THIRTEENTH 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, 2007 – September 30, 2008

The Joint Center for Earth Systems Technology

Thirteenth Annual Report
October 1, 2007 – September 30, 2008

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Preface

This volume is the thirteenth annual report describing the scientific accomplishments and status of the Joint Center for Earth Systems Technology (JCET). This Center was established July 1, 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 Earth Sciences Division (formerly the Earth Sciences Directorate), and the Solar System Exploration Division have 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's Departments of Physics, Geography and Environmental Systems, Chemistry, Mathematics and Statistics, Mechanical Engineering and Computer Science and Electrical Engineering. JCET's administrative office is in the second building of the new technology park expansion 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 35 JCET faculty members (listed in Section III.10), a decrease of six percent from the previous year, partly due to faculty becoming civil servants or transferring to our sister center, the Goddard Earth Sciences & Technology Center (GEST). The number of JCET Fellows increased by 2 to 20 (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 associate staff members (listed in Section III.12). Brief biographies of each JCET faculty and associate staff member are presented in Section III.9. The overall management and administration of JCET is governed by the executive board and carried out by an expert administrative staff (listed in Section III.13), which also supports JCET's sister center GEST. In the spirit of cooperation between UMBC and GSFC, the Director is also a Professor of Physics at UMBC, while the Board Chairman and an Associate Director are civil servant scientists at GSFC. To further facilitate the scientific management of JCET, six research groups were created this year, which are aligned with GSFC research areas. These groups are also shared with the members of GEST. They ensure the flow of information between management and scientists while enhancing collaboration within and between the disciplines. Each group has a faculty mentor who provides advice and guidance to new employees. In addition, an Associate Director-Academics supports the Director in linking the academic mission of the center with ongoing scientific research.

The body of this report (see Section II) is divided into six sections, each of which is devoted to the scientific activities of the research groups mentioned above. 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, 2007 to September 30, 2008. Each report includes a description of the research, accomplishments for FY 07-08, and objectives for FY 08-09. 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 70 refereed papers (and 29 others submitted for review), along with 190 conference presentations and publications and non-refereed publications (see Section III.4) comprise the principal direct contribution of JCET scientists to the Earth sciences. Two patent applications, listed in Section III.7, were submitted during the fiscal year. In addition to their current research, JCET scientists planned for the future through submission of 70 grant proposals, listed in Section III.8, 40% of which have already been awarded to be administered through individual PI or Co-I assignments, while decisions remain pending on 37%.

JCET scientists also contributed to education at UMBC by teaching and mentoring graduate students in the Departments of Physics, Computer Science and Electrical Engineering and Mathematics/Statistics. The 12 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 12 graduate students, and providing research opportunities for a number of additional undergraduate and graduate students from UMBC and other universities.

R. E. Hartle, Associate Director September 2008
J. B. Halverson, Associate Director
R. M. Hoff, Director

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Executive Summary

The Joint Center for Earth Systems Technology (JCET) now enters its 14th year as a prestigious cooperative institute between UMBC and NASA's Goddard Space Flight Center (GSFC). During the past year, both JCET and UMBC have received high accolades as centers of excellence in research and education. UMBC, known for its emphasis on STEM (Science-Technology-Engineering-Math) and prominence as a University System of Maryland incubator/accelerator in Research and Development, was recently ranked Number Five as an Up and Coming Top University in *US News and World Report*. And, according to statistics compiled for 2006, UMBC has moved upward once again on the ladder of NASA grant and cooperative agreement research funding, earning the number two position in the entire nation for 2006.

Within JCET, our faculty continue to be highly productive in terms of peer-reviewed research publications, teaching, international scientific exchange, student mentoring and research independence. As you read through the Preface of this report, it is noteworthy that while the JCET faculty ranks have decreased slightly over the past three years (35 in 2007-2008 compared with 40 in 2004-2005), the net productivity of each JCET faculty member has remained constant (an average of two peer-reviewed papers, two grant proposal submissions and five to six scientific conferences attended per year). Since last year, the ranks of our Fellows have grown from 18 to 20. Within our ranks, we promoted two Assistant Research Professors to the Associate level (Dr. Tamas Varnai and Dr. Fred Huemmrich).

In line with the original JCET vision formulated by Dr. Harvey Melfi (the Center's first director) and Dr. Franco Einaudi (Chief of GSFC's Laboratory for Atmospheres at the time), JCET is a place where young faculty members can begin their careers, become successful in gaining reputation and funding, and build a satisfying research position for themselves. Thus, one measure of the success of JCET is its role as an "incubator/accelerator" for young faculty, who then go onto tenure-track positions at other universities, or enter into the civil service at national laboratories. In 2007, several JCET faculty successfully migrated to tenure-track positions, including Dr. Simon Carn (Michigan Technological University), Dr. Omar Torres (Hampton University) and Dr. Marco Tedesco (City College of New York). Additionally, Dr. Lazaros Oraiopoulos was hired into the civil service at NASA Goddard.

At the same time, JCET welcomed several new faculty members in 2007-2008. Dr. David Lary came to the Center from the Goddard Earth Sciences and Technology Center (GEST). Dr. Lary is both Research Professor in JCET and Affiliate Professor in Physics, and he brings much cross-disciplinary expertise to JCET through his research in NASA Aura validation, neural networks for accelerating atmospheric models, and the use of Earth Observing data for health and policy applications. Dr. Tianle Yuan comes to the group from Science Systems and Applications, Inc., and is starting his JCET career as a Research Associate working in the field of climatological effects of aerosols on different types of clouds and precipitation globally and in highly sensitive regions. And we congratulate JCET Research Associate Ben Johnson, who recently received his Ph.D. from the University of Wisconsin. Dr. Johnson develops retrieval algorithms for snowfall using passive microwave and radar remote sensing methods.

Dr. Vanderlei Martins (a former JCET Research Professor who joined the tenure-track ranks in UMBC's Physics Department, and presently a JCET Fellow) has taken the Center one step closer to another of Dr. Melfi and Einaudi's long-term visions for JCET, namely, the establishment of a UMBC-led space mission. Dr. Martins is actively pursuing a proposed instrument for CubeSat, a type of research picosatellite designed for low-weight scientific payloads utilizing commercial off-the-shelf components. Dr. Martins is developing a multi-wavelength instrument to study cloud optical properties, and is aggressively pursuing funding opportunities both within the National Science Foundation (NSF) and a potential partnership with Northrop-Grumman Corporation.

In 2008, UMBC contributed to the Governor of Maryland's Commission on Climate Change. The scientific and technical sections of the Climate Change report had input from JCET faculty and a graduate student, Paul Schou. The report "Global Warming in the Free State" can be found at *http://www.umces.edu/climateimpacts/index.html.*

Along the academic front, JCET faculty members now hold departmental affiliations in six UMBC academic units, including rapid growth of affiliations within Geography and Environment Systems (GES). The GES department successfully launched its graduate studies program with an incoming cohort of 15 students, providing new opportunities for teaching 600-level courses for the JCET faculty, committee positions and mentorship of graduate students. In 2007-2008 JCET appointed a record 12 students into Graduate Research Assistantships, mainly to support the work of M.S. and Ph.D. candidates in Physics, but also within Computer Science and Mathematics and Statistics. And, in 2007-2008 the JCET faculty taught a diverse stable of courses, ranging from Computational Physics to Remote Sensing of the Environment to Severe Storms and Their Socioeconomic Impact.

