FIFTEENTH ANNUAL REPORT
JOINT CENTER FOR EARTH SYSTEMS TECHNOLOGY

A Cooperative Agreement Between:

University of Maryland, Baltimore County

and

NASA Goddard Space Flight Center

October 1, 2009 – September 30, 2010

The Joint Center for Earth Systems Technology

Fifteenth Annual Report
October 1, 2009 – September 30, 2010

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Preface

This volume is the fifteenth 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 serves as a means to increase the effectiveness of university research and teaching resulting from the collaboration, and provides a venue to train personnel for research in relevant Earth science and technology areas. The NASA Earth Sciences Division has participated in establishing, funding, and collaborating with JCET. At UMBC, JCET is administered through the Office of the Vice President for Research. JCET personnel are currently associated with the university Departments of Physics, Geography and Environmental Systems, Chemistry, Mathematics and Statistics, and Computer Science and Electrical Engineering. JCET's administrative office is in the second building of the BWTech Research Park at UMBC, which also includes space for a few faculty members and a conference room. JCET also has offices in the Physics and Academic IV-A buildings on the UMBC campus.

There are 23 JCET faculty members (listed in Section III.10 and 20 Fellows (listed in Section III.11). This category of JCET membership includes civil servants from NASA, other government agencies and private research institutions in addition to UMBC faculty. JCET research is also supported by two research analysts and a research engineer (listed in Section III.12). Brief biographies of each JCET faculty and associate staff members are presented in Section III.8. The overall management and administration of JCET is governed by the executive board and carried out by an expert administrative staff, who also support JCET's sister center GEST (listed in Section III.12). In the spirit of cooperation between UMBC and GSFC, the Director is also a Professor of Physics at UMBC, the Associate Director for Academics is an Associate Professor of Geography, and the Board Chairman is a civil servant scientist at GSFC.

The body of this report (see Section II) is divided into eight sections, each of which is devoted to the scientific activities of eight research groups. The eight groups are 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 October 1, 2009 to September 30, 2010. Each report includes a description of the research, accomplishments for FY 09-10, and objectives for FY 10-11. Although some of the efforts were not initiated at the beginning of the fiscal year, research completed during this period that was supported by both JCET and previous sources is also included in these descriptions. References cited in the reports are listed in Section III.1, while those papers that were submitted, in press, or published in the refereed literature by JCET authors this fiscal year are also listed separately in Sections III.2 and III.3. The 42 refereed papers (and 23 others submitted for review), along with 113 conference presentations and publications and non-refereed publications (see Section III.4) comprise the principal direct contribution of JCET scientists to the Earth sciences. In addition to their current research, JCET scientists planned for the future through submission of 61 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 and Mathematics/Statistics. The 11 different courses they taught this fiscal year are listed in Section III.5. Colloquia and seminars are an integral method to share knowledge in the academic community, and JCET researchers regularly provide such instruction, as listed in Section III.6. In addition, JCET faculty are mentoring or providing direct supervision for 10 graduate students, and providing research opportunities for a number of additional undergraduate and graduate students from UMBC and other universities.

September 2010

J. B. Halverson, Associate Director
R. M. Hoff, Director

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Executive Summary

Looking Back, Looking Ahead

The date October 1, 2010 marks a very special date for JCET, namely the successful renewal of the organization's Cooperative Agreement with NASA Goddard's Earth Science Directorate, through 2014. JCET was formed in 1995 and has become an internationally recognized center of research and scholarly excellence. JCET has been a central factor in transforming UMBC into a Carnegie High Research Activity university and it has spawned other Centers at the University (including the Goddard Earth Science and Technology (GEST) center and Center for Research in Exploration and Space Sciences (CRESST)). JCET has also transformed GSFC, providing a model of a well-run University center that interacts seamlessly with a major government laboratory. Yet it remains distinct from other UMBC Centers because of its inclusion of undergraduate and graduate education as its core activity. The JCET faculty have the opportunity to affiliate within their academic discipline, to mentor graduate students, teach a formal three-credit course, and become Research Professors at UMBC. This provides a distinctive career path for JCET faculty who will, later in their careers, become civil servants or professors at UMBC or other universities. Since JCET's inception, four JCET faculty have been hired at UMBC as full-time faculty and six have been hired as faculty at other universities. In addition, six have gone on to become civil servants at GSFC, and two have gone on positions in federal laboratories.

JCET, now in its Teen Years, has also served as a model for achieving exemplary levels of faculty productivity, through diverse and inter-disciplinary research in the Earth and Space sciences. Over 60% of the Center funding comes not from the Cooperative Agreement but from grants, other cooperative agreements and contracts which the JCET Faculty have been able to leverage from NASA, NOAA, DOE, USDA, DOD, and state and local agencies. In terms of scholarly productivity, JCET has maintained a remarkably consistent and high level of peer-reviewed publications. For the period 2004-2010, the JCET faculty published 450 journal (refereed) papers, delivered 1000 conference presentations, and submitted 450 grant proposals to major funding agencies. Approximately 1/3 of these proposals were selected for funding. As you glance through the research summaries and highlights throughout this Annual Report, note the depth and scope of Earth systems research being conducted by JCET faculty and their professional colleagues.

JCET's involvement in promoting undergraduate and graduate education continues to flourish. JCET has faculty who are currently teaching in four UMBC departments (Physics, Chemistry, Geography and Environmental Systems, and Mathematics and Statistics) and in the past JCET has held affiliations in Computer Science/Electrical Engineering and Mechanical Engineering. Over the last five years, JCET faculty have taught 120 credit hours of courses in these departments. Faculty have also provided direct support for approximately 30 students on JCET Graduate Research

Assistantships. Along with GEST, JCET sponsors the on-campus JCET Summer Intern Program that brings 3-4 undergraduate interns to UMBC labs each summer. This is in addition to the JCET/GEST management of the GSFC Summer Institute and Goddard Summer Student Programs, which bring in 12-15 students each summer through an internationally competitive process to work one-on-one with GSFC scientists. Many graduates of UMBC's graduate programs have gone on to immediate hiring positions in such prestigious organizations as Lockheed Martin, LaRC, NESDIS, NOAA NCEP, U.C. Davis, Northrop-Grumman Corporation and Princeton University.

Without doubt, JCET and its sister centers have helped propel UMBC into the highest national university and college rankings including #1 U.S. News and World Report upcoming university for two years in a row and a top 5 ranking for undergraduate education. We are also proud of our top 10 ranking for its University President – serious accolades that increasingly recognize UMBC as a powerhouse in science and engineering.

The past year has brought additional recognition and a few changes to JCET's faculty and staff. Drs. Hoff and Halverson are co-Is on two separate five-year NASA Venture Class grants awarded to UMBC, one to pursue hurricane research using unmanned aerial vehicles (Halverson) and the other to study air quality (Hoff). Dr. Hoff recently came off his in-house sabbatical and has resumed the role of Director of both JCET and GEST. Dr. Christine Chiu left JCET as an Assistant Research Professor to become a Reader at the University of Reading, U.K. Dr. David Lary (Senior Research Professor in JCET) took a tenured position at the University of Texas at Dallas. Several JCET faculty including Drs. Petya Campbell (Assistant Research Professor) and Benjamin Johnson (Research Associate) taught courses for three-day professional development workshop on satellite remote sensing, sponsored by Northrop-Grumman Corporation and the UMBC Training Center. Dr. Arlin Krueger (Senior Research Professor) retired after spending decades as a world-class scientist involved in atmospheric trace gas measurements. Dr. Krueger played a key role in the discovery of the ozone hole and mapping volcanic emissions as a threat to aviation safety using satellite imagery. Dr. Kevin McCann, Research Associate Professor, left JCET to concentrate more fully on teaching within the Physics Department. Dr. Erricos Pavlis, Research Associate Professor, moved over to GEST. On the staffing side, Ms. Joann Maxim and Ms. Grace Roscoe left the GSFC JCET office to pursue other opportunities, while we welcomed Ms. Brizjette Lewis as our new Executive Administrative Assistant at the GSFC JCET office and Ms. Yonghong Luo as a Business Specialist in the JCET's UMBC office.

Dr. Jeffrey Halverson, JCET Associate Director, Academics

Dr. Raymond Hoff, JCET Director

September 2010

II. TECHNICAL VOLUME

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Global Modeling and Assimilation Office
(Code 610.1)

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NSF Grant: **CMG: Variational Approaches to Geomagnetic Data Assimilation**

Task 49: **Carbon Cycle Data Assimilation** ***(Sponsor: M. Rienecker)***

Investigators: Andrew Tangborn, Research Associate Professor, Mathematics; Weijia Kuang, JCET Fellow, GSFC; Steven Pawson, GSFC; Ivanka Stajner, Noblis, Inc.; Gary Egbert, Professor, Oregon State University, Louis-Francois Meunier, Meteo-France.

Description of Research

Tangborn's research is carried out in the field of data assimilation, with applications in atmospheric trace gases and geomagnetism.

The trace gas data assimilation has been focused on the carbon cycle species of carbon monoxide and carbon dioxide. The purpose of this work is to develop techniques to improve estimation of sources, transport and distributions of these species. This research has implications for climate modeling and air quality, and involves the assimilation of satellite measurements from MOPITT (Measurement of Pollution in the Troposphere), AIRS (Atmospheric Infrared Sounder) and MLS (Microwave Limb Sounder).

Geomagnetic data assimilation, funded by both NSF and NASA, employs 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.

Accomplishments for FY 09-10

Work involving carbon cycle data assimilation has been focused on carbon monoxide observations from MOPITT (Measurement Of Pollution In The Troposphere) and SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CartograpHY).

Tangborn's team has also been involved in the transition from the GEOS-4 to GEOS-5 data assimilation systems. The existing constituent assimilation system has been connected to the GEOS-5 system, to be run in a 'replay' mode, in which stored meteorological analysis fields are used to restart the model and transport the trace gases. This system is an efficient means to make use of the new GEOS-5 meteorological fields in the assimilation of carbon monoxide observations. The development of this system has been extended during the past year to include carbon monoxide observations from MOPITT, MLS (Microwave Limb Sounder) and carbon dioxide measurement from AIRS (Atmospheric InfraRed Sounder). Improvements to the distribution of carbon species in the atmosphere have been verified through comparison with aircraft data.

In addition, initial development of carbon monoxide assimilation in GEOS-5 has been completed, using MOPITT version 4 observations. This system will allow for the 4D-Var assimilation of carbon species from a much more dense set of observations.

The geomagnetic data assimilation group has continued to test and develop the current system, and the results of this work are summarized in Kuang *et al.* (2009). Work continues on improving the ability to forecast future changes to the geomagnetic field, and to improving estimates to the dynamics of the Earth's core. They continue to pursue national and international collaborations in this work and with continued funding from NSF. They also have begun to develop a variational data assimilation system in a collaborative project with Oregon State University. Several papers resulting from this work on geomagnetic data assimilation are currently in press.

Objectives for FY 10-11

Work on geomagnetic data assimilation with a focus on a variational method will continue during the coming year. Additionally, work will continue on adding data types to GEOS-5, including those from MLS, AIRS, GOSAT, and ultimately OCO when it is launched in 2012. Multiple instrument assimilations will require the implementation of a bias correction scheme for each of the data sources. Experiments will also be undertaken to estimate model errors, with the goal of improving the quality of estimated trace gas distributions.

Earth Sciences Division
(Code 610.6)

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JCET Highlight: Comparisons of Elastic Lidar
Investigator: Mr. Ruben Delgado

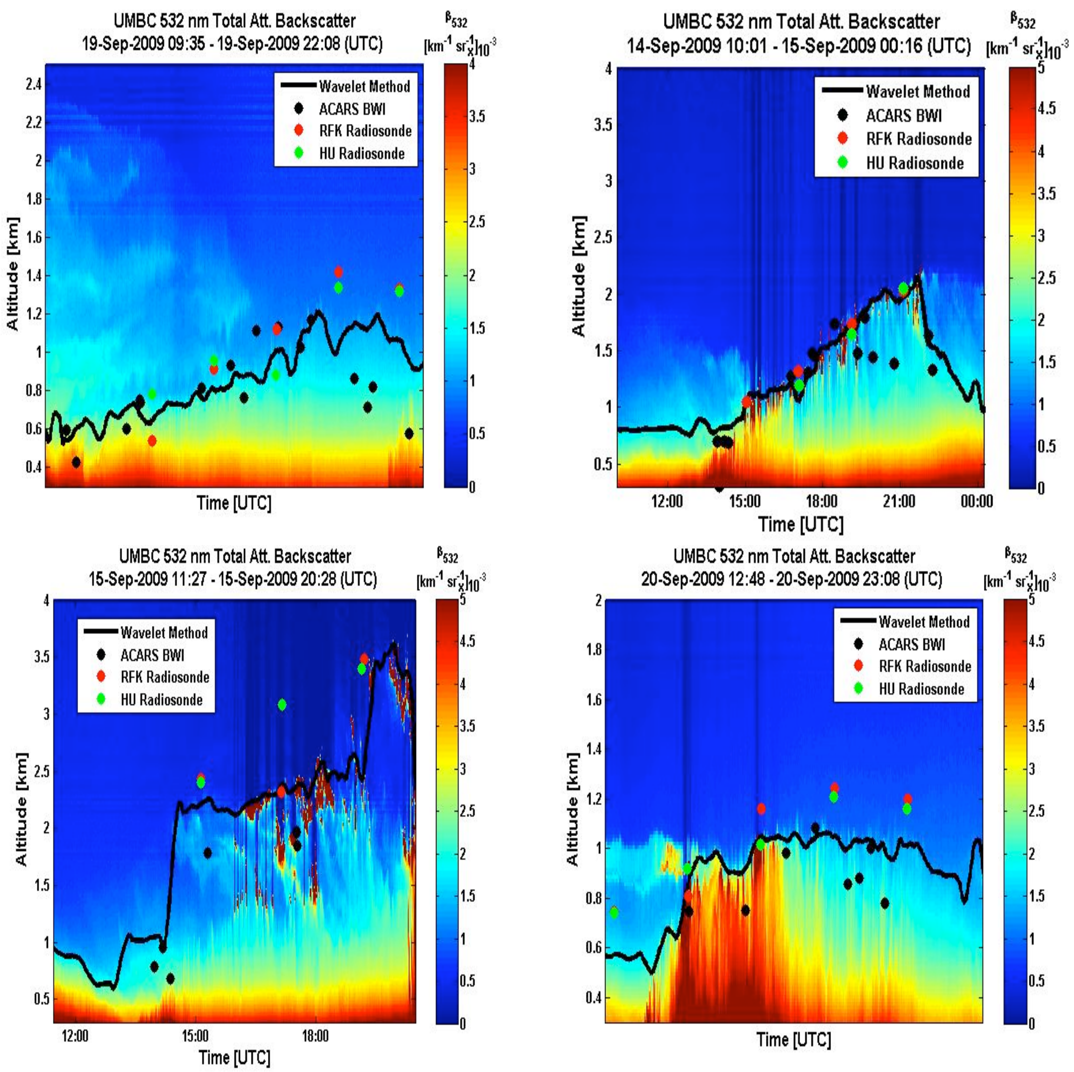

Figure 1. Comparison of UMBC Elastic of Elastic Lidar (ELF) estimates of PBLH (km, black line) to BWI Aircraft-ACARS (black dots), NOAA/ARL radiosonde launches at RFK Stadium (red) and NCAS/Howard University (green) in Washington, DC, on September 14, 15, 19 and 20, 2009. ELF total attenuated backscatter (color shaded) is also depicted.

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CCNY Subcontract: Cooperative Remote Sensing Science and Technology (NOAA-CREST) Center (49100-00-02-B)

MDE Grant: Measurement of Nocturnal Low Level Jets and Air Quality Events over Baltimore with the UMBC ELF Lidar (U00P8201154)

Investigators: Rubén Delgado, Research Associate; Raymond Hoff, Director, JCET and GEST; Kevin McCann, Research Associate Professor, (JCET); Timothy A. Berkoff, Assistant Engineer (UMBC/GEST), and several co-investigators from institutions outside UMBC.

Students: Debra Wicks Kollonige, Daniel Orozco, and Patricia Sawamura (UMBC Graduate Students); Jaime Compton (UMBC Undergraduate Student).

Description of Research

Elastic lidar measurements have been conducted at different wavelengths - 355 (LEOSPHERE ALS-450), 527 (Sigma Space Micropulse Lidar), and 532 (Elastic Lidar Facility) - to measure the vertical distribution of aerosols over the Baltimore-Washington metro area to understand and aid in determining whether the excess of air pollutants and particulate matter smaller than 2.5 mm ($PM_{2.5}$) in the Baltimore-Washington metropolitan area is 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, and Nocturnal Low Level Jet studies, sponsored by the Maryland Department of the Environment (MDE). Additionally this year, studies of the exchange of ozone from the stratosphere to the troposphere have been added to the CREST workplan.

Accomplishments for FY 09-10

Lidar measurements carried out by UMBC's Atmospheric Lidar Group (ALG) provide a set of atmospheric profiles of aerosols by which analysts can query their vertical distribution in near real time and compare to the input of three-dimensional forecast models. The UMBC lidar measurements have been useful for NASA A-train (Aqua, Terra, CALIPSO, etc.) satellite retrieval studies, performing instrument accuracy assessments and using data generated by 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, and to determine the relative impact of long-range transport versus local emissions during nocturnal low level jet (NLLJ) and wintertime pollution events over the Baltimore-Washington region.

Column aerosol optical properties of aerosols and particle depolarization over the metropolitan Baltimore-Washington area from sun photometer and lidar measurements, respectively, have been combined with ground-based particulate matter (PM_{10} and $PM_{2.5}$) and scattering coefficient measurements from a nephelometer during air quality events (Air Quality Index: Code Orange/Unhealthy for Sensitive Groups) to provide physics and chemical characteristics of urban aerosols and their influence upon the air quality and solar radiation budget. The lidar determination of extinction vertical profile and aerosol optical depth (AOD) in the atmosphere allows quantification of aerosol concentrations within the planetary boundary layer (PBL), presumably where it is well mixed and would be best represented by ground-based $PM_{2.5}$ measurements. Breaking the AOD into two separate values (below and above PBL) helps Delgado and his team to understand how lofted aerosols may alter the relationship between column optical depth retrievals, from satellite and sun photometers, and $PM_{2.5}$ concentrations. The fusion of the instrumentation (discussed above) to lidar retrievals are parallel to the UMBC Monitoring of Atmospheric Pollution (UMAP) Profiling Air Quality over Baltimore project (*see Hoff's report*). The description of the project and data from instrumentation discussed above can be found online: http://alg.umbc.edu/umap.

UMBC lidar systems supported the joint NOAA/ARL and NCEP ad hoc field study in the Baltimore-Washington metro area. Conducted September 14-22, 2009, this campaign developed a meteorological database to investigate the evolution and spatial variability of the urban atmospheric boundary layer height, and simultaneously allowed comparison of boundary layer height detection from various instrumentation platforms and forecasting models (see highlight). Lidar measurements helped to identify problems with the automatic PBLH calculation in the Real-Time Mesoscale Analysis (RTMA), used by plume dispersion modelers.

During the past year, the CREST Lidar Network listserve was created (cln@lists.umbc.edu), which allows for immediate communication between CREST institutions prior and during air quality events, aiding in determining the impact of regional and long-range transport of pollutants into the eastern US states and Caribbean. Lidar observations at UMBC are carried out following the WMO-GALION guidelines.

Finally, studies of ozone, water and other trace gases near the tropopause have allowed identification of stratospheric folds and intrusions. This work involves combining data from NASA aircraft missions - AIRS, HIRDLS and TES - and this research forms the core of Ms. Kollonige's Ph.D. dissertation (expected May 2011).

Objectives for FY 10-11

The seasonal variability of hourly $PM_{2.5}$ (TEOM and BAM monitors) and ozone mass concentrations will be evaluated. Chemical speciation of 24-hour $PM_{2.5}$ and PM_{10} filters will be carried out to discriminate local and long-range transport pollutant sources (*e.g.*, forest fire smoke, Asian dust, etc.), and to determine the seasonal variability of PM composition in the Baltimore-Washington metropolitan area. Meteorological processes within the PBL are critical in the transport, diffusion and chemical transformation of pollutants. Boundary-layer parameters for studying air pollution, such as PBL heights, ventilation coefficients (product of mixing height and surface wind speed) and cloud coverage, will be determined for air quality events and their relationship to $PM_{2.5}$, and ozone levels will be established and compared to AQ forecasts and models.

Further, UMBC was awarded a portion of a Venture Class proposal called DISCOVR-AQ (James Crawford, PI), which is designed to examine the representativeness of column optical properties from satellites to ground-based air quality. This work will start in Fall

2010. Baltimore will be the initial study site in summer 2011 and the UMBC team will be very involved in the ground-based verification of NASA aircraft overflight data. In addition, Delgado and his collaborators will participate in TIGER-Z, a gridded AOD experiment led by Brent Holben (GSFC).

NASA Grant: **Particle Absorption Characterization for the Retrieval of Aerosol Optical Depth from Calipso Observations (NNX08AR46G)**

NASA Grant: **CloudSat and CALIPSO Science Team and Modeling/Analysis of A-Train related data (NNH05ZDA001N-CCST)**

Investigators: Sergio DeSouza-Machado, Assistant Research Professor, Physics; Adam Robinson (UMBC Undergraduate Student).

Description of Research

Dust can travel very large distances and affect the outgoing long-wave radiation as well as the reflection of sunlight over those parts of the Earth the dust is transported. Instruments onboard orbiting satellites measure different parameters of the dust storm, such as amount, thickness and albedo. Since it is rare for one instrument to be able to determine all these parameters accurately, by using a suite of instruments, each sensitive to measurements in different portions of the electromagnetic spectrum, it is possible to determine these parameters. In this study, dust layer heights for various storms between 2006-2008 have been obtained using a synergetic retrieval involving AIRS thermal infrared radiances and MODIS optical depths. Unlike radiances obtained in the visible, thermal infrared radiances are sensitive to both the dust optical depth and height. The resulting heights will then be used by OMI, an ultraviolet instrument, to determine scattering albedos. DeSouza-Machado and his team plan to use this research to make a climatological height database for the period 2006-2008.

