D.C., 7 March.

Mehta, A.V. (2013), Using Satellites for Improved Flood Monitoring and Prediction, *The World Bank*, Washington D.C., 7 March.

Remer, L.A. (2013), VIIRS aerosol algorithm and products: Report to AeroCenter annual meeting. *GSFC AeroCenter Annual Meeting*, GSFC, Greenbelt, Maryland, 31 May.

Remer, L.A., T. Yuan, H. Yu (2012), Dust and volcanoes: Natural aerosols in human-induced climate change, *UMBC Dept. of Physics Colloquium*, Baltimore, Maryland, October.

Remer, L.A, T. Yuan, M. Chin and H. Yu (2013): Dust and volcanoes: Natural aerosols in human-induced climate change, *GSFC Climate and Radiation Laboratory seminar*, GSFC, Greenbelt, Maryland, June.

Shuman, C.A. (2012), Fall Colloquium Series, Warm Events At Summit, Greenland During 2012 Relative To An Evolving Climate Record, *Physics Department*, Baltimore, Maryland, 19 September.

Shuman, C.A. (2012), Fall Seminar Series, Warm Events At Summit, Greenland During 2012 Relative To An Evolving Climate Record, Center for Space Research, *University of Texas*, Austin, Texas, 22 August.

Shuman, C.A. (2013), Antarctica's Larsen B Embayment, A Decade+ of Ice Losses Detailed by Satellite Observations, *University of Georgia*, Athens, Georgia, 25 April.

Turpie, K.R. (2013), Mapping Pelagic Autotrophs from Space: Converting Photons to Food for Thought, *Department of Geography and Environmental Systems Seminar Series, UMBC*, 24 April.

III.7 Proposals Submitted by JCET Members

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
A Program of Satellite Ground Truth Measurement in the Eastern United States	NASA		Georgieva, Elena	Pending
Abundance of Methane by Interferometric Glint Observation (AMIGO)	NASA		Georgieva, Elena	Not Awarded
Advancing Broadband LIDAR Technology Readiness for the ASCENDS Mission	NASA		Georgieva, Elena	Pending
Characterizing aerosol effects on the heating profiles and atmospheric stability from MODIS, AIRS, OMI and CALIPSO products	NASA	Remer, Lorraine	Martins, J. Vanderlei Koren, Ilan	Pending
Climate Studies using Time Evolution of probability distribution functions from 10+ years of AIRS measurements	NASA	De-Souza-Machado, Sergio	Tangborn, Andy	Pending
Communicating scientific findings concerning aerosols, particulate matter, air quality and radiative effects	NASA	Martins, Vanderlei	Remer, Lorraine	Awarded
Data assimilation of GPP across northern latitudes from direct satellite observations	OSU (NASA)		Hall, Forrest	Pending
Deteriming aerosol properties and radiative forcing over heterogeneous land surfaces	NASA		Remer, Lorraine	Pending
Extending Atmospheric Latent Heating Estimates to the Extra-tropics Using Satellite Radar-Radiometer Data, High-Resolution Regional Model Simulations, and Reanalysis Products	NASA	Olson, William	Johnson, Benjamin	Awarded
Fire and land use perturbations on the energy and water cycles of the American West	NASA	Remer, Lorraine	Martins, J. Vanderlei Koren, Ilan	Pending
HiTech: The road to a STEM career, Institute of Museum and Library Services	Howard County Library System (NASA)	Hoban, Susan	Cook, Laurie	Pending
HyperAngular Rainbow Polarimeter (HARP-CubeSat)	NASA	Martins, Vanderlei	Remer, Lorraine Borda, Roberto	Awarded
Low Cost, High Precision Measuring, Reporting and Verifying System for Greenhouse Gas Total Column	NASA		Georgieva, Elena	Pending

Multiangle Optical–Lidar Approach to Canopy Structure Measurements	USRA (NASA)		Várnai, Tamás	Pending
Multi-decadal sulfur dioxide climatology from satellite instruments	NASA		Evans, Keith Yurganov, Leonid	Awarded
Assessing Elevation and Mass Balance Change across Antarctica's Getz Ice Shelf: Timing, Causes, and its Climate-Ice-Ocean System	NASA		Shuman, Christopher	Not Awarded
Applications of MODIS, ASTER, and MISR to Ice Sheet Processes and Modeling	NASA		Shuman, Christopher	Pending
Observational Characterization of Extreme Precipitation Events over Global Tropical and Midlatitude regions	NASA	Mehta, Amita		Pending
Parametric Form of the Particle Size Distribution: Relevance to the Validation Efforts of the TRMM and GPM Precipitation Retrieval Algorithms	NASA	Tokay, Ali		Not Awarded
Precise Greenhouse Gas Column Monitoring by Fabry-Perot Interferometer	NASA		Georgieva, Elena	Not Awarded
Precison Passive Greenhouse Gas Measurement System	NASA		Georgieva, Elena	Not Awarded
Combining surface reflectance and emissivity to assess the changes in ecosystem diversity and function due to natural and anthropogenic stress factors / disturbance effects	NASA	Campbell, Petya K.E.		Not Awarded
Quantifying particle size distributions in support of GPM combined precipitation retrieval algorithms	NASA		Tokay, Ali	Awarded
Retrievals of Precipitating Snow Using CloudSat Reflectivities and Radiometric Brightness Temperatures	NASA		Johnson, Benjamin	Pending
Spatially and temporally continuous vegetation dynamics derived from MODIS using the multi-angle implementation of atmospheric correction (MAIAC) algorithm	Oregon State U (NASA)		Hall, Forrest	Pending
Study of aerosol properties in the vicinity of clouds using multiplatform and multisensor data fusion	NASA	Várnai, Tamás		Pending
Synthesis of GPM GV Hydrometeor Datasets for Combined Precipitation Retrieval Algorithms	NASA		Tokay, Ali	Awarded
The Global Ecosystem Dynamics Mission (GEDI)	NASA		Hall, Forrest	Pending
Use of co-located CALIPSO and MODIS observations in understanding aerosol properties in the vicinity of	NASA		Várnai, Tamás	Pending

clouds				
HyspIRI Ecosystem Spectral Library Coastal Class Spectra	NASA	Turpie, Kevin	Campbell, Petya	Not Awarded
Integrating VIIRS Aerosol Products into the Air Quality Proving Ground	NOAA	Remer, Lorraine		Awarded
Characterization of 3D cloud variability and its radiative impacts	DOE	Várnai, Tamás		Not awarded
Convective cloud life cycle and aerosol impact: ASR based observational and modeling investigation	DOE	Yuan, Tianle		Pending
Total aerosol radiative forcing caused by urban intrusion into the Amazon	DOE	Remer, Lorraine	Martins, J. Vanderlei Koren, Ilan	Pending
Development of a Polarized Imaging Nephelometer (DEVOTE)	NASA	Martins, Vanderlei	Remer, Lorraine Borda, Roberto	Awarded
Advancing MODIS Climate Data Records with Algorithm MAIAC	NASA		Wang, Yujie	Pending
AEROSUMS: Robust Unification of Aerosol Data Products from Multiple Satellite Sensors for Research and Applications	NASA		Chu, Allen	Not Awarded
Airborne, Polarized Imaging Nephelometer for Measuring Aerosol Phase Matrix: In Situ Experiments and Comparison to the New Generation of Remote Sensors	NASA	Martins/ Dolgos	Martins, J. Vanderlei Dolgos, Gergely	Awarded
An improvement on secondary organic aerosol simulation in NASA GMI/CCM at present day and the year 2050:Implication for air quality and climate studies	NASA	Bian, Huisheng		Not Awarded
An Inter-comparison reanalysis and flux inversion for CO_2 using observations from AIRS, ACOS GOSAT and OCO-2	NASA	Tangborn, Andrew	Imbiriba, Breno	Pending
Assess rain Frequency and Intensity Spectra of Synoptic-Scale, Mesoscale, and Cloud-Scale Rain Events from NEXRAD Observations and a NASA Cloud-System resolving Global Model Over Continental United States	UMD (NASA)		Mehta, Amita	Not Awarded
Building capacity for project evaluation via NASA and ESIP Participation in the Environmental Evaluators Network Annual Conference	NASA	Prados, Ana		Awarded
Carbon Monitoring and Ecosystem Feedbacks	NASA	Huemmrich, K.F.		Pending

Central Greenland Temperatures 1978-2015 - Combination and Calibration of Satellite and AWS Records for Climate Trends and Model Validation	NASA	Shuman, Christopher		Not Awarded
Characterizing Uncertainties in Large-Scale Atmospheric Heating Distributions Derived from TRMM Observations and Reanalysis Datasets	NASA	Olson, William		Awarded
Combining surface reflectance and emissivity to assess the changes in ecosystem diversity and function due to natural and anthropogenic stress factors / disturbance effects	NASA	Campbell, Petya		Pending
Consistent multi-satellite data records for carbon dioxide and methane	JPL NASA	Strow, L. Larrabee		Not Awarded
Continuing the Production of the Useful and Popular Satellite-based Global Air-sea Turbulent Fluxes (GSSTF) Datasets for Global Water and Energy Cycle Research	NASA	Shie, Chung-Lin		Not Awarded
Defining a MODIS Light Use Efficiency Product	NASA	Huemmrich, K.F.		Pending
Development and Evaluation of Improved Ice and Mixed-Phase Precipitation Models for GPM Combined Radar-Radiometer Retrieval Algorithm Applications	NASA		Johnson, Benjamin	Awarded
Development and Evaluation of Improved Ice and Mixed-Phase Precipitation Models for GPM Combined Radar-Radiometer Retrieval Algorithm Applications	NASA	Olson, Bill		Awarded
Development of a Laboratory Based Data Base of Aerosol Optical Properties	NASA	Martins, Vanderlei		Not Awarded
Evaluate and constrain aerosol indirect effect in the trade cumulus regime with NASA data and models	NASA		Yuan, Tianle	Selected
Evaluation of the Synergy Between Airborne BRDF and Lidar Measurements In Remote Sensing of the Canopy Structure and Biophysical Properties of Forested Landscapes	NASA		Várnai, Tamás	Pending
Extending the Earth Surface and Atmospheric Reflectivity ESDR (1979-2011) into the past 1970-1978 using NIMBUS/BUV and into the future (2012-2018) using OMI and SBUV satellite Data	NASA	Herman, Jay		Not Awarded
Farmland and Agriculture Remote	NASA		Huemmrich, K.F.	Pending