We encourage you to browse through this 13th Annual Report, where you will note an impressive number of accomplishments of JCET, including select research highlights that demonstrate the broad scope of the Center's cutting-edge research in Earth and Space Sciences.

Raymond M. Hoff

JCET Director
Professor, Physics

Jeffrey B. Halverson

JCET Associate Director-Academics
Associate Professor, Geography and Environmental Systems

September 2008

II. TECHNICAL VOLUME

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Global Modeling and Assimilation Office
(Code 610.1)

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NSF Grant:	**CMG: Geomagnetic Data Assimilation**
NSF Grant:	**CMG: Variational Approaches to Geomagnetic Data Assimilation**
NASA Grant:	**Assimilation of MOPITT Carbon Monoxide Observations**
TASK 49:	**Carbon Cycle Data Assimilation** ***(Sponsor: S. Cohn, GSFC Code 610.1)***
Investigators:	Andrew Tangborn, Research Associate Professor, Mathematics; Zhibin Sun, Research Associate, JCET; Weijia Kuang, JCET Fellow, Goddard Space Flight Center; Jeremy Bloxham, Professor, Harvard University; Steven Pawson, Goddard Space Flight Center; Ivanka Stajner, Noblis, Inc.; Daniel Jacob, Professor, Harvard University; Gary Egbert, Professor, Oregon State University.

Description of Research

Research is carried out in the field of data assimilation, with applications in Earth's core research (geodynamo), Carbon cycle research and Stratospheric polar winds. The geomagnetic data assimilation research group, funded by both NSF and NASA, is a collaborative project involving scientists and graduate students from UMBC, Goddard Space Flight Center, Oregon State University and Harvard University. Dr. Tangborn and his team have been employing techniques traditionally used in Numerical Weather Prediction (NWP) with the goals of predicting future changes to the Earth's magnetic field, and gaining better estimates of the fluid motion inside the Earth's core. Carbon cycle data assimilation, funded by two grants from NASA, is concerned with developing the means to assimilate measurements of carbon species into the constituent assimilation system in the Global Modeling and Assimilation Office (GMAO) at GSFC. Stratospheric polar wind assimilation uses observations from long-lived polar balloons to produce highly accurate analyses of the spring warming and polar vortex breakdown over the Antarctic.

Accomplishments for FY 07-08

During the past year, the investigators have completed work on the initial phase of developing a geomagnetic data assimilation system, and the results of this work are summarized in Kuang *et al.* (2008). 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 have found that assimilation runs as short as 100 years can result in increased knowledge of the unobserved components of the magnetic field. Longer runs, on the order of 1000 years, have been found to be necessary for making improvements to the fluid flow computations. To this end, the investigators have begun assimilating both historic geomagnetic observations (1590-2000) and archeomagnetic data (from about 3000 BC). Dr. Tangborn and his team continue to pursue national and international collaborations in this work as well as funding from both NSF and NASA. Most recently they have been awarded new NSF funding for developing the next-generation geomagnetic data assimilation system using variation techniques.

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). They have completed impact studies of SCIAMACHY observations (Tangborn, *et al.* 2008). This work has shown that data assimilation can be used not only to improve estimation of the distribution of long-lived trace gases in the atmosphere, but it can also help to improve the estimation of surface emissions. Direct comparisons can be made by interpolating the assimilated fields to locations of aircraft measurements from MOZAIC (Measurement of Ozone and water vapor by in-service Airbus aircraft).

Polar vortex studies have been carried out using observations from the 2005-06 Vorcore experiments. The investigators have assimilated the wind velocities derived from the drifting balloons and assimilated them into the GEOS-5 assimilation system. The goal of this work is to improve the investigators' knowledge of the polar vortex that develops during the Antarctic winter and its subsequent breakdown in the spring. Assimilation of the balloon data is found to improve wind estimates at all times, especially during the vortex breakdown process. This should lead to better estimates of the duration and strength of the Antarctic ozone as a whole, and an improved understanding of climate change processes. A proposal to NSF has been submitted with collaborators at UCLA and UMCP to continue this work.

Objectives for FY 08-09

Work on geomagnetic data assimilation will continue, using both ensemble and variational methods. A post-doctoral researcher will be hired through Oregon State University in the coming year, and Dr. Tangborn expects to be able to fund a graduate student at UMBC as well. The former will be involved in developing an adjoint geodynamo model needed for the variation system, and the latter will continue with development of the ensemble-based system. The investigators expect to submit two more papers from the work carried out on the initial NSF grant.

Carbon cycle research will be focused almost entirely on implementing the carbon monoxide assimilation algorithm into the GEOS-5 data assimilation system at the GMAO. Initial observations to be assimilated will be AIRS and IASI total column CO measurements.

The Antarctic polar vortex studies will depend partially on winning support from NSF. In response to a proposal to Meteo-France, a graduate student will be coming to work with Dr. Tangborn on Lagrangian assimilation of Antartctic balloons for six months beginning in January 2009. Additionally, the investigators plan to write a paper to be submitted to *GRL* on the initial results of this study.

Earth Sciences Directorate (Code 610.6)

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JCET Highlight: Determination of the Variability and Height Distribution of Tropospheric Aerosol and Water Vapor from Elastic and Raman Lidar Measurements

Investigator: Ruben Delgado

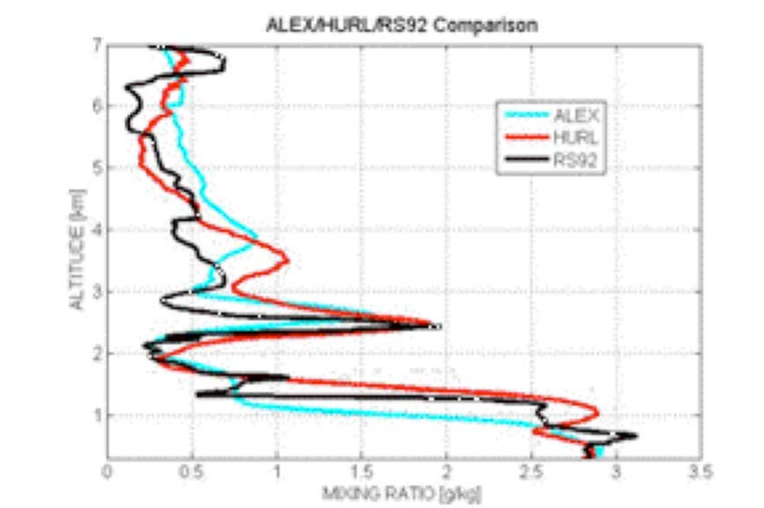

Figure 1. *Comparison of balloon-borne (Vaisala RS-92) and ground-based lidar (ALEX-UMBC and HURL-Howard Univ.) on March 6, 2008, during WAVES 2008 campaign, to assess the relative and absolute accuracy of water vapor mixing ratio measurements and characterization of water vapor and aerosol variability on the sub-pixel scale.*