Accomplishments for FY 09-10

Adam Robinson, an undergraduate Physics major at UMBC, has been assisting with this project since February 2010. One of the accomplishments has been the development of a more sensitive dust detection flag for AIRS that can be used over the ocean. This allows the JCET team to detect dust at lower optical depths, therefore providing greater areal coverage than the dust flag present in the AIRS L1 and L2 datasets (also developed by Dr. DeSouza-Machado).

When compared against optical depth retrievals using MODIS visible data, optical depths derived from AIRS data indicate that there is a straight-line relationship between the MODIS and AIRS retrieved optical depths. This relationship varies systematically with placement of the dust layer. By finding the height at which an optimal IR: VIS optical depth ratio of 4 is obtained, the researchers have used three years of collocated AIRS/MODIS data to provide the genesis of a climatological height database. IR retrievals are inherently ill-posed, and they have implemented a 1D-variational retrieval scheme (Optimal Estimation) to stabilize the retrieval. The scheme is initialized with atmospheric state parameters from ECMWF model fields.

The JCET PI and his team have begun an intensive comparison of several co-located MODIS and AIRS dust-contaminated FOVS. Data from June 2006 to December 2008 is being used, as it can be compared against heights provided by the CALIPSO lidar. The preliminary work has been done over ocean, but they plan to extend the study over land as well.

This team has also collaborated with Mr. Ruben Delgado and Dr. Raymond Hoff (JCET) to unambiguously track Asian dust as it travels from Asia to North America, using the high spectral resolution information of AIRS.

Another collaboration is the study of Deep Convective Clouds with Dr. George Aumann of Jet Propulsion Laboratory. This research is partially funded by the support provided to Dr. Larrabee Strow to develop scattering algorithms for AIRS. The fruits of this study are a better understanding of the changes to measured AIRS radiances under conditions of deep convection, including frequency of occurrence over ocean and land, and possible transport of moisture from the upper troposphere to lower stratosphere.

Objectives for FY 10-11

Going forward, DeSouza-Machado and his team plan to complete and evaluate the climatological database, for dust over ocean. This database will cover the main geographic regions over which dust travels, namely the Atlantic between West Africa and the Caribbean, the Mediterranean, the Red Sea/Persian Gulf area, as well as the Pacific between the Far East and the Canadian coast. The database will be passed along to Dr. Omar Torres, who will re-evaluate the single scattering albedo derived from OMI measurements. The JCET team also plans to develop a dust detection flag over land and use it to construct a similar database over land.

Additionally, depending on funding, work on transport of trace gases under conditions of deep convection will also be pursued.

NASA Grant:	A Three-Dimensional Air Quality System with augmentation for SERVIR-Air (NNS06AA02A)
NASA Grant:	Profiling Air Quality over Baltimore (NNX08AO93G)
NOAA Grant:	The GOES-R Air Quality Proving Ground in the United States (NA09NES4400022)
NASA STTR*:*	Ultra-compact Cloud Physics Lidar for Cloud Studies (NNX08CA42)
Co-Investigators:	Raymond Hoff, Director, JCET and GEST; Rubén Delgado, Research Associate (JCET); Kevin McCann, Associate Professor, Physics; Timothy A. Berkoff, Assistant Research Engineer (UMBC/GEST; Hai Zhang (JCET); and numerous co-investigators from institutions outside UMBC.
Students:	Daniel Orozco, Patricia Sawamura, Abou Traore (UMBC Graduate Students); Chris Cahoon and Jaime Compton (UMBC Undergraduate Students).

Description of Research

For the last six years, the Atmospheric Lidar Group at UMBC has built a substantial capability in ground based and remote sensing of the lower troposphere. As part of a NASA Applications funded proposal, the group has been instrumental in transitioning two decision support tools: the Integrating satellite Data into Environmental Applications (IDEA) product to NOAA NESDIS and the three-dimensional satellite data from NASA and NOAA satellites into EPA's Remote Sensing Information Gateway (RSIG) (described at http://alg.umbc.edu/3daqs/). A second large award from NASA enabled the acquisition of a suite of instruments to characterize the spatial structure of aerosols over Baltimore. This suite is described at http://alg.umbc.edu/umap/. As new satellites are launched (NPP with VIIRS, and ABI on GOES-R), the group has been funded to examine the transition to newer air quality products and build a user community that is ready to use these data on day 1 after launch. Finally, Hoff's group is looking at new technologies for use on airborne platforms and as core instruments in lidar networks, such as the Global Atmosphere Watch's Aerosol Lidar Observation Network (GALION).

Accomplishments for FY 09-10

The 3D-AQS project ended in September 2010 after four years of research. The project made two major contributions to NOAA and EPA decision support systems, as described above. Two journal papers were submitted and three others accepted during the reporting year. These papers addressed the relationship of $PM_{2.5}$ to aerosol optical depth across the United States and the results were included in a revised IDEA algorithm which predicts ground $PM_{2.5}$ from the AOD from GASP and MODIS. In the final year of the project, the linkage between air quality and human health was examined in some detail in cooperation with Amy Huff of Battelle Memorial Institute, John Braggio of the Maryland Department of

Health and Mental Hygiene, and Fred Dimmick of the EPA. The results of the project have been benchmarked, and the work resulted in an increase of a factor of ten in the public's use of IDEA, a doubling in the usage of the US Air Quality Smog Blog at UMBC and the creation/augmentation of the RSIG tool.

The UMBC Monitoring of Atmospheric Pollution Profiling Air Quality over Baltimore led to the purchase of a Leosphere EZLidar, an MPL, a CIMEL sunphotometer, augmentation of the detectors and receivers for the ALEX Raman lidar, detector electronics for the Elastic lidar facility (ELF) and for ALEX, a Tapered Element Oscillating Microbalance (TEOM), a Beta Attenuation monitor, a three-wavelength integrating nephelometer, and a Vaisala upper air system. The project allowed Hoff to spend the year in the lab getting the equipment installed and working with his students, who now have a wide range of tools to conduct their research. The intent of the project is to provide a 3-dimensional view of the atmosphere over Baltimore and to be able to compare that with satellite sensing of the region, from NASA and NOAA satellites.

The GOES-R project allowed the JCET researchers to couple the ground-based observations, profiling at UMBC (along with partners at University of Alabama-Huntsville, Hampton University and the City College of New York), and simulations of what GOES-R will see upon launch. The Air Quality Proving Ground is NOAA's only effort to involve the air quality community in the GOES-R algorithm design and planning for real-time utilization of those data after launch. IDEA is being viewed as a model for the data dissemination of GOES-R ABI AOD data to the public, and a user group of 25 state, local and tribal air quality forecasters, EPA and NOAA personnel along with the AQPG team will meet in September 2010 to help define NOAA's delivery of these products.

Lastly, Hoff's group participated with SigmaSpace Corporation in the design of a new version of the Cloud Physics Lidar to be installed on the NASA Unmanned Aerial Vehicle (UAV). UMBC is available for ground-based validation of this new instrument when it flies, and the MPL purchased under UMAP will be a ground truth instrument for this comparison.

Objectives for FY 10-11

UMBC will continue to operate the UMAP instruments. UMBC was awarded a portion of a Venture Class proposal called DISCOVR-AQ (James Crawford, PI), which is designed to examine the representativeness of column optical properties from satellites to ground-based air quality. This work will start in Fall 2010 and Baltimore will be the initial study site in summer 2011 and the UMBC team will be very involved in the ground-based verification of NASA aircraft overflight data. In addition, we will participate in TIGER-Z, a gridded AOD experiment led by Brent Holben (GSFC). The suite of instrumentation is also used by the State of Maryland (*see Delgado report*).

Several additional research lines are being examined. Proposals were written to lead the Air Quality Applications Science Team and NASA; to continue the Air Quality Proving Ground; to engage in Risk Reduction in GOES-R; and, to use the UMBC water vapor Raman lidar to assess trends in lower and upper tropospheric water vapor as climate changes. The latter project is with Chris Barnet and Antonia Gambacorta of NOAA and will allow the assessment of the IASI and AIRS water vapor product retrievals and their applicability to assessment of these trends.

Lastly, along with NOAA and NASA Langley, UMBC is pursuing the ability to use CALIPSO to determine global PBL heights and to evaluate near-real time Level 1.5 and Level 2 products from CALIPSO for air quality forecasting use.

NASA Grant:	Improving an Air Quality Decision Support System through the integration of Satellite Data with Ground-Based, Modeled, and Emissions Data (NNH07ZDA001N)
NASA Grant:	Multi-Sensor Data Synergy Advisor (NNX09AH65G)
Task 116:	Monitoring the Air Quality Effects of Anthropogenic Emissions Reductions and Estimating Emissions from Natural Sources and Dynamic Updating of Emissions by Systematic Integration of Bottom-Up Activities and Satellite-Based Top-Down Constraints to Support Air Quality Forecasting and Analysis *(Sponsor: K. Pickering)*
Task 123:	Utilization of NASA Atmospheric Products for Improved Nutrient control decisions in the Gulf of Mexico *(Sponsor: K. Pickering)*
Task 107:	Coordination of NASA Air Quality Training Activities *(Sponsor: G. Leptoukh)*
Investigators:	Ana I. Prados (co-I); Uma Shankar (PI), University of North Carolina, Shawn McClure (co-I), CIRA; Greg Leptoukh (PI), NASA/GSFC; Ken Pickering (PI), NASA/GSFC; Dale Allen (co-I), University of Maryland College Park; Sundar Christopher (co-PI), University of Alabama, Huntsville; Richard Kleidman (co-PI), NASA/SSAI.

Description of Research

Prados led a NASA project providing training activities internationally and across the U.S on the utilization of NASA remote sensing data for air quality applications, with a focus on teaching decision-makers. She also used Ozone Monitoring Instrument (OMI) NO_2 observations in conjunction with Global Ozone Monitoring Experiment (GOME) NO_2 measurements to examine trends in NOx emissions over the continental U.S. This work also supported the development of the Visibility Exchange Web System (VIEWS), which makes available a variety of NASA Earth science datasets, modeling, and surface *in situ* observations, and the development of the Giovanni Multi-Sensor Data Synergy Advisor, which enables scientists to gain information and make better decisions about NASA dataset intercomparisons.

Accomplishments for FY 09-10

Prados coordinated NASA Applied Sciences Program air quality remote sensing trainings. A total of 5 remote sensing workshops were developed during the reporting period. The main purpose of the training workshops is to enable scientists and air quality managers as well as other technical staff supporting decision-making activities to utilize NASA observations and decision-support tools for air quality applications. The workshops were conducted in several settings. One- or two-day trainings at national and international conferences were offered, in which activities were meant for a broad audience and provided exposure to the available datasets and decision-support tools. They included hands-on activities and examples of applications via Case Studies. Two- to three-day training activities were also offered, which were tailored to the needs of specific applications users. These workshops, held in the fall of 2009, focused on training air quality modelers in close collaboration with the Community Modeling and Analysis System Center at the University of North Carolina, Chapel Hill. They included computer hands-on activities on access to NASA imagery and comparisons to air quality model output. Finally, week-long trainings with several tracks were available. The decision-maker track specifically highlighted the policy-relevancy of NASA observations and examples of how NASA data are currently being used for air quality decision-support.

During the reporting period, the project also developed a webpage for announcements and posting of all educational materials (http://arset.gsfc.nasa.gov/), with a section devoted to Case Studies or historical events that provide good examples of utilization of NASA satellite imagery for air quality analysis. Prados' team also translated many of the project's educational modules into Chinese and began translations into Spanish. Prados has presented an overview of these activities at several conferences (*Prados, et al.*, 2010a).

She also continued to provide guidance and expertise regarding air quality satellite data products being incorporated into the Visibility Information Exchange Web System (VIEWS), as well as providing advice on satellite data formats, data quality, data access, and interoperability opportunities with other web-tools. In addition, synergies between VIEWS and NASA training activities were pursued, with planning currently underway to add VIEWS and European web tools into the workshop agendas.

The Multi-Sensor Data Synergy Advisor (MDSA) ROSES 09 Project is a service that provides users with better interpretation and utilization of parameter difference and correlation visualizations within Giovanni. Giovanni is a web-tool at NASA GSFC. The JCET PI's main accomplishments for this project were Use Case Development; Aerosol Ontology Development; Project Portal Development; Assistance with Sensitivity Studies; and Assistance with overall Project Management. Prados participated in all major aspects of the project at the NASA GSFC GES DISC and also assisted with overall project coordination. The data ontology development superficially required that she apply her scientific knowledge of aerosol retrievals for incorporation into the advisory service. The sensitivity studies for this project have lead to significant findings regarding differences in NASA aerosol data products (Leptoukh *et al.,* 2009). The source of these differences is currently not easily accessible to users, but will now become available through the Giovanni MDSA advisory service to help advance aerosol research within the scientific community. Prados also submitted and published a paper that details Giovanni's capabilities for visualization, analysis and interoperability of NASA air quality remote sensing data sets (Prados *et al.,* 2010b).

Prados continued her research examining OMI NO_2 trends over the eastern half of the continental U.S. The purpose of this project is to determine whether NO_2 measurements from OMI are sensitive to known emissions reductions over the eastern U.S over the last several years. Some of these results were published in October 2009 (Neil *et al.*, 2009). She examined 2-4 specific state regions over the eastern as well as the central U.S. She and her team also added GOME-2 NO_2 measurements to the analysis, provided by NOAA

NESDIS. The preliminary results suggest some correlation in the trends between both instruments for the time period we analyzed. Prados compared the satellite data to EPA *in situ* monitor data, as well as Continuous Emissions Monitors (CEMs) located within at emissions sources throughout the U.S. The comparisons to the CEMS data confirm OMI's ability to detect both increases and decreases in NO_2 over the eastern U.S between 2005 and 2008.

Finally, Prados began work on the NASA ROSES09 Utilization of NASA Atmospheric Products for improved Nutrient control decisions in the Gulf of Mexico, preparing and providing support for the OMI NO_2 data to be compared to 2006 EPA air quality model output.

Objectives for FY 10-11

In the coming year, Prados will continue all of the above-mentioned projects. Research activities related to OMI NO_2 trends will focus on comparisons of OMI NO_2 to EPA air quality model output. For the Gulf of Mexico Project, she plans to complete the re-gridding of the OMI NO_2 imagery to the EPA air quality model grid. For a third year, Prados will continue to coordinate NASA satellite training activities, developing training activities tailored to the needs of specific EPA regions, and incorporating them into the training of additional web tools, such as the Remote Sensing Information Gateway (RSIG) at EPA, and European datasets and web tools. She will assist in the coordination of standardizing the already developed training materials and the deployment of interactive Case Studies that enable current or potential users of NASA earth science data to submit their own air quality analysis, with feedback from the project scientists.

NASA Grant:	**A Hyperspectral Infrared Radiance Climate Record using AIRS, IASI, and CrIS (NNX08AD34G)**
NASA Grant:	**Cross-Validation of TES with AIRS: Radiances and Radiative Transfer (NNX07AG73G)**
NOAA Grant:	**Calibration, Validation, and Radiative Transfer for the CrIS Sensor (DG133E06CQ0024)**
JPL:	**AIRS Climate and Calibration (Contract 1364443)**
NOAA Grant:	**Fast Radiative Transfer Modules For CrIS (NA08NES42800024)**
JPL:	**An Improved OLR Algorithm for AIRS (NM0710861)**
Investigators:	L. Larrabee Strow, Full Research Professor, Physics (JCET); Sergio DeSouza-Machado, Research Assistant Professor, (JCET); Scott Hannon, Faculty Research Assistant, (JCET); Breno Imbiriba, Research Associate, (JCET); Paul Schou, Research Analyst, (JCET).

Description of Research

The Atmospheric Spectroscopy Laboratory (ASL) activities center around the development, validation, and use of infrared hyperspectral sounders for weather and climate research. Strow's team has core expertise in infrared spectroscopy and radiative transfer modeling, and provides NASA and NOAA with operational radiative transfer models for NASA's Atmospheric Infrared Sounder (AIRS), EUMETSAT's Infrared Atmospheric Sounding Interferometer (IASI) flying on METOP, and the Cross-Track Infrared Sounder (CrIS) that will fly on NASA's NPP mission and on the future U.S. operational weather satellite system NPOESS.

The group's guiding philosophy is to actively participate in all phases of the life of these sensors, including direct involvement in pre-launch thermal vacuum testing, retrieval algorithm development, and validation. This provides the researchers an in-depth understanding of both the sensor operation and performance, and the use of the sensor for geophysical research. Their research using these sensors concentrates on topics that stress both the sensor and forward model accuracy (CO_2 retrievals, climate trending) or involves the retrieval of geophysical variables not performed by NASA and NOAA (mineral dust, minor gases).

Strow and his researchers work closely with the Integrated Program Office (IPO) that is developing the CrIS sensor to ensure that instrument and algorithm development will meet the needs of the numerical weather prediction community. In addition, they have continually worked with the CrIS test data and in-orbit operations plans to help ensure that CrIS will be able to also contribute to climate monitoring. Most of their efforts in this regard concentrate on the spectral calibration of CrIS and subsequent spectral and radiometric validation of the sensor.

The JCET researchers provide the community with state-of-the-art clear sky radiative transfer algorithms, referred to as Stand-Alone Radiative Transfer Algorithm (SARTA). The SARTA model is based on parameterizations of optical depths computed using their line-by-line infrared radiative transfer algorithm, KCARTA, which is the Reference Forward Model for NASA's AIRS instrument, and can compute radiances in a clear or cloudy sky, as well as include daytime NLTE effects. They have also extended SARTA for scattering atmospheres to support their work in the retrieval of dust and cloud properties.

Recent research has concentrated on the retrieval of dust using hyperspectral infrared, where we have shown that AIRS dust retrievals are very competitive with those from visible sensors (MODIS, PARASOL, OMI), and of course provide nighttime observations. Strow's team has also recently produced a lower-tropospheric "column" CO_2 retrieval for 5+ years using AIRS.

Accomplishments for FY 09-10

The JCET researchers have significantly improved their 7-year climatology of mid- to lower-tropospheric CO_2 that was created using the AIRS hyperspectral radiance record. This was the result of removing small viewing angle dependencies, and water vapor continuum errors in their radiative transfer algorithm (RTA), reducing relative errors in the computed brightness temperatures from 0.2K to below 0.03K. Detailed comparisons have been made to NOAA's global model CarbonTracker, which assimilates a wide range of global *in situ* data. Although the spatial patterns of CO_2 in Strow's AIRS CO_2 product and in CarbonTracker are quite similar, the AIRS CO_2 shows 2-4 times more spatial and temporal variability than CarbonTracker. This suggests that the model CO_2 transport is too weak, in qualitative agreements by recent global measurements of the CO_2 column by the SCIMACHY instrument on ENVISAT. Strow has also shown that CO_2 patterns observed over the Eastern U.S. with AIRS agree with model patterns of anthropogenic emission.
Work continues on the spectral and radiometric calibration of AIRS, in preparation for producing an AIRS L1C climate-quality hyperspectral radiance product. They have found that the AIRS spectral calibration has a slight cross-track dependence, which was unexpected, but can be corrected in the L1c product.

The JCET team evaluated the pre-launch spectral calibration of the CrIS sensor performed by the instrument vendor, and found that it is not accurate enough for the sensor to meet specification using degraded IASI data for simulation studies. Moreover, they modeled the in-flight performance of the CrIS spectra calibration, which must be performed after launch, and found that it is impossible to spectrally calibrate the shortwave band unless the (now) JPSS Program records the complete interferogram, which is not the present JPSS configuration. This issue is being addressed by the IPO, and the JCET team hopes the JPSS Program considers implementing this in the present NPP CrIS instrument.

Objectives for FY 10-11

Increased attention will be paid to preparing for the launch and validation of the CrIS sensor on NPP. One of Strow's team's roles will be to provide very quick validation of the sensor (days) and feedback on changes to the CrIS SDR (L1b) radiance algorithm as the instrument is brought into operational status. Additionally, they hope to interest more modeling groups in their AIRS CO_2 product and to develop techniques to perform cloud-forcing trends directly using AIRS radiances.

NASA Grant: **An Intercomparison of Tropospheric Carbon Monoxide (NNX07AM45G)**

NASA Grant: **Validation of TES Tropospheric CO and CO3 and OMI (NNG06GB04G)**

NASA Grant: **Tropospheric Chemistry, ARCTAS Support and Analyses (co-PI) (NNX08AD24G)**

NASA Grant: **A Global Modeling Initiative (GMI) Study of the Long-Range Transport of Pollution using Fused Carbon Monoxide Measurements from EOS (PI: Bryan Duncan) (NNX08AF91G)**

Task 117: **Understanding Ozone Between 500 and 50mb *(Sponsor: S. Pawson)***

Investigators: Juying Warner, Research Associate Professor, Geographical and Environmental Systems; Zigang Wei, Assistant Research Scientist (JCET); Allen Chu, Associate Research Scientist (UMBC/GEST); Andrew Tangborn, Research Associate Professor (JCET); Bryan Duncan (GSFC); Steven Pawson (GSFC).

Description of Research

Warner's projects involve evaluating the current NASA tropospheric trace gas measurements and the developments of more accurate methods to retrieve these quantities that are important to air quality and climate change studies. The detailed aspects of her team's work can be summarized in the following areas: inter-comparison of AIRS/TES/MOPITT/MLS CO using current AIRS operational products; usage of these products jointly to increase the temporal and spatial coverage and vertical sensitivity; development of new retrievals for AIRS trace gases using the Optimal Estimation (OE) method to generate not only the trace gas quantities but also other sensitivity related retrieval variables, such as the Averaging Kernels (AKs), error covariance matrices, and degrees of freedom, similarly defined as other sensors; development of science analyses for the emission and transport of pollutions to the Arctic regions; assimilation of AIRS ozone radiances in the GEOS-5 to global forecast model to improve forecast accuracies; and collaborations and support to the greater community.