Monitoring Sensor (FARMS) Hyperspectral Technology Demonstration - Step 2				
Improving and exploiting global satellite hyperspectral measurements for ecosystem assessment and modeling	NASA		Huemmrich, K.F.	Pending
Improving estimates of CO emissions from biomass burning using FRP and its applicability to atmospheric models	NASA	Hoff, Raymond	GRA Karandana, Thishan Gamalathge	Not Awarded
Inferring drought stress through remotely-sensed leaf chemistry: seeing the forest through the leaves	NASA		Huemmrich, K.F.	Pending
Interannual Variability of Fundamental Global and Monsoonal Water Cycles using Satellite-based Estimation of Precipitation and Evaporation	Center for Research on Changing Earth (NASA)		Mehta, Amita	Not Awarded
Model Assimilation of New Spaceborne Light Use Efficiency Estimates to Quantify Spatially Explicit, Diurnal and Seasonal Exchanges of Biogenic Carbon	NASA	Hall, Forrest		Not Awarded
Central Greenland Temperatures 1978-2015 - Combination and Calibration of Satellite and AWS Records for Climate Trends and Model Validation	NASA	Shuman, Christopher		Not Awarded
Evaluation of ICESat-1 Inter-Campaign Bias Assessments Using Operation IceBridge Altimetry Data Over Ice Sheets	NASA	Shuman, Christopher		Pending
Near Real-time Volcanic Cloud Products for Aviation Alerts	NASA		Evans, Keith	Awarded
Parametric Form of the Particle Size Distribution: Relevance to the Validation Efforts of the TRMM and GPM Precipitation Retrieval Algorithms	NASA	Ali Tokay		Not Awarded
Potential Precipitation Products for PATH: Channel Optimization, Sensor Fusion, and Forward Modeling	UMCP (NASA)		Johnson, Benjamin	Not Awarded
Retrieval and Validation of fAPARchl from the MODIS Sensors Onboard TERRA and AQUA:A New Product	NASA		Wang, Yujie	Awarded
Satellite-Derived Surface-Temperature CDRs and Melt Maps of the Greenland and Antarctic Ice Sheets	NASA	Shuman, Christopher		Pending
Science Education Exploration Center (SEEC) (submitted with Conaty of	NASA	Hoban, Susan		Not Awarded

Goddard Education)				
Spatial scaling of vegetation biogeochemical cycle from pan arctic remote sensing data	NASA	Hall, Forrest		Pending
Spectral Bio-Indicators of Ecosystem Photosynthetic Efficiency III	NASA	Huemmrich, K.F.	Campbell, Petya	Pending
Spectral Bio-Indicators Successor Study	NASA		Huemmrich, K.F.	Pending
Synthesis of GPM GV Hydrometeor Datasets for Combined Precipitation Retrieval Algorithms	NASA		Tokay, Ali	Not Awarded
The representation of PBL physics in mesoscale models with applications to air quality and wind resource modeling in the Mid-Atlantic	NASA	Sparling, Lynn	GRA Baker, Barry	Not Awarded
Transition of GIFS-IIP Prototype to Science Campaign-Ready Airborne Chlorophyll Fluorescence Instrument (ACFI)	NASA		Huemmrich, K.F.	Pending
Use of the Pandora Spectrometer Network to Validate NPP/OMPS, AURA/OMI, AURA/MLS Ozone Column Amount and Profiles and OMI Trace Gases (NO_2, HCHO, BRO	NASA	Herman, Jay		Pending
Value of High Signal to Noise Hyperspectral and Multi-angle Data: The FARMS-Ground Simulator	NASA		Huemmrich, K.F.	Pending
Satellite methane data set since 2002 as indicator of emissions from the arctic shelf	NASA ROSES-12	Yurganov, Leonid		Not Awarded
Enabling Interactions among AQAST, “Key End-Users*” and NASA Mission Planners	NASA Air Quality Applied Sciences Team (AQAST)		Prados, Ana	Awarded
An Integrated Cross-Scale Analysis of the Physical, Biological, and Chemical Context of Forest Diversity	NASA and NSF		Huemmrich, K.F.	Not Awarded
Dimensions NASA: Collaborative Research: Integrating and extrapolating the biodiversity of forest carbon flux across time and space	NASA and NSF		Huemmrich, K.F.	Pending
Development of an Advanced Earth Sciences Imager for CubeSat Applications	NASA	Borda, R. Fernandez		Pending
Hydrological monsoon indices derived from the satellite-based sea surface latent heat fluxes and rain-rates	NASA	Shie, Chung-Lin		Not Awarded
An Inter-comparison Reanalysis and Flux Inversion for CO_2 using	NASA	Tangborn, Andrew		Awarded

observations from AIRS, ACOS GOSAT and OCO-2				
Spectral Bio-Indicators of Ecosystem Photosynthetic Efficiency III: Quantifying Plant Stress Down-Regulation of GPP	NASA		Campbell, Petya K.E.	Not Awarded
Investigating the QBO Modulation of Tropical Stratospheric Upwelling Using Satellite Measurements and GEOSCCM Simulations	NASA		Lee, Jae N.	Not Awarded
Investigation of boundary-layer cloud changes and their impacts on the Arctic warming	NASA		Lee, Jae N.	Pending
Understanding cloud roles in Arctic amplification: a NASA contribution to IASC efforts	NASA		Lee, Jae N.	Not Awarded
Characterization of Spectral Solar Irradiance Short-Term Variability with SORCE SIM Observation	NASA	Lee, Jae N.		Pending
Characterization of boundary-layer cloud properties during cold-air outbreaks with MODIS and MISR	NASA		Lee, Jae N.	Pending
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	NASA		Lee, Jae N.	Pending
Satellite Thermal IR Retrievals and Modeling of the Arctic Methane: Towards Quantification of Emission from Clathrates and Permafrost	NASA	Yurganov, Leonid		Pending
Long-term Satellite Data Fusion Observations of Arctic Ice Cover and Methane as a Climate Change Feedback	NASA		Yurganov, Leonid	Pending
Aerosol Trans-Pacific transport, deposition, and interactions with clouds and radiation: A perspective from decadal satellite measurements and model simulation	NASA		Bian, Huisheng	Pending
Solar Excited Chlorophyll Fluorescence System for the Assessment of Vegetation Photosynthetic Function". [PI E. Middleton]	NASA		Campbell, Petya K.E.	Pending
Collaborative Research: A new ensemble-OI hybrid approach to geomagnetic data assimilation	NSF	Tangborn, Andrew		Pending
Dimensions: An integrated cross-scale analysis of the physical, biological and chemical context of	NSF	Campbell, Petya	Huemmrich, K.F.	Not Awarded

forest diversity				
i STEM: Inspiring STEM: An Energizing Approach to Middle School Teacher Certification (submitted with Cerkovnik of Anne Arundel Community College)	NSF		Hoban, Susan	Not Awarded
Interannual Variability of Fundamental Global and Monsoonal Water Cycles using Satellite-based Estimation of Precipitation and Evaporation	NSF		Mehta, Amita	Not Awarded
Understanding Near-Equator Geomagnetic Spots Via Data Assimilation, Sponsored by NASA,	NASA		Tangborn, Andrew	Awarded
An integrated cross-scale analysis of the physical, biological and chemical context of forest diversity	NSF		Campbell, Petya K.E.	Pending
Direct Remotely Sensed Quantification of Light Use Efficiency and GPP in North America	Ohio State University (NASA)	Hall, Forrest		Not Awarded
Evaluation of differences between Dobson and Brewer ozone measurements specific to calibration scheme	U of Colorado, Boulder (NASA)	Herman, Jay		Not Awarded
Methane emission from the Arctic Ocean: satellite and ground-based measurements	UMBC SRAIS	Yurganov, Leonid		Not Awarded
New CO and O_3 Products for Climate and Air Quality Studies Using Data Fusion from Multiple Sensors on A-train Satellites	UMCP (NASA)	Tangborn, Andrew		Pending
Waste Dumping in Drainage Channels in Port-au-Prince, Haiti: A Method for Floating Trash Separation During Periods of Storm Water Flow	USAID	Bulmer, Mark		Pending
STEM Innovation Incubator	USDE	Hoban, Susan		Pending
Fine tuning the MODIS dark target aerosol algorithm and products: comprehensive error analysis	NASA		Remer, Lorraine	Pending
Investigating the impacts of absorbing aerosols overlying marine boundary layer clouds over the southeast Atlantic Ocean: Aerosol-adjusted cloud optical properties and aerosol direct radiative forcing	USRA (NASA)		Zhang, Zhibo	Awarded
Evaluating marine boundary layer clouds in a MMF model using collocated CloudSat and MODIS observations with a focus on cloud microphysics and warm rain	NASA	Zhang, Zhibo		Pending

properties				
Using MODIS, ASTER, CloudSat and Large-eddy-simulation to better understand the microphysical and optical properties of heterogeneous and precipitating marine boundary layer clouds	NASA	Zhang, Zhibo		Pending
Enhancing CALIPSO's Capability of Measuring Above-Cloud Absorbing Aerosols and Assessing Aerosol Long-Range Transport and Radiative Effects Through an A-Train Integration	UMD (NASA)		Zhang, Zhibo	Pending
Improving the representation of aerosol-cloud-precipitation processes in global climate models using observations from CloudSat, CALIPSO and other A-train sensors	PNNL (NASA)		Yuan Tianle	Pending
Trade Cumuli Variability and Interactions with Aerosols: Diagnostic and Modeling Studies with A-Train Data and an LES Model	NASA	Yuan, Tianle		Pending
Convective cloud system size and structure: Linking atmospheric thermodynamics and aerosols to convective cloud cover	Desert Research Institute (NASA)		Yuan, Tianle	Pending
High Clouds Overlapping Low Clouds: Observational Characterization and Impact Assessment	NASA	Yuan, Tianle		Pending
Support for the Detailed aerosol characterization and estimates of direct forcing from combination of Glory-APS, MODIS, CALIPSO and ground-based observations	GSFC	Martins, J. Vanderlei	Borda, Roberto	Awarded
A global network of aerosol sampling stations	MIPS	Martins, J. Vanderlei		Not Awarded
Mini Fourier-Transform Spectrometer for Cubesat-Based Remote Sensing	Appalachian State /(NASA)		Hewagama, Tilak	Pending
Measurements of Terrestrial and Offshore Wind Resource over Maryland for Strategic Planning and Development of Offshore Wind Energy Projects	Maryland Energy Administra-tion	Delgado, Ruben		Awarded
Wind Dispersal of Aerosols in Coastal Regions: Environmental and Health Impacts	U of Delaware (NSF)		Delgado, Ruben	Not Awarded
UMBC Monitoring of Atmospheric Pollution: Vertical Profiling of Baltimore's Lower Troposphere for Air Quality Applications	Maryland Dept. of the Environment		Delgado, Ruben	Awarded

Evaluate and constrain aerosol indirect effect in the trade cumulus regime with NASA data and models	NASA MAP	Yuan, Tianle		Pending

III.8 Biographies

Dr. Nader Abuhassan received an electrical engineering degree from the University of Damascus, Syria in 1983 and a PhD in Geophysics from the University of Pierre and Marie Curie Paris 6, France in 1995. Since 1997, he has been working at NASA's Goddard Space Flight Center. During the past 25 years, 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 has great interest in all aspects of hardware and software sensors design.

Dr. William Barnes is a Senior Research Scientist with the Joint Center for Earth Systems Technology, University of Maryland, Baltimore County and an emeritus research scientist with the Sciences Exploration 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 representative 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.