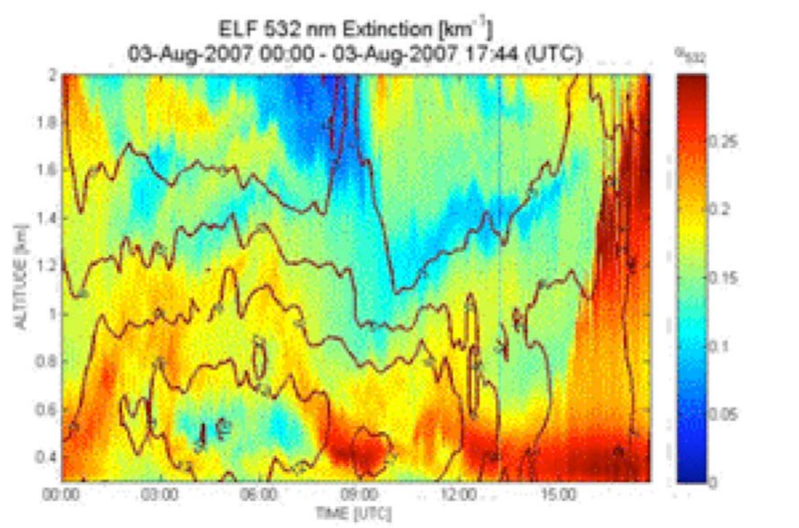

Figure 2. *Elastic lidar timeseries for August 3, 2007 during a low level jet event. Contours represent wind speeds (m/s) from MD Dept. of the Environment (MDE) wind profiler in Beltsville, Md. The development and structure of the boundary layer associated with a low-level jet is shown in the lidar timeseries. The vertical distribution of aerosols in the nocturnal boundary layer aids in the identification of the nose/core (airmass with greatest wind speeds) of the low level jet at a height of 0.2 – 0.6 km between 3:00-7:30 UTC. The turbulence generated by the low level jet induces nocturnal mixing events and enhances the surface-atmosphere exchange, thereby influencing the dispersion of pollutants near the surface. The colorbar indicates the amount of material involved in scattering light from the lidar transmitter: blue represents an air mass with less material (cleaner air) to scatter light from; red an air mass filled with particulates (aerosol, smoke or dust) that light can scatter back to the lidar receiver.*

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NASA Grant:	**Simultaneous Validation of OMI and Calipso Using Ground-Based Lidar, Aeronet, and Satellite Optical Depth Measurements (NNG06GA73G)**
Investigators:	Rubén Delgado, Research Associate, JCET; Raymond Hoff, Director, JCET and Professor, Physics; Wallace McMillan, Associate Professor, Physics; and several co-investigators from institutions outside UMBC.
Students:	Matthew Potyraj, Undergraduate Student; Chris Wilson, Graduate Student; Mengsteab Weldegaber, Graduate Student.

Description of Research

Elastic (ELF) and Raman (ALEX) lidar measurements have been conducted to measure the vertical distribution of aerosols and water vapor over the Baltimore-Washington metro area, and to understand the transport of particulates and air pollutants. The UMBC Elastic and Raman lidar was operated during the Water Vapor Validation Experiments' (WAVES) July-August 2007 and February-April 2008 campaigns. Coincident lidar data was taken at times that corresponded to AURA and CALIPSO overpasses over the Baltimore-Washington region. Observations were carried out to assess the relative and absolute accuracy of balloon-borne and ground-based lidar measurements of water vapor and temperature, and involved the following instrumentation: Cryogenic Frostpoint Hygrometer, ATM+Sippican, Vaisala RS-92 and RS-80, and Raman lidar (NASA, Howard, UMBC). Lidar intercomparison allows characterization of water vapor and aerosol variability on the sub-pixel scale using ground-based Raman lidar systems stationed at UMBC, Beltsville and GSFC. Active measurements from ELF and ALEX also support the Regional East Atmospheric Lidar Mesonet, 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 (NLLJ), sponsored by the Maryland Department of the Environment (MDE).

Accomplishments for FY 07-08

Lidar measurements carried out by UMBC's Atmospheric Lidar Group supported the WAVES campaigns by providing a robust set of lidar profiles of atmospheric water vapor and aerosols useful for AURA/Aqua and CALIPSO satellite retrieval studies, performing instrument accuracy assessments and using WAVES data, generated by various independent active and passive remote sensing instruments for case studies of regional water vapor and 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 NLLJ events over the Baltimore-Washington region. ELF and ALEX lidar observations show a distinct signature of the nose/core of the NLLJ event, where wind speeds are supergeostrophic (greater than 10 m/s). Lidar data combined with MDE's wind profiler and radiosonde data allow Delgado and his team to correlate the dispersion of pollutants near the surface to the turbulence generated by the wind shear in the NLLJ to nocturnal mixing events that enhance surface-atmosphere exchange. The horizontal distributions of the nocturnal low level jet over Maryland have been modeled using the Weather Research and Forecasting model (WRF), after agreement between the wind profiler timeseries and model is achieved, in order to assess the transport of ozone, water vapor mixing ratio and pollutants from elevated reservoirs aloft throughout the Baltimore-Washington region. A manuscript is in preparation that documents the lidar/wind profiler measurements of low level jet (LLJ) made in a joint effort by UMBC and MDE to assess the impact of long-range transport and distribution of pollutants.

To further test the comparison between ground-based remote sensors and TES water vapor profiles, the investigators added to their experiments the UMBC Baltimore Bomem Atmospheric Emitted Radiance Interferometer (BBAERI) to provide simultaneous IR retrievals of water vapor and column. Integration of the lidar water vapor mixing ratios has been carried out to generate a column precipitable water vapor timeseries that can be compared to UMBC's Suominet station and BBAERI. In addition, BBAERI provides a vertical temperature timeseries that Delgado can correlate to changes in atmospheric aerosol concentration and water vapor mixing ratios observed in the lidar timeseries due to meteorological events.

Objectives for FY 08-09

Delgado will continue his detailed evaluation of sub-pixel variability in the water vapor fields in the Baltimore/Washington area by comparing lidar measurements to WRF modeling of water vapor mixing ratio for Baltimore and Beltsville. These results will be compared to the Trophospheric Emission Spectrometer, the Atmospheric Infrared Sounder, and, subject to availability, the National Oceanography and Atmospheric Agency Infrared Atmospheric Sounding Interferometer. He also plans to generate aerosol extinction at 355nm using ALEX for comparison with Ozone Monitoring Instrument aerosol extinction product and to generate physical properties of aerosols. He and his team will generate lidar planetary boundary layer heights from ELF and ALEX, which will be assimilated to Environmental Protection Agency and National Weather Service forecasting products.

NASA Grant:	**NASA African Monsoon Multidisciplinary Activities (NAMMA) (NNX07AJ13G)**
Investigators:	Sergio DeSouza-Machado, Research Assistant Professor, Physics, JCET; D. Allen Chu, GEST (PI); Chung-Lin Shie, GEST; Ruei-Fong Lin, GEST

Description of Research

Desert dust storms play an important yet not completely understood role in climate radiative forcing. A suite of new generation instruments on board NASA's A-train can be used to detect, track and study dust storms. While most studies use visible or ultraviolet passive instruments as well as active lidar instruments, there is a wealth of information also available from AIRS, a hyperspectral infrared instrument on the Aqua platform.

AIRS thermal infrared radiance data can be used to detect dust day and night, over ocean and land. Infrared dust forcing can be studied more accurately if there is information about the altitude of the dust cloud. This research focused on extracting information about the height placement, using AIRS thermal infrared radiances and ancillary infomation from MODIS-retrieved optical depths during the day. Data from the NAMMA experiments was used as well. Preliminary studies of dust storms off the coast of West Africa in late August/early September 2006 were conducted, and they indicated that the straight-line relationship between the MODIS- and AIRS-retrieved optical depths varies systematically with placement of the dust layer.

Accomplishments for FY 07-08

Some preliminary comparisons of atmospheric state retrievals from AIRS data against *in situ* microwave radiometer and radiosonde retrievals were performed, on the edge of a dust storm off the West Africa coast on August 25, 2006, as part of the NAMMA campaign. This was a very limited dataset, but it did serve to show that the 1D-variational retrievals being done using AIRS data in the presence of dust showed evidence of the heating and drying of the atmosphere.