Accomplishments for FY 09-10

Tropospheric CO comparisons between AIRS and MOPITT are partly published by Warner *et al.* (2007), and this year's efforts are focused on the comparisons of all the collocated CO profiles between AIRS and TES operational products for years 2006 to 2008. In general, TES are lower in the mid-troposphere by an average of less than 10 ppbv and higher in the lower troposphere to as much as 30 ppbv or higher, especially over the Southern Hemisphere (SH) (Warner *et al.*, 2010). TES CO variability is significantly higher than AIRS due to its smaller footprints and higher Signal Noise Ratio (SNR). AIRS and TES profiles are also compared against *in situ* profiles from INTEX-B field experiments. This grant period ended May 31, 2010, and a final report to NASA Tropospheric Chemistry Program (TCP) is in preparation. The final report will include the ozone comparisons between AIRS, TES, OMI, MLS, and HIRDLES. Validation also includes comparisons of these satellite ozone products against ozone sounds.

The JCET researchers developed a data fusion technique by using TES near real-time CO products in AIRS CO retrievals. This technique was created due to the fact that in the vertical areas where AIRS CO instrument information content is high, the CO signals are based on AIRS measurements, and where AIRS CO information content is low, the TES CO measurements are used. TES measurements are taken within 15 minutes of AIRS and the nadir points are always collocated. Warner's team's study for data fusion has been extended to include AIRS, MLS, and GOES-5 model so that the CO information in the Upper Troposphere and Lower Stratosphere (UTLS) is primarily from the MLS and the lower tropospheric CO is from AIRS combined with model results.

Using the OE method (Rodgers, 2000) for AIRS retrievals provides a way to compare CO accuracy and information contents of AIRS against MOPITT, TES, and MLS using quantities with the same definitions. It is also Warner's objective to compare AIRS operational algorithm with the algorithm using OE formulations. She and her team have completed much of this project in the reporting year and demonstrated that AIRS OE CO results are much more realistic than AIRS V5 operational CO, especially in the lower troposphere and in the SH (Warner *et al.*, 2010). They presented global CO comparisons between AIRS OE, TES V3, and MOPITT V4 at selected pressure levels as well as for the total column amounts, and concluded that the tropospheric CO retrievals from AIRS OE and TES V3 agree to within 5–10 ppbv or 5% on average globally and throughout the free troposphere. The agreements in total column CO amounts between AIRS OE and MOPITT V4 have improved significantly with a global relative RMS differences at 12.7%.

This year, Warner's group has switched their focus to satellite algorithm validation and refinements in the participation of the NASA TCP ARCTAS campaign that occurred in the spring and summer of 2008. They concluded that AIRS CO retrievals at high latitudes perform very well in the summer campaign, which achieved similar accuracies as those at mid- to low-latitudes. However, the satellite CO products under-estimate significantly compared with the *in situ* data in the spring portion of the campaign. They have also studied the pollution transport patterns into the Arctic Circle and co-authored a paper by Fisher *et al.* (2010).

The ongoing Task 117 with the GMAO chemistry data assimilation group is for the ozone radiance assimilation in GEOS-5 using AIRS measurements. The original scheme resulted in erroneous conclusions, especially over the Antarctic due to inappropriate inclusions of AIRS O_3 radiances, and these functions were switched off in 2006. Warner's efforts began with identifying the problems and tracing back to the sources contributing to the high O_3 biases. They examined the various factors that may affect ozone concentrations in the model, such as the effects due to the surface, clouds, water vapor and temperature interferences, as well as radiance channel selections. They are now focusing on testing the model background error distributions and Jacobian effect to the O_3 distributions.

Objectives for FY 10-11

Looking ahead, Warner plans to publish research results that were produced in the last three years. She and her team will also analyze CO distributions and global pollution transport using their improved products with a focus on the added measurement capabilities that were not possible using the operational products. They will thoroughly compare AIRS CO using OE with all existing *in situ* measurements, MOPITT, and TES CO with all available multi-year/global datasets. In the new algorithm, they will add proper QA for the retrievals and add global and seasonal varying *a priori* as defined by MOPITT V4. Warner's team will study the spectral band information and try to further improve the retrieval in the lower troposphere and try to improve the computational speed so that near real-time products are possible. They also plan to expand their current algorithm and products for other trace gases, such as ozone and methane.

JPL Subcontract:	**Optimization, Validation, and Integrated EOS Analysis of AIRS Trace Gas Products**
NASA Grant:	**AIRS Trace gas retrievals for INTEX-B: Mission Planning, Analysis and Satellite Validation (NNG06GB06G)**
NSF:	**US-Russia Planning Visit: North Asian Sources of Greenhouse Gases: Collaborative Research Using Ground–and Space-Based Instruments (OISE-0827507)**
Investigators:	Dr. Leonid Yurganov, Senior Research Scientist (JCET); Dr. W. Wallace McMillan *(deceased)*, Associate Professor, Physics (JCET)
NASA Grant:	**Cross Validation of TES with AIRS (NNX07AG73G)**
Investigators:	Dr. Leonid Yurganov, Senior Research Scientist (JCET); Dr. L. Larrabee Strow, Research Professor (JCET)

Description of Research

Three main topics of Yurganov's research are validating and reconciling satellite data using ground-based spectrometers and analyzing global CO variations; developing and validating CO retrieval technique for a ground-based IR spectrometer and analyzing measurements; and, developing a CH_4 retrieval algorithm for the orbital IASI spectrometer.

Accomplishments in FY 09-10

A paper published in early 2010 (Yurganov *et al.*, 2010a) summarizes the results obtained during the last two years. This paper discusses the long-term stability of CO measurements using two different instruments, MOPITT/Terra and AIRS/Aqua, both of which were investigated. Also, two different versions of standard MOPITT/Terra, v3 and v4, were considered and compared. A positive instrumental drift for MOPITT v3 amounting to 1.3 % per year in both hemispheres discovered earlier by the JCET researchers was confirmed. It was shown, however, that there is no such drift in the current MOPITT v4 data set. Several drawbacks of AIRS v5 data set were found, especially in the Southern Hemisphere. Both instruments revealed lower than usual CO abundance in the Northern Hemisphere and in the tropical belt in late 2008 – early 2009. This effect was at least partly due to the global economic recession. Lower than usual fire activity in Brazil affected the tropics as well.

Another paper, published electronically in 2010 (Yurganov *et al.*, 2010b), presents a new algorithm for CO retrieval from the Atmospheric Emission Radiance Interferometer (AERI) spectra deployed at the ARM/SGP site in Oklahoma. The old algorithm is subjected to a significant influence of erroneous water vapor profiles at humid conditions; additionally, the retrieved CO mixing ratios are affected by parasitic solar radiation scattered by aerosol and thin clouds in day time. Both effects have been considered and a long set of results have been presented. In particular, this dataset confirmed a diminution of CO mixing ratio in late 2008 – early 2009, which is in good agreement with the above-mentioned satellite data.

A new CH_4 retrieval code for IASI/MetOp-1 has been under development since November 2009. The main idea is to use CH_4 lines near 3.6 μm where solar radiation reflected from the ground is equally important with the thermal Earth radiation. This makes sounding lower parts of the troposphere possible; the thermal Earth's radiation spectra alone allow measurements above 6 km of altitude only. The current status is as follows: satellite data are in agreement with aircraft sounding of CH_4 for the shape, but not for the amplitude of the seasonal cycle. Latitudinal distribution of CH_4 is in accordance with models. Presently Yurganov and his team are trying to determine sources of errors in the algorithm.

Catastrophic forest and peat fires in Russia in July-August 2010 demonstrated a topicality of the satellite-based CO measurements. Yurganov's previous results allowed his team real-time estimations of CO emissions from these fires. This research is expected to continue during the next year.

Objectives for FY 10-11

Going forward, Yurganov plans to continue his analysis of global CO and CH_4 using all available satellite data. The validation of satellite data requires close cooperation with colleagues involved in ground- and air-based measurements. New proposals to NASA, NATO, and NSF will be submitted.

Special attention will be devoted to investigating the Russian Fires of 2010. The PI's team believes that this highly unusual phenomenon might be a result of changing global circulation under the pressure of human activity. CO as an easily measurable atmospheric component which, emitted by fires, is a good indicator for biomass burning.

Accomplishing these objectives, however, will depend on future funding.

NOAA Grant: **An IDEA product for GOES-R data (NA09NES4400010)**

Investigators: Hai Zhang, Research Associate, Research Faculty; Raymond M. Hoff, Professor (JCET).

Description of Research

Zhang has been making contributions in the use of satellite measurements of aerosol optical depth (AOD) as a surrogate for air quality indices such as $PM_{2.5}$ for several years. He is collaborating with NOAA to develop and improve the Infusing satellite Data into Environmental Applications product (IDEA) (http://www.star.nesdis.noaa.gov/smcd/spb/aq/), which is currently running at NOAA/NESDIS and is providing near real-time satellite aerosol measurements and forecasting guidance from multiple satellites instruments, including MODIS Terra, MODIS Aqua, GOES east, GOES west, and OMI. Many air quality forecasters use this product every day for air quality forecasting. The IDEA system will be configured to support inclusion of the GOES-R aerosol product as the primary AOD measurement when GOES-R becomes operational. Zhang and Hoff are also making efforts to explore a new AOD retrieval algorithm to improve the retrieval accuracy from the current operational GOES imager.

Accomplishments in FY 09-10

During the past year, they have continued to work on improving the IDEA product and developing a new AOD retrieval algorithm for GOES.

They developed the $PM_{2.5}$ estimation product and it is now running operationally on the IDEA site. Daily $PM_{2.5}$ estimation is generated from MODIS Terra, Aqua, and GASP East AOD. The estimations are generated as daily AOD is first derived from MODIS Terra, Aqua, and GASP east with following criteria: use the average AOD from Terra and Aqua in areas where MODIS AOD from both satellite instruments is available; use AOD from MODIS in areas where MODIS AOD is available from only one MODIS instrument; use average GASP AOD in areas where MODIS AOD is not available but GASP AOD from GOES East is available (only use the period of 12UTC to 22UTC). This method is because the AOD retrievals from MODIS are more accurate than GASP AOD retrievals. They then use the linear regression relations over ten EPA-defined regions and four seasons, from their recent *JAWMA* paper (Zhang *et al.*, 2009), to derive daily surface $PM_{2.5}$ from daily average AOD. At the boundaries between EPA regions, Zhang and Hoff use linear interpolation to generate a smooth transfer of the slopes and intercepts from one region to another. The $PM_{2.5}$ estimation is updated in near real-time whenever new AOD data is available.

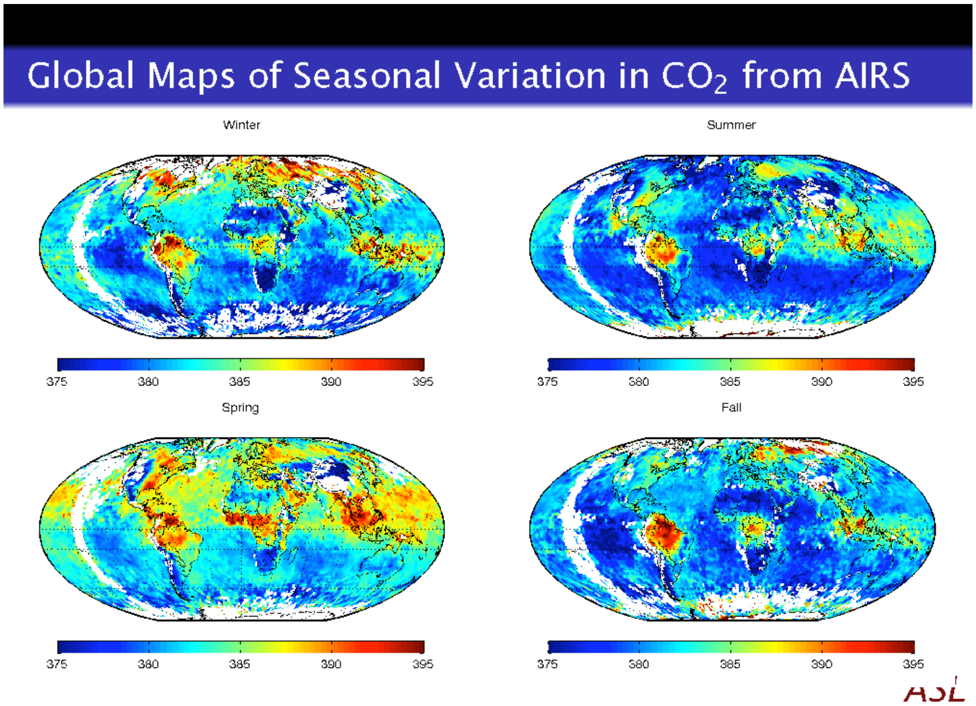
Collaborating with Dr. Alexei Lyapustin (UMBC/GEST), the JCET team continued working on a new retrieval algorithm for GOES modified from the MAIAC algorithm for MODIS. In this algorithm, the seasonal average MODIS Bidirectional Reflection Distribution Function (BRDF) surface at 2.1 μm band is used along with the GOES visible channel images for retrieving surface reflectance and aerosol optical depth. The surface BRDF in the GOES visible channel is assumed to have the same shape as MODIS 2.1um band BRDF. The ratios between them are retrieved through time sequence analysis. This algorithm can retrieve surface reflectance using GOES images from a much shorter period of time than the 28-day period used in current operational GASP (GOES Aerorol and Smoke Product) algorithm. They have made many further improvements on this algorithm, such as Zhang's revision of the MAIAC for GOES code developed last year to make the algorithm work with a non-Lambertian surface. The revised code uses a look-up table (LUT) generated by Dr. Lyapustin using the SHARM radiative transfer model instead of the previous LUT from the Lambertian 6S model. The aerosol model was also changed from a continental model to a model similar to that found at GSFC's AERONET site. The algorithm was validated through comparisons against the AERONET and GASP AOD retrievals at six AERONET sites across the continental US. MAIAC AOD shows a good comparison with AERONET AOD at two western US sites, *i.e.* Railroad Valley and UCSB, and is better than GASP retrievals at these two sites. At the other four eastern and central sites, MAIAC algorithm has similar retrieval accuracy with GASP. This is probably due to the relative large variations of the seasonal BRDF caused by the vegetation in the eastern and central areas. Seasonal average MODIS BRDF may introduce relatively large errors, if used to represent daily BRDF in areas with good vegetation coverage. The vegetation coverage is much less in the western US; therefore, seasonal BRDF can be a good representation of daily value of BRDF. Zhang and Hoff expect the MAIAC algorithm to be especially suitable for arid areas where the BRDF does not change from season to season due to the seasonal change in vegetation. In addition, they also found that the AOD retrieval error at backscatter position of sun-satellite geometry is very large, which is caused by the different sampling geometry between MODIS and GOES; hence, they filtered out the AOD retrievals at such geometry.

To prepare IDEA for GOES-R, the JCET researchers built a test system using GOES-R ABI proxy AOD, which is generated daily from MODIS data by scientists at NOAA NESDIS. IDEA for GOES-R ABI proxy AOD is now tested at http://idea.umbc.edu/GOESR/ with two components: national/regional AOD map and 48-hour trajectory forecast. GOES-R ABI AOD has a delay of about 15 days. Since the data only include locations with retrievals, the pixel size cannot be obtained. In order to make the plot, they project the data to latitude-longitude grid with a size similar to MODIS pixel size (10km). Therefore, the pixels on the GOES-R ABI AOD map look different from MODIS pixels.

Objectives for FY 10-11

In the coming year, Zhang and Hoff will work on the following developments and research: revising the GOES AOD retrieval algorithm in order to retrieve BRDF directly from time sequence analysis of GOES images; develop synthetic green signal generation method for GOES-R data to prepare for GOES-R RGB image generation in IDEA; and, collaborate with GOES-R Air Quality Proving Ground, develop and test the IDEA system using GOES-R proxy data at a high temporal resolution.

JCET Highlight: Global Maps of Seasonal Variation in CO_2 from AIRS
Investigator: Dr. L. Larrabee Strow



The change in global CO_2 with season is illustrated in the above figure. Following the known behavior of CO_2 in the boundary layer, the northern latitudes produce excess CO_2 during the winter months (*top left*). This CO_2 is transported to higher altitudes and lower latitudes by spring (*bottom left*), while the CO_2 production at the highest latitudes starts to diminish. By summer (*top right*), the greening of the northern hemisphere drastically lowers the CO_2 and global production is dominated by the tropics. Fall CO_2 (*bottom right*) is similar to summer, although the tropical LAN areas appear to now be emitting more CO_2 than in other seasons. All of the spatial patterns shown here vary by a factor of 2 to 4 times more than found in NOAA's CarbonTracker assimilated CO_2 model.

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NASA Grant:	**Differences and Similarities of Tropical Cyclone Rainfall Over Land and Sea Using Multisatellite Analyses: Implications for Inland Flooding Prediction (NNX07AL41G)**
Investigators:	Jeffrey B. Halverson, JCET Associate Director-Academics and Associate Professor of Geography; Haiyan Jiang, University of Utah
NASA Grant:	**Multiscale Analysis of Tropical Storm Hot Tower And Warm Core Interactions Using Field Campaign Observations (NNX09AG03G)**
Investigators:	Jeffrey B. Halverson, JCET Associate Director-Academics, Associate Professor of Geography; Gerald Heymsfield, (GSFC); Lin Tian (UMBC/GEST)
NASA Grant:	**In Situ Measurement of Meteorological State Variables Using Dropsondes On the NASA DC-8 and Global Hawk During NASA GRIP, and Composite Analysis of a Large Dropsonde Database (NNX09AV79G)**
Investigator:	Jeffrey B. Halverson, JCET Associate Director-Academics and Associate Professor of Geography

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 Middle Atlantic Region, and also to discern their socioeconomic impacts.

Accomplishments in FY 09-10

During the past year, Halverson and Ross Dixon, the Physics M.S. student he co-mentored with UMBC Physics Professor Lynn Sparling, examined the physical processes leading to heavy rain generation in two tropical cyclones that made landfall in the Mid-Atlantic region. The goal of the research is to better understand the meteorological evolution of these tropical systems that undergo extratropical transition, which includes interactions with mid-latitude frontal systems, jet streams and the Appalachian Mountains. The results from the research have been written up into a draft journal article and will be submitted early in the fall of 2010.

Halverson continued his research as a member of NASA's Hurricane Science Team. The thrust of activity has been planning for the next field campaign to investigate hurricane structure and evolution in the Atlantic Basin, GRIP (Genesis and Rapid Intensification Processes), during Fall 2010. Halverson has been extensively involved in developing a new dropsonde system for the Northrop-Grumman Global Hawk, a cooperative effort between NASA, NOAA and the National Center for Atmospheric Research (NCAR). Halverson also serves as dropsonde P.I. on the NASA DC-8 for the GRIP campaign. He has been working with other GRIP mission scientists developing aircraft flight strategies, assembling a team of weather forecasters for the experiment, and participating in a tri-agency forecast and mission planning exercise or "Dry Run" in preparation for the upcoming GRIP campaign. Halverson's new graduate student Ms. Janel Thomas (St. Louis University) will participate in GRIP as a dropsonde technician on the DC-8, and she will begin developing an M.S. Thesis using NASA field campaign data to study hurricane intensity change. Halverson also collaborated with scientists at NASA Goddard and other institutes to propose a multi-year Hurricane Severe Storms Sentinel mission, involving two instrumented Global Hawks to study Atlantic hurricanes from the NASA Wallops Flight Facility. The proposal was selected for funding as part of the NASA Venture Class program. Halverson also accepted a three-year appointment as an Affiliate Scientist at NCAR, where he will work with lab scientists to develop a comprehensive 15-year database of hurricane dropsonde data, applying consistent quality control and analysis procedures. Finally, Halverson prepared a manuscript reviewing NASA's 25-year involvement in hurricane research for a special upcoming journal issue.

Objectives for FY 10-11

Halverson's primary research continues to focus on storminess in the Mid-Atlantic region. This important geographic region is home to the greatest concentration of eastern U.S. inhabitants within the D.C.-Baltimore-Philadelphia-New York City megalopolitan corridor. Diverse physiographic influences including the Atlantic, Chesapeake Bay, Blue Ridge Mountains and Appalachians interplay to weave a dynamic mosaic of meteorological processes influencing the genesis, evolution and decay of severe storms. The fate of cold-, warm- and tropical-season storm systems has profoundly shaped the history and socio-economic condition of millions in this region, and will continue to do so. The impact of severe storms on transportation webs and other vital infrastructures in the Mid-Atlantic requires intensive investigation.

Specifically, Halverson and Tom Rabenhorst (UMBC Geography) are preparing an extended manuscript on the meteorology of Hurricane Isabel (2003) in the Mid-Atlantic. The goal is for this manuscript to serve as the prototype for a book to be titled "Second Wind: Hurricane Remnants in the Mid-Atlantic and Their Rebirth as Weather Catastrophes". The book will detail the meteorological evolution and impacts of ten tropical storm case studies that transformed into "hybrid" systems, doing their greatest damage well inland over the Piedmont and mountains of the Mid-Atlantic. The intended audience for the book includes students of meteorology, professional meteorologists, hydrologists, historians and geographers. A major strength of the book is the way surface and upper air meteorological processes will be graphically portrayed using a consistent, full-color set of three-dimensional visuals for each storm. In this manner, basic meteorological processes on the synoptic scale and mesoscale can be compared and contrasted easily between the various cases.

Task 87: **Passive and active microwave retrievals of frozen and melting precipitation hydrometeors** ***(Sponsor: G. Jackson)***

NASA Grant: **Retrieval Algorithm Development for Precipitating Snow Detection and Estimation using High Frequency Observations (NNH06ZDA001N-PMM / WBS 573945.04.01.06)**

NASA Grant: **Retrievals of Precipitating Snow and Light Rain Using Synergistic Multi-Sensor Active and Passive Observations (NNH05ZDA001N-CCST)**

Investigators: Benjamin T. Johnson (Co-I); Mark Kulie, University of Wisconsin; Gail Skofronick-Jackson (PI), NASA GSFC; James W. Wang, NASA GSFC, William Olson, NASA GSFC/JCET; Mircea Grecu (GEST).