Mr. Timothy Berkoff was an Assistant Research Engineer at the Joint Center for Earth Systems Technology, University of Maryland, Baltimore County. He has more than 15 years of experience in the development of optical instrumentation for remote sensing applications and has served as the instrument manager for NASA's Micro-Pulse Lidar Network, a global network of lidar systems to provide long-term observations of aerosols and clouds. Mr. Berkoff's research background includes lidar, fiber-optic sensing techniques, interferometry, spectroscopic gas detection, tunable diode lasers, optical design, opto-electronics, and optical diagnostics. This includes the successful demonstration of new sensor technology on aircraft as well as surface and submersible ships in various field campaigns. He has more than 20 peer-reviewed publications, numerous conference proceedings, and is an inventor with two patents in the field of optical sensing. Mr. Berkoff obtained a B.S. in Optics from the University of Rochester. Mr. Berkoff accepted a civil service position at NASA Langley in June 2013.

Dr. Huisheng Bian received a B.S. in atmospheric science from Nanjing University in 1985, a M.S. in 1988, and a Ph.D. from University of California, Irvine (UCI) in 2001. From 1988 to 1995, she worked in the 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 the 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 aerosol simulation, particularly nitrate and secondary organic aerosols, and applying multiple chemical transport models (CTMs) to atmospheric chemistry studies.

Dr. Roberto A. Fernandez Borda received his Master's degree in Physics in 1996, from the University of Buenos Aires (UBA), Argentina, working in the development of a Solar Hard X ray sensor which was part of the payload of the first Argentinian Satellite, Sac-B. In

1997, he received a graduate-fellowship to finish his Ph.D at the Institute of Astronomy and Space Physics at UBA. During this period, under the framework of an international agreement with the Max Plank Institute for Extraterrestrial Physics, Germany, he was involved in the instrument automation and the calibration algorithms of a new H-alfa telescope for Solar Physics. As a result of his work, he obtained his PhD in 2001 in Physics/Applied Physics from UBA. In 2002, he got a Post-Doctoral fellowship from the National Research Council, United States, to work at the Planetary Physics branch of GSFC. He was involved in the instrumental development of flux magnetometers for planetary applications (Ares Mission), as well as signal processing algorithm designs for their onboard calibrations and data analysis (Wind and Voyager Missions). In 2006, he became part of the Goddard Earth Sciences and Technology Center, University of Maryland, Baltimore County (UMBC), working in the Climate and Radiation Branch of GSFC. As a member of this team, he was involved in different instrumental projects: the Particles Aerosols & Cloud Physics Suite (PACS), the Cloud Scanner Cube-sat, and many field experiments: Milagro campaign (Mexico), Co-Claim Campaign (Brazil), and Vocals Campaign (Chile). In 2009, he received an award from the Climate and Radiation branch of GSFC for his contributions to the optical design of PACS and the Rainbow Camera. In 2010, he joined JCET as a Research Assistant Scientist.

Dr. Mark Bulmer has 18 years of experience in pure and applied fields of geology, remote sensing, GIS, emergency management plus instrument design. He became a NATO Civil Expert on Civil Protection and in 2011 contracted to the Institute for Water Research at the US Army Corps of Engineers. He is an advisor to the National UK Co-ordination Agency for Fire and Rescue Aid. He sits on the wise council at the Bulmer Foundation which runs a Masters Degree in Sustainable Development Advocacy that trains graduates to become experts in sustainable development and apply this thinking to the real world in business, in policy making or in the community. He has taught undergraduate and graduate courses in Natural Hazards, Geomorphology and Planetary Geology. He is an expert in geophysical flows combining field derived measurements with remotely sensed data and emergency management. He has led or participated in over 30 major field tests, campaigns and responses to natural disasters working on land (volcanoes, mountains, deserts and glaciers), at sea, or in the air. He has experience as project and team leader, chief instructor, assessor and planner. He has worked in real, synthetic and simulated environments. In the field, he has worked in Haiti, Nepal, Taiwan, Italy, Spain, Peru, New Zealand, Pakistan, Morocco, Iceland, North America and the UK. This has involved collaborations with government and international agencies (e.g. UN, UNHCR, DFID/UKAID, USAID, World Bank) and non-government organizations (e.g. Red Cross, Oxfam, CRS, MercyCorps). Dr. Bulmer has installed prototype hazard monitoring systems on the Hubbard Glacier in Alaska, in the Sierra Nevadas in USA, mountain slopes in eastern Nepal, around Muzaffarabad in Pakistan and in the Peruvian rain forest. He has an on-going collaboration with emergency medical teams to examine the nature and survivability of injuries sustained in landslide disasters.

Dr. Petya K. Entcheva Campbell received a BS in Forestry from the Academy of Forest Engineering, Sofia, Bulgaria in 1988, a MS in Forest Sylviculture and Ecology from the University of Massachusetts at Amherst, MA in 1994 and a Ph.D. in Natural Resources Management / Remote Sensing in 2000 from the University of New Hampshire, Durham, NH, where her research focus was on the development of remote sensing techniques for forest health assessment. In 2000, Dr. Petya Entcheva Campbell joined NASA as a National Research Council associate and worked at Goddard Space Research Center for two years before joining JCET where she is currently employed. Her experience and expertise are in remote sensing for natural resources, with a specific interest in vegetation health and function, especially spectral analyses and development of methods (algorithms and measurement techniques) for vegetation stress assessments and land cover change detection. Dr. Campbell started work as a post-doctoral research associate, and later continued as a Principal Investigator on a NSF project for the "Evaluation of vegetation Solar Chlorophyll Fluorescence properties" targeting the assessment of solar exited chlorophyll fluorescence (ChlF). At GSFC she participates in NASA's "Light Use Efficiency and Carbon Science" and has participated in the development of the satellite hyperspectral mission/s Flora/SpectraSat/HyspIRI for vegetation assessment. Currently, she is a part of a research effort to develop spectral bio-indicators of vegetation stress, to facilitate the remote sensing assessment of vegetation photosynthesis and carbon sequestration. As part of the spectral research she has used various spectrometers and simulated/compared the abilities of the currently available earth observing sensors for vegetation stress detection. Currently, Dr. Campbell participates in an EO-1 Hyperion data intercalibration and analysis effort, with the goal to compare existing and suggest new land cover products, addressing vegetation type and function. At UMBC, Dr. Campbell teaches the class "Introduction to Remote Sensing for Environmental Applications" for undergraduate and graduate students at the Department of Geography and Environmental Systems (GES).

Ms. Valerie Casasanto is Program Coordinator for the University of Maryland, Baltimore County's Joint Center for Earth Systems Technology (JCET) since 2005. In addition, Ms. Casasanto is Principal Investigator for the NASA ROSES Education and Public Outreach (E/PO) award, Beautiful Earth: Experiencing and Learning Science in a New and Engaging Way (beautifulearth.gsfc.nasa.gov) engaging students and the general public in NASA Earth Science through music, art, and indigenous perspectives. Ms. Casasanto has more than 20 years of experience in designing, managing and implementing small and large-scale earth and space science educational programs to diverse age groups in multicultural environments. She has successfully managed and integrated student designed and PI science microgravity payloads on 15 space missions. Ms. Casasanto is a graduate and former employee of the International Space University (ISU), where she organized summer programs in a different host country each year. Ms. Casasanto is an active member and Vice-Chair of the International Astronautical Federation (IAF) Space Education and Outreach Committee (since 2002), member of GSFC's Education Implementation Team (since 2006), and member of GSFC's Native American Advisory Committee (since 2008). In February 2013, Ms. Casasanto became the Education Public Outreach lead for the ICESat-2 Mission.

Dr. Hyoun-Myoung Cho obtained a M.S. and B.S. in Atmospheric Sciences from Seoul National University in 1999 and 2002, respectively. He then worked at Forecast Research Laboratory at the National Institute of Meteorological Research, Seoul, Korea as assistant researcher. Following that position, he received a Ph.D. from Texas A&M University in Dec. 2011. His research interests are in the area of satellite-based remote sensing of clouds and aerosols. In Jan. 2012, he joined the Joint Center for Earth Systems Technology at University of Maryland, Baltimore County, where he worked on the development of an enhanced infrared cloud property retrieval algorithm with Dr. Zhibo Zhang.

Dr. D. Allen Chu received a BS in Atmospheric Sciences from the National Taiwan University in 1982 and a Ph.D. in Atmospheric Sciences from Georgia Institute of Technology in 1988. In 1989, he joined the ISAMS (Improved Stratospheric and Mesospheric Sounder) team at NASA Langley Research Center where he worked on the ozone and nitric acid retrievals using ISAMS measurements as well as radiance simulations using line-by-line/broadband radiative transfer models. In 1996, he was recruited by the MODIS (Moderate Resolution Imaging Spectroradiometer) aerosol team at NASA Goddard Space Flight Center to work on MODIS aerosol retrievals and lead quality assurance for the MODIS atmosphere products. In 2004, he joined UMBC JCET as an Associate Research Scientist. Since then, he has been heavily involved in a number of projects including the application of MODIS AOD to air quality, evaluation of aerosol radiative forcing in a number of field campaigns studying dust radiative and microphysical process on precipitation and energy budgets over the tropical Atlantic Ocean, as well as intercomparisons of model (e.g, GOCART, GEOS-CHEM, and CMAQ) and MODIS-derived aerosol properties. In 2007, he joined the UMBC GEST to continue his research. He has served as a PI of NASA's Intercontinental Chemical Transport Experiment - Phase B (INTEX-B), the NASA African Monsoon Multidisciplinary Analyses (NAMMA), and Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) programs, and EPA Advanced Monitoring Initiative (AMI) pilot project, as well as UMBC PI of DISCOVER-AQ and AirNow.

Mr. Jan Dominik Cieslak is a graduate from the Poznan University of Technology; Faculty of Electrical Engineering (1997). He started his professional carrier by working in the printing industry, as the technology engineer. Since 2005 he has been working at NASA's Goddard Space Flight Center/JCET. During the last 8 years He has been designing and building new in situ and remote sensing instruments, like nephelometers (PI-Neph), wide angle polarimetric cameras (RPI), and dust collecting filters stations. He has also participated in many field campaigns.

Dr. Ruben Delgado is a Faculty Research Assistant in JCET. He received a Ph.D. in Chemistry from the University of Puerto Rico in 2011. His dissertation was titled "Observations and Modeling of Sporadic Metal Layers over the Arecibo Observatory". He joined JCET as a Research Associate in November 2006. Currently, he is working with the Atmospheric Physics Group at UMBC in research involving active atmospheric measurements of atmospheric aerosols gases and wind with LIght Detection And Ranging (LIDAR) techniques.