Objectives for FY 08-09

Direct funding from this grant for Sergio DeSouza-Machado has ended. However, related work will be pursued, subject to funding from other grants.

NASA Grant:	**A Three-Dimensional Air Quality System - 3DAQS (NNG05-79A)**
NOAA Grant:	**CREST Cooperative Agreement (CCNY Subaward - 49100-0001B)**
Investigators:	Raymond Hoff, Director, JCET and Professor, Physics; Hai Zhang, Research Associate, JCET; Jill Engel-Cox, JCET Fellow, Battelle Memorial Institute; Ana Prados, Assistant Research Scientist, JCET; Meloë Kacenelenbogen, Research Associate, JCET; Rubén Delgado, Research Associate, JCET; Nikisa Jordan, Graduate Student, Physics; several other co-Investigators from outside UMBC.

Description of Research

Research under these grants supports observation of the lower atmosphere with lidar in combination with satellite remote sensing of particulate column optical depth. UMBC leads a consortium to provide data for three-dimensional decision support systems for air quality management and assessment, based at EPA and NOAA NESDIS. The goal is to have satellite, ground and profile data included in one data system by which analysts can query air quality parameters in near-real time and compare those inputs with three-dimensional forecast models of aerosols. A suite of satellite measurements of air quality are appropriate (MODIS, OMI, CALIPSO, GASP). Data are available from NASA and NOAA, but co- location of air quality relevant subsets of the data in one place is only now being attempted.

Accomplishments for FY 07-08

Two near-real time components contribute measurements to this system. First, UMBC operates the US Air Quality Smog Blog (http://alg.umbc.edu/usaq) using student and faculty input 365 days a year. With almost 15 million hits since September 2003, about 1800 people access this site weekly: academics, students, state and local air quality analysts and managers, and even astronomers -- people who care about what is happening in the way of US air quality. This year, Hoff's group cloned this site to cover Central America, forming the Mesoamerican and Central American Smog Blog (http://alg.umbc.edu/MAC), to be operated by students at the University of Panama. Second, the NOAA NESDIS IDEA product has rapidly grown to include not only NASA products but also satellite measurements from NOAA and KNMI in Holland. This project is jointly funded with NESDIS, and the reader can refer to a separate report by Dr. Hai Zhang.

3D-AQS is in the final stages of the work under the cooperative agreement. The major developments have been to match MODIS Terra and Aqua AOD data to ~500 ground $PM_{2.5}$ monitoring sites within the EPA AIRQUEST decision support system, allowing for correlations of $PM_{2.5}$ and aerosol optical depth to be derived for the U.S. At least two papers addressing the results of this product are being prepared. Hoff's group has pushed matchup data from the NOAA GASP product with these same EPA ground sites to EPA's database, which will lead to a third paper by Zhang *et al.* Also, NO_2 columns from the KNMI and NASA OMI satellite measurements are being matched to these sites and submitted to AIRQUEST.

The same MODIS and GASP data have been regridded to the Community Multiscale Air Quality (CMAQ) model 12x12 km grid so that air quality forecast modelers can readily compare model predictions and satellite data. NOAA's National Center for Environmental Prediction (NCEP) is examining these data for validation of the new EPA/NOAA $PM_{2.5}$ forecasting system. Critical to the three-dimensionality needed to evaluate the performance of these models, Hoff's group is mining the CALIPSO lidar extinction data and matching those measurements to the CMAQ grid. Also, ground-based lidar measurements taken by the CREST lidar groups are being contributed to the EPA Remote Sensing Information Gateway (RSIG) as a repository of these gridded and profile measurements.

To improve product visualization and provide results desired by the community, UMBC hosted a NASA-sponsored 3-D Visualization workshop; further work on 3-D visualization tools has arisen and will involve UMBC and NASA's Langley and Goddard Research Centers.

A final CREST-funded initiative is the Ph.D. research of Nikisa Jordan, MEES graduate student, who is retrieving planetary boundary layer heights from CALIPSO lidar overpasses over the western hemisphere with a view to improve the Goddard GEOS-5 predictions of that variable. With Dr. Julio Bacmeister, Ms. Jordan has developed a hybrid PBL-retrieval technique which can be automated to process a large number of CALIPSO overpasses and compare them with GEOS-5 output.

Objectives for FY 08-09

CREST activities will center around two areas: continuation of lidar profiling for air quality purposes in Baltimore and support of Ms. Jordan's project. Hoff expects CREST lidar activities to contribute to the new World Meteorological Organization Global Atmosphere Watch Atmospheric Lidar Observation Network (GALION). UMBC leads the management activities for GALION and will contribute to the international network development in 2009.

The 3D-AQS activities will wind down with the completion of the project deliverables; 3D-AQS should be fully transferred to NOAA and EPA by the end of 2008 with the final benchmarking process completed in 2009. Subsequently, sustaining the near-real time activities of the Smog Blog and developments overseas will depend on further funding by NOAA, EPA, and NASA. The PI's role as Chair of the NASA Applied Science Advisory Panel has precluded a direct follow-on for 3D-AQS through NASA, but it is expected that components will continue under other agency funding and further NASA competitive proposals. Three papers will be submitted in the next year on 3D-AQS, and Hoff has been asked to contribute a keynote lecture and paper at the Air and Waste Management Association's annual meeting in 2009 on satellite measurements of air quality.

Finally, a new project awarded to UMBC will significantly advance the profiling capability in the Baltimore region and contribute to GALION activities: under NASA funding, UMBC will be adding three new lidars to its suite of instrumentation in the Physics Building. Two parallel micropulse (MPL) lidars will be run in vertically pointing mode and a position will be available to test an additional third MPL against these two reference lidars. Scanning over the city of Baltimore will be conducted with an eye-safe 355 nm lidar. An eye-safe 1.55um lidar will be constructed which will also allow scanning over the city.

NASA Grant: **A Hyperspectral Infrared Radiance Climate Record using AIRS, IASI, and CrIS (#NNX08AD34G)**

Investigators: B. Imbiriba, JCET; L. L. Strow, Physics (PI); S. DeSouza-Machado, Physics; S. Hannon, JCET

Description of Research

Carbon dioxide (CO_2) is the most relevant and the best-known greenhouse gas in the Atmosphere, but its precise concentration as a function of global position is poorly known. Such knowledge is relevant for the production of accurate climate models. Using the AIRS hyperspectral Thermal Infrared instrument, Imbiriba and his fellow JCET investigators measured the carbon dioxide concentration at 500 mbar, producing a global CO_2 map. One motivation for their research is that previous works with the AIRS instrument were sensitive at the 200-300 mbar range (approximately 9 Km to 12 Km), the upper Troposphere [1]. Their choice of AIRS channels enabled them to increase the pressure layer sensitivity to about 500 mbar (about 5Km), which is considerably closer to the surface and hence the CO_2 sources and sinks. In this way, results will be less dependent on the atmospheric transport and will relate to the source in a simpler fashion. It is important to see that the present (AIRS/IASI) and future thermal infrared instruments (CrIS, GOSAT) will be the only way to produce long track records (starting from 2002) of global CO_2.