Description of Research

Research has focused 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.

Accomplishments for FY 09-10

The primary accomplishments this past year were focused on precipitation retrieval algorithm development for the upcoming Global Precipitation Measurement Mission. The researchers' main goal has been to modify an existing Bayesian retrieval algorithm to improve snowfall retrieval accuracy. A critical component of this task is to develop a physically based retrieval database, which uses model data from the WRF model (W.K. Tao, *et al.*) and simulated observations. Johnson has focused on computing the microwave properties of realistically shaped hydrometeors and incorporating this into the database; previously, the researchers assumed spherical hydrometeors, which were shown to be inadequate for simulating co-located radar / radiometer observations.

Johnson is also presently a co-investigator with Dr. William Olson (JCET) on creating a melting-layer model for use in the official combined radar/radiometer retrieval algorithm for GPM. This involves the development of a 3-D precipitation particle-melting model, which is designed to realistically simulate the melting of complex ice-particle shapes and aggregates of these shapes.

Johnson's other research topics involved estimating retrieval sensitivity to variations in land surface emissivity and particles shapes for precipitation retrievals over land. This research operates in conjunction with the Centre for Atmospheric Research Experiments (CARE) CloudSat/Calipso validation program (C3VP) field experiment research, in Egbert, Canada.

During this year, Johnson has been serving on the Ph.D. committee of Lijun Diao (UMBC, Physics), who is working with Dr. Olson on developing a melting model for radar observations.

In addition to his research, Johnson is a member of the Global Precipitation Mission (GPM) combined radar/radiometer precipitation algorithm development team, and radiometer-only algorithm team. As members of these teams, he is tasked with developing the standard GPM algorithm for combined retrievals. He is also an active member of the ice/mixed phase working group, land surface emissivity working group, and the precipitation detection working group; the latter two operate in support of the GPM project. Additionally, Johnson has been an active reviewer for the *Journal of Applied Meteorology and Climatology* (*JAMC*), and *Journal of Geophysical Research* (*JGR*).

Objectives for FY 10-11

In addition to submitting papers for publication in the coming year, Johnson also plans to continue comparing spherical particles with more realistic shape models and properties (e.g., using the discrete dipole approximation) and connecting the 3-D particle melting simulation with the thermodynamic melting model. He will also continue with over-land retrievals using CloudSat radar observations to Improve land surface emissivity and radar cross-sections, as well as understanding terrain influences on the retrievals.

Johnson's primary objective is to develop GPM-era combined GMI/PR2 radar retrieval algorithm(s) for light rain and snow over both land and ocean, with his primary direction aimed toward a working algorithm for GPM, which will combine all aspects of the aforementioned research: realistically shaped melting particles, improved retrieval capability, improved forward modeling capability, and retrieval over land and ocean of both rain and snowfall.

Task 89: **Modeling of Rainfall Statistics from Satellite and Ground Based Remote Sensing Measurements (NNG05GQ79A)** ***(Sponsor: T. Bell)***

NASA Grant: **Error Estimates for TRMM and GPM Average Rain-rate Maps (Task 913-18-130)**

Investigators: Prasun K. Kundu, Research Associate Professor, Physics; Thomas L. Bell (GSFC).

Description of Research

There are four major goals of the research performed under this task: developing mathematical models of rainfall statistics; applying these models to describe statistical behavior of precipitation datasets from a variety of sources, including satellite and ground-based remote sensing measurements as well as rain gauge networks; a detailed study of statistics of precipitation data obtained from low earth-orbiting satellites, such as TRMM Special Sensor Microwave/Imager (SSM/I); and, developing statistical validation techniques for intercomparison of satellite observations of rain and comparison with ground-based radar and rain gauge observations in connection with the validation problem for the rainfall products from the upcoming Global Precipitation Measurement (GPM) Mission, which takes into account the natural variability of rain and the spatio-temporal mismatches for near-collocated observations.

Accomplishments for FY 09-10

In collaboration with Dr. Ravi Siddani, a former graduate student at JCET, Kundu investigated the temporal scale dependence of rainfall intermittence using the time-averaged precipitation data (TRMM standard product 2A56) from a network of 300+ tipping bucket gauges located in Central and South Florida as part of the TRMM ground validation (GV) program. The study resulted in a simple stretched exponential type formula for the probability of zero rain over a length of time, which successfully fits the observed scaling behavior of wet periods over more than three decade of time scales ranging between 1 min to 3 days. The new formula approximates a power law scaling at large scales but predicts a nearly scale-independent behavior at small scales in agreement with observation. The behavior at small time scales that is difficult to ascertain from tipping bucket gauge data is confirmed from disdrometer data from the NASA Wallops Flight Facility provided by Dr. Ali Tokay (JCET). A similar empirical relationship was found to hold for the spatial scale dependence of the zeroes of rain in the multi-year gridded radar rainfall data (TRMM standard product 2A53) collected at the TRMM GV site near Melbourne, FL. A theoretical explanation was provided for the observed behavior of the probability of zeroes as a function of the averaging time scale in terms of a simple probabilistic model based on the premise that the rainfall process has an intrinsic memory. The observed behavior reveals an interesting aspect of the rainfall process that can be interpreted as a phenomenon of “persistence of drought”, namely, the longer a zero rain period, the less likely it is for it to end. A paper based on these results is being prepared for publication.

With the help of Mr. James Travis, a graduate student at UMBC's Department of Mathematics and Statistics, Kundu has initiated a new project of obtaining a comprehensive statistical model of area- and time-averaged precipitation from collocated radar and rain gauge measurements at a GV site. The model is based on a linear stochastic differential equation introduced in Bell and Kundu (1996) and Kundu and Bell (2003) to describe the second-moment statistics of radar rainfall data over the tropical oceans. Their work concentrates on the rain gauges located within the field of view of the Melbourne radar. To date, the model spectrum has been found to fit the statistics of the precipitation time series from the individual gauges within the network rather well. Current work focuses on fitting the spatial covariance between pairs of gauges and estimating the model parameters appropriate for the network as a whole. A parallel study of the second-moment statistics of the Melbourne radar data is also underway. A unified description of the statistical properties of both near-instantaneous spatially averaged rain rate from a radar and time-averaged rain rate from a rain gauge network located within the radar's field of view will be extremely useful for the purpose of quantifying the inevitable statistical sampling error in rain rate estimation (Bell and Kundu, 2003). An unambiguous separation of this sampling error from the various retrieval errors is essential for a successful rainfall validation program.

Objectives for FY 10-11

In the coming year, Kundu plans to obtain a spectral model of second-moment statistics of rain rate that is capable of describing both radar and gauge measurements at the TRMM ground validation (GV) sites, and examine spatial statistics of TRMM PR- (Precipitation Radar) derived rain data and test the model predictions with regard to the multi-scaling behavior. He will also use the second-moment statistics to formulate an error model for improving a regression analysis of pairs of nearly space-time collocated satellite observations of rain over an area in collaboration with T.L. Bell (GSFC, retired) and X. Lin (GEST). Finally, he will pursue the problem of obtaining a parameterized model of the joint probability distribution of rain at slightly different times in terms of a suitably chosen copula by using existing GV radar data as a step towards statistically characterizing the difference between two nearly collocated satellite datasets.

Task 28: Research Support for Precipitation Science *(Sponsor: E. Smith)*

Investigator: Amita V. Mehta, Research Assistant Professor, Geography and Environmental Systems

Description of Research

For the past year, Mehta's main objective has been to finalize atmospheric pollution data obtained from a multi-model inter-comparison project -- Hemispheric Transport of Air Pollution (HEMITAP) web-based portal under the Goddard Earth Sciences Data and Information Services and Interactive Online Visualization and analysis Infrastructure (Giovanni). Additional activities included ongoing projects related to the retrieval, the observational analysis, and the modeling of precipitation with the focus on Gulf of Mexico - Caribbean Sea (GM-CS) basin and Mediterranean basin (Med).

Accomplishments in FY 09-10

The Hemispheric Transport of Air Pollution (HEMITAP), a web-based data analysis and visualization facility, was finalized in Giovanni (http://disc.sci.gsfc.nasa.gov/giovanni/additional/users manual/G3_manual_Chapter_20_HEMITAP#features). In addition, the inter-comparison of the HEMITAP model data with surface measurements of SO_2, NO_x, and $PM_{2.5}$ over South Asia was started. The surface measurements showed a strong annual cycle of these quantities where a rise was noted in the pollutants during boreal winter/spring and decrease after the summer monsoon rainfall.

Under an ongoing project of Cloud Dynamics and Radiation Database (CDRD) for improved rain retrievals from future microwave radiometers, Mehta has created a database of hydrometeor profiles and related dynamical and thermodynamical variables associated with heavy rainfall resulting from hurricanes over GM-CS and storms over the Mediterranean basin.

An analysis of rainfall over the Med was carried out which showed that there are substantial differences in climatological precipitation properties between land and sea over the Mediterranean basin. While there is a significant correlation between the North Atlantic Oscillation Index (NAO) and Med precipitation, it is clear that the relationship changes depending on whether the correlation is made with respect to over-land time series, over-sea time series, or combined land-sea time series, raising further questions about the importance of regional processes over the Med region.

Objectives for FY 10-11

The main objective for next year is to conduct in-depth and quantitative analysis of the water cycle over the Med region under NASA's Energy and Water Cycle Studies (NEWS) program, particularly to explain why the moisture source property of the Med region changes seasonally and interannually. Additional activities will include the usage of a moisture-tracking algorithm applied to atmospheric re-analysis data and/or Aqua-AIRS moisture data to understand moisture sources for heavy precipitation over GM-CS and Med regions. The CDRD project will continue with cloud-resolving model simulations of light to moderate rain systems over GM-CS and Med Regions.

NASA Grant:	Combined Radar/Radiometer Estimates of Precipitation and Latent Heating Profiles for Training Spaceborne Passive Microwave Radiometer Algorithms (NNX07AK46G)
Task 104:	Global Retrieval of Precipitation and Latent Heating Distributions from Spaceborne Radiometer/Radar Observations *(Sponsor: A. Hou)*
NASA Grant:	Retrieval Algorithm Development for Precipitating Snow Detection and Estimation Using High Frequency Observations (06-PMM06-0045)
NASA Grant:	Multi-frequency Polarimetric Radar, Profiler, and Space-Borne Studies of Particle Size Distributions and Mixed Phase Processes in Cold and Warm Season Precipitation (NNX07AK39G)
NASA Grant:	Calibration and Analysis of Global Latent Heating Estimates Using Passive and Active Microwave Sensor Data (NNG06GC99G)
NASA Grant:	A Long-Term Precipitation Dataset with Uncertainty Information (NNX08AT04A)
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)
Investigators:	William S. Olson, Research Associate Professor, Physics; Mircea Grecu (UMBC/GEST); Lin Tian (UMBC/GEST); Chung-Lin Shie (UMBC/GEST); Gail S. Jackson (GSFC 613.1); Benjamin Johnson (JCET); Kwo-Sen Kuo, Caelum Research Corp.; Arthur Hou (GSFC 610.1; Christian D. Kummerow, Colorado State University; Walter A. Petersen, University of Alabama-Huntsville.

Description of Research

The main emphasis of Olson's 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 (Tropical Rainfall Measuring Mission or TRMM) and 14 + 36 GHz radar (Global Precipitation Measurement mission or GPM) and 94-GHz radar (CloudSat mission) in conjunction with a range of passive microwave multispectral observations. Regarding precipitation, Olson's group's specific objectives are to improve the representations of ice and mixed-phase particles in combined radar/passive microwave algorithms. The remote sensing of latent heating vertical distributions using spaceborne radar and passive microwave observations is a related area of study, with implications for understanding the earth's water and energy cycles.

Accomplishments in FY 09-10

With an anticipated launch date in mid-2013, the GPM core mission observatory will include both spaceborne radar (14 and 36 GHz) as well as a range of passive microwave radiometer channels (10-183 GHz). These channels will provide the researchers' "best" estimates of precipitation and latent heating vertical profiles; in turn, these will be used to cross-calibrate radiometer-only profile estimates from an international fleet of radiometers flying in complementary orbits. Prof. Hirohiko Masunaga (Nagoya University) and Olson co-lead a team to develop and implement a combined radar-radiometer algorithm that will be applied operationally to the GPM core instruments. This past year, the radar-only and combined algorithm teams met for the second time at University of Maryland to assign subgroup leads for algorithm construction and testing tasks. Dr. Grecu and Olson are developing a combined radar-radiometer algorithm for satellite applications based upon an optimal estimation framework; at the core of the algorithm is a dual-wavelength radar algorithm that was successfully tested this year, using airborne 13 and 36 GHz radar data. This radar algorithm "module" can generate candidate precipitation profile solutions that are variationally adjusted using additional microwave radiometer data.

Also under GPM, Dr. Robert Meneghini (GSFC) and Olson lead a working group to improve the representation of ice and mixed-phase precipitation physics in combined algorithms. The combined radar-radiometer algorithm framework previously described will be tested against airborne radar-radiometer data using different vertical precipitation profile parameterizations that can be modified by inserted alternative precipitation particle single-scattering tables. In a related investigation with Dr. Walter Petersen, Dr. Benjamin Johnson, and Ms. Lijun Diao (UMBC graduate student), the single-scattering properties of melting, aggregate ice particles are being modeled, and their radiative properties are being calculated using the discrete dipole approximation.

Under NASA's Energy and Water cycle Study (NEWS), the large-scale diabatic heating estimation algorithm developed with Drs. Grecu, Chung-Lin Shie, and Tristan L'Ecuyer (Colorado State University) was improved by adding the effects of convective boundary layer latent and eddy sensible heating. With the help of Xianan Jiang (UCLA/JIFRESSE) and Guojun Gu (UMCP/ESSIC), the resulting 11-year satellite-based record of total diabatic heating was analyzed to describe the meridional structure of heating in the Madden-Julian Oscillation (MJO), and the production of available potential energy in the MJO. The westward vertical tilt of estimated MJO heating structures agrees reasonably well with rainsonde-derived time series of MJO vertical heating structures, and available potential energy distributions are consistent with earlier estimates derived from model-based reanalyses.

Supported by the NASA MEaSUREs program, long-term, the researchers are testing global precipitation products for their sensitivity to input microwave brightness temperature calibration and precipitation algorithm parameterizations. Under the direction of Dr. Christian Kummerow, Olson's group created and compared datasets derived from 10 years of standard- and modified-calibration Special Sensor Microwave/Imager input.

Objectives for FY 10-11

Drs. Grecu and Olson will assemble precipitation algorithm components and develop a "default" GPM algorithm based upon the optimal estimation framework. This algorithm will be modified and evaluated by the GPM combined algorithm team during the first half of 2011 using airborne radar-radiometer observations. The ice/mixed-phase-precipitation working group will evaluate physical parameterizations of precipitation, including the GEST researchers' thermodynamic/electromagnetic melting parameterization, against field observations. Studies of the climatology of atmospheric diabatic heating and the extension of this climatology to over-land regions will also be performed. The long-term record of consistently calibrated rainfall estimates from SSM/I will be used to adjust Global Precipitation Climatology Project (GPCP) infrared rain estimates.

NASA Grant:	**Measurements of the Hydrometeor Size Distribution through Surface-based Instruments (NNX07AF45G)**
NASA Grant:	**Improved Ground Validation Rain Estimates at Kwajalein and Central Florida for Comparison to and Validation of TRMM and Other Satellite Estimates (NNX07EJ50C)**
NASA Grant:	**Quantifying Particle Size Distributions in Support of GPM Combined Precipitation Retrieval Algorithms (NNH09ZDA001N-PRECIP)**
Task 34:	**A proposed Mid-Latitude Coastal Ground Validation Site for the NASA Precipitation Measurement Mission** ***(Sponsor: M. Schwaller)***
Task 122:	**Measurements of Hydrometeor Size Distributions during Global Precipitation Measurement (GPM) Field Campaigns** ***(Sponsor: M. Schwaller)***
Investigator:	Ali Tokay, Research Associate Professor, Affiliated Associate Professor

Description of Research

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

Accomplishments for FY 09-10

A publication that appeared in a peer-reviewed journal (Tokay *et al.* 2010a) was related to the accuracy of the operational gauge networks. This study employed collocated dual or triple research and a single operational gauge in the mid-Atlantic region. The research gauges were in the field for more than a year in each site, and the study has been conducted for daily and monthly rainfall. The purpose of this study is to determine the reliable gauge networks for validating the satellite precipitation products.

A manuscript has been accepted by a peer-reviewed journal (Tokay *et al.* 2010b) on the variability of raindrop size distribution and rain parameters in radar pixel. The study was conducted by employing three disdrometers at NASA Wallops Flight Facility (WFF). The statistics (correlation coefficient and standard deviation) of four-month long observations showed noticeable differences in size distribution and rainfall parameters.

A study on the performance of Parsivel disdrometer in snow appeared in a peer-reviewed journal (Battaglia *et al.* 2010). The measuring principles of Parsivel have been revisited, and its performance was evaluated through a comparative study of collocated Parivel and two-dimensional disdrometer measurements during a field campaign in Southern Ontario, Canada.

Additionally, Dr. Kurtulus Ozturk, Visiting GEST Fellow, led a study in which the Multi-sensor Precipitation Estimate (MPE) was evaluated using a rain gauge network in the mid-Atlantic region. Since the gauges are not part of the MPE, they provide an independent source of evaluation. The comparisons were conducted on hourly, three-hourly, six-hourly, daily, and monthly time scales. The results showed that the gauge adjustment is an important component for the accuracy of MPE product.

Dr. Ozturk also led a study on the variability of rainfall within a satellite footprint, which was conducted through six dual rain gauge sites at WFF. This study focused on the rainfall correlation distance and its dependency on the time integration and rainfall types. The researchers considered time integration between 5-minute and daily rainfall and stratified two years of observations by season, six-month, and yearly periods. The observations were also stratified by frontal rain and tropical cyclones, as well as by uniform, variable, and highly variable rainfall.

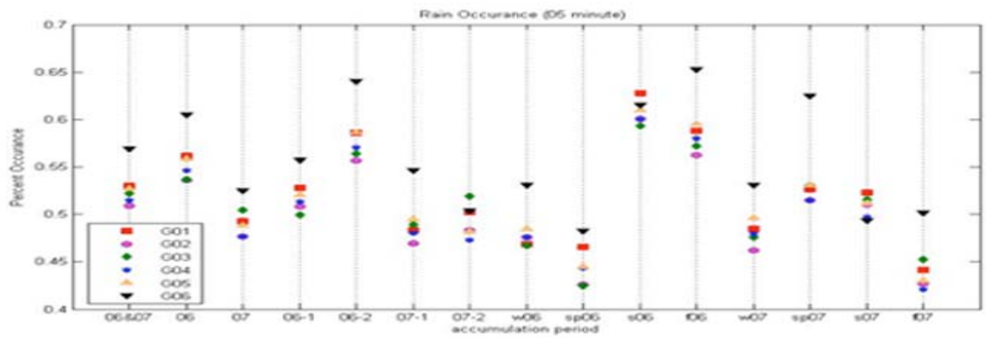
During a field campaign in Northeast Brazil, a study was conducted on the measurement accuracy of collocated optical Parsivel and impact Joss-Waldvogel (JW) disdrometers. The preliminary findings show the overestimation of large drops in Parsivel, which also underestimates the small drops more severely than the JW disdrometer.

A more comprehensive study on the accuracy of collocated Parsivel, JW, and two-dimensional video disdrometers was conducted by employing a six-month- long database from Northern Alabama. The collocated gauge was considered to be the reference for event rainfall. Parsivel overestimated the rainfall due to its overestimation of large drops, but it performed better in Alabama than in Brazil. The JW disdrometer measures the small drops more accurately than the other two disdrometers, while the large drops were captured in a video disdrometer.

Objectives for FY 10-11

Tokay expects to complete ongoing studies and submit two manuscripts to peer-reviewed journals. New research on the variability of raindrop size distribution will be conducted using two different datasets. Tokay will participate in two field campaigns in Finland and Oklahoma. The first field campaign will investigate the characteristics of raindrop size distribution in cold-climate light rain and mixed events, while the second field campaign has more broad objectives, including variability of raindrop size distribution within satellite field of view and characteristics of size distribution in deep mid-continent precipitation. 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 area. The available disdrometers and NASA's S-band polarimetric radar will also be used in the experiment. Measurements of raindrop size distribution have been continuously collected at the roof of NASA GSFC's Building 33, and this site is expected to serve many science objectives among GSFC colleagues.

JCET Highlight: Partial Beam Filling
Investigator: Dr. Ali Tokay



Partial beam filling results from two effects: a) the satellite field of view (footprint) is not completely covered by precipitation, and b) there are variables of precipitation within the field of view. In reality, both may occur at the same time.

In this study, we tried to separate these two effects. We had 6 rain gauges that were in a nearly straight line and separated with a distance ranging from 0.4 to 5.0 km. Note: the footprint of TRMM precipitation radar is 5.0 km after its boosts in August 2001. The upcoming GPM dual frequency radar will have a more complicated footprint structure, but at a single frequency it will be around 5.0 km.

We were interested in the percent of rain occurrence (not including any snow) at a single gauge site with respect to the "base" rainfall, the number of rainy periods (for gauges 5-minute) where at least one of the gauges reports rainfall. This is what satellites report as rainfall. The study was conducted based on two years of datasets. We examined the percent of rain occurrence for individual gauge for a given season, for a six-month period, a twelve-month period, and two years period.

Amazingly, we found that all gauges reported rainfall less than 50% of time during Spring 2006! An individual gauge reports rainfall no more than 67% of time in any season during two years of study. This hints at just how crucial partial beam filling is.