Dr. Sergio DeSouza-Machado obtained a B.A. from the College of Wooster, OH in 1988, and an M.Sc and Ph.D. in 1990 and 1996, respectively, from the University of Maryland at College Park (Plasma Physics). After this, he joined the Atmospheric Spectroscopy Laboratory at the University of Maryland, Baltimore County in September 1996. He has developed the kCompressed Radiative Transfer Algorithm (kCARTA), a package that rapidly computes monochromatic absorption spectra, radiances and jacobians, and does scattering as well as NonLTE (non-equilibrium local thermal effects) computations His current research work is on retrievals of dust heights and optical depths, radiative transfer codes and trace gas retrievals, as well as studying climate trends and hydrodynamics. Dr. DeSouza-Machado also actively participates in teaching Physics classes, at both the undergraduate and graduate levels at UMBC.

Dr. Elena M. Georgieva received her PhD in physics in 1998 from the University of Sofia. She was a research associate at Lasers and Optical Characterization Laboratory, Georgetown University where she worked on nanoparticle characterization and correlation spectroscopy (2000-2001). Georgieva was a research associate at the NIST Center for Neutron Research and Johns Hopkins University (2001-2002). For four years, she was a Senior Systems Scientist/Engineer at Science Systems and Applications Inc, and worked at the NASA Goddard Laser and Electro-optics branch on instrument development for measurement of atmospheric species (2002-2006). She has research experience in remote sensing, data analysis and validation, instrument development, spectroscopy, interferometry, 3-D imaging laser radar systems, and polarimetry. Previous positions held by Georgieva include Assistant Professor at the Institute of Applied Physics, Technical University of Sofia; Bulgaria (1995–1999); Graduate Research Assistant, Department of Physics, University of Sofia (1988–1994); Research Associate, Institute of Applied Mineralogy, Bulgarian Academy of Sciences, Sofia (1987-1988). She has more than 30 refereed publications and is a member of Optical Society of America and the International Society for Optical Engineering (SPIE). In July 2010, she transferred from GEST to JCET (Joint Center for Earth Systems Technology). Her current research interests are in the development of active and passive sensors for remote sensing applications including the design, testing, and evaluation of advanced instrumentation for Earth and Planetary projects.

Dr. Forrest Hall is a physicist and currently teaches Climatology and Astronomy at Maryland Institute College of Art (MICA) and at Johns Hopkins University's Odyssey program. He is located at NASA's Goddard Space Flight Center in the GSFC/UMBC Joint Center for Earth Systems Technology. Dr. Hall has been active since 1980 in global change research using earth-observing satellites and models to monitor human-induced and natural changes to the earth's land ecosystems and the effects those changes have had on the earth's climate. He has authored more than 60 scientific papers on satellite monitoring of the global carbon cycle and climate change, many highly cited. Dr. Hall is a regular lecturer, both nationally and internationally. He has addressed a broad range of audiences on climate science: middle and high schools, universities, women's groups, state and national congressional representatives, religious organizations, and scientific meetings. Dr. Hall has a BS in Mechanical Engineering from the University of Texas, and an MS and PhD in Physics from the University of Houston.

Dr. Jeffrey B. Halverson has traveled the world's tropical latitudes to better understand how intense storms of rain and wind develop and intensify. He has conducted research in Brazil, Australia, the South China Sea, Costa Rica, the Marshall Islands, West Africa and various locations in the Caribbean studying tropical weather systems. His research examines the atmospheric factors that cause hurricanes to rapidly change intensity. In 2001, he helped pioneer a new aircraft-based, upper atmospheric measuring system to take direct measurements in the eye of a mature hurricane from an altitude of 70,000 feet. Dr. Halverson is currently an Associate Professor of Geography at the University of Maryland, Baltimore County (UMBC). He also served as Deputy Project Manager at NASA Headquarters, where he managed NASA field programs to investigate hurricanes in 2005 and 2006. Dr. Halverson has authored more than 28 professional papers and writes a monthly column on severe and unusual weather for *Weatherwise Magazine*. He is currently examining the extra-tropical transition of hurricanes making landfall over the Mid Atlantic.

Dr. Shin-Chan Han received a Ph.D. (2003) and a MS (2000) in Geodetic Science from Ohio State University (OSU), Columbus, OH, and a BS (1998) in Earth Science from Seoul National University, Seoul, Korea. His MS thesis is on absolute point positioning from Global Positioning System (GPS) and Ph.D. dissertation is on the global and regional gravity recovery from satellite tracking data and geophysical applications. He worked for two years as a Postdoctoral Research Associate at the Space Geodesy and Remote Sensing Laboratory at OSU and for one year as a Research Scientist at the School of Earth Sciences as OSU. During this period, he made several invited talks on Earth gravity field at various institutions and universities. In 2006, he joined the Planetary Geodynamics Laboratory at NASA Goddard Space Flight Center and GEST at UMBC, as a member of the research faculty; in 2011, he joined JCET at UMBC. He has been publishing papers on gravity estimation theory, coseismic and postseismic deformation, hydrological mass variation over the large river basins, ocean tides in polar regions, GPS/INS, and gravity gradiometry. Dr. Han accepted a civil servant position at GSFC in January 2013.

Dr. Jay Herman received an MS in physics from Clarkson College in Potsdam, New York in 1959 followed by PhD at Pennsylvania State University in 1965. He then worked for NASA until September 2009 followed by an appointment to JCET. The current primary focus of his research is the continuing development of the Pandora spectrometer system deployed for satellite validation and for developing a long-term climate data record of cloud amount and its change since 1979. Previously, he was Project Scientist for the Triana mission 1998 - 2009, and the Principal Investigator for NASA's Meteor-3/TOMS mission. During this time, he published extensive studies of UV radiation, aerosol amounts, and ozone distribution. Prior to working on the TOMS series of instruments he developed the first complete photochemical model of the Earth's atmosphere. He has extensive experience in radiative transfer for visible and UV radiation. Dr. Herman currently has 133 peer-reviewed articles in scientific journals.

Dr. Tilak Hewagama received a BSc in Physics & Mathematics from the University of Colombo, Sri Lanka and a PhD from the Dept. of Physics & Astronomy, University of Maryland, College Park. In his PhD thesis, Dr. Hewagama developed an infrared polarimeter to study magnetic fields in solar active regions. Tilak was a member of the COBE calibration team and EPOXI science team. He also developed radiative transfer algorithms for modeling and interpreting high resolution spectra of gas giant and terrestrial planetary atmospheres including earth. Dr. Hewagama is co-investigator in a NASA/GSFC effort to miniaturize Fourier transform spectrometers using waveguides and photonic circuits fabricated using MEMS techniques. He is currently an associate research scientist with UMBC/JCET participating in earth science investigations and the calibration of earth observing spectrometers with Dr. L. Larrabee Strow..

Dr. Susan Hoban is the JCET Associate Director for Academics, an Affiliate Associate Professor in the Department of Physics, and a UMBC Honors College Fellow. Dr. Hoban's research interests include dust in the universe and information technologies for science, technology, engineering and mathematics (STEM) education. She has a particular interest in contributing to the STEM foundation of our nation's K-12 educators. Prior to joining JCET, she was a Senior Research Scientist at UMBC's Goddard Earth Sciences & Technology (GEST). Dr. Hoban received her Ph. D. in astronomy from the University of Maryland, College Park in 1989. She conducted research in cometary science at NASA Goddard Space Flight Center, first as a National Research Council fellow, then as part of USRA Visiting Scientist Program, from 1989 – 1993. In 1993, she began working on information systems for science and education. In 1996, Dr. Hoban received the NASA Special Service Award for her work on web-based educational outreach. She joined UMBC's Computer Science and Electrical Engineering Department in 1996 as part of the Center of Excellence in Space Data and Information Science (CESDIS) at Goddard. From 1998-99, Dr. Hoban served as Acting Associate Director of CESDIS and from 1999 through the conclusion of CESDIS in 2000 as Acting Director. Her interests include scientific information systems, and information technologies for science, technology, engineering and mathematics (STEM) education. Dr. Hoban is the PI on the NASA's BEST Students (Beginning Engineering, Science and Technology) project that provides professional development for educators and curriculum support resources with a space exploration theme for engineering clubs for elementary and middle school students. The project also hosts engineering challenges and two-week summer bridge programs centering on lunar exploration for middle and high school students. She has a particular interest in contributing to our nation's educators' understanding of STEM subjects. She serves on the STEM Council at UMBC, the STEM Advisory Council for Anne Arundel County Public Schools, the HiTech Advisory Board for the Howard County Library System, and the Advisory Board for the STEM Achievement in Baltimore Elementary Schools (SABES) project at the Johns Hopkins University.

Dr. Raymond M. Hoff is a Professor of Physics at the University of Maryland, Baltimore County. He is also serving as the Science Advisor for the Joint Center for Earth Systems. Dr. Hoff has 37 years of experience in atmospheric research. His research interests are in the optical properties of aerosols and gases. Dr. Hoff has been central in formulating major research programs using lidars including Raman, differential absorption, airborne and spaceborne systems. He has investigated 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. He has held memberships in six scientific societies and served as Chairman of committees for those societies. In 2008, he became a Fellow of the American Meteorological Society. In 2012, he was awarded the NASA Distinguished Public Service Medal.

Dr. Karl Fred Huemmrich Dr. Karl Fred Huemmrich received a B.S. in physics from Carnegie-Mellon University in 1977 and a Ph.D. in Geography from the University of Maryland, College Park in 1995. In 1978 he began working as a NASA contractor at Goddard Space Flight Center, initially as operations analyst on the satellite attitude determination and control. Later he provided programming and analysis support of passive microwave remote sensing data of sea ice, where he was task leader. In 1987, he joined the team for the First International Satellite Land Surface Climatology Project Field Experiment (FIFE), a multidisciplinary field experiment on the Kansas prairies. Following the completion of FIFE, he worked on the Boreal Ecosystem and Atmosphere Study (BOREAS), a field experiment in the Canadian boreal forests. Dr. Huemmrich was the assistant Information Scientist on these experiments and has experience in the development and operation of interdisciplinary information systems in support of large field experiments. He has developed and used models of light interactions with vegetation, has studied the use of remotely sensed data to collect information on biophysical variables using both computer models and field measurements concentrating on uses of bidirectional and hyperspectral reflectance data. He has performed field work in a variety of habitats including arctic and sub-arctic tundra, boreal and temperate forests, croplands, prairies, and deserts.

Dr. Breno Imbiriba received his B.Sc. degree in 1997 from the Universidade Federal do Para (UFPA) in Belem, Brazil. In 1999, received his M.Sc. degree in Theoretical Physics from the Instituto de Fisica Teorica (IFT) in Sao Paulo, Brazil. In 2007, he received his Ph.D. in Physics from the University of Maryland, at College Park, Maryland. His research was on numerical simulation of binary black hole collision and gravitational wave extraction. In 2006, he became a post-doctoral researcher at the Joint Center for Earth Systems Technology (JCET) at University of Maryland, Baltimore County (UMBC). His research was on trace gases retrieval using thermal infrared sounders, and other instruments for remote sensing. In 2010, he became a visiting professor at UFPA, in the "Nucleus for the Environment" program where he taught Introduction to Remote Sensing, and was a scientific advisor in its master graduate program. In 2012, he returned to JCET in order to continue his global CO_2 retrieval research and radiance based climate studies.