Accomplishments for FY 07-08

The AIRS retrievals are made by means of a bias minimization method, similar to the Newton's method, on the relevant spectral channels. Imbiriba and his group used two regions of the infrared spectrum. In order to detect the effect of unknown factors, these regions were chosen far enough apart so that they would be affected differently. One region (longwave) is the 791.75cm^{-1} CO_2 Q-branch, and the other (shortwave) is at the broad 2400cm^{-1} CO_2 R-branch region. Both regions allows for peak sensitivity at around 550 mbar, reaching the surface. The most significant improvement over the previous work of this group was to enable the CO_2 retrieval over land, for which they had to assimilate a Global land emissivity database in their calculations, as well as modify their cloud detection algorithm.

The JCET investigators were able to generate preliminary CO_2 maps for several months of the years 2003 through 2007 (for April 2004, see *Fig. 1*). The results are encouraging, showing correct seasonal patterns. They also show regions of high concentration, which could be blow-offs from the continental areas. These results are compatible with the NOAA model GlobalView [2] (a 3-D assimilated model for atmospheric CO_2) and with recent SCIAMACHY CO_2 data [3]. Several issues to be addressed remain, such as the presence of low clouds on the AIRS fields-of-views, which do distort the results, and spectroscopy errors.

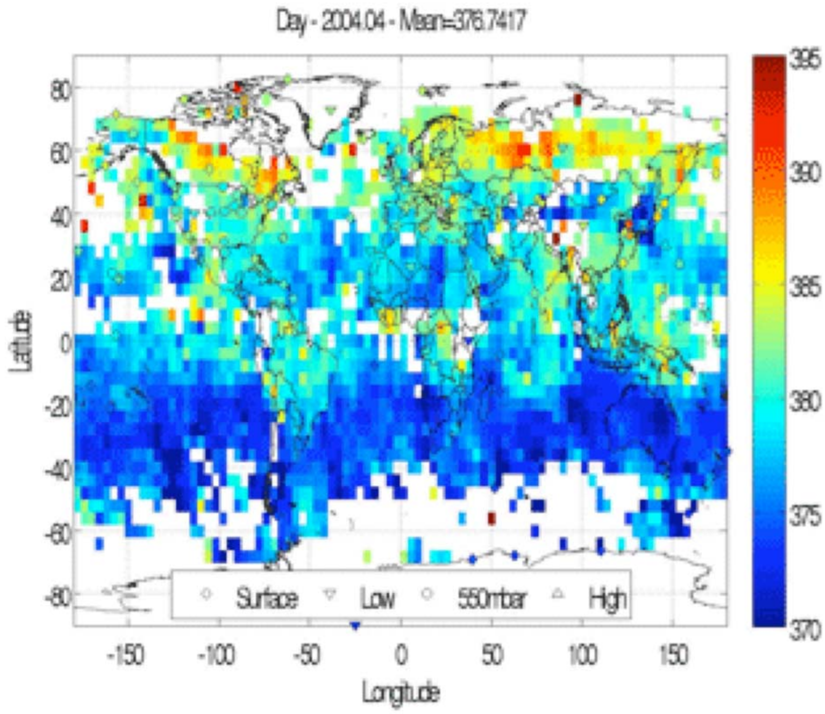


Figure 1: Geographical distribution of CO_2 concentration, in parts per million in volume. The colored symbols on the map represent actual measurement sites as reported by the CarbonTracker (NOAA) system. The Seasonal CO_2 pattern is presented here, highs at the Northern Hemisphere and lows at the Southern Hemisphere. Tropical and Arctic highs may be due to cloud contamination.

Objectives for FY 08-09

In the coming year, Imbiriba's research will focus on validating the CO_2 retrieval algorithm and comparing with CO_2 models, like GlobalView. The JCET investigators also will push for the incorporation of their algorithm into the AIRS product system, making it then available to the wide community. In parallel, they are going to perform similar global CH_4 retrievals, which use very similar techniques, but have a worse signal-to-noise ratio. With the IASI instrument they plan to measure CO_2 and CH_4 four times a day for each Globe location (1:30, 13:30 for AIRS, 9:30, 21:30 for IASI) and attempt to observe the diurnal CO_2, CH_4 cycles.

UMBC:	**Remote Sensing of Volcanic and Anthropogenic SO_2 Emissions**
NASA Grant:	**Near Real-time NASA Volcanic Cloud Data for NOAA, FAA and USGS Decision Support Systems (NNS06AA05G)**
NASA Grant:	**Mapping SO_2 Emissions with NASA AURA Ozone Monitoring Instrument (OMI) and GOCART Model for Air Quality and Climate Science (ROSES 2005 Atmospheric Composition NRA)**
NASA Grant:	**Validation of OMI L_2 Sulfur Dioxide Retrievals over Volcanic and Anthropogenic Sources (NNG06GJ02G)**
Investigators:	Arlin Krueger, Research Professor, Physics; Nickolay Krotkov, Senior Research Scientist, Research Faculty, GEST; Kai Yang, Assistant Research Scientist, GEST; Simon Carn, Assistant Research Scientist, Research Faculty, JCET; Keith Evans, Research Analyst, JCET

Description of Research

The SO_2 emissions group in JCET is a leader in UV remote sensing of volcanic clouds, renowned for providing unique observations from the TOMS and OMI sensors to the scientific community. The goals of this research are to determine the effects of volcanic eruptions and passive volcanic emissions of SO_2 on the environment and climate and to ascertain the time-dependent properties of volcanic clouds containing SO_2, ash and sulfate aerosols. Krueger and his investigators also seek a fuller understanding of the solid earth processes that control the production and emission of SO_2 and ash in order to refine and develop methods of eruption prediction and airborne hazard mitigation using remotely sensed data. OMI measurements are being used to develop an accurate inventory of global SO_2 emissions, and will be exploited in operational environments such as volcanic eruption alarm and aviation hazard mitigation systems.

Accomplishments for FY 07-08

The complete OMI SO_2 dataset was reprocessed using the ECS collection-3 calibration after determining that the calibration was an improvement over the collection-2 calibration. The Linear Fit (LF) SO_2 algorithm, for retrieval of high SO_2 column amounts using OMI measurements [Yang *et al*, 2007), and the precursor $OMTO_3$ total ozone algorithm were modified to remove artifacts produced when IR cloud heights were used instead of UV cloud heights. The OMI Science Team has adopted the modified $OMTO_3$ algorithm for production of the official total ozone dataset. The new data are now available in the public release of the Aura-OMI Level-2 Sulfur Dioxide Product ($OMSO_2$), available from NASA's GSFC Earth Sciences (GES) Data and Information Services Center (DISC). The SO_2 group website (http://so2.umbc.edu) now carries images of volcanic regions using operational OMI SO_2 measurements. These images are being posted daily on the SO_2 group website to visualize volcanic degassing and eruption clouds. Collaborators at NOAA/NESDIS released similar near real-time (NRT) $OMSO_2$ data on their pre-operational website (http://satepsanone.nesdis.noaa.gov/pub/OMI/OMISO2/index.html).

The unusual eruptions of Jebel al-Tair (Yemen) on September 30, 2007, the first eruption of this Red Sea volcano since 1883, and Llaima (Chile) in January 2008 were tracked with OMI. Halemaumau caldera on Kileuea in Hawaii started a sustained degassing period beginning in March 2008 and continuing through the end of this reporting period. On May 2, 2008, Chaitén volcano (southern volcanic zone, Chile) erupted for the first time in many thousands of years, marking the first monitored eruption of rhyolite magma from a caldera and the first VEI 5 eruption of this century.