Climate and Radiation
(Code 613.2)

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NASA Grant: **Aerosol optical depth retrievals using reflectance ratios from MODIS data (NNX09AD55G)**

DOE Grant: **Use of the ARM measurements of spectral zenith radiance for better understanding of 3D cloud-radiatio processes and aerosol-cloud Interaction**

Investigators: J.-Y. Christine Chiu, Research Assistant Professor, Physics (JCET); Alexander Marshak, JCET Fellow (GSFC 613.2); Warren Wiscombe (GSFC 613.2).

Description of Research

Cloud optical depth is the most fundamental cloud property determining the Earth's radiative energy balance. However, cloud optical depth is poorly predicted by climate models and is very difficult to remotely sense from the surface using traditional methods. This project focuses on remote sensing clouds from the ARM measurements of spectral zenith radiance, including passive radiometers and active lidars. These measurements are used not only to retrieve cloud optical properties, but also to study spectral behavior in the area around cloud edges. In addition, based on satellite observations, a number of studies have shown that aerosol optical depth increases with cloud cover. This positive correlation could be attributed to a number of reasons, such as humidification of aerosols, cloud contamination, and radiative transfer effects. To reduce retrieval error from the cloud-induced enhancement in clear sky reflectances (3D cloud radiative effects), a method proposed by Kassianov and Ovtchinnikov (2008) using reflectance ratios is tested on MODIS data.

Accomplishments for FY 09-10

Work on the transition zone between cloudy and cloud-free regions continued, using one-second-resolution zenith radiance measurements from the Atmospheric Radiation Measurement program's new shortwave spectrometer (SWS). The SWS points straight up and measures zenith radiance at 418 wavelengths between 350 and 2200 nm. In the previous report, a striking spectral-invariant linear relationship in zenith radiance observations was found: the relationship suggested that the spectral signature of the transition zone is a linear mixture between the two extremes (definitely cloudy and definitely clear). To better understand what factors dominate in characterizing the spectral-invariant relationship, sensitivity tests have been conducted using radiative transfer simulations. Factors used in sensitivity tests include cloud and aerosol properties, underlying surface type, and the finite field-of-view of a radiometer. Overall, the linear relationship at all wavelength bands is insensitive to aerosol properties, underlying surface type, and the finite FOV. Mainly, the spectral-invariant relationship in the transition zone is sensitive to cloud properties. At non-absorbing wavelengths (*e.g.,* 400–870 nm), the slope and intercept functions are mainly determined by cloud optical depth and are insensitive to cloud drop effective size. But at liquid-water absorbing wavelengths (*e.g.*, 2110–2220 nm), while cloud optical depth still dominates the slope, cloud absorption properties dominate the intercept. These results suggest that the spectral-invariant relationship can be used to infer cloud properties even with insufficient or no knowledge about spectral surface albedo and aerosol properties.

The retrieval method for AOD using reflectance ratios from MODIS data was investigated. Current MODIS aerosol models were found to significantly overlap each other on the reflectance ratio domains; thus, it is impossible to retrieve aerosol type using this ratio method. In addition, the method is very sensitive to measurement uncertainty. To make retrievals more robust, Chiu and her researchers are investigating whether the spectral invariance behavior found in zenith radiance measurements can shed light on refinement of the current retrieval method.

The new "cloud mode" operation in the Aerosol Robotic Network (AERONET) has made tremendous progress, which inexpensively yet dramatically increases cloud optical depth observations on a global scale. Currently, more than 15 sites over the world are participating in the cloud mode operation. The GEST researchers' retrieval algorithm for cloud optical depth has been tested on a daily basis and shows good agreement with retrievals from other instruments. Additionally, the ability to retrieve cloud drop size using additional 1640 nm wavelength has been carefully investigated; the retrieval method is under development.

Dr. Alan Betts initiated collaboration with Chiu's team to explore the coupling of the energy, water, and carbon cycles over land in mid-latitudes and to understand how surface fluxes, the boundary-layer equilibrium, and the cloud cover change for a warmer, doubled CO_2 climate. For this study, an idealized equilibrium model and 1D SBDART radiative transfer model are used. They have found that the doubling of CO_2 decreases the canopy conductance, reduces transpiration, increases the surface sensible heat flux, and then gives a much warmer and deeper mixing layer with a lower surface humidity. There is a corresponding ~15% drop of relative humidity at the base of mixing layer and a ~60 hPa rise of cloud base. In addition, since equilibrium cloud is sensitive to temperature, subsidence, and CO_2, changes of mean subsidence will play a critical role in determining changes in cloud cover in a warmer, high CO_2 climate.

Objectives for FY 10-11

Dr. Chiu will begin a faculty position at the University of Reading in the UK in September 2010, but will continue to work on this DOE project and to collaborate with Drs. Wiscombe and Marshak, and NASA AERONET team members.

Task 18:	**Studies of Aerosol Particles from Biomass Burning and its Radiative Effects** ***(Sponsor: L. Remer)***
MIT Grant:	**Climate Effect of Black Carbon Aerosol on Tropical Convective Clouds and Precipitation (5710002182)**
NASA Grant:	**Remote Sensing Measurements of Aerosol Absorption and its Effects on Climate Forcing (NNX08AJ78G)**
NASA Grant:	**Investigation of Aerosol Spectral Absorption Properties from UV to NIR (NNX07AT47G)**
NASA Grant:	**Rainbow and Cloud Side Remote Sensing: A Novel Look at Cloud-Aerosol Interaction and its Effect on Cloud Evolution (NNX08AU97H)**
Investigators:	J. Vanderlei Martins, Associate Professor, Physics; Tianle Yuan, Research Associate (JCET); Dominik Cieslak, Engineer (JCET)
Students:	Steven Buczkowski; Gergely Dolgos; Li Zhu; Adriana Rocha Lima (all PhD Students at UMBC)

Description of Research

The optical properties of aerosol particles and their effect 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. One of the novel spectral absorption techniques applied in this project provides detailed information on wide wavelength range (350-2500nm) for samples from several regions of the globe, including India, China, Brazil, Israel, USA, Mexico, UAE, Chad, and others. Another very important topic in aerosol research is the impact of aerosol in clouds and precipitation, which is addressed via the study of aerosol microphysical properties and via the measurement of cloud spectral properties using novel instrumentation developed in Martins' laboratory. Major efforts in this task are also devoted to the development of new ground-based, airborne, and satellite techniques to measure aerosol, clouds, aerosol interactions and consequences. Prototype instruments were built and are being applied to the measurement of cloud properties from the ground and from aircraft. These instruments are also being studied as prototypes for future satellite measurements, including the PACS (Passive Aerosol and Cloud Suite) polarimeter that is part of the ACE Mission, which is included in the National Academy of Sciences Decadal Survey. Recent efforts have also been devoted to developing Pico-satellites for measuring aerosol and cloud properties.

Accomplishments for FY 09-10

In FY10 Martins and his team have continued their efforts on developing algorithms, instrumentation and methods for the measurement of aerosol absorption and scattering properties via remote sensing and *in situ* techniques, on developing and applying instrumentation for measuring the effect of aerosols on the vertical profile of cloud effective radii and thermodynamics, and on developing instrumentation and methods for measuring polarized radiances for the retrievals of aerosol and cloud microphysical and thermodynamic properties. They also continued to collect and analyze *in situ* data from several field campaigns and ground stations. Significant efforts were spent toward the development of new remote sensing measurement concepts from aircraft and space. Important efforts were also dedicated to understanding the effect of aerosol particles on cloud formation, evolution, and lifetime. During this past year, they continued with their effort to build the airborne simulator of the PACS polarimeter, which is being proposed as part of the ACE Decadal Survey Mission. They also have developed a laboratory setup for the generation and study of aerosol and cloud particles, and have further developed the Imaging Nephelometer system, which will be used for the detailed *in situ* characterization of aerosol and cloud particles.

Specific developments in this area include the construction of the second-generation tethered balloon sonde for the measurement of the vertical profile of scattering and absorption properties of aerosols, as well as the initiation of manufacturing the PACS airborne polarimeter prototype for the ACE Mission proposal. Other developments included algorithms and methods for measuring cloud microphysical propertied using the polarized cloud-bow; dry and wet aerosol generators for the production and measurement of various types of aerosols in the laboratory; the I-Neph instrument for measuring the polarized aerosol phase function; the application of techniques for the measurement of the spectral absorption properties of aerosols from 200-2500nm; and, a concept and instrumentation for the measurements of cloud microphysical properties using Pico Satellites.

Regarding the interaction of aerosols-clouds-climate, Martins' team published a paper in *Journal of Climate* (Yuan and Li, 2010a) demonstrating a tight relationship between ice microphysics and cloud top temperature, which is among the first of its kind. They show that, for deep convective clouds, cloud top ice particle effective radius is positively correlated with cloud top temperature when the temperature is colder than a certain point. At warmer temperatures it is usually the opposite (as expected) from both theoretical and observational evidences. They also analyzed how this relationship changes with environmental conditions and found that the slope of the correlation has a universal dependence on latitude. They proposed mechanisms to explain this correlation and its latitudinal dependence. This observed relationship can serve as a potential constrain on model simulations. Also, it provides the foundation to further analyze the aerosol effects on deep convective clouds (*e.g.* Yuan *et al.*, 2010b and c).

In another study (Fan *et al.*, 2009), the JCET researchers used a cloud-resolving model and showed that aerosol's effect on convective strength and precipitation is qualitatively determined by lower troposphere wind shear. They demonstrated that the wind shear effect may be responsible for the reported controversies regarding aerosol effect on deep convective clouds. Also, a paper was published (Yuan *et al.*, 2010d) on how to estimate glaciation temperature, a critical parameter of deep convective clouds, using passive measurements. The technique combines MODIS retrievals of ice microphysics and cloud temperature. It is validated with independent measurements and retrievals from a cloud scanning radiometer that is capable of directly finding the glaciation temperature. Two papers (Yuan *et al.*, 2010b and c) utilized the techniques and the relationship observed in previous studies and examined aerosol effects on deep convective clouds, both microphysical properties and macro-physical properties.

Objectives for FY 10-11

In FY11 Martins' group intends to finish the first prototype of the ACE/PACS VNIR imaging polarimeter and perform its first field/aircraft tests. They will continue the development of new *in situ* instrumentation for aerosol sampling; the measurement of aerosol scattering and absorption properties; 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. Additionally, they will continue to develop the cryogenic component of their laboratory aerosol generator, which will allow them to study phase transitions between water and ice, detailed properties of cloud ice particles, and their interaction with several aerosol types including dust, smoke, and such.

Dr. Yuan will continue to work on the issue of aerosol-deep convective cloud interaction. A comprehensive study (Yuan *et al.*, 2010b) that utilizes relationship and techniques in Yuan *et al.* (2010a and d) will be finalized and several other studies will be performed on lightning and aerosols (Yuan *et al.,* 2010c, and 2010e), and on the effect of aerosols on warm trade cumulus cloud properties (Yuan *et al.*, 2010f).

Task 72: **Retrieval of cloud and sea ice properties from THOR lidar measurements** *(Sponsor: R. Cahalan)*

DOE Grant: **Parameterization and analysis of 3D solar radiative transfer in clouds**

Investigators: Tamás Várnai, Research Associate Professor, Physics; Alexander Marshak, JCET fellow, GSFC 613.2; Robert F. Cahalan, JCET fellow, GSFC 613.2; Stefani Huang, SSAI

Description of Research

The overall goal of Várnai's research is to improve the researchers' understanding of the 3D radiative processes that occur in clouds, snow and sea ice. Their work focuses on four areas in particular. First, it examines the influence of 3D radiative interactions on solar heating and cloud development. Second, it investigates the uncertainties 3D radiative processes cause in satellite retrievals of cloud optical thickness and aerosol properties near clouds, and uses the results to examine the changes in aerosol properties that occur near clouds. Third, it explores 3D radiative processes in lidar measurements of thick clouds, snow, and sea ice. Fourth, it brings improvements to the 3D radiative transfer tools available to the research community by coordinating model intercomparisons and providing on-line resources.

Accomplishments for FY 09-10

This year Várnai's team continued their research on the impact of 3D radiative processes on solar radiative heating and cloud development. In order to enable dynamical cloud simulations to consider the 3D nature of radiative processes, they continued to develop a new radiation parameterization. As part of training for this parameterization, they completed a large database of cloud structures at three sites of the Department of Energy Atmospheric Radiation Measurement program and performed radiative simulations for them. The results (Várnai, 2010) indicate that 3D effects increase large-scale long-term average solar heating and satellite radiances, especially for high sun and for cumuliform clouds. The findings also indicate locally strong 3D effects in a large portion of cloudy regions.

They also continued their research on 3D radiative processes that affect satellite retrievals of aerosol properties in the vicinity of clouds. In order to separate the effects of changes in particle properties from the effects of 3D radiative processes that they explored last year (Várnai and Marshak, 2009), they analyzed CALIPSO lidar data that are not influenced by 3D processes. The CALIPSO results indicate significant aerosol changes near clouds due to processes such as particles swelling in humid air, but they also show that some of the strong tendencies observed in MODIS data cannot be explained by changes in particle properties and can be attributed to 3D radiative processes (Várnai and Marshak, 2010). Next year the JCET researchers plan to explore co-located CALIPSO and MODIS observations in order to characterize the effects of various cloud and aerosol properties on changes in particle characteristics and satellite radiances near clouds.

As a continuation of their work on 3D radiative processes in snow and sea ice, they began to explore how the penetration of lidar pulses into the medium impacts altimetry measurements. The results reported at an international conference indicate that multiple scattering of lidar pulses in snow and sea ice delays the return of photons to the lidar detector, which results in underestimations of surface altitude. The JCET teams' simulations and observations by their collaborators indicate that the magnitude of this effect can reach several cm-s for green lasers, such as the one planned for the ICESat-2 mission.

Finally, they further advanced the third phase of the I3RC (Intercomparison of 3D Radiative Codes) project; in particular, they created an archive of illustrative images on 3D radiative processes at the I3RC web site (http://i3rc.gsfc.nasa.gov). They also improved the user-friendliness of the I3RC community model of 3D radiative transfer and started developing the first online 3D radiative transfer calculator, which is expected to become operational in the near future.

Objectives for FY 10-11

Next year Várnai and his team plan to complete the development of a parameterization that is fast enough to allow 3D radiative calculations even in dynamical cloud models. They then plan to use this parameterization in high-resolution cloud simulations that will examine the influence of 3D radiative processes on cloud development.

In addition, they will continue to explore the 3D radiative effects through which clouds influence aerosol measurements near them, and continue to develop a technique that will adjust aerosol measurements for the influence of 3D effects. In particular, they plan to combine observation statistics from co-located MODIS and CALIPSO data with radiative simulations in order to estimate both real particle changes near clouds and 3D radiative effects in aerosol optical thickness and particle size retrievals.

Additionally, they intend to use their datasets of simulated clouds and cloud structures observed at DOE sites for examining the implications of 3D radiative effects in satellite measurements of cloud properties. Their ultimate goal is to help improve these measurements by establishing statistical relationships between easily observable features, such as cloud texture and 3D influences, on cloud optical thickness retrievals.

Finally, they plan to further improve the I3RC website so that it provides additional resources for the 3D community, with the main focus being on the completion of the first online 3D radiative transfer calculator and the expansion of the archive of illustrative images on 3D radiative processes.

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Atmospheric Chemistry and Dynamics
(Code 613.3)

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Task 58: **MODIS Calibration and Characterization Support** *(Sponsor: J. Xiong)*

Investigator: William L. Barnes, Senior Research Scientist

Description of Research

The Moderate Resolution Imaging Spectroradiometer (MODIS), currently operated aboard both the EOS Terra and Aqua spacecrafts, was launched on December 18, 1999 and May 04, 2002, respectively. This task supports the ongoing calibration and characterization of both MODIS sensors and the documentation of 18-plus years of on-orbit performance.

MODIS, a complex imaging radiometer, was designed for NASA's Earth Observing System to extend and enhance the global observations of several heritage sensors and to support the development of climate data records. It collects data in 36 spectral bands, covering wavelengths from 0.41 to 14.4μm. Observations are made at three different (nadir) spatial resolutions: 250m (bands 1-2), 500m (bands 3-7) and 1km (bands 8-36). In addition to improved spatial and spectral resolution, the MODIS calibration requirements are more stringent than those of its heritage sensors. Both Terra and Aqua MODIS went through extensive radiometric, spatial, and spectral calibration and characterization activities pre-launch. In order to enable continuous on-orbit characterization and calibration, the MODIS design includes a complete set of onboard calibrators.

The MODIS-calibrated and geo-located L1B data is the primary input for more than 40 products generated by the MODIS Science Team. It is critical to mission success that the L1B data is of the highest quality possible and that this quality is maintained for the life of the mission. The MODIS Calibration Support Team (MCST) has the responsibility for generating and maintaining the L1B algorithms and for monitoring sensor performance. It is important that the MCST efforts be documented in both the scientific literature and internal documents available to the MODIS users. This effort is not only important for the present and future user communities, it also serves as a critical input to follow-on sensors such as the NPOESS/VIIRS.

Accomplishments for FY 09-10

This past year, tasks were principally in the ongoing areas of sensor calibration and performance monitoring. Barnes supported the MCST at a calibration workshop in Greenbelt, MD, attended a MODIS Science Team meeting in Washington, DC (note: the GEST PI resides in Texas), participated in a workshop in Greenbelt on the performance and operation of the Aqua/MODIS cold focal-plane assembly (CFPA), and provided input during bi-weekly calibration teleconferences with the MODIS sensor Working Group (MsWG).

Objectives for FY 10-11

The MODIS calibration team plans to continue monitoring sensor performance and generating documentation to keep the user community abreast of the latest developments. Presentations and publications are being planned for the Optics and Photonics Symposium in San Diego and various international meetings.

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Hydrospheric and Biospheric Sciences
(Code 614x)

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Task 71: **NASA Terrestrial Ecosystems, Spectral Bio-Indicators of Ecosystem Photosynthetic Light Use Efficiency** *(Sponsor: E. Middleton)*

Investigator: Petya K. E. Campbell, Ph.D.

NASA Grant: **EO1-Hyperion: Data analysis and product generation, in support of future satellite missions**

Investigators: P. Campbell; E. Middleton and S. Ungar, Biospheric Sciences Branch, Laboratory for Terrestrial Physics, NASA/GSFC.

NASA Grant: **Spectral Bio-Indicators of Ecosystem Photosynthetic Efficiency**

Investigators: P. Campbell; E. Middleton, Biospheric Sciences Branch, Laboratory for Terrestrial Physics, NASA/GSFC.

Description of Research

With the changing climate, understanding the dynamics of ecosystem carbon uptake through seasonal changes and in response to environmental conditions such as water, temperature, and light and nutrient availability is critical (Sarmiento and Wofsy, 1999; Walther et al., 2002). Remote sensing offers a unique opportunity to monitor ecosystems at synoptic time and space scales through observation and to understand ecosystem carbon-related spectral responses. A measure of ecosystem carbon uptake is the photosynthetic light use efficiency (LUE), a ratio of the Gross Ecosystem Production (GEP) to the Absorbed Photosynthetically Active Radiation (APAR), or LUE = GEP/APAR. The distributions and compositions of ecosystems are largely regulated by environmental factors, such as temperature, water availability, nutrient accessibility, atmospheric CO_2, and sufficient sunlight. These factors have been studied in the context of particular questions, but the role of sunlight on the LUE of vegetation at all scales (leaf, plant, canopy, ecosystem), given that the other factors are sufficient/adequate, requires further studies.

The goal of the EO1 Hyperion study is to compare existing land cover products and suggest new ones, addressing vegetation type and function. Initiated in Spring 2007, this effort uses the only available space-borne spectrometer (EO1 Hyperion) to contribute to the comparisons of current data products that are generated by multiple and frequently disparate systems. Datasets and comparisons will be produced for core EOS sites and will be available for use in calibrating long-term data records for understanding climate dynamics and change. The development of new products assessing vegetation physiology would contribute toward the development of HyspIRI (Hyperspectral/IR Imagery) and GEO-CAPE (Geostationary Coastal and Air Pollution Events) missions.

Regarding the Spectral Bio-Indicators of Ecosystem Photosynthetic Efficiency, recent studies show that superior results can be achieved with narrow-band visible/near-infrared spectral reflectance analyses, as compared to results using traditional wide-band (>20 nm) reflectance, for remote assessment of vegetation type and condition. To plan for future hyperspectral satellites, new studies are critical to define the optimal narrow band information required for monitoring ecosystem health from space. With this research, high-spectral resolution reflectance data obtained for vegetation over a range of functional types, such as species, phenology, and stress conditions, are evaluated to establish which spectral algorithms perform rigorously with respect to the correlation to photosynthetic function and efficiency.

Accomplishments for FY 09-10

LUE

Previous studies at multiple sites found that the sunlit foliage fraction under relatively high solar irradiance levels typically displays short-term and reversible physiological stress that causes reduced LUE. In contrast, the shaded fraction, which is correlated to the total leaf area, maintains its LUE unless the high irradiance intensities are associated with unfavorably high temperatures or water deficits, although a large leaf volume in a canopy buffers these negative influences. For example, Campbell observed in a previous study that on sunny days the sunlit foliage fraction (top and outer leaves) had a daily average photosynthetic LUE that was approximately half that of the shaded foliage in a Douglas-fir forest in British Columbia, Canada. Additionally, the LUE for the “sunlit fraction” under diffuse or cloudy skies equaled that of the shaded fraction across the growing season in this forest. Similar trends were found in other sites, and in the researchers’ two nearby intensive study areas: a cornfield and a deciduous forest. They believe these observations have significant implications for ecosystem response to changing environments brought about by climate changes. There is a knowledge gap in describing the connection between canopy structure and physiological responses. The research will establish a robust approach in the use of spectral reflectance to detect vegetation physiological status, and will examine how structural properties of canopies affect the ecosystem responses to stress and their associated reflected signals.