Dr. Benjamin Johnson received his Bachelor of Science degree in Physics from Oklahoma State University in 1998, a Master of Science degree in Atmospheric Sciences from Purdue University in December 2001, and completed his Ph.D. degree in December 2007 from the University of Wisconsin—Madison. He is currently an Assistant Research Scientist in JCET. His research interests cover a broad spectrum of precipitation cloud modeling, radiative transfer, cloud microphysics, and radar/radiometer remote sensing from air, space, and ground. Dr. Johnson is focusing on combined dual-frequency radar and multi-channel radiometer retrievals of frozen and mixed-phase precipitation at microwave frequencies in the 10 to 340 GHz range, with a focus on the upcoming Global Precipitation Measurement (GPM) and the ongoing CloudSat missions. Dr. Johnson is a member of the GPM radiometer algorithm team, combined radar/radiometer algorithm team, and is a member of several working groups, including the International Precipitation Working Group (IPWG), and is actively involved in developing improved retrieval algorithms for measuring falling snow using passive microwave and radar remote sensing methods.

Dr. Ilan Koren received his degrees from the department of Geophysics and Planetary Sciences in Tel Aviv University, Israel. He received his Ph.D with distinction in 2002 where his major research interest was on spatial and temporal patterns in clouds and aerosols. He joined NASA's MODIS aerosols team –as a National Research Council (NRC) fellow and received two awards for Best Senior Author Publication for his work on cloud-aerosol interaction. In summer 2004 he joined JCET as an Assistant Research Scientist. His research interests include remote sensing and modeling of clouds and aerosols, the role of aerosols on climate, and the impact of aerosols on the lifecycle and optical properties of clouds.

Dr. Prasun K. Kundu received a B.Sc. (with honors) in Physics from Calcutta University, India in 1974 and a M.Sc. in Physics from the Indian Institute of Technology, Kharagpur, India in 1976. He then joined the High Energy Physics Group at the University of Rochester in New York where he earned his Ph.D. degree in 1981 in theoretical physics for his work on a new class of an exact and asymptotic solution to the Einstein field equations of general relativity. During 1980-82 he was a postdoctoral research associate at the Enrico Fermi Institute, University of Chicago, and subsequently during 1982-85 he was an instructor at the University of Utah, Salt Lake City. In 1985 he joined the Department of Physics and Astronomy at Ohio University, Athens, as assistant professor where he taught a variety of graduate and undergraduate courses in Physics and continued research in relativistic gravitation theory. Since 1992 he has worked at the

Climate and Radiation Branch, GSFC on various aspects of rainfall statistics related to the Tropical Rainfall Measuring Mission (TRMM) and other satellite and ground based remote sensing measurements of precipitation. For his work he received an exceptional scientific support award in 2000. Dr. Kundu is currently a Research Associate Professor at JCET, UMBC. He has taught graduate level physics courses in thermodynamics and statistical mechanics at UMBC and the Johns Hopkins Applied Physics Laboratory. His past work in collaboration with Dr. T. L. Bell at GSFC involves theoretical development of stochastic dynamical models of precipitation and their application to rainfall sampling problems. He has recently co-supervised the Ph.D. dissertations of Mr. R.K. Siddani, and Mr. J.E. Travis, both graduate students at the Mathematics and Statistics Department, UMBC, leading to new theoretical formulations of the statistics of rainfall.

Dr. Jae N. Lee received a BS in Physics from Yonsei University, Seoul, Korea and a PhD in Marine and Atmospheric Science from Stony Brook University in 2008. The primary focus of her research activities has been in the application of remote sensing observations to climate studies, with particular emphasis on the sun-climate connections. She is currently working on the TSIS (Total and Spectral Solar Irradiance Sensor) project due for launch on the Polar Free Flyer in 2016-2017. Her current research interests include the 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. During her NASA NPP fellow years at JPL, she found interest in remote sensing of cloud and aerosols to address climate change from both the natural and anthropogenic effects, especially in the Arctic region.

Dr. Jasper Lewis received his B.S. degree from Norfolk State University (1999) and a M.S. degree from Georgia Institute of Technology (2002), both in physics. After teaching in the Virginia public school system for several years, Dr. Lewis continued his education at Hampton University and received a Ph.D. in physics/atmospheric science in 2010. He is currently a post-doctoral research associate in JCET and conducts research at the NASA Goddard Space Flight Center as a member of the Micropulse Lidar Network (MPLNET) team.

Dr. Simone Lolli received his M.S. degree in Physics, at the University of Florence on Microwave remote sensing in 1996. He joined the Microwave Remote Sensing Group of the Institute of Applied Physics IROE of the Italian National Research Council, Firenze, to study the interaction between artificial rough bare soils and microwaves. In 2001 he was a visiting scientist in the group of applied physics of the University of Geneva to develop a direct detection Doppler Wind Lidar in the framework of the ADM/Aeolus (Atmospheric Dynamics Mission Aeolus) mission of the European Space Agency (ESA). In 2008, he joined the Atmospheric Lidar Group of the Laboratoire de Meterologie Dynamique (Prof. Pierre Flamant) to complete his Ph.D in physics, obtained in December 2011 at the Ecole Polytechnique, France, with the title: “Atmospheric wind profile measurements by Doppler Lidar means: development and validation in the frame of the Earth Explorer Atmospheric Dynamic Mission (ADM-Aeolus). He is member of the American Geoscience Union, convener and member of scientific committees of several international conferences. Currently Dr. Lolli is studying the impact of aerosols on radiative transfer by Lidar measurements of MPLNET NASA Lidar network under Dr. Judd Welton.

Dr. J. Vanderlei Martins received his Bachelor's degree in physics in 1991, a Master's degree in physics/nuclear applied physics in 1994, and a Ph.D. in physics/applied physics in 1999 from the University of Sao Paulo (USP), Brazil. He joined the Group of Air Pollution Studies at the Institute of Physics (USP) in 1990, and conducted research in environmental and atmospheric applied physics. In particular, he developed analytical nuclear techniques using particle accelerators for material analysis, including aerosols and tree-rings, and participated in several ground-based and aircraft field experiments studying properties of aerosols from biomass burning and biogenic emissions. He was a member of the University of Washington, Department of Atmospheric Sciences, Cloud and Aerosols Research Group, from November 1995 to August 1996, and of the GSFC Climate and Radiation Branch from August to December 1996, as a Visiting Scientist. He taught at the University Sao Judas Tadeu between 1998 and 1999 while conducting research at the University of Sao Paulo. After starting his postdoctoral work at the University of Sao Paulo, he joined JCET in December 1999 as a Visiting Assistant Research Scientist. He has authored and co-authored over 40 refereed papers and has given over 60 presentations at international conferences, the most recent being on the spectral absorption properties of aerosol particles, on the measurement of the vertical profile of cloud microphysical and thermodynamic properties, and on the development of new instrumentation for the measurement of aerosol and cloud particles. He served as elected member of the International Radiation Commission from 2001-2008. In 2006 he assumed an Associate Professor position in the Department of Physics of the University of Maryland, Baltimore County, while keeping his affiliation with JCET.

Dr. Amita Mehta Dr. Amita Mehta joined JCET as a research scientist in May 2000. Dr. Mehta obtained her M.Sc. in Physics from Gujarat University, India in 1982, and obtained her Ph.D. in Meteorology from Florida State University in 1991. After completion of her Ph. D, Dr. Mehta worked as a research scientist in the Sounder Research Team (SRT) at Goddard Space Flight Center until August 2001. Since then Dr. Mehta is working in mesoscale Atmospheric Processes Branch as a research scientist, and is an affiliated assistant professor in the Department of Geography and Environmental Systems, UMBC. Dr. Mehta's interest and expertise are in satellite remote sensing of geophysical parameters and their analysis to understand climate variability.

Dr. William Olson received an AB in Physics from Cornell University in 1978 and a Ph.D. in Meteorology from the University of Wisconsin-Madison in 1987. The primary focus of his research activities has been in the field of satellite microwave radiometry, with particular emphasis on the remote sensing of precipitation and latent heating distributions. In 1987 he developed the first minimum variance approach for the physical retrieval of rain distributions from satellite microwave data. He later designed, with Dr. William Raymond, a method for assimilating latent heating estimates from SSM/I into numerical weather prediction model forecasts, and more recently collaborated with scientists at NCEP and NASA to assimilate precipitation distributions into global models. His current work involves the development of combined radar-radiometer methods for estimating precipitation and latent heating vertical structure, and the creation of a satellite-based, atmospheric diabatic heating record for evaluating climate models and closing the atmosphere's energy budget.

Dr. Ana I. Prados is a Research Assistant Professor at the Joint Center for Earth Systems Technology, University of Maryland, Baltimore County. She has a Ph.D. in Chemistry and a Master's in Public Policy from the University of Maryland, College Park. Dr. Prados currently manages the Applied Remote Sensing Training Program (ARSET) for NASA Applied Sciences, where she develops courses for end-users on the application of satellite imagery to environmental decision-making activities related to water resources, disaster management and air quality. Other areas of interest include the application of NASA imagery for air pollution monitoring, environmental policy making in the context of water resources management and climate change, program/project evaluation, and communicating scientific information to the public.

Dr. Lorraine Remer spent 21 years at the NASA Goddard Space Flight Center involved in the remote sensing of aerosol and the use of remote sensing data for the study of aerosols in climate processes, how aerosol particles affect clouds, aerosol transport and particulate air pollution. Her first position at Goddard in 1991 was in the role of a support scientist, employed by Science Systems and Applications, Inc. (SSAI), where she contributed to the development of the MODIS aerosol algorithms. In 1998 Dr. Remer joined the Federal civil service, and in 2012 she left NASA to become a Senior Research Scientist at UMBC/JCET. Dr. Remer has been a member of NASA's MODIS, CloudSat/CALIPSO, NPP, Glory and Global Aerosol Climatology Project Science Teams. She has contributed to the U.S. Climate Change Science Change Program (US CCSCP) and to the WMO International Task Force on Hemispheric Transport of Air Pollution (HTAP). She has contributed leadership to more than 12 major field experiments and has over 130 publications in the refereed literature. Her Ph.D. is from the University of California, Davis (U.C. Davis) in Atmospheric Science (1991). She also has a M.S. in Oceanography from the Scripps Institution of Oceanography, University of California, San Diego and a B.S. in Atmospheric Science from U.C. Davis.