An iterative spectral fit (ISF) algorithm development is showing improved total ozone and sulfur dioxide retrievals, especially in large volcanic clouds containing high SO_2 amounts above 100 DU. Cloud tonnages are shown to be underestimated by a factor of 2 in some cases. The ISF algorithm has also produced information on the height of SO_2 layers. This unexpected result is of great interest, particularly to the aviation and climate change communities. This may enable safe flights of aircraft either above or below a volcanic cloud, thus saving fuel.

A significant validation of OMI SO_2 data was conducted with aircraft data collected over Ecuador, Colombia and Mexico during the NASA Tropical Composition, Cloud and Climate Coupling (TC4) campaign in July-August 2007. Although the aircraft could not fly in the higher SO_2 portion of the plume from Tungurahua over Ecuador due to flight restrictions, data from the ozone lidar was converted into SO_2 concentrations by adjusting for cross-section differences.

Objectives for FY 08-09

An AIRS SO_2 algorithm will be developed for implementation in the NOAA NRT SO_2 data delivery system, and Krueger and his group hope to incorporate GOME-2 SO_2 data from the European MetOp platform. They will also conduct ground-based SO_2 measurements at volcanoes and pollution sources using a new UV spectrometer system. The NRT system at NOAA is expected to become operational, including GOME-2 and AIRS quantitative retrievals.

NASA Grant:	**CALIPSO Science Team Support (NAS1-99107)**
Investigators:	Kevin McCann, Research Associate Professor, Physics/JCET; Raymond Hoff, Director, GEST-JCET; Rubén Delgado, Research Associate, JCET; Meloë Kacenelenbogen, Research Associate, JCET; Matt Potyraj, Undergraduate Student/UMBC.

Description of Research

McCann and his group have been primarily concerned with two research areas: the development of new approaches to the detection and classification of features by CALIPSO, and a multi-instrument approach to the measurement of aerosol optical depth (AOD) in conjuction with the passive instruments OMI and AIRS. The algorithm development work has focused on the use of image processing techniques, as opposed to the use of traditional single-profile techniques, to detect and identify aerosols and clouds. Their work with the OMI and AIRS instruments has provided each system's respective retrieval algorithms with the altitude structure of aerosol plumes, which has led to new approaches to the retrieval of aerosol properties by the passive instruments.

Accomplishments for FY 07-08

The JCET investigators have successfully implemented two new feature detection techniques for the CALIPSO lidar. These techniques use image-processing approaches including threshold detection and edge detection. While the results are still preliminary, to date the group has been very successful in the distinction between aerosols and clouds.

McCann and his team have examined several cases of dust and smoke plumes and have retrieved aerosol optical depths for these cases. These data have also been compared with optical depth measurements made by MODIS and AERONET.

Objectives for FY 08-09

A manuscript is in preparation that documents the AIRS/CALIPSO optical depth retrievals. McCann and his group will continue to work closely with researchers at NASA/Langley to continue validation and improvement of the aerosol optical depth retrieval algorithms. Presently, the JCET investigators are implementing the application of their new algorithms to large data sets for comparison with the Level-2 products that are produced from the NASA/Langley algorithms.

NASA Grant:	**AIRS Trace Gas Retrievals for INTEX-B: Mission Planning, Analysis and Satellite Validation (NNG06GB06G)**
NOAA Grant:	**Monitoring Tropospheric CO2, CH_4 and CO Profiles Using a Distributed Network of High Resolution Infrared Spectrometers (NA04AOAR4310095)**
NASA Grant:	**AIRS Trace Gas Retrieval Validation and Analysis and Fire Detection (NNG04GN42G)**
JPL Subcontract:	**Optimization, Validation, and Integrated EOS Analysis of AIRS Trace Gas Products**
JCET Task 112:	**A global model study of emissions and long-range transport of aerosols and trace gases using Terra and Aqua satellite data** ***(Sponsor: M. Chin, GSFC Code 613.3)***
Investigators:	W. Wallace McMillan, Associate Professor of Physics, UMBC/JCET; Leonid Yurganov, Senior Research Scientist, JCET/UMBC; Keith Evans, Research Analyst, JCET/UMBC; Chris Wilson, Ph.D. Graduate Student, UMBC; Debra Wicks Kollonige, Ph.D. Graduate Student, UMBC; Kimberly Wall, Ph.D. Graduate Student, UMBC; Tony Salemi, Undergraduate Student, UMBC

Description of Research

Dr. McMillan's research has spearheaded the use of infrared spectra of atmospheric thermal emission for retrievals of tropospheric CO from ground, air, and space, and O_3 from the ground. Consulting with ABB Bomem of Quebec, Canada, McMillan equipped his Atmospheric Remote-sensing Facility (ARF) with the first commercial prototype FTIR atmospheric sounding system, the Baltimore Bomem AERI (BBAERI). The Baltimore NOAA AERI (BNAERI) has now joined ARF and is proposed for several field deployments. Through participation in the MOPITT Correlative Measurements Team, AIRS Validation Team, and AIRS Science Team, McMillan's group has provided products for validation of satellite CO and O_3 measurements and is developing tropospheric CO and O_3 climatologies from archived ground-based FTIR spectra. As leader for the AIRS Science Team Minor Constituents Focus Group, McMillan continues to oversee validation and optimization of AIRS CO retrievals. CO was included as a new standard product in the version 5 AIRS team algorithm in 2007.

Accomplishments for FY 07-08

Validation, optimization, analysis, and interpretation of satellite (AIRS) and ground-based (AERI) CO and O_3 retrievals dominated the group's research activities, with Mr. Evans joining the group to assist with analyzing AIRS CO data. The group has published four papers, submitted two more, and given or contributed to 23 talks and posters. A major accomplishment was the delivery of CO retrievals as a new standard product in the AIRS v5 team retrieval algorithm, operational at the NASA GSFC DISC in July 2007. As of January 2008, v5 CO retrievals were publicly available for the entire record of AIRS data. Validation of AIRS v5 CO retrievals is ongoing, with a publication to be submitted in late 2008, and the group's research continues to evaluate new optimization and retrieval techniques for inclusion in AIRS v6 CO retrievals for delivery in early 2009. Their research contributed to the validation of AIRS v4 CO retrievals [McMillan *et al.*, 2008a], analysis of the five-year climatology of AIRS v5 CO [McMillan *et al.*, 2008b], comparison of AIRS v4 CO to MOPITT CO retrievals and reconciliation with bottom-up CO emissions estimates [Yurganov *et al.*, 2008], and investigations of long-range transport across the Pacific Ocean [Zhang *et al.*, 2008]. AIRS v4 CO retrievals also are utilized in the validation of CO retrievals from the new airborne MicroMAPS instrument [Hopkins *et al.*, 2008]. Additional papers will be submitted in 2008 regarding AIRS, other A-Train and aircraft observations of the Mexico City pollution plume during INTEX-B/MILAGRO, and continental influences on Houston air pollution during the TexAQS2006 experiment. Collaborations continue with numerous modeling groups to utilize AIRS CO retrievals in studies of local and regional pollution, long-range transport, source inversions, and diagnosis of atmospheric dynamics. BBAERI data from McMillan's ABOVE field experiments contributed to one published [Nalli *et al.*, 2008] and one submitted [Lightner *et al.*, 2008] paper.