EO1 Hyperion

The Photochemical Reflectance Index (PRI) utilizes reflectance at 531 nm as an indicator of high light (and related drought) stress, relative to a defined reference band. In a vegetation canopy, the sunlit foliage subset dominates the hotspot backscatter signal in remotely acquired directional spectral reflectance. The shaded canopy fraction is correlated with total leaf area index (LAI) in closed canopies, and defines the forward scatter in the cold spot’s spectral reflectance volume scatter signal. Under cloudy or highly diffuse skies, this partitioning is minimized or lacking, so that the LUE of upper and outer (most exposed) foliage is similar to that of foliage in the lower/inner canopy. To understand the dynamics of carbon uptake affecting LUE, the light environment and temperature per sector, and canopy structure must be considered.

Spectral Bio-Indicators of Ecosystem Photosynthetic Efficiency

Researchers are assembling reflectance data that have contemporaneous photosynthetic data from their various field measurement projects and through collaborations with other investigators. This dataset is supplemented by additional focused data collections; in particular, the reduction or enhancement in photosynthetic efficiency resulting from environmentally induced physiologic stress and nitrogen application is being characterized. They are also considering the impact of chlorophyll fluorescence contributing to the apparent red edge reflectance. Further evaluations are being performed on flux and environmental data provided by AmeriFlux collaborators, from tower sites representing a range of ecosystems. High performances of candidate spectral bio-indices, ascertained from an *a priori* list compiled from previous research, are being evaluated for remote sensing application at ecosystem scales at the AmeriFlux and intensive sites by 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. This project addresses a NASA program on plant functional types and physiology, and supports research to justify missions currently under development by several agencies, including NASA (Flora, from EO-1 Hyperion heritage) and the European Space Agency (FLEX, Fluorescence Explorer).

Objectives for FY 10-11

Campbell and her team endeavor to fully describe the interaction of physiology and structure for their two intensive study sites, as a bridge between their earlier prototype studies and future intensive studies to be conducted across a diverse range of ecosystems.

Additional goals include data analysis and product generation in support of future satellite missions, development of new demonstration Level 2 science products, as prototypes for HyspIRI; assisting with the collection/generation of an EO-1 archive of research Level 0, Level 1 and 2 data; producing 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.

The goal of the fluorescence research team is to evaluate existing and emerging fluorescence technologies for use in determining vegetation photosynthetic function and carbon/nitrogen cycling dynamics in plants exposed to environmental stresses linked to alterations in the global nitrogen cycle. As result from this effort, they expect to validate the use of active fluorescence for monitoring vegetation stress, and to demonstrate the use of passive fluorescence as an innovative remote sensing carbon sequestration monitoring capability.

An additional activity is anticipated toward the end of FY10. With Drs. Ungar and Middleton, Campbell is working on NOAA/NASA MOU for “Support for NOAA’s GOES-R calibration and validation in specific technical areas”, using EO-1 Hyperion data. NOAA’s GOES-R Calibration/Validation Working Group oversees the development and implementation of the cal/val of the GOES-R instruments. Its goal is to ensure that each instrument’s calibration is in compliance with its performance requirements, is referenced to recognized international standards, and conforms to “best” calibration/validation practices. Members of the working group consist of scientists from NOAA, NASA, NIST, and the instrument manufacturers.

GOES-R is NOAA's next-generation geostationary satellite with an improved Advanced Baseline Imager as the main payload. ABI has six reflective solar bands in the 0.4-2.5 mm spectral region, compared to one band for the current GOES Imager. Preliminary studies show that NASA's EO-1/Hyperion hyperspectral observations, which cover the same spectral range but with a much finer spectral resolution, are very useful for ABI calibration in characterizing the vicarious calibration targets, such as the deep convective clouds (DCC), the moon, and desert sites. Unfortunately, the Hyperion data are not acquired globally; therefore, special arrangements have to be made for such studies. In addition, the operational processing of Hyperion data is not optimized for calibration purposes, and the Hyperion sensor's impact on calibration have to be well understood.

Task 31: **MODIS Light Use Efficiency** ***(Sponsor: J. Ranson)***

Investigator: Forrest G. Hall, JCET; H. Margolis, PI of the major Canadian effort to study terrestrial ecosystems; Dr. Andy Black, Dr. Nicholas Coops and Thomas Hilker of the University of British Columbia; Dr. Caroline Nichole at the University of Edinburgh

NASA Grant: **Lidar and Passive Optical Project for Biophysical Parameter Estimation and Vegetation Photosynthetic Activity (NNX08AL55G)**

Investigator: Forrest G. Hall

Task 97: **DESDynI Mission Formulation Teams** ***(Sponsor: J. Masek)***

Investigator: Forrest G. Hall

Description of Research

Hall's research involves three general activities. The Light Use Efficiency effort is focused on the remote sensing of ecosystem primary production using multi-view angle narrow-band spectral sensors, specifically investigating the use of the Photochemical Reflectance Index to quantify vegetation light use efficiency. The effort is in collaboration with Dr. Nicholas Coops, Dr Thomas Hilker and Dr. Andy Black of the University of British Columbia and Dr. Caroline Nichole at the University of Edinburgh. A new satellite concept is being developed and a hardware build proposed. This effort would also expand previous light use efficiency work on MODIS to produce regional light use efficiency maps.

The focus of the Lidar and Passive Optical activity is to use lidar, hyperspectral and multi-angle passive optical data to infer the 3-D structure and biophysical properties of vegetation. Lidar gives tree height and foliage vertical profile, and multi-angle and hyperspectral data provide crown diameter to height ratio, ground cover tree density and mean crown diameter. Hall is working in collaboration with Ranga Myneni and Yuri Knyazikhin of Boston University.

Regarding his third activity, Hall is collaborating with the DESDynI mission formulation group, developing DESDynI mission requirements and participating in mission design exercises, including OSSEs and coordinating the field campaign to develop and evaluate DESDynI technology and algorithms.

Accomplishments in FY 09-10

MODIS BIOPHYS

The development of an algorithm to retrieve biophysical parameters continues as does testing and validation for both Landsat and MODIS data (Soenen *et al.*, 2009; Peddle *et* *al*., 2010). A proposal to the NASA TE program has been submitted to extend this algorithm to include Radar data sets from the PALS sensor aboard ALOS. A second proposal has been submitted to use the MODIS algorithm to produce regional light use efficiency data sets.

Vegetation Light Use Efficiency
Hall's research team has demonstrated from tower and from a space-borne sensor that multi-view angle remote sensing can retrieve vegetation light use efficiency and gross primary production across vastly different biomes, climate zones and years. One publication is in review in *Remote Sensing of Environment* and another in preparation for submission to *Nature*. An Instrument Incubator Program Proposal (PI: Compton Tucker, GSFC) has been submitted to build a prototype instrument capable of making these new measurements, eventually from space.

DESDynI Mission Formulation Teams
Hall participated in regular teleconferences and meetings with the DESDynI team to define mission science requirements, in support of global measurements of vegetation 3-D structure for global biomass surveys, forest disturbance and recovery to estimate global land carbon flux, and for habitability and biodiversity surveys. The JCET PI continues to serve as co-editor on two special issues for DESDynI, one for *JGR* and the other for *RSE*. In addition, he has submitted to *RSE* a DESDynI measurement requirements paper articulating the measurement requirements, science justification and technology state of the art (Hall *et al*., in preparation). He has also co-authored two other DESDynI papers (Shugart *et al*., in press, Houghton *et al.,* 2010)

Objectives for FY 10-11
The three main activities for FY11 will be the continuation of algorithm development for biophysical variable retrievals and development of the DESDynI mission. The focus of this new effort is to include lidar data, along with multi-angle MISR data and hyperspectral data, to improve the retrievals of vegetation biophysical parameters. Hall has been funded by the GSFC mission formulation team to support the development of the DESDynI mission. Additionally, in 2010, he will be assuming the role of Manager of the GSFC Carbon Office, coordinating and representing carbon research at GSFC.

Task 79: 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: J. Ranson)*

Investigators: K. F. Huemmrich, Research Assistant Professor, JCET; E. Middleton, PI, GSFC 614.1; P. Entcheva-Campbell, JCET; C. Daughtry, USDA/ARS; G. Parker, Smithsonian Environmental Research Center; L. Corp, Sigma Space Corp.

Description of Research

The focus of this research is to develop methods of using multispectral and hyperspectral remote sensing data of landscapes to determine biophysical characteristics of vegetation, and to link those characteristics to carbon fluxes, plant growth, biodiversity, and disturbance. This work includes studies of data from a variety of ecosystems, including boreal forests, arctic tundra, cropland, prairie, and temperate forests. Reflectances can be simulated with canopy reflectance models that take vegetation structural information (*e.g.* leaf area index and tree crown shape) and optical properties (*e.g.* leaf spectral reflectance and transmittance) and use them to calculate the observed reflectance for a given viewing direction and solar illumination conditions. Model results provide a physical basis to infer biophysical characteristics of vegetation.

Hyperspectral and narrow-band multispectral data can detect changes in apparent leaf spectral reflectance associated with plant stress. Combining reflectance data with measurements of carbon flux provides the opportunity to see if these stress effects can be observed and utilized to monitor ecosystem carbon exchange. Measurements made at a leaf level are used in models that merge canopy reflectance with photosynthesis models to develop relationships linking spectral reflectance and carbon, water, and energy fluxes. These relationships are also explored at a canopy level by 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, Aqua, and Terra satellites.

Accomplishments for FY 09-10

Studies using ground- and satellite-based observations for a number of different ecosystem types are being performed to examine 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 sensor on the EO-1 satellite and narrow MODIS spectral bands intended for ocean studies over land. The researchers' work has shown that an index using two narrow spectral bands is related to the light use efficiency, the rate of carbon dioxide taken up by plants for photosynthesis per unit of light absorbed by the canopy. However, they have also found that the amount of shadows in the sensor's field of view can affect the interpretation of the reflectance index and that different vegetation types have different spectral response patterns.

To further examine vegetation spectral reflectance changes associated with stress in a more detailed manner, field experiments were conducted where the researchers measured leaf-level reflectance and carbon exchange in conjunction with measurements of whole canopy reflectance and carbon exchange. This fieldwork is being performed on tulip poplar trees and in a cornfield in conjunction with Smithsonian and Department of Agriculture scientists. Hyperspectral reflectance data has been collected at multiple times diurnally in a cornfield, and these observations were 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 corn. To measure at multiple levels in the tulip poplar forest, researchers ascend to the canopy level in a basket suspended from a crane. These studies have shown that canopy structure is important in determining the light environment of plant canopies, and affects the overall productivity of vegetation and the manner in which it responds to stress conditions.

In addition to conducting the research described above, Huemmrich is presently on the committees for five PhD students: two in the Forestry Department at Virginia Tech, one in the Geography Department at UMCP, one at the University of Idaho, and one in the Forestry Department at Laval University.

Objectives for FY 10-11

Huemmrich plans to continue to work on the remote sensing of plant stress. He also expects to publish an analysis on 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. His research team will 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.

His work will continue on the development of research activities on monitoring high latitude ecosystem change. Also, Huemmrich will examine the use of high temporal frequency reflectance data in describing vegetation seasonality and temporal patterns of carbon flux.

Heliophysics & Solar System Divisions (Code 660-699)

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NASA Grant:	**Topography Data on Mars: Optimizing its Collection and Application Using Laser Scanning (NNX08AT15G)**
World Bank Grant:	**Vilcanota Valley Slope Monitoring for Flash Floods and Other Natural Hazards (0000002683)**
Investigator:	Mark Bulmer, Research Associate Professor, Geography and Environmental Systems

Description of Research

Bulmer's research includes remote sensing applications to the Earth, terrestrial planets and icy satellites; mechanics and landslide hazard and risk assessment; integrating spaceborne, airborne, surface and sub-surface data; configuring Unmanned Aerial Vehicles (fixed wing, rotor and lighter-than-air) and sensors (cameras), and designing data collection devices. In addition, he is involved in Resilience Planning and has provided assistance during civil emergencies. He has taught undergraduate classes including 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 09-10

TOPOGRAPHY DATA ON MARS: OPTIMIZING ITS COLLECTION AND APPLICATION USING LASER SCANNING – NASA Mars Fundamental Research Program

In Year 2 of this grant, the project team has continued to make advances in their ability to identify the optimal collection parameters, analytical protocols, and supplemental data needed to resolve features on a terrestrial rocky surface. A particular focus this year has been on gaining greater understanding of the characteristics of blocky lava flows. In addition, the researchers' thinking about future missions to Mars and other bodies, considering topographic sensors, has been informed by involvement in responses to natural disasters, such as the earthquakes in Haiti and Chile, which they have conceived as proxies for Mars missions. They have provided input and recommendations to the emergency management community regarding the value of obtaining and utilizing topography data at meter to sub-meter scales. In-line with what they proposed using Mars data, Bulmer and his team have been able to demonstrate the potential of laser scanning-derived topography to substantially increase the interpretation of high-resolution images. Presentations on topography collection, analysis and dissemination have been given in expert and non-expert academic, government and commercial forums. Due to the amount of laser scanning work now being carried out by European research groups, Bulmer and his researchers presented project findings at the 2010 European Geophysical Union (EGU) Conference. Manuscripts submitted in Year 2 address issues related to characteristics of surface structures on blocky lava flows, handling of laser points clouds and digital elevation model generation, and bridging the gap between expert systems and non-expert decision makers. A variety of reports have been written predominantly focused on the utility of topography data.

VILCANOTA VALLEY SLOPE MONITORING FOR FLASH FLOOD PREVENTION - World Bank
In July 2009, the GFLO team submitted a second report to The World Bank that laid out the GFLO team's evaluation of a number of candidate early warning technologies that had been undertaken during the second mission. Based upon their field experiences, the report contained a series of technical studies to define the recommended approaches to further develop a permanent warning system in MPP. In preparation for Mission Three, a digital elevation model (DEM) with a 30 m posting was generated by Bulmer, using bands 3N (nadir-viewing) and 3B (backward-viewing) of an ASTER Level 1-A image acquired in the Visible Near Infrared (VNIR), which was used to generate a series of improved resolution derivative products over MPP. One of the challenges identified during the second mission was how the MPP Municipality could access and display geospatial data, such as those the researchers have compiled in the remote sensing archive. Bulmer examined how datasets could be displayed in Google Earth software, and was successful when the raster image (*e.g.* topography) files were converted into .KML, thus allowing them to be displayed. These experiments have demonstrated that the MPP Municipality could display geospatial data using Google Earth software, which they can obtain at no cost. Bulmer was invited to present at the 2010 EGU Conference in a session entitled “Warning Systems for Natural and Man-Made Hazards”. A manuscript submitted to the *Journal of Natural Hazards and Earth System Science* is in review. A variety of reports have been written predominantly focused on bridging the gap between expert warning systems and non-expert decision makers.

Objectives for FY 10-11
Proposals will be submitted to NASA Mars Data Analysis and Army Research Programs related to the manipulations of point cloud data.

III. Supporting Information

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III.1 References

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Olson, W. S., T. S. L'Ecuyer, M. Grecu, and M. Bosilovich (2009), Atmospheric Diabatic Heating Distributions Derived from a Combination of Satellite Sensor Data, AGU Fall Meeting, San Francisco, CA, Dec 14-18.

Pappalardo, G. and R. M. Hoff (2010), GALION Observations of the Eyafjoll Volcanic Plume, AEROCENTER GSFC, Greenbelt, MD, May.

Pickering, K., R. Pinder, A. Prados, E. Celarier, J. Gleason (2009), Use of OMI Data in Monitoring Air Quality Changes Resulting from NOx Emission Regulations over the United States, *Community Modeling and Analysis System Annual Conference*, Chapel Hill, NC, Oct 19-21.

Pounder, N. L., R. J. Hogan, and T. Várnai (2010), Cloud retrievals exploiting multiple scattered lidar returns, AMS 13th Conference on Atmospheric Radiation, Portland, OR, June 28-July 2.

Prados, A. I., R. Kleidman, and S. Christopher (2009), Applied Air Quality Remote Sensing Trainings, NASA Applied Science Air Quality Team Meeting, Washington, DC, Oct 27-29.

Prados, A. I., R. Kleidman, and S. Christopher (2010), Training Workshops on Use of NASA Data and Tools for Air Quality Applications, Federation of Earth Science Information Partners, Winter Meeting, Washington, DC, Jan 5-7.

Sawamura, P., R. Delgado, R. M. Hoff (2010), Demonstration for Data Exclusion Component North Carolina Exceptional Events – June 2008: Satellite Component, Quarterly RAMMPP Meeting, Maryland Department of the Environment, Baltimore, MD, June.

Trahan, S., L. C. Sparling, V. Tallapragada, S. A. Braun, and J. Halverson (2010), Statistical comparison of scales and spatial distributions of convection in observational data and simulated hurricanes, AMS 29th Conference on Hurricanes and Tropical Meteorology, Tucson, AZ, May 10-14.

Várnai, T. (2009), Three-dimensional phenomena in satellite observations of clouds, The Days of Meteorology—A symposium organized by the Hungarian Meteorological Service on behalf of the Hungarian Academy of Science, Budapest, Hungary, Nov 19-20.

Várnai, T., and J. Y. Harrington (2010), Statistics and parameterization of shortwave horizontal photon transport effects, 1st ASR Science Team Meeting, Bethesda, MD, Mar 15-18.

Várnai, T., A. Marshak, W. Yang, and G. Wen (2010), Aerosol properties near clouds: Insights from MODIS and CALIPSO observations, AMS 13th Conference on Atmospheric Radiation, Portland, OR, June 28-July 2.

Várnai, T., and A. Marshak (2009), MODIS Observations of 3-D Radiative Effects in Clear Areas Near Clouds, MOCA-09 conference co-sponsored by the International Assoc. of Meteorology and Atmospheric Sciences (IAMAS), Montreal, Canada, July 19-29.

Várnai, T., and A. Marshak (2010), Statistics of MODIS radiances and CALIPSO backscatter in clear areas near clouds, MODIS-VIIRS Science Team Meeting, Washington, DC, Jan 26-27.

Várnai, T., and J. Y. Harrington (2010), Multiyear statistics and parameterization of 2-D shortwave radiative effects at three ARM Climate Research Facility sites, AMS 13th Conference on Atmospheric Radiation, Portland, OR, June 28-July 2.

Várnai, T., and J. Y. Harrington (2009), Statistical behavior of 2-D solar radiative effects over two ARM sites, ARM Radiative Processes Working Group Meeting,

Boulder, CO, Sept 15-18.

Venema, V., R. Lindau, T. Várnai, and C. Simmers (2009), Combining surrogate clouds with geostatistics to ease the comparisons of point radiation measurements with cloud measurements, ISTP8 Conference, Delft, The Netherlands, Oct 18-23.

Venema, V., R. Lindau, T. Várnai, and C. Simmer (2010), Two new algorithms to combine kriging with stochastic modeling, EGU General Assembly 2010, Vienna, Austria, May 2-7.

Venema, V., R. Lindau, T. Várnai, and C. Simmer (2010), Two new algorithms to combine kriging with stochastic modeling, AMS 13th Conference on Atmospheric Radiation, Portland, OR, June 28-July 2.

Warner, J., *et al.* (2009), Tropospheric CO Differences Between Two Minimization Methods and Validations, AIRS science team meeting, Greenbelt, MD, Oct 13-16.

Warner, J., *et al.* (2009), Improved AIRS CO products Using Optimal Estimation and Validation with ARCTAS Spring Measurements, AGU Fall Meeting, San Francisco, CA, Dec 14-18.

Warner, J., *et al.* (2010), An alternative AIRS CO algorithm, AIRS Spring Meeting, Pasadena, CA, Apr 21-23.

Wen, G., A. Marshak, T. Várnai, R. F. Cahalan, L. A. Remer, and S. Mattoo (2010), Application of CERES observations to correction of MODIS aerosol optical thickness in the vicinity of cloud: a case study over the SGP site of the ARM program, AMS 13th Conference on Atmospheric Radiation, Portland, OR, June 28-July 2.

Wicks-Kollonige, D., W.W. McMillan, L. C. Sparling, S. Trahan, R. M. Hoff (2010), Study of the Spatial and Temporal Variability of Stratosphere-Troposphere Exchange with A-Train Observations, NOAA CREST External Advisory Board Meeting, City College of New York, New York, NY, May.

Wilson, R.C., R. Delgado, W. W. McMillan, R. M. Hoff (2010), Atmospheric Remote Sensing at UMBC: A PBL Study, 1st District of Columbia-American Meteorological Society Chapter Meeting, Howard University, Washington DC, February.

Yang, W., A. Marshak, and T. Várnai (2010), Some issues of using CALIPSO data to study the backscattering properties of aerosol in the vicinity of clouds, AMS 13th Conference on Atmospheric Radiation, Portland, OR, June 28-July 2.

Yuan, T., L. A. Remer, J.V. Martins, and Z. Li (2009), Aerosol effects on convective clouds, NASA AEROCOM, Princeton, NJ, Oct 5-7.

Yuan, T. (2009), Aerosol effects on convective clouds: mechanisms and regimes, MOCA IAMAS Joint Assembly, Montreal, Canada, July 19-24.

Yuan, T. (2009), Estimating glaciation temperature from passive measurements, MOCA IAMAS Joint Assembly, Montreal, Canada, July 19-24.

Yuan, T. (2009), Overshooting clouds as observed by A-Train with physical relationship and their statistics, MOCA IAMAS Joint Assembly, Montreal, Canada, July 19-24.

Yuan, T., L. A. Remer, J. Fan, J. V. Martins, and Z.Li (2009), Aerosol effects on convective clouds: regimes and mechanisms, GRC on Radiation and Climate, New London, NH, July 5-10.

Yuan, T., L. A. Remer, K.E. Pickering, H. Yu (2009), Aerosol-cloud-lightning interactions and their consequences in atmospheric chemistry, AGU Fall meeting, San Francisco, CA, Dec 14-18.

Yuan, T., L.A. Remer, K.E. Pickering, H. Yu (2010), Aerosol-cloud-lightning interactions and their consequences in atmospheric chemistry, AMS cloud physics and radiation joint conference, Portland, OR.

Yurganov, L., W. McMillan, C. Wilson, M. Fischer, S. Biraud, P. C. Novelli (2009), Retrieval of CO Mixing Ratios From the Atmospheric Emission Spectra of Down-Welling Middle IR Radiance in Oklahoma, *Eos Trans. AGU, 90*(22), Jt. Assem. Suppl., Abstract A11C-06.