Dr. Chung-Lin Shie received a B.S. in Atmospheric Sciences from the National Taiwan University, a M.S. and Ph.D. in Meteorology from Pennsylvania State University and Florida State University, respectively. He started working at NASA/GSFC as a research scientist since February 1993. Shie first affiliated with Science Systems and Applications Inc. (SSAI) as Research Meteorologist, then Senior Research Meteorologist before joining UMBC as Associate Research Scientist at GEST and JCET in April 2001 and May 2011, respectively. Shie started serving as part-time Project Scientist of the GES DISC in January 2013. During his early career, Shie participated in a pioneering project in producing GSSTF (global air-sea turbulent fluxes) datasets. He won a NASA MEaSUREs proposal in 2008 and has further produced a series of improved GSSTF datasets including the most upgraded GSSTF3 completed in November 2012. Shie is also involved in diverse research interests and projects in recent years. He was once involved in research projects performing numerical simulations using cloud resolving model. He is currently still involved in a project investigating the Saharan Air Layer (SAL) impacts on Atlantic hurricane formation and intensification. Shie has won various awards in his career ranging from outstanding merit performance, meritorious science community service, to outstanding mentoring.

Dr. Christopher A. Shuman joined JCET in May 2011, after being with GEST for four years. He is currently working with Dr. Thorsten Markus and Dr. Thomas Neumann at NASA/GSFC, among others, to enable calibration and validation of the planned Ice, Cloud, and land Elevation Satellite 2 (ICESat-2, launch planned in mid-2016). He is also working with Dr. Dorothy Hall at NASA/GSFC to calibrate temperature records in central Greenland's 'Summit' Station area. He continues to collaborate with Dr. Ted Scambos (NSIDC) and Dr. Etienne Berthier (LEGOS) on the dramatic ongoing changes to the

Antarctic Peninsula's ice cover. From 2001-2007, he was a Physical Scientist with the Cryospheric Sciences Branch, and the Deputy Project Scientist for the ICESat-1 Mission (2001-2005), as well as an Adjunct Research Faculty, Earth System Science Interdisciplinary Center (ESSIC), University of Maryland, College Park. From 1999-2001 he was an Assistant Research Scientist, ESSIC, University of Maryland, College Park. 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, associate at GSFC's Oceans and Ice Branch, Greenbelt, MD working with Dr. Robert A. Bindschadler. From 1992-1994, he was a post doctoral researcher at the Earth System Science Center (ESSC) and Department of Geosciences of The Pennsylvania State University, working with Dr. Richard B. Alley. Dr. Shuman received his Ph.D. in Geosciences in 1992 and his M.S. in Geology in 1987 from The Pennsylvania State University, and his B.S. in Geology in 1982 from Moravian College.

Dr. Lynn C. Sparling is an Associate Professor of Physics at UMBC and is a UMBC affiliate member of JCET. She received a B.S. in Chemistry from the University of New Mexico in 1976, a M.S. in Physics from the University of Wisconsin-Madison in 1980 and a Ph.D. in Physics from the University of Texas at Austin in 1987. She held postdoctoral research positions in chemical engineering and pharmacology, and conducted research in biophysics at the National Institutes of Health until 1992. She joined STX Corp. In 1993, working under contract to NASA at Goddard Space Flight Center, became a member of JCET in 1998 and joined the faculty at UMBC in 2001. During her career, Dr. Sparling has performed theoretical work in a variety of different areas in statistical mechanics, biophysics and hydrodynamics, and is currently working in the areas of atmospheric dynamics and tracer transport and mixing.

Dr. L. Larrabee Strow received the B.S. degree in physics from University of Maryland, Baltimore County in 1974, and M.S. and Ph.D. degrees from the University of Maryland at College Park in 1977 and 1981, respectively. He is currently a Professor with the Department of Physics at UMBC. His research interests include molecular spectroscopy, especially spectral line shapes, and atmospheric remote sensing. He is a member of the AIRS Science Team.

Dr. Andrew Tangborn received undergraduate degrees from the University of Washington In Mathematics and Mechanical Engineering and MS and PhD degrees from the Massachusetts Institute of Technology in Mechanical Engineering. Since coming to JCET he has been involved in research projects in the field of data assimilation, with a variety of geophysical applications. He is the PI on grants from the National Science Foundation on geomagnetic data assimilation and is Co-I on a NASA Earth Surface and Interiors Grant. In addition to his collaboration with scientists at NASA, he has been active in advising graduate students at UMBC and METEO-France. He has taught several different graduate courses at UMBC and has given invited lectures in graduate courses in the atmospheric sciences department at the University of Maryland, College Park for the past 6 years.

Dr. Ali Tokay received his B.S. from the Istanbul Technical University in 1984, his M.S. from the Saint Louis University in 1988, and his Ph.D. from the University of Illinois at Urbana-Champaign in 1993. Dr. Tokay was a research associate through the National Research Council Fellowship between 1993 and 1995. He then joined the Saint Louis University as

Assistant Professor in 1995 and the University of Maryland, Baltimore County (UMBC) as a Research Assistant Scientist in 1997. He was later promoted to Research Assistant Professor and became Research Associate Professor in 2007. Dr. Tokay was a principal investigator during a series of field campaigns under the NASA Tropical Rainfall Measuring Mission. He has taught a number of undergraduate and graduate courses in both Saint Louis University and UMBC. Dr. Tokay was an advisor of a M.S. student who graduated in 1998. He also mentored 15 undergraduate and 8 graduate students. Dr. Tokay is an Affiliated Associate Professor of the Department of Geography and Environmental Systems and Research Associate Professor of JCET at UMBC. Dr. Tokay is a member of the NASA precipitation science team. Dr. Tokay was the co-chair of the 34th AMS radar meteorology conference and he is member of the AMS radar meteorology committee.

Dr. Kevin Turpie Dr. Kevin Turpie received a BS in Computer Science at the University of Maryland, College Park, a MS in Applied Mathematics at The Johns Hopkins University, and a PhD in Geographic Sciences at the University of Maryland, College Park. In 1993, he worked with Nobel laureate Dr. John Mather on the NASA mission called the Cosmic Background Explorer (COBE), where he mapped the distribution of foreground emission lines that marked the location of water and carbon across our galaxy. In the years that followed, he worked with the Ocean Ecology Branch (OEB) at Goddard Space Flight Center on the problem of detecting and mapping the biological signature of the Earth's oceans from space. In 2003, while still at NASA, he came to the Department of Geographical Sciences as a Ph.D. student. There he became particularly fascinated with those special regions where land and sea blend. For remote sensing of coastal wetlands, he saw that it would become necessary to draw on techniques developed by both terrestrial and aquatic scientists. Given his background in ocean remote sensing and his studies in terrestrial remote sensing, he chose this area as the focus for his Ph.D research, which he completed early in 2012. Meanwhile, he continues to work on remote sensing of the pelagic biosphere using the Visible Infrared Imaging Radiometer Suite (VIIRS) as a member of the NASA Science Team, which is part of the Suomi National Polar-orbiting Partnership (NPP) mission. On this team, he is the Ocean Color Science Principle Investigator, Ocean Discipline Lead, and lead of the VIIRS Ocean Science Team under the OEB. He is also a member of the Hyperspectral and Infrared Imager (HyspIRI) Science Study Group, where he is applying his combined experience of terrestrial and aquatic problems to help define the future HyspIRI mission. He is the founding chair of the HyspIRI Aquatic Studies Group, overseeing the definition and development of coastal and in-land water aquatic remote sensing for the HyspIRI mission.

Dr. Tamás Várnai received his M.Sc. equivalent degree in Meteorology from the Eötvös Loránd University, Budapest, Hungary in 1989. He then joined the Hungarian Meteorological Service for two years, after which he enrolled in the McGill University in Montreal, Canada. His research focused on how cloud heterogeneities influence the way clouds reflect solar radiation. After receiving his Ph.D. in Atmospheric and Oceanic Sciences in 1996, he continued his research as a post-doctoral fellow first at McGill University, then at the University of Arizona. In addition to examining the theory of three-dimensional radiative effects, his work also included the development of operational algorithms for the MISR (Multi-angle Imaging SpectroRadiometer) instrument on board the Terra satellite, calculating the amount of solar radiation clouds reflect. Dr. Várnai joined JCET in 1999, where he works on considering 3D radiative effects in satellite retrievals of cloud and aerosol properties, focusing mostly on the MODIS (Moderate Resolution Imaging Spectroradiometer) satellite instrument, the CALIPSO satellite, and the airborne THOR (THickness from Offbeam Returns) lidar system and CAR (Cloud Absorption Radiometer) instrument.

Dr. Yujie Wang received a BS and MS in physics from the Tsinghua University, Beijing, China in 1994 and 1998 respectively, and a Ph.D. in geography from the Boston University, Boston, MA in 2002. He also received a certificate of advanced programmer in 1993. Dr. Wang joined the GEST center of UMBC in July of 2002, currently as an Associate Research Scientist. During his Ph.D. study, Dr. Wang's research was mostly focused on the prototyping and validation of radiative transfer based EOS MODIS/MISR LAI/FPAR algorithm. At present, he is developing a new generic aerosol retrieval and atmospheric correction algorithm for the EOS MISR, and NPOESS VIIRS instrument.

Dr. Zigang Wei received his Bachelor degree from the department of Application Physics of Beijing Institute of Technology, Peoples Republic of China in 1996, and his Ph.D. degree in Geomagnetism from the Institute of Geology and Geophysics, Chinese Academy of Science in 2001. He subsequently joined the Institute of Geology and Geophysics as a research associate. His research experiences ranged from the geomagnetic observation, modeling geomagnetic survey data and compiling charts, studying main geomagnetic field and its secular variations. He joined JCET in August 2005. Since 2007 he has been involved in the retrieval of atmospheric satellite data. In Septemer 2012, Dr. Wei joined the Department of Atmospheric & Oceanic Science at the University of Maryland, College Park.

Dr. Glenn Wolfe has been a post-doctoral research associate 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. Current projects include 1) in situ observations of formaldehyde, an important oxidation tracer, throughout the troposphere, and 2) investigation of biosphere-atmosphere interactions and their impact on pollutant precursors using a 1-D resolved forest canopy model. Prior to arriving at NASA, Glenn was a NOAA Climate and Global Change Post-doctoral fellow at the University of Wisconsin, Madison, WI. He holds a B.A. in Chemistry from Johns Hopkins University and a Ph.D. in Chemistry from the University of Washington. As of 2013, he has co-authored 24 peer-reviewed publications and participated in 9 collaborative field campaigns.

Dr. Tianle Yuan Dr. Tianle Yuan received B.S. in both Atmospheric Science and Computer Science from the Peking University in 2001 and a Ph.D. in atmospheric and oceanic sciences in 2008 from the University of Maryland, College Park. In 2008 he joined JCET as a research associate and became an Assistant Research Scientist in 2012. His research interest includes aerosol radiative forcing, aerosol-cloud interactions, aerosol-chemistry-climate interactions.