Wicks Kollonige continues her research of stratospheric-tropospheric exchanges utilizing AIRS O_3, CO, and H_2O data in conjunction with other A-Train satellite observations and *in situ* aircraft measurements. In May, she successfully defended her thesis proposal; a related publication should be submitted in late 2008. Wilson's research regarding trace gas retrievals from AERI spectra continues, with a concentration now on O_3 retrievals and the dynamics of the boundary layer. During the winter and spring 2008, Wilson ran BBAERI during the WAVES 2008 field experiment in coordination with lidar operations at UMBC. Analysis of WAVES 2008 data for low level jets will be a central component of his thesis proposal planned for defense in late summer 2008. Prior to pursuing teaching opportunities, Wall assisted the PI with maintenance of the ARF weather station and analysis of AIRS observations of pyrocumulonimbus events. After graduating in May 2007, Salemi continued with ARF until he accepted a position with NOAA in October 2007.

Yurganov continues to lead the group's analysis and interpretation of AERI and BBAERI trace gas retrievals and incorporation into validation and analyses of AIRS retrievals. His paper comparing AIRS v4 CO to MOPITT CO retrievals and reconciling them with bottom-up CO emissions estimates was published in JGR [Yurganov *et al.*, 2008], and he continues to expand this analysis with AIRS v5 CO retrievals. He has developed empirical regressions to account for errors in solar scattering and total column water vapor on AERI boundary layer CO retrievals, and he continues to lead the effort to validate AERI CO retrievals with correlative *in situ* measurements. Yurganov has taken responsibility for identifying opportunities for field deployments of BNAERI with another proposal submitted in 2007. In addition, he has pursued collaborative opportunities with colleagues in Russia with a successful NSF proposal to support a trip to Russia with site visits and invited talks at an international conference in October 2008.

Objectives for FY 08-09

The coming year will see validation and continued analysis of AIRS v5 CO and delivery of an improved v6 CO algorithm. McMillan's group will continue their collaborative analysis of INTEX-A, INTEX-B, and TEXAQS data with several planned publications. They will expand their satellite CO analyses to include data from the European IASI instrument, offering higher spatial and spectral resolution versus AIRS but utilizing the same algorithm strategy as AIRS through collaboration with NOAA colleagues. With support from a pending proposal, the group expects to deploy BNAERI for an extended field experiment, either at the Mount Bachelor Observatory in Oregon or the Howard University Beltsville Campus. Yurganov will continue analysis of the AERI archive data as well as BBAERI data with publication of validation of the AERI CO retrieval algorithm; Wilson will continue work on improving AERI trace gas retrievals as part of his dissertation research; and Wicks Kollonige will continue her integrated analysis of AIRS products with other A-Train observations as part of her dissertation research.

Task 107: **Air Quality support for Giovanni** *(Sponsor: G. Leptoukh, GSFC Code 610.2)*

Investigators: Ana I. Prados, Assistant Research Scientist, JCET; Gregory Leptoukh, NASA GSFC 610.2

Description of Research

This work supported the acquisition and integration of EPA surface $PM_{2.5}$ observations into Giovanni, NASA Goddard's web-based tool for Earth science remote sensing data exploration and visualization. It also supported the development of an Air Quality Instance within Giovanni that includes both satellite and *in situ*-based observations for air quality applications, enabling easy comparisons of these two measurement techniques and the evaluation of satellite data for tracking surface air pollution. As part of the 3D-AQS project, (please refer to R. M. Hoff's report), Prados contributed weekly summaries of U.S air quality through the Smog Blog, provided tropospheric NO_2 columns for the project, and assessed OMI NO_2 through comparisons with EPA NO_2 *in situ* concentrations.

Accomplishments for FY 07-08

The use of remote sensing data to complement and enhance surface air pollution networks is currently an active area of research. However, uncertainty remains regarding the ability of satellite-based sensors to be used as a proxy for surface air quality. One way to increase the understanding of the utility of these datasets is by collocating satellite observations and surface monitor data in space and time.

Giovanni, an existing tool at NASA Goddard Space Flight Center, provides the public with easy access to NASA Earth Science Data Sets. It also includes a number of science exploration and visualization tools, such as the ability to view satellite data on latitude/longitude, Hovmoller, or time series plots, or compare data sets via scatter plots and correlation maps. As part of this task, Prados integrated $PM_{2.5}$ station data into Giovanni. The data were obtained from DataFed, another web-based portal for access to Earth Science data, where the data were mapped to a grid and time-averaged to maximize collocation with satellite overpass times over the U.S prior to integration into Giovanni. She performed the data integration from DataFed into Giovanni via a web-based internet protocol called WMS, which is executed every time a user performs a data or service request. The end product is gridded $PM_{2.5}$ concentrations on the same 1x1 degree grid as remote sensing products already in Giovanni. Once the datasets are on the same grid, Giovanni can be used to provide the public and researchers with the ability to quickly perform comparisons among the datasets.

Once the protocol for integrating surface $PM_{2.5}$ observations into Giovanni had been established, Prados worked on the creation of an Air Quality Instance, which refers to a grouping of datasets by satellite sensor or topic, such as aerosols. She also wrote the user documentation for the new datasets. Recently the instance became operational and is now open to the public. Satellite datasets include MODIS Aerosol Optical Depth and OMI aerosol extinction and Aerosol Index. While the OMI Aerosol Index is not generally sensitive to aerosols above the Planetary Boundary Layer, Aerosol Optical Depth observations from MODIS Terra and Aqua have been shown to correlate with $PM_{2.5}$ concentrations; in other words, the MODIS AOD algorithm is sensitive to fine particulates within the Planetary Boundary Layer (PBL). To this end, Prados has explored the AOD/ $PM_{2.5}$ correlations using Giovanni and has found the correlations to be lower yet comparable to analysis using the *in situ* (non-gridded) $PM_{2.5}$ concentrations and the higher resolution Level 2 satellite data. The correlations indicate that Giovanni can be used as a tool to further explore these relationships. Furthermore, because Giovanni provides the MODIS AOD and $PM_{2.5}$ on the same geographical grid, Giovanni correlation maps can be generated easily to better understand the geographical and temporal variability of the correlations. Results of this work were presented by Giovanni team members at the 2007 Fall AGU meeting and the 2008 Spring AGU meeting.

As part of this task, Prados has also used Giovanni-generated products to construct 3-Dimensional views of Air Quality. Although Giovanni does not yet include fully vertically-resolved extinction profiles from Calipso, the A-Train Instance provides aerosol curtain plots with aerosol flags that indicate the presence of aerosols and clouds. Because all 2D-Giovanni products are also available as KMZ datafiles that can be viewed with tools such as Google Earth, lat/lon maps used in conjunction with Calipso curtain plots can provide a 3D-view of air quality. This work also involved identifying case studies with Calipso overpasses during high surface aerosol events. Prados presented the results of this work at the UMBC 3D-Visualization Workshop on June 2-4, 2008.

Objectives for FY 08-09

For the next fiscal year, Prados will continue to maintain and improve the Air Quality Instance at the GES DISC and continue research efforts on the correlation between satellite AOD measurements and surface $PM_{2.5}$ concentrations. She will also provide support for the recently funded Giovanni HTAP project. Also, on two additional tasks she will provide OMI tropospheric NO_2 columns and assist with analysis of this product for examining NO_2 pollution over the U.S and in China, as well as assist with comparisons with model data. NO_2 is a criteria pollutant leading to both ozone formation and $PM_{2.5}$ or fine particles, which are also criteria pollutants. Finally, Prados will continue to lead a NASA-funded effort to develop training modules on the use of NASA Earth Science products and tools, such as Giovanni, IDEA, and the AERONET synergy tool, and the coordination of training activities at national and international conferences.