Yurganov, L., W. McMillan, E. Grechko, and A. Dzhola (2009), Anomalies of CO Global and Regional Burdens Measured by Satellites: Update to Present Time, *Eos Trans. AGU, 90*(22), Jt. Assem. Suppl., Abstract B73B-09.

Zhang, H., A. Lyapustin, Y. Wang, S. Kondragunta, I. Laszlo, P. Ciren, R. M. Hoff, (2010), Development of a Multi-angle Aerosol Optical Depth Retrieval Algorithm for current GOES, GOES-R Algorithm Working Group Risk Reduction Review 2010 Meeting, Madison, WI, June 7-11.

Zhang, H., R. M. Hoff, and S. Kondragunta (2009), Development of IDEA product for GOES-R aerosol data, *Proc. SPIE*, 7456, 74560O, doi:10.1117/12.828095, San Diego, CA, Aug 2-6.

Zhang, H., R. M. Hoff, and S. Kondragunta (2009) Estimating $PM_{2.5}$ using MODIS and GOES aerosol optical depth retrievals in IDEA, 6th GOES Users Conference, Madison, WI, Nov 3-5.

Zhang, H., A. Lyapustin, Y. Wang, S. Kondragunta, and I. Laszlo (2009), A Multi-angle Aerosol Optical Depth Retrieval Algorithm for GOES, 6th GOES Users' Conference, Madison, WI, Nov 3-5.

Zhang, H., A. Lyapustin, Y. Wang, S. Kondragunta, and I. Laszlo (2009), A Multi-angle Aerosol Optical Depth Retrieval (AOD) Algorithm for GOES, AGU Fall Meeting, San Francisco, CA, Dec 14-18.

Zhu, L., V. Martins, and L. Remer (2009), Aerosol absorption measurements with MODIS, AGU Fall Meeting, San Francisco, CA, Dec 14-18.

Zhu, L., V. Martins, and L. Remer (2010), Aerosol absorption measurements with MODIS, MODIS Science Team meeting, Washington, DC, January.

III.5 Courses Taught

ENME 489: *Special Topics in Mechanical Engineering* — Selected topics of current importance in mechanical engineering. (Taught by W. Jiang, Fall 2009)

GES 311: *Weather and Climate* — The 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 though class web page, http://userpages.umbc.edu/~tokay. (Taught by A. Tokay, Fall 2009)

PHYS 122H: *Introductory Physics II: honor session discussions* — This course emphasizes electricity, magnetism, heat and thermodynamics. Topics include Coulomb's law, Gauss's law, electric fields and electric potential, currents, simple circuits and Kirchhoff's laws, generation of magnetic fields by charges in motion, electromagnetic induction, magnetic materials, oscillatory circuits, temperature, heat and the laws of thermodynamics. (Taught by J. V. Martins, Spring 2010)

PHYS 224: *Physics of Waves* — This course emphasizes vibrations, wave motion and optics. Topics include mathematical characterization of vibrations and waves, sound, superposition of standing waves, geometrical and physical optics, diffraction, interference and polarization of light. (Taught by S. Desouza-Machado, Fall 2009 and Spring 2010)

PHYS 303: *Thermal and Statistical Physics* — Thermodynamic description of systems and statistical interpretation of thermodynamic quantities. The first and second laws of physics, temperature, entropy and thermodynamics, and their relationship to a statistical description of many-particle systems. Applications to magnetic systems, gases and liquids and radiation are discussed. (Taught by K. McCann, Fall 2009)

PHYS 602: *Atmospheric Physics II* — The following topics were covered: Fundamentals of drop size distribution and measurement techniques of individual raindrops and snowflakes, and bulk rainfall at the ground. (Taught by K. McCann, Fall 2009)

PHYS 602: *Atmospheric Physics II* — The following topics were covered: Fundamentals of drop size distribution and measurement techniques of individual raindrops and snowflakes, and bulk rainfall at the ground. (Guest Lecturer A. Tokay, Spring 2010)

PHYS 622: *Atmospheric Physics II* — This course covers properties of aerosols and cloud particles, and their evolution in the atmosphere. The radiation component covers Beer's law; description of molecular absorption; Rayleigh and Mie scattering; simple solutions to the radiative transfer equation, and other selected topics, time permitting (*e.g.*, atmospheric electricity, climatology, atmospheric chemistry). The lectures also covered the impact of aerosols, clouds, and radiation on climate and weather. (Co-Taught by J. V. Martins and T. Varnai, Spring 2010)

PHYS 721: *Atmospheric Radiative Transfer* — This course introduces the student to formal radiative transfer theory, which is quickly simplified for application to Earth's atmosphere. The physical processes, which contribute to absorption and scattering in Earth's atmosphere, are examined. Topics include molecular absorption via vibration-rotation transitions and spectral line formation in homogeneous atmospheres. Rayleigh 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 Earth and implications for weather and climate are also examined. (Taught by J. V. Martins, Fall 2009)

PHYS 722: *Atmospheric Remote Sensing* — This course discusses the fundamentals of radiative transfer as applied to remote sensing and includes an 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 by C. Chiu, Spring 2010).

UMBC Remote Sensing Training Courses (NGC):

Remote Sensing Overview: Introduction to remote sensing, definitions, inverse theory, and overview of methods for remote sensing at commonly used wavelengths.

Physics Fundamentals for Remote Sensing: Introduction to the physics of remote sensing, focus on radiative transfer through materials, sources and sinks of electromagnetic radiation.

Atmospheric Sensing: Microwave: Microwave remote sensing, both active and passive, of the atmosphere. Discusses features unique to microwave radiation and its interaction with the atmosphere and constituents. (All taught by B. Johnson, Spring 2010).

III.6 Colloquia and Seminars

Bulmer, M., Water Scarcity and Hydro Politics, South Asia, RUSI, 15 July 2010.

Bulmer, M., DRAC Conference, Bovington, 29-30 March 2010.

Bulmer, M., European Geosciences Union, Vienna, Austria, 2-7 May 2010.

Bulmer, M., Natural Hazards. 21 Century Challenges. Royal Geographical Society with the Institute of British Geographers, 25 May 2010.

Bulmer, M., The Risks and Opportunities of Armies Delivering Aid, International Rescue Committee. Royal Geographic Society with the Institute of British Geographers,14 June 2010.

Bulmer, M., The Future Defense Review: Time for Trade-Offs –The Strategic Defense and Security Review 2010. RUSI Whitehall, London,14 June 2010.

Bulmer, M., Exercise BURGAS - G10 Summit Resilience Exercise 09, Headquarters 143 (West Midlands) Brigade, Copthorne Barracks, 1-2 November 2009.

Bulmer, M., Exercise White Water. Testing the South Staffordshire Emergency Flood Plan, Headquarters 143 (West Midlands) Brigade, 2-4 November 2009.

Bulmer, M., Technical assistance on geohazard briefing for UK deployment in response to the 12 January 2010 Haitian Earthquake, Response to UK Ministry of Defense and Department for International Development.

Bulmer, M., Technical advice on the use of high-resolution topography to assist in the sighting of internally displaced peoples (IDP) camps in Haiti after the 12 January, 2010 Earthquake, Response to USACE and NGA.

Bulmer, M., Embassy of Chile, London, Response to request for technical expertise after the Magnitude 8.8 earthquake, 27 February 2010.

Bulmer, M., Short Brief on Eyjafjöll, Iceland, pp.2, Correspondence with Military Support and Stabilization Group, UK Ministry of Defense, 16 April 2010.

Bulmer, M., Geo expertise to an UNDAC deployment to the Hunza Valley, Correspondence with United Nations Disaster Assessment and Coordination *(*UNDAC*)* team, 27 May 2010.

Bulmer, M., Flooding in South Asia. Correspondence with Response to UK Ministry of Defense and D Department for International Development, 8 Aug 2010.

Campbell, P., Bi-weekly science meetings, conducted for discussions, coordination of data processing and analyses activities.

Campbell, P., Attended bi-weekly EO1-Hyperion Working Group meetings.

Campbell, P., Attendance/presentation at Hyperspectral Workshop, Frascati, Italy.

Campbell,, P., Hyperspectral Symposium, NASA/GSFC.

Campbell, P., Attendance of the CEOS/WGCV meeting at NIST, Plenary meeting.

Campbell, P., Hyperspectral Infrared Imager (HyspIRI) Science Workshop, Pasadena, CA.

Dolgos, G., In Situ Phase Matrix Measurements, Annual Doctoral Student Review (2010), presented at UMBC to preliminary committee members: Dr. Brian Cairns, Dr. Raymond M. Hoff, Dr. J. Vanderlei Martins, Dr. Todd Pittman, Baltimore, MD, 5 May.

Hall, F. G., Howard County Legacy Leadership Institute: The Global Carbon Cycle, GSFC Visitor Center, Jan 28, 2010.

Hall, F. G., The world view from Newton to Einstein, Seminar to the Montgomery College Round Table, March 4, 2010.

Hall, F. G., Cosmos and Consciousness – Seminar at Baltimore Community College, Dec 9, 2009.

Hall, F. G., Cosmos and Consciousness – Seminar at JHU Homewood, Dec 10, 2009.

Hall, F. G., Remote Sensing and the Carbon Cycle: GSFC Summer Fellow Series, Invited

Kundu, P., Rainfall: A statistical conundrum, Johns Hopkins University, Applied Physics Laboratory, May 11, 2010.

Martins, J. V., A look on the future of clouds and aerosols measurements. Invited talk presented at the Weizmann Institute, Rehovot, Israel.

Yuan, T., Torture EOS and related data products in sync to investigate aerosol-cloud-chemistry interconnections, NASA GSFC AEROCENTER, 2009.

Yuan, T., Aerosols, deep convective clouds, and atmospheric chemistry, NASA GISS, 2009.

Yuan, T., Aerosol-cloud-chemistry interactions as observed from space, NOAA ESRL Chemical Sciences Division (CSD), 2009.

Tangborn, A., Wavelets in time series analysis, Lectures in METEO 630 class, Department of Meteorology, University of Maryland, College Park, May 9, 2010.

Warner, J. X., Tropospheric CO Differences Between Two Minimization Methods and Between EOS Sensors, Department of Earth and Planetary Sciences and School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, May 14, 2010.

III.7 Proposals Submitted by JCET Members

(primary sort alphabetical by funding agency, then proposal title)

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
Aerosol modulating tropical convection: A missing link in tropical dynamics and climate modeling?	DOE		Várnai	Pending
Airborne Open Polar/Imaging Nephelometer for Ice Particles in Cirrus Clouds and Aerosols	DOE	Martins		Awarded
Characterization of 3D cloud variability, and the analysis and parameterization of its radiative impacts	DOE	Várnai		Pending
Dominant Role of Wind shear in aerosol-deep convective cloud interactions: ASR based observational and modeling study	DOE	Yuan		Pending
Evaluate and Improve Representation of Aerosol-Cloud Interactions in a GCM with ASR Observational Data	DOE		Yuan	Pending
Laboratory studies of the interaction between aerosol/cloud droplets/ ice/thermodynamics and its modeling implications	DOE	Martins		Pending
Vertical profiles of aerosol microphysical properties from ARM data: improving aerosol and CCN predictions in global models	DOE		Yuan	Pending
Air Quality Information Systems and GEOSS	GEO Earth Observations in Decisions Support Projects		Prados	Pending

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
Use of Earth Observations to Build Capacity for Air Quality Decision Support in the Middle East and Europe	Group on Earth Observations (GEO) Earth Observations in Decisions Support Projects		Prados	Pending
A Combined Satellite Radar-Radiometer Precipitation Algorithm for TRMM and GPM, Based upon Ensemble Filtering	NASA	Grecu (GEST)	Olson; Tian (GEST)	Awarded
A multi-spectral approach to evaluating the response of deep organized convection to aerosols	NASA		Yuan	Pending
Active and Passive Microwave Properties of Mixed-Phase Precipitation Particles	NASA	Johnson		Pending
Aerosol Optical-Physical-Chemical Models from Remote Sensing and Spectral Absorption In Situ Measurements	NASA		Martins	Not funded
Analyzing Tropospheric CO data Records from AIRS and IASI	NASA	Warner		Pending
Aqua and Terra MODIS New Data Products for fAPARchl	NASA		Huemmrich	Pending
Assimilation of CO from AIRS, MOPITT and other instruments for estimating and reducing instrument and model biases	NASA	Tangborn	Warner, Ott (GEST)	Pending
Comprehensive framework for development of aerosol/cloud retrieval algorithms for advanced sensors	NASA		Martins	Pending

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
Construction of the Next Generation UV/VNIR/SWIR wide FOV, Hyperangular Imaging Polarimeter for Aircraft and Space Applications	NASA	Martins		Pending
Correction of lidar altimetry data for range delay due to the effects of cloud forward scattering and snow-ice penetration	NASA		Várnai	Pending
Detailed aerosol characterization and estimates of direct forcing from combination of Glory-APS, MODIS, CALIPSO and ground-based observations	NASA		Martins	Awarded
Effect of aerosol and land use changes on clouds and precipitation in the Amazon	NASA	Martins		Pending
Extending the Vertical Dimension of Air Quality Studies	NASA		Zhang	Pending
Improved Ice and Mixed-Phase Precipitation Models for Combined Radar-Radiometer Retrieval Algorithm Applications	NASA	Olson	Johnson; Grecu and Tian (GEST)	Awarded
Integrated multi-sensor approach to improve CO, Ozone, and Water Vapor profile retrievals in the UTLS region using AIRS and Aura Limb Sounder data	NASA	Warner		Pending
Interactions between tropical biomass burning, clouds, precipitation and land use changes on a regional scale	NASA		Martins	Not funded
Investigation of aerosol effects on clouds using CALIOP-MODIS joint retrieval over ocean	NASA		Martins	Not funded

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
Microphysical and Radiative Properties of Midlatitude Cirrus: Modeling and Observation	NASA		Várnai	Not Funded
MODIS aerosol properties in the vicinity of clouds	NASA		Várnai	Pending
NASA Satellite Training Activities	NASA		Prados	Awarded
New Global Measurements of Tropospheric NH3 and HDO from AIRS	NASA	Warner	Strow	Pending
Novel Strategies for Exploiting MOPITT, Observations of Methane	NASA		Warner	Pending
Observing system simulation experiments to optimize the assimilation of high resolution co2 measurements from space	NASA	Ott (GEST)	Tangborn	Pending
Optimizing Major Sources and Sinks of Tropospheric Anthropogenic Aerosols in an Aerosol-Climate Model	NASA		Martins	Not funded
Retrieval Algorithm Development for Falling Snow Detection and Estimation over Land	NASA		Johnson	Awarded
Retrievals of Precipitating Snow Using CloudSat Reflectivities and High Frequency Brightness Temperatures	NASA		Johnson	Awarded
Studying Land Cover Through Spectral Dynamics in The Anthropogenic Biosphere	NASA	Huemmrich		Pending
Toward a Global Atmospheric Diabatic Heating Product from Aqua Observations	NASA		Olson; Grecu (GEST)	Pending

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
Transitioning the PACS imaging polarimeter to the ER-2 aircraft for the ACE Decadal Survey mission	NASA	Remer	Martins	Not Funded
Use of CALIPSO in understanding the effect of clouds on aerosol properties and interpreting MODIS aerosol observations near clouds	NASA		Várnai	Awarded
Using Terra and Aqua MODIS Cloud Product to Constrain and Improve Moist Convection Parameterization	NASA	Yuan	Martins	Pending
Training Future Women Scientists in Climate Research using NASA Earth Science Data	NASA Global Climate Change Education Program	Mehta	Kostis (GEST)	Not Funded
CLOUDSAT Technology Development & Implementation	NASA GSFC	Sparr	Martins	Pending
Continuation of the ACE/PACS polarimeter effort for field measurements	NASA GSFC	Remer	Martins	Pending
On-board calibration system for the ACE/PACS polarimeter	NASA GSFC	Remer	Martins	Awarded
Proposal for 6U CloudCubesat instrument	NASA GSFC	Remer	Martins	Awarded
Direct Measurement of Global Photosynthesis from Space Technology Development and Airborne Demonstration	NASA Instrument Incubator Program		Hall; Lyapustin (GEST)	Pending
Solar Excited Chlorophyll Fluorescence System for the Assessment of Vegetation Photosynthetic Function	NASA IRAD		Campbell	Pending
The LACO/UMBC Polarized Imaging Nephelometer (PI-Neph)	NASA Langley	Martins	Dolgos	Awarded

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
Quantifying particle size distributions in support of GPM combined precipitation retrieval algorithms	NASA MSFC		Tokay	Awarded
Assessing ecosystem sustainability and urban boundaries using surface reflectance and emissivity at varying spectral and spatial scales	NASA ROSES	Campbell		Pending
Assessment/Cross-comparison of Global Land Cover Products, Generated by Multiple Satellite Sensors	NASA ROSES	Campbell		Pending
Improved ground validation rain estimates at Kwajalein, RMI and Melbourne, Florida for comparison and validation to TRMM and Other Satellite Estimates	NASA ROSES		Tokay	Awarded
Measurements of the hydrometeors size distribution through surface based instruments	NASA ROSES	Tokay		Awarded
Spectral bio-indicators of ecosystem photosynthetic efficiency II: Synthesis and integration	NASA ROSES		Huemmrich, Campbell; Q. Zhang (GEST)	Awarded
Statistical error model of satellite and ground-based rain rate estimates for validation of GPM rainfall products	NASA ROSES	Kundu		Not Funded
Diagnosing Moisture, Clouds, and Dust Characteristics Associated with Mediterranean Rain Systems using AIRS and MODIS Retrieval Products from the Aqua Satellite	NASA Terra-Aqua	Mehta	Desousa-Machado; Reale (GEST)	Pending

Proposal Title	Funding Agency	PI (JCET)	CO-I(s) (JCET)	Status
Mapping Ecosystem Light Use Efficiency Using Aqua and Terra MODIS Data	NASA Terra-Aqua	Huemmrich		Pending
Multi-Sensor Retrieval of Vegetation 3-D Structure and Biomass using Physically-Based Algorithms	NASA Terra-Aqua	Hall		Pending
A Model for NASA Satellite Air Quality Applications in Developing Countries	NASA-ROSES	Prados		Pending
Alternate Algorithm Development of GOES AOD Retrievals	NOAA	Zhang		Awarded
Predictability and Prediction of Decadal Climate and its Societal Impacts in the Missouri River Basin with Climate, Hydrologic, and Crop Yield Earth System and Economic Land Use Models	NSF		Mehta	Pending

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III.8 Biographies

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 as 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.

Dr. Mark Bulmer is a Research Associate Professor in the Joint Center for Earth Systems Technology affiliated with the UMBC Department of Geography and Environmental Sciences. He is an Adjunct Associate Professor of Geology at University of Buffalo, SUNY, a Visiting Scientist at the Smithsonian Institute, and an Associate Fellow at the Royal United Services Institute. He has 15 years of experience in pure and applied fields of geology, remote sensing, GIS plus instrument design. I am an expert in geophysical flows combining field-derived measurements with remotely sensed data. I have 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. I have worked in 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. UNHCR, DFID/UKAID, USAID, World Bank) and non-government organizations (e.g. Red Cross, Oxfam, CRS, MercyCorps). After the 2005 Pakistan earthquake I worked with the Geological Survey of Pakistan in Kashmir and NWFP to identify landslide prone areas. I have installed prototype hazard monitoring systems on the Hubbard Glacier, Alaska, around Muzaffarabad, Pakistan and in the Peruvian rain forest. I have an on-going collaboration with emergency medical teams to examine the nature and survivability of injuries sustained in landslide disasters. I have taught undergraduate and graduate courses in Natural Hazards, Geomorphology and Planetary Geology.

Dr. Petya K. Entcheva Campbell received a BS in Forestry from the Academy of Forest Engineering, Sofia, Bulgaria in 1988, MS in Forest Sylviculture and Ecology from the University of Massachusetts at Amherst, MA and a Ph.D. in Forest Analysis/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 NRC associate and worked at Goddard Space Research Center for two years before joining JCET/UMBC where she is currently employed. Her experience and expertise are in remote sensing for natural resources (PhD), with a specific interest in remote sensing, especially spectral analyses and assessments for the development of methods (algorithms, measurement techniques) for vegetation stress assessments and land cover change detection. Dr. Campbell started work in this direction as a post doctoral research associate of Dr. Midleton at NASA/GSFC, and later continued as a Prime Investigator on a Small Grant for Exploratory Research (funded by the National Science Foundation) working on the "*Evaluation of vegetation Solar Chlorophyll Fluorescence properties".* With a small team of three scientists and two students she quantified the ChlF signal, for a number of vegetation species and considered the requirements for building a sensor for measuring solar ChlF. Of high interest to this end are the currently under development at ESA FLEX mission, which targets the assessment of solar exited ChlF. At GSFC she participates in the NASA's "*Light Use Efficiency and Carbon Science"* research led by Dr. Middleton and have participated in the development of the satellite hyperspectral mission/s *Flora/SpectraSat/HyspIRI* for vegetation assessment led by Drs. Green, Ungar and Asner. 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, she 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 the University of Maryland, Baltimore County (UMBC) Dr. Campbell has taught the Remote Sensing of Environment undergraduate/graduate classes at the department of geography.

Dr. J.-Y. Christine Chiu received her Bachelor of Science in Atmospheric Science from National Central University of Taiwan in 1992. Following the acquisition of a Master of Science degree in Atmospheric Physics from National Central University in 1994, she worked at the Environmental Protection Agency of Taiwan for three years. In 1998, she commenced her doctorate at Purdue University, and received her Ph.D. in Earth and Atmospheric Sciences in 2003. She has worked in the area of microphysics schemes in both mesoscale and microwave radiative transfer modeling, and microwave retrieval algorithm development, validation, and applications, with an emphasis on the retrieval of instantaneous rain intensity, water vapor, and surface wind speed over the ocean. In 2003 she joined JCET as a Research Associate. Her research currently focuses on the spatial correlation of cloud droplets, the shortwave radiative interactions between the surface and clouds, and their impact on climate modeling and remote sensing applications.