Dr. Leonid Yurganov is a Senior Research Scientist with UMBC, has been with JCET since 2006. His research expertise is connected with remote sensing of tropospheric composition. He graduated from the Leningrad State University in 1969 (MS) and the Institute of Atmospheric Physics in 1979 (Ph.D.) (both in Russia). For many years, he has been using grating spectrometers for atmospheric research in Moscow and St. Petersburg Russia. He studied total column and surface CO abundances in 1995 - 1996 at the Geophysical Institute, UAF, in Fairbanks, Alaska. Validation of the MOPITT Terra instrument was his duty during 1997-2001 at the University of Toronto. Between 2001 and 2006, he studied variations of CO burden in the Northern Hemisphere at the Japan Marine and Earth Science and Technology Center (JAMSTEC) in Yokohama. Evaluation, validation and analysis of CO satellite data was his research focus at JCET until 2011. Currently he is working with AOD, SO_2, and NO_2 satellite data and is performing preliminary analysis of methane retrievals in the Arctic. He is a co-author of 45 refereed publications.

Dr. Hai Zhang received his B.S. in physics in 1992 from Nankai University and M.S. in optics in 1995 from Xi'an Institute of Optics and Precision Mechanism in China. He received his M.S. in computer science in 2002 from Towson University. He received his Ph.D. in atmospheric physics from the University of Maryland, Baltimore County in 2006. He joined JCET in 2006 and is currently an assistant research scientist. During his PhD study, he carried out research on atmospheric circulation modeling using quasi-uniform grids. After graduation, he has been working on satellite remote sensing of aerosols and its application in air quality monitoring and forecasting. He developed and enhanced the IDEA (Infusing satellite Data into Environmental Applications) system at NOAA, which provided air quality community near-real-time satellite imagery and AQ forecasting. He also worked on the development of aerosol retrieval algorithms for geostationary satellites, such as current GOES, SEVIRI, and GOES-R. In January 2013, Dr. Zhang joined IMSG to work at NOAA.

Dr. Zhibo Zhang received a Ph.D. in Atmospheric Sciences (2008) and an MS (2004) from the Texas A&M University and a BS in Meteorology (1998) from the Nanjing University, China. His Ph.D. thesis is on satellite-based remote sensing of ice clouds. In January 2009, he joined the Goddard Earth Sciences and Technology Center (GEST) at the University of Maryland, Baltimore County, where he worked with the MODIS cloud science team led by Dr. Steven Platnick on the development of infrared cloud property retrieval algorithm. In 2011, he joined JCET. In August 2011, he joined the Physics Department at University of Maryland, Baltimore County (UMBC).

III.9 Table 1: JCET Faculty (as of June 30, 2013)

NAME	TITLE	AFFILIATION
Dr. Nader Abuhassan	Associate Research Engineer	Research Faculty
Dr. William Barnes	Senior Research Scientist	Research Faculty
Dr. Huisheng Bian	Associate Research Scientist	Research Faculty
Dr. Roberto Borda	Assistant Research Scientist	Research Faculty
Dr. Mark Bulmer	Associate Research Scientist	Research Faculty
Dr. Petya Entcheva-Campbell	Research Assistant Professor	Geography & Environmental Sys.
Dr. Hyoun-Myoung Cho	Post-Doctoral Research Associate	Research Faculty
Dr. Allen Chu	Associate Research Scientist	Research Faculty
Mr. Dominik Cieslak	Faculty Research Assistant	Research Faculty
Dr. Ruben Delgado	Faculty Research Assistant	Research Faculty
Dr. Sergio DeSouza-Machado	Research Assistant Professor	Physics
Dr. Elena Georgieva	Associate Research Scientist	Research Faculty
Dr. Forrest Hall	Senior Research Scientist	Research Faculty
Dr. Jay Herman	Senior Research Scientist	Research Faculty
Dr. Tilak Hewagama	Associate Research Scientist	Research Faculty
Dr. Susan Hoban	Senior Research Scientist	Physics
Dr. Raymond Hoff	Research Professor	Physics
Dr. K. Fred Huemmrich	Research Associate Professor	Geography & Environmental Sys.
Dr. Breno Imbiriba	Research Associate	Research Faculty
Dr. Ben Johnson	Assistant Research Scientist	Research Faculty

NAME	TITLE	AFFILIATION
Dr. Ilan Koren	Assistant Research Scientist	Research Faculty
Dr. Prasun Kundu	Research Associate Professor	Physics, Mathematics & Statistics
Dr. Jae Nyung Lee	Assistant Research Scientist	Research Faculty
Dr. Jasper Lewis	Post-Doctoral Research Associate	Research Faculty
Dr. Simone Lolli	Assistant Research Scientist	Research Faculty
Dr. Amita Mehta	Research Assistant Professor	Geography & Environmental Sys.
Dr. William Olson	Research Associate Professor	Physics
Mr. Derek Peddle	Senior Research Scientist	Research Faculty
Dr. Ana Prados	Research Assistant Professor	Chemistry
Dr. Lorraine Remer	Senior Research Scientist	Research Faculty
Dr. Chung-Lin Shie	Associate Research Scientist	Research Faculty
Dr. Christopher Shuman	Associate Research Scientist	Research Faculty
Dr. Andrew Tangborn	Research Associate Professor	Mathematics & Statistics
Dr. Ali Tokay	Research Associate Professor	Geography & Environmental Sys.
Dr. Kevin Turpie	Associate Research Scientist	Research Faculty
Dr. Tamás Várnai	Research Assistant Professor	Physics
Dr. Glenn Wolfe	Post-Doctoral Research Associate	Research Faculty
Dr. Tianle Yuan	Assistant Research Scientist	Research Faculty
Dr. Leonid Yurganov	Senior Research Scientist	Research Faculty

III.10 Table 2: JCET Fellows (as of June 30, 2013)

NAME	AFFILIATION
Dr. Robert Cahalan	NASA GSFC
Dr. Jeffrey Halverson	UMBC Geography and Environmental Systems
Mr. Ernest Hilsenrath	NASA GSFC (retired)
Dr. Weijia Kuang	NASA GSFC
Dr. Thorsten Markus	NASA GSFC
Dr. Alexander Marshak	NASA GSFC
Dr. Vanderlei Martins	UMBC Physics
Dr. Harvey Melfi	Emeritus
Dr. Lazaros Oreopoulos	NASA GSFC
Dr. Steven Platnick	NASA GSFC
Dr. Lynn Sparling	UMBC Physics
Dr. David Starr	NASA GSFC
Dr. L. Larrabee Strow	UMBC Physics
Dr. David Whiteman	NASA GSFC
Dr. Zhibo Zhang	UMBC Physics

III.11 Table 3: JCET Associate Staff (as of June 30, 2013)

NAME	TITLE
Mr. Keith Evans	Research Analyst
Mr. John David Hall	Research Analyst
Mr. Paul Schou	Research Analyst
Mr. Hamilton Townsend	Research Analyst

III.12 Table 4: JCET Administrative Staff (as of June 30, 2013)

NAME	TITLE
Ms. Valerie Casasanto	Program Coordinator
Ms. Mary Dawson	Business Manager
Ms. Danita Eichenlaub	Director
Dr. Susan Hoban	Associate Director, Academics
Dr. Raymond Hoff	Science Advisor
Ms. Brizjette Lewis	Executive Administrative Assistant
Ms. Cathy Manalansan	Administrative Assistant II
Mr. Kevin Mooney	Accountant I
Ms. Margo Young	Business Manager

III.13 Acronyms and Abbreviations

7-SEAS	Seven SouthEast Asian Studies
ABI	Advanced Baseline Imager
ACARS	Aircraft Communications Addressing and Reporting System
ACE	Aerosol-Cloud-Ecosystems
ACPD	Atmospheric Chemistry and Physics discussion
ADM/Aeolus	Atmospheric Dynamics Mission Aeolus
AERI	Atmospheric Emitted Radiance Interferometer
AeroCom	Aerosol Comparisons between Observations and Models
AERONET	Aerosol Robotic Network
AGU	American Geophysical Union
AIRS	Atmospheric Infrared Sounder
AK	Averaging Kernels
ALEX	Atmospheric Lidar Experiment
ALG	Atmospheric Lidar Group
AOD	Aerosol Optical Depth
APAR	Absorbed Photosynthetically Active Radiation
APS	Aerosol Polarimetry Sensor
APU	Accuracy, Precision and Uncertainty
AQAST	Air Quality Applied Sciences Team
AQPG	Air Quality Proving Ground
ARCTAS	Arctic Research of the Composition of the Troposphere from Aircraft and Satellites
ARM	Atmospheric Radiation Measurement
ARSET	Applied Remote Sensing Training Program
ASOS	Automated Surface Observing System
ASP	Aerosol Simulation Program
ASRVN	AERONET-based Surface Reflectance Validation Network

ASTE	Association for Science Teacher Education
ASTER	Advanced Spaceborne Thermal Emission and Reflection radiometer
AVIRIS	Airborne Visible and Infrared Imaging Spectrometer
AWS	Automatic Weather Station
BAMS	Bio-Aerosol Mass Spectrometry
BBAERI	The Baltimore Bomem Atmospheric Emitted Radiance Interferometer
BEST	Beginning Engineering, Science, and Technology
BOREAS	Boreal Ecosystem Atmosphere Study
BRDF	Bidirectional Reflectance Distribution Function
C3VP	Canadian Cloudsat/CALIPSO Validation Project
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarization
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CAR	Cloud Absorption Radiometer
CB	Cumulonimbus
CCD	Charge Coupled Device
CCM	Chemistry-Climate Model
CDRD	Cloud Dynamics and Radiation database
ChlF	Chlorophyll Fluorescence
CLN	CREST Lidar Network
CM	Cloud Mask
CMAQ	Community Multiscale Air Quality
CMB	Core Mantle Boundary
CMIP	Coupled Model Inter-Comparison Project
COBE	Cosmic Background Explorer
COG	Center of Gravity
CONUS	Contiguous US
CoSMIR	Conical Scanning Millimeter-wave Imaging Radiometer
CREST	Cooperative Remote Sensing Science and Technology Center

CrIS	Cross-track Infrared Sounder
CRM	Cloud Resolving Model
CRTM	Community Radiative Transfer Model
CTMs	Chemical Transport Models
CTT	Cloud Top Temperatures
CWT	Covariance Wavelet Transform
DAAC	NASA Data Active Archive Center
DC-3	Deep Convective Clouds and Chemistry
DDA	Discrete Dipole Approximation
DEMs	Digital Elevation Models
DEVOTE	Development and Evaluation of Validation Tools by Experimenters Development and Evaluation of satellite ValidatiOn Tools by Experimenters
DIAL	Differential Absorption Lidar
DISC	Data Information Service Center
DISCOVER-AQ	Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality
DLN	Distance Learning Network (DLN)
DOE	U.S. Department of Energy
DOFS	Degrees Of Freedom for Signal
DRAGON	Distributed Regional Aerosol Gridded Observation Networks
DSCOVR	Deep Space Climate Observatory
ECMWF	European Centre for Medium-Range Weather Forecasts
EDR	Environmental Data Record
EGU	European Geoscience Union
EIA	Earth Incidence Angle
ELF	Elastic Lidar Facility
EMS	ESDIS Metrics System
EO-1	Earth Observing-1 Mission
EOF	Empirical Orthogonal Function
EOS	Earth Observation System