NASA Grant:	Cross-Validation of TES with AIRS: Radiances and Radiative Transfer (NNX07AG73G)
NASA Grant:	A Hyperspectral Infrared Radiance Climate Record Using AIRS, IASI and CrIS (NNX08AD34G)
NASA Grant:	NNP CRIS Sensor: Calibration and Radiative Transfer (NNG04GE10A)
NASA Grant:	Refinement of the AIRS Radiative Transfer Algorithm (NNG04GG03G)
NASA Grant:	Participate in NGST CrIS instrument and algorithm reviews and calibration/validation planning and oversight (NCC5-494)
NOAA Grant:	NPOESS Internal Government Studies (IGS) Analysis of CrIS/ATMS Instrument Test DATA and Operation Software (DG133E-06-CQ-0024-2 (-3))
NOAA Grant:	Fast Radiative Transfer Modules For CrIS (DG133E-07-SE-3518)
NOAA Grant:	CrIS/ATMS Product System (DG133E-06-SE-5235)
NOAA Grant:	Production and Evaluation of the AIRS Trace Gas Products (DG133E-06-SE-5843)
NOAA Grant:	Production & Evaluation of the AIRS Trace Gas Products (DG133E-06-SE-5849)
NOAA Grant:	AIRS Cloud Clearing Risk Reduction (DG133E-07-SE-2796)
JPL:	An Improved OLR Algorithm for AIRS (NM0710861)
Investigators:	L. Larrabee Strow, Research Professor, Physics, JCET; Sergio DeSouza-Machado, Research Assistant Professor, Physics, JCET; Scott Hannon, Faculty Research Assistant, JCET; Howard Motteler, Research Associate Professor, Physics, JCET; Breno Imbiriba, Research Associate, JCET

Description of Research

This group's work centers on remote sensing of the atmosphere using high spectral resolution satellite sounders (AIRS on NASA EOS-Aqua, IASI on EUMETSAT-Metop), with an emphasis on radiative transfer, spectroscopy, instrument validation, and climate trends. They are also participating in the development and pre-launch testing of the NPOESS Cross-Track Infrared Sensor (CrIS) that will become the operational U.S. weather satellite sounder for the next 15+ years.

Their work partially centers on providing accurate operational radiative transfer algorithms (RTAs) for these sensors and using them to validate sensor performance, especially with regard to spectral calibration. Now that the AIRS record is six-years long, it is also being used to measure climate radiative forcing trends due to CO_2 and mineral dust. Work has also begun on measuring CH_4 variability and trends. This work naturally feeds back into operational algorithms for weather forecasting.

Accomplishments for FY 07-08

Strow and his investigators successfully produced a 4-year climatology of mid- to lower-tropospheric CO_2 derived from AIRS observations over ocean. Validation suggests accuracies of ~0.5 ppm, which should allow meaningful tests of CO_2transport models which are key to understanding global CO_2 sinks. Especially interesting are the time phase relationships between the AIRS nominal 650 mbar CO_2seasonal cycles and the boundary layer cycle. The CO_2 rectifier effect is clearly seen in that the group's AIRS CO_2 product has a smaller seasonal amplitude than at the boundary layer. Strow also observed enhanced CO_2 levels in the Indian Ocean due to blow-off from the Asian continent. The group's observed 4-year growth rates of CO_2 (measured as a function of latitude) are about 0.4 ppm/year larger than estimated boundary layer rates for the same time period. This work represents the most comprehensive measurement of mid-tropospheric CO_2 and the only global measurement of background (ocean) growth rates. These measurements are currently being extended to land areas, where cloud contamination is more difficult to avoid because of the variability in the surface emissivity and temperature.

Using similar techniques, the group has also measured CH_4 upper-tropospheric amounts as a function of latitude. These measurements have similar latitudinal variability to known boundary-layer CH_4, but show higher amounts of CH_4 in the Southern Hemisphere tropical upper-troposphere due to transport from the Northern Hemisphere. They see 3-year growth rates of CH_4 of ~ -1.1 ± 3.2 ppb/year, which are very small growth rates compared to 30 years ago where 15 ppm/year was common. However, significantly higher growth rates are seen in the NH than in the SH, where growth rates were negative for this time period.

The horizontal and vertical structure of the covariance between water vapor and temperature in the tropical troposphere was examined using AIRS retrievals. This work, done in collaboration with graduate student A. Gambacorta, C. Barnet (NOAA/NESDIS), and B. Soden (U. Miami) reveals a rich variety of covariances that can be an order of magnitude larger than given by the Clausius-Clapeyron equation. These data provide new information on the large-scale tropical circulation, especially with regard to the relationship between upper tropospheric water and temperature.

Strow and his group have finished a comprehensive comparison between their retrievals of mineral dust with AIRS to other instruments on the A-Train: MODIS, OMI, CALIPOSO, and POLDER. This work validates their AIRS dust retrievals, and should allow future accurate measurements of dust radiative forcing (and trends) with AIRS that would be a unique contribution to the present understanding of the effects of dust on the atmosphere. This work also showed that AIRS-only retrievals can give better estimates of dust heights than presently available (GOCART).

NASA and NOAA use Strow's group's RTAs (for both AIRS and IASI) for operational sounding products. These operational RTAs were improved this year to include better spectroscopy and scattering to allow operational retrievals of cloud properties (cirrus) and dust with infrared sounders. The group has made these RTAs available to the community. A significant feature for climate studies is the fact that both the AIRS and IASI RTAs contain identical spectroscopy, allowing careful comparisons between both instrument's geophysical products.

Strow and his investigators have developed a double-difference technique using these RTAs to perform cross-validation of the AIRS and IASI sensors. AIRS observations generally occur four (4) hours after IASI. Model data (ECMWF) is used to essentially interpolate over this time difference. By difference the AIRS and IASI observed minus computed (from ECMWF) radiances, the group can compare radiances differences over a wide range of spectral channels. In many spectral regions these differences are well below 0.1K, an encouraging result that should eventually give confidence to time series that combine these two instruments.

During Spring 2008 the group participated in the thermal vacuum testing of the CrIS sensor, which will fly on NASA's NPP platform and on the operational NPOESS system. They analyzed a very comprehensive set of gas cell spectra taken with CrIS (of CO_2, CH_4, and HBr) along with spectra of a CO_2 laser source, to determine the CrIS spectral line shape and frequency calibration accuracy. These tests were very successful and indicate that the CrIS spectral accuracy will be far below specification, close to values needed for measurements of long-term climate change. This work represents the culmination of several years of preparation, primarily by Howard Motteler, who retired in June 2008, and is a testament to the quality of his research.

Objectives for FY 08-09

Journal articles on the AIRS dust validation, the CH_4 measurements, the AIRS and IASI cross validation, and the CrIS spectral calibration will be prepared this year. In addition, raw data is in hand for a comprehensive measurement of the AIRS spectral calibration that the group hopes to complete in the next six months.

Major efforts will be put into AIRS CO_2 retrievals over land (this has been reported on at meetings), and the group has very encouraging results that they believe mostly require slightly better quality control. They plan to compare their 4-year AIRS CO_2 climatology to model results, such as NOAA's CarbonTracker, to determine how well it represents CO_2transport. Strow’s group is also assisting NASA/JPL in the development of an L1c AIRS radiance product that can be used directly for climate studies. Work is just beginning on incorporating their AIRS dust retrieval into the AIRS retrieval system, and that will continue this year. Finally, they will start construction of a validation system for the CrIS sensor using IASI data that is easily transformed to CrIS specifications.

NASA Grant:	**AURA Validation, TES CO and O3 Validations