Mr. Ruben Delgado is a Faculty Research Assistant in JCET. He received a Chemistry B.S and M.S from the University of Puerto Rico in 1995 and 2004, respectively. He expects to receive his Ph.D. in 2010, also from the University of Puerto Rico, for his dissertation work entitled "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, under the supervision of Dr. Raymond M. Hoff, in research involving active atmospheric measurements of atmospheric aerosols and gases with LIDAR. He has published 4 refereed journal articles about LIDAR measurements and chemical models of the mesospheric potassium layer. During his career, he has also carried out computational and experimental research involving laser photolysis of gas phase polyatomic species followed by probing of the nascent radicals and ions with Laser Induced Fluorescence and Time-of Flight Mass Spectroscopy.

Dr. Sergio DeSouza-Machado obtained a B.A. from the College of Wooster, OH in 1988. He then attended graduate school at the University of Maryland at College Park, where he obtained his M.S. in 1990 and Ph.D. in Plasma Physics in 1996. After this, he joined the Atmospheric Spectroscopy Laboratory at the University of Maryland, Baltimore County in September 1996. He has developed kCARTA, a package that rapidly computes monochromatic absorption spectra, radiances and jacobians, and does scattering and NonLTE computations. In addition, he has developed a line-by-line code that includes CO2 P/R linemixing and water continuum corrections. His current research work is on retrievals of dust heights and optical depths, radiative transfer codes and trace gas retrievals. Dr. DeSouza-Machado also actively participates in teaching Physics classes, at both the undergraduate and graduate levels.

Dr. Forrest Hall a physicist, currently with the University of Maryland, Baltimore County, is located at the 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 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 or co-authored over 50 scientific papers on satellite monitoring, the global carbon cycle and climate change. In addition to many other awards, in 2009 Dr. Hall recieved the William T. Pecora Award recognizing outstanding contributions toward understanding the Earth by means of remote sensing, and the Career Achievement Award from the Canadian Remote Sensing Society. 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. Dr. Halverson's 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. Jeffrey Halverson is currently an Associate Professor of Geography at the University of Maryland Baltimore County (UMBC). He also serves as Associate Director-Academics at the Joint Center for Earth Systems Technology (JCET), a cooperative institute between NASA and 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 extratropical transition of hurricanes making landfall over the Mid Atlantic.

Mr. Scott Hannon received his BA and MS in physics at UMBC, and stayed on as a research assistant with Dr. Strow since 1991. His work has primarily focused on the development of fast radiative transfer algorithms for AIRS and other infrared spectrometers.

Dr. Richard Hartle received a B.S. from the University of Michigan in 1959, and a Ph.D. in Physics in 1964 from Pennsylvania State University, where his major research interest was theoretical plasma physics. In 1964, he joined NASA, and worked at the Ames Research Center for three years before transferring to GSFC, where he is still employed. During his career, he has carried out theoretical and experimental research on the solar wind, planetary atmospheres and ionospheres, plasma physics, and gas dynamics using measurements made from the instruments on satellites such as the Atmosphere Explorers, Dynamics Explorer, Mariner 10, Voyager, Pioneer Venus, Galileo and Cassini. He has published over 100 refereed papers; the most recent concentrate on various gas escape mechanisms and how they affect the evolution of planetary atmospheres, and especially the evolution of water (oceans) on Venus and Mars. He is also active in plasma studies of Saturn's moons, especially Titan, using measurements made from the Cassini orbiter. At GSFC, he has been the head of the Planetary Atmospheres Branch (1975 – 1985, 1991 – 1995), project scientist for the Earth Observing System (1983 – 1987), and assistant chief of the Laboratory for Atmospheres (1985 – 1991).

Dr. R. M. Hoff is a Professor of Physics at the University of Maryland, Baltimore County. He is Director of the Joint Center for Earth Systems Technology and Director of the Goddard Earth Sciences and Technology Center. Dr. Hoff has 36 years of experience in atmospheric research. His research interests are in the optical properties of aerosols and gases in the atmosphere. Dr. Hoff has formulated major research programs on Differential Absorption, Raman, ground-based, airborne and spaceborne lidar, volcanic emissions, atmospheric transport of toxic chemicals to the Great Lakes, atmospheric visibility, Arctic Haze, and dispersion of pollutants. He has led or participated in over 20 major field experiments. He is the author of 97 journal articles and book chapters, 97 other refereed works and numerous public presentations of his work. Dr. Hoff obtained a Bachelor of Arts degree in Physics at the University of California Berkeley in 1970 and a Ph.D. in Physics from Simon Fraser University in 1975. He has conducted research at UMBC, Environment Canada, NASA Langley Research Center, the Jet Propulsion Laboratory, and the National Oceanographic and Atmospheric Administration's Environmental Research Laboratories. Dr. Hoff was a member of the Science Advisory Group for the NASA Laser In-Space Technology Experiment (LITE), a space shuttle experiment. He is also a science team member on the ESSP-2 spaceborne lidar, named CALIPSO. He was a member of the International Radiation Commission International Coordination Group on Laser Atmospheric Studies (ICLAS), the American Meteorological Society Committee for Laser Atmospheric Studies (CLAS) and the Stratospheric and Upper Tropospheric Aerosol focus of the International Global Aerosol Program (SUTA/IGAP/IGAC). He was Rapporteur for Long Range Transport on the WMO Executive Committee Panel of Experts/Commission of the Atmospheric Science Working Group on Environmental Pollution and Atmospheric Chemistry. Dr. Hoff is a member of the Science Advisory Group on Aerosols to the Commission of the Atmospheric Sciences of the World Meteorological Organization, Chair of the NASA Applied Sciences Advisory Group, and a member of the NASA Earth System Sciences subcommittee of the NASA Advisory Council. He is co-chair of the WMO Global Atmosphere Watch Aerosol Lidar Observation Network (GALION) steering group. He has had committee and peer review roles at NASA, EPA, NOAA, Department of Energy Atmospheric Radiation Measurement (ARM), Environment Canada, Canadian Space Agency, and the European Economic Community. He has held memberships in six scientific societies and served as Chairman of committees for those societies. He is a Fellow of the American Meteorological Society.

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 fieldwork in a variety of habitats including arctic and sub-arctic tundra, boreal and temperate forests, croplands, prairies, and deserts.

Dr. Breno Imbiriba was born in Belem, Brazil. He received his B.Sc. degree in 1997 from the Universidade Federal do Para (UFPA) - Belem, Brazil, and his M.Sc. degree in Theoretical Physics from the Instituto de Fisica Teorica (IFT) - Sao Paulo, Brazil in 1999. In 2007, Dr. Imbiriba received his Ph.D. in Physics from the University of Maryland (UMD) at College Park, MD. Since Fall 2006, he has been a Research Associate at the Joint Center for Earth Systems Technology (JCET) at University of Maryland Baltimore County (UMBC) in Baltimore, MD. His research interests include remote sensing studies on climate change, and numerical modeling.

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 a Research Associate 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 ongoing CloudSat missions. He 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 aerosol 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. Weijia Kuang received his B.Sc. degree in Space Engineering Sciences from Changsha Institute of Technology, Peoples Republic of China (PRC) in 1982, his M.Sc. degree in Theoretical Physics from Wuhan University, PRC in 1985, and his Ph.D. degree in Applied Mathematics from the University of California, Los Angeles in 1992. He subsequently joined Harvard University as a postdoctoral fellow, and later as a research associate. He joined JCET as a Research Associate Professor in June 1998. His research interests range from nonlinear wave-wave interactions and pattern formations, instabilities in magnetohydrodynamic systems, to general computational geophysical fluid dynamics. His main research activities are focused on studying dynamic processes in the deep interior of the Earth, in particular the nonlinear convective flow in the Earth's outer core and generation of the geomagnetic field. He has developed one of the first two working dynamo models (Kuang-Bloxham model) to simulate three-dimensional, fully nonlinear core flow. He has had more than 20 peer-reviewed papers published, most recently a paper on the application of geodynamo modeling to geopotential studies.

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 exact and asymptotic solution 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, a 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 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 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 problem. He has recently co-supervised the Ph.D. dissertation of Mr. R.K. Siddani, a graduate student at the Mathematics and Statistics Department, UMBC, leading to the discovery of a novel type of probability distribution governing the statistics of rainfall.

Dr. J. Vanderlei Martins received a Bachelor's degree in physics in 1991, a Master's degree in physics/nuclearapplied 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 NASA GSFC Climate and Radiation Branch from August to December 1996, both 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 25 refereed papers and has given over 60 presentations in 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 Comission from 2001-2008. In 2006 he assumed an Associate Professor position in the Department of Physics of the UMBC, while keeping his affiliation with JCET.

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 Sciences, UMBC. Dr. Mehta's interest and expertise are in satellite remote sensing of geophysical parameters and their analysis to understand climate and its 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 (2000) and she is also currently a master's candidate in Public Policy at the University of Maryland, College Park. Her main area of expertise is the application of air quality remote sensing data for decision-support and the development of web-tools for access to Earth Science data. She currently coordinates and conducts remote sensing training workshops for the NASA Applied Sciences Program and performs research on the utilization of NASA data for examining air quality trends in the eastern U.S.

Mr. Adam Robinson is an undergraduate student at the University of Maryland, Baltimore County, double majoring in physics and math. He is currently working on retrieving dust heights and optical depths. He has improved the AIRS dust flag, an algorithm to determine where there is dust, over ocean and is working on making it work over land.

Mr. Paul Schou received a B.A. from Michigan Technology University in Physics in 2006 and currently is working on finishing his M.S. in Atmospheric Physics at UMBC. His research interests include retrieving atmospheric profiles from 600 mb to the surface from various skydiving sites, as well as collocating AIRS and IASI radiance data with ECMWF geophysical fields.

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 done 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 the 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, 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 M.S. and Ph.D. 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 Modeling, Analysis and Prediction (MAP) grant on carbon cycle data assimilation. 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 Istanbul Technical University in 1984, his M.S. from Saint Louis University in 1988, and his Ph.D. from the University of Illinois at Urbana-Champaign in 1993. He was a research associate through National Research Council Fellowship between 1993 and 1995. He joined Saint Louis University as assistant professor in 1995 and then the University of Maryland Baltimore County (UMBC) as a research assistant scientist in 1997. He was 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 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 MS student who graduated in 1998, and has also mentored 14 undergraduate and 5 graduate students. A member of the NASA precipitation science team, he is an affiliated associate professor of UMBC's Department of Geography and Environmental Sciences and research associate professor at JCET/UMBC.

Dr. Tamas 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 to 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.

Dr. Juying X. Warner received a B.S. from Nanjing University in Atmospheric Physics in 1983 and a Ph.D. in Meteorology in 1997 from the University of Maryland College Park where her major research interest was radiative transfer modeling. In 1997 she joined the National Center for Atmospheric Research and worked at Atmospheric Chemistry Division until she joined the University of Maryland Baltimore County at the Joint Center for Environmental Systems Technology in 2004. During her career after her doctorate degree she has focused on the remote sensing of atmospheric chemistry and other properties using satellite and airborne technologies. She has published over 20 refereed papers on the analyses of the atmospheric chemistry and remote sensing algorithms and techniques and received four awards from NASA and NCAR for her contributions to the science and technology advancements.

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 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.

Dr. Tianle Yuan received a 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. His major interests are cloud physics, radiation, and aerosol science. In 2008, he joined JCET as a research associate. His research interests include aerosol radiative forcing, aerosol-cloud interactions, and aerosol-chemistry-climate interaction.

Dr. Leonid Yurganov is a Senior Research Scientist at UMBC, Physics Dept. and JCET. His current research expertise is connected with remote sensing of tropospheric composition, mostly CO and other members of carbon family, as well as ozone. He graduated from Leningrad State University in 1969 (MS) and Institute of Atmospheric Physics in 1979 (Ph.D.) (both in Russia). During 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, Fairbanks, Alaska. Validation of 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. He is a co-author of 43 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, and his Ph.D. in Atmospheric Physics from the University of Maryland Baltimore County in 2006. He has been working in JCET as a Research Associate since 2006. He carried out research on atmospheric circulation modeling using quasi-uniform grids. His recent research interest is in atmospheric aerosol remote sensing, and the applications in the air quality monitoring and forecasting.

III.9 Table 1: JCET Faculty (as of September 30, 2009)

NAME	TITLE	AFFILIATION
Dr. William Barnes	Senior Research Scientist	Research Faculty
Dr. Roberto Borda	Assistant Research Scientist	Research Faculty
Dr. Mark Bulmer	Research Associate Professor	Geography and Environmental Systems
Dr. Petya Entcheva-Campbell	Research Assistant Professor	Geography and Environmental Systems
Dr. Christine Chiu	Research Assistant Professor	Physics
Mr. Ruben Delgado	Research Associate	Research Faculty
Dr. Sergio deSouza-Machado	Research Assistant Professor	Physics
Dr. Forrest Hall	Senior Research Scientist	Research Faculty
Dr. Jeffrey Halverson	Associate Professor	Geography and Environmental Systems
Mr. Scott Hannon	Research Assistant	Research Faculty
Dr. Jay Herman	Senior Research Scientist	Research Faculty
Mr. Ernest Hilsenrath	Professor of Practice	Research Faculty
Dr. Raymond Hoff	Professor	Physics
Dr. K. Fred Huemmrich	Research Associate Professor	Geography and Environmental Systems
Dr. Breno Imbiriba	Research Associate	Research Faculty
Dr. Weiyuan Jiang	Research Assistant Professor	Mechanical Engineering
Dr. Ben Johnson	Research Associate	Research Faculty
Dr. Ilan Koren	Assistant Research Scientist	Research Faculty
Dr. Nikisa Jordan	Research Associate	Research Faculty
Dr. Arlin Krueger	Research Professor	Physics
Dr. Prasun Kundu	Research Associate Professor	Physics

NAME	TITLE	AFFILIATION
Dr. David Lary	Research Professor	Physics
Dr. Kevin McCann	Research Associate Professor	Physics
Dr. Amita Mehta	Research Assistant Professor	Geography and Environmental Systems
Dr. William Olson	Research Associate Professor	Physics
Dr. Ana Prados	Research Assistant Professor	Chemistry
Dr. Andrew Tangborn	Research Associate Professor	Mathematics and Statistics
Dr. Ali Tokay	Research Associate Professor	Geography and Environmental Systems
Dr. Tamás Várnai	Research Assistant Professor	Physics
Dr. Juying Warner	Research Assistant Professor	Geography and Environmental Systems
Dr. Zigang Wei	Assistant Research Scientist	Research Faculty
Dr. Mengsteab Weldegaber	Research Associate	Research Faculty
Dr. Tianle Yuan	Research Associate	Research Faculty
Dr. Leonid Yurganov	Senior Research Scientist	Research Faculty
Dr. Hai Zhang	Research Associate	Research Faculty

III.10 Table 2: JCET Fellows (as of September 30, 2009)

NAME	AFFILIATION
Dr. Robert Cahalan	NASA GSFC
Dr. Belay Demoz	Hampton
Dr. Jill Engel-Cox	Battelle Memorial Institute
Dr. Richard Hartle	NASA GSFC
Dr. Weijia Kuang	NASA GSFC
Dr. Thorsten Markus	NASA GSFC
Dr. Alexander Marshak	NASA GSFC
Dr. Vanderlei Martins	UMBC Physics
Dr. W. Wallace McMillan	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. Larrabee Strow	UMBC Physics
Dr. Marco Tedesco	NASA GSFC
Dr. David Whiteman	NASA GSFC

III.11 Table 3: JCET Associate Staff (as of September 30, 2009)

NAME	TITLE
Mr. Dominic Cieslak	Research Engineer
Mr. Keith Evans	Research Analyst
Mr. Aaron Knister	Systems Administrator
Mr. Paul Schou	Research Analyst

III.12 Table 4: JCET Administrative Staff (as of September 30, 2009)

NAME	TITLE
Ms. Valerie Casasanto	Program Coordinator
Ms. Mary Dawson	Business Manager
Ms. Danita Eichenlaub	Acting Director
Dr. Franco Einaudi	Chair, Executive Board
Dr. Jeffrey Halverson	Associate Director
Dr. Richard Hartle	Associate Director
Dr. Raymond Hoff	Executive Director
Ms. Amy Houghton	Communications Specialist
Ms. Camilla Hyman	Accountant I
Ms. Cathy Manalansan	Administrative Assistant II
Ms. Katie Nguyen	Business Specialist
Ms. Grace Roscoe	Executive Administrative Assistant
Mr. Derek Stivers	Business Specialist
Ms. Nina von Gunten	Administrative Assistant I
Ms. Margo Young	Business Manager

Acronyms and Abbreviations

ABOVE	AIRS BBAERI Ocean Validation Experiment
ACCA	Landsat-7's Automated Cloud Cover Assessment
ADRO	Application Development and Research Opportunity
AERI	Atmospheric Emitted Radiance Interferometer
AERONET	Aerosol Robotic Network
AFL	Atmospheric Fourier Transform Infrared (FTIR) Laboratory
AGU	American Geophysical Union
AIRS	Advanced Infrared Sounder
ALEX	Atmospheric Lidar Experiment
AMSR-E	Advanced Microwave Scanning Radiometer – EOS
AMSU	Advanced Microwave Sounding Unit
AOD	Aerosol Optical Depth
ARM	Atmospheric Radiation Measurement
BBAERI	Baltimore Bomem Atmospheric Emitted Radiance Interferometer
BOREAS	Boreal Ecosystem Atmosphere Study
C3VP	Canadian Cloudsat/CALIPSO Validation Project
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CHAMP	Challenging Minisatellite Payload
CLAMS	Chesapeake Lighthouse and Aircraft Measurements for Satellites
CMAQ	Community Multiscale Air Quality
CNR	Italian National Research Council
CREST	Cooperative Center for Remote Sensing Science and Technology
CrIS	Cross-Track Infrared Sounder
CRM	Cloud Resolving Model
CRYSTAL-FACE	Cirrus Regional Study of Tropical Anvils and Cirrus Layers – Florida Area Cirrus Experiment

DOE	U.S. Department of Energy
DRU	Data for Research Use
ELF	Elastic Lidar Facility
EOS	Earth Observation System
ESA	European Space Agency
ETM+	Enhanced Thematic Mapper Plus
EUMETSAT	European Organization for the Exploration of Metrological Satellite
GALION	Global Atmosphere Watch Atmospheric Lidar Observation Network
GASP	GOES Aerosol and Smoke Product
GCM	General Circulation Model or Global Climate Model
GEST	Goddard Earth Sciences and Technology Center
GOCE	Gravity Field and Steady-State Ocean Circulation Mission
GOES	Geostationary Operational Environmental Satellite
GOME	Global Ozone Monitoring Experiment
GPM	Global Precipitation Measurement Mission
GPS	Global Positioning System
GRACE	Gravity and Climate Recovery Experiment
GRSP	Geologically Rough Surfaces Project
GSFC	Goddard Space Flight Center
GV	Ground Validation
HSB	Humidity Sounder Brazil
I3RC	Intercomparison of 3-D Radiation Codes
IAG	International Association of Geodesy
IASI	Infrared Atmospheric Sounding Interferometer
IDEA	Infusing satellite Data into Environmental Applications
IEEE	Institute of Electrical and Electronics Engineers
IERS	International Earth Rotation Service
IGAC	International Global Atmospheric Chemistry Project
IGARSS	IEEE International Geoscience and Remote Sensing Symposium
IHOP	International H_2O Project

ILRS	International Laser Ranging Service
ISCCP	International Satellite Cloud Climatology Program
ISLSCP	International Satellite Land Surface Climatology Project
LAGEOS	Laser Geodynamics Satellites
LANDMOD	Landslide Modeling and Forecasting Utilizing Remotely Sensed Data
LaRC	Langley Research Center
LBA	Large Scale Biosphere Atmosphere Experiment
LIDAR	Light Detection and Ranging
LITE	Lidar In-Space Technology Experiment
MASSMOVE	Mass Movement (model)
MGS	Mars Global Surveyor
MISR	Multiangle Imaging SpectroRadiometer
ML	Maximum Likelihood
MODIS	Moderate Resolution Imaging Spectroradiometer
MOSST	Modular, Scalable, Self-consistent, Three-dimensional
MPLNET	Micropulse Lidar Network
NACP	North American Carbon Program
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NESDIS	National Environmental Satellite, Data, and Information Service
NGS	National Geodetic Survey
NIMA	National Imagery Mapping Agency
NLLJ	Nocturnal Low Level Jet studies
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
NRA	NASA Research Announcement
NSF	National Science Foundation
NWP	Numerical Weather Prediction

OMI	Ozone Monitoring Instrument
OSTM	Ocean Surface Topography Mission
PDF	Probability Distribution Function
PI	Precipitation Index or Principal Investigator
PR	Precipitation Radar
R	Rain Rate
RAMMMP	Regional Air Monitoring, Measurement, and Modeling Program
REALM	Regional East Atmospheric Lidar Mesonet
SCS	South China Sea
SCHIMACHY	Scanning Imaging Absorption SpectroMeter for Atmospheric Cartography
SLR	Satellite Laser Ranging
SSM/I	Special Sensor Microwave/Imager
SWCRF	Shortwave cloud radiative forcing
SWS	Shortwave spectrometer
THOR	Thickness from Offbeam Returns
TMI	TRMM Microwave Imager
TOGA	Tropical Ocean Global Atmospheres Experiment
TOMS	Total Ozone Mapping Spectrometer
TRF	Terrestrial Reference Frame
TIROS	Television Infrared Observation Satellite
TRMM	Tropical Rainfall Measuring Mission
UMBC	University of Maryland, Baltimore County
USDA	U.S. Department of Agriculture
USNO	U.S. Naval Observatory
UV	Ultraviolet
VIEWS	Visibility Exchange Web System
WAVES	Water Vapor Validation Experiments
WMO	World Meteorological Organization
WVIOP	Water Vapor Intensive Operations Period
Z	Radar Reflectivity Factor