EPA	Environmental Protection Agency
EPO	Education and Public Outreach
ERA	ECMWF Re-Analysis
ESA	European Space Agency
ESDIS	Earth Science Data and Information System
ESDSWG	Earth Science Data System Working Group
ESSIC	Earth System Science Interdisciplinary Center
EUMETSAT	European Organization for the Exploration of Metrological Satellite
FIFE	First International Satellite Land Surface Climatology Project Field Experiment
FIR	Finite Impulse Response
FPI	Fabry-Perot Interferometer
FRP	Fire Radiative Power
GALION	Global Atmosphere Watch Atmospheric Lidar Observation Network
GAMIT	GPS analysis software
GASP	GOES Aerosol and Smoke Product
GCM	Global Circulation Model
GCPEx	GPM Cold-season Precipitation Experiment
GEDI	Global Ecosystem Dynamics Mission
GEO	Group of Earth Observations
GEO-CAPE	Geostationary Coastal and Air Pollution Events
GEOS-5	Goddard Earth Observing System model version 5
GEOSCCM	GMI and Goddard Chemistry Climate Model
GEP	Gross Ecosystem Production
GES	Geography and Environmental Systems
GES	Goddard Earth Sciences
GES DISC	Goddard Earth Sciences Data and Information Services Center
GEST	Goddard Earth Sciences and Technology Center
GESTAR	Goddard Earth Sciences Technology And Research

GISS	Goddard Institute for Space Sciences
GMAO	Global Modeling and Assimilation Office
GMI	Global Modeling Initiative
GMI	GPM Microwave Imager
GMU	George Mason University
GOES	Geostationary Operational Environmental Satellite
GOES-R	Geostationary Operational Environmental Satellite “R” Series
GOME	Global Ozone Monitoring Experiment
GOSAT	Greenhouse Gas Observing Satellite
GPCP	Global Precipitation Climatology Project
GPM	Global Precipitation Measurement Mission
GPP	Gross Primary Production
GPROF	Goddard PROFiling algorithm
GPS	Global Positioning System
GRACE	Gravity and Climate Recovery Experiment
GRIP	Genesis and Rapid Intensification Processes
GRL	Geophysical Research Letters
GSFC	Goddard Space Flight Center
GSI	Gridspace Statistical Analysis
GSSTF	Goddard Satellite-based Surface Turbulent Fluxes
GSSTF2b	Goddard Satellite-based Surface Turbulent Fluxes, Version 2b
GSSTF2c	Goddard Satellite-based Surface Turbulent Fluxes, Version 2c
GSSTF3	Goddard Satellite-based Surface Turbulent Fluxes, Version 3
GV	Ground Validation
HARP	HyperAngular Rainbow Polarimeter
HASG	HyspIRI Aquatic Studies Group
HCHO	Formaldehyde
HDO	Hydrogen Deuterium Oxide

HIWRAP	High-altitude Imaging Wind and Rain Airborne Profiler
HLH	Haze Layer Height
HPLC	High Performance Liquid Chromatography (HPLC
HSRL	High Spectral Resolution Lidar
HyspIRI	Hyperspectral Infrared Imager
I3RC	Intercomparison of 3-D Radiation Codes
IAF	International Astronautical Federation
IAGOS	Aircraft for a Global Observing System
IASI	Infrared Atmospheric Sounding Interferometer
ICESat	Ice, Cloud, and land Elevation Satellite
ICESat-2	Ice, Cloud, and land Elevation Satellite
IDEA	Integrating satellite Data into Environmental Applications
IEEE	Institute of Electrical and Electronics Engineers
IGAC	International Global Atmospheric Chemistry Project
IGARSS	IEEE International Geoscience and Remote Sensing Symposium
IGRF	International Geomagnetic Reference Field
ILRS	International Laser Ranging Service
IMSG	I.M. Systems Group, Inc.
INTEX-B	Intercontinental Chemical Transport Experiment - Phase B
IPCC	Intergovernmental Panel on Climate Change
IR	Infrared
IRAD	Internal Research and Development
ISAF	In Situ Airborne Formaldehyde
ISAMS	Improved Stratospheric and Mesospheric Sounder
ISES	International Society for Exposure Science
IST	Ice Surface Temperature
ISU	International Space University
JAMSTEC	Japan Marine and Earth Science and Technology Center

JCET	Joint Center for Earth Systems Technology
JPL	Jet Propulsion Laboratory
JPSS-1	Joint Polar Satellite System-1
L2	Level 2
LaRC	Langley Research Center
LEGOS	Laboratoire d'Etudes en Géophysique et Océanograhie Spatiales
LES	Large-Eddy-Simulation
LHF	Latent Heat Flux
LIDAR	Light Detection and Ranging
LITE	Lidar In-Space Technology Experiment
LOLA	Lunar Orbiter Laser Altimeter
LP	Lunar Prospector
LRO	Lunar Reconnaissance Orbiter
LUE	Light Use Efficiency
LUT	Look-Up-Table
MAIAC	Multi-Angle Implementation of Atmospheric Correction
MASTER	MODIS/ASTER Airborne Simulator
MBL	Marine Boundary Layer
MC3E	Midlatitude Continental Convective Cloud Experiment
MDE	Maryland Department of the Environment
MDSA	Multi-Sensor Data Synergy Advisor
MEA	Maryland Energy Administration
MEaSUREs	Making Earth System Data Records for Use in Research Environments
MERRA	Modern-Era Retrospective Analysis for Research and Applications
MISR	Multiangle Imaging SpectroRadiometer
MIT	Massachusetts Institute of Technology
MLS	Microwave Limb Sounder
MODIS	MODerate resolution Imaging Spectroradiometer

MOPITT	Measurements of Pollution In The Troposphere
MoSST_DAS	Modular Scalable Self-consistent and Three dimensional core dynamic model Data Assimilation System
MPE	Mean PBL Extinction
MPLNET	Micropulse Lidar Network
MRB	Missouri River Basin
MRO	Mars Reconnaissance Orbiter
NACP	North American Carbon Program
NASA	National Aeronautics and Space Administration
NBS	NASA BEST Students
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NESDIS	National Environmental Satellite, Data, and Information Service
NEWS	NASA Energy and Water cycle Study
NExT	NASA's Engineering Exploration Training
NH	Northern Hemisphere
NIFA	National Institute for Food and Agriculture
NIST	National Institute of Standards and Technology
NLLJ	Nocturnal Low-Level Jet
NMQ	National Mosaic & Multi-Sensor Quantative Precipitation Estimate
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	National Polar-orbiting Partnership
NPP	NPOESS Preparatory Project
NSE	Near-Surface Extinction
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
OBPG	Ocean Biology Processing Group
OE	Optimal Estimation

OEB	Ocean Ecology Branch
O-F	Observation – Forecast
OMI	Ozone Monitoring Instrument
OMPS	Ozone Mapping and Profiler Suite
Open-INeph	Open Imaging Nephelometer
OSSE	Observing Systems Simulation Experiments
OSTM	Ocean Surface Topography Mission
PACE	Pelagic and Coastal Ecosystem
PACS	Passive Aerosol and Cloud Suite
PAR	Photosynthetically Active Radiation
PBL	Planetary Boundary Layer
PBLH	Planetary Boundary Layer Height
PCTM	Parameterization Chemistry Transport Model
PCTM	PCM-CSM Transition Model
PGRF	Preliminary Geomagnetic Reference Field
PIDDP	Planetary Instrument Definition and Development Program (PIDDP)
PI-Neph	Polarized Imaging Nephelometer
PMF	Positive Matrix Factorization
PMM	Precipitation Measurement Mission
POLDER	POlarization and Directionality of Earth’s Reflectiveness
PPS	Precipitation Processing System
PRI	Photochemical Reflectance Index
PSS	Precision Sub-sampling System
Qa	Surface specific humidity
RAMP	Rapid Arctic Methane Pulse
re	effective particle radii (after http://modis.gsfc.nasa.gov/data/atbd/atbd_mod05.pdf)
RMSE	Root-Mean-Square Error
ROSES	Research Opportunities in Space and Earth Sciences

RPI	Rainbow Polarimetric Imager
RTA	Radiative Transfer Algorithm
RUSI	Royal United Services Institute
SAL	Saharan Air Layer
SARTA-Cloudy	Stand-Alone AIRS Radiative Transfer Algorithm
SBUV	Solar Backscatter UltraViolet
SDR	Sensor Data Records
SDT	Science Definition Team
SEAC4RS	Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys
SEMAA	Science, Engineering, Mathematics and Aerospace Academy
SENEX	Southeast Nexus
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SH	Southern Hemisphere
SHF	Sensible Heat Flux
SiB	Simple Biosphere
SIF	Science Innovation Fund
SIF	Solar Induce Fluorescence
SIF	Solar-Induced Chlorophyll Fluorescence
SLA	Sea Level Anomaly
S-NPP	Suomi National Polar-orbiting Partnership
SOA	Secondary Organic Aerosol
SORCE	Solar Radiation and Climate Experiment
SR	Surface Reflectance
SRAIS	Special Research Assistantship/Initiative Support
SRT	Sounder Research Team (SRT)
SSAI	Science Systems and Applications Inc.
SSM/I	Special Sensor Microwave Imager
SST	Sea Surface Temperature

STEM	Science, Technology, Engineering and Math
STTRSTT	Small Business Technology Transfer
SV	Secular Variation
SWAT	Soil and Water Analysis Tool
TB	Brightness Temperature
TCTE	TIM Calibration Transfer Experiment
TEOM	Tapered Element Oscillating Microbalance
TES	Tropospheric Emission Spectrometer
THOR	Thickness from Offbeam Returns
TIROS	Television Infrared Observation Satellite
TMI	TRMM Microwave Imager
TOA	Top Of Atmosphere
TOLNET	Tropospheric Ozone Lidar Network
TOMS	Total Ozone Mapping Spectrometer
TransCom-CH4	Atmospheric Tracer Transport Model Intercomparison Project
TRMM	Tropical Rainfall Measuring Mission
TSI	Total Solar Irradiance
TSIS	Total Solar Irradiance Sensor
UAF	University of Alaska, Fairbanks
UMBC	University of Maryland, Baltimore County
UMCP	University of Maryland, College Park
UMD	University of Maryland, College Park
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGP	United States Great Plains
USGS	United States Geological Survey
UV	Ultraviolet
UWNMS	University Wisconsin Non-hydrostatic Modeling System

V6	Version 6
VIEWS	Visibility Exchange Web System
VIIRS	Visible Infrared Imaging Radiometer Suite
WACCM	Whole Atmosphere Community Climate Model
WFOV	Wide Field of View
WMO	World Meteorological Organization
WRF	Weather Research and Forecasting
WRF-CHEM	Weather Research and Forecasting Model
WRF-CMAQ-SMOKE	Weather Research and Forecasting Model Community Multi-Scale Air Quality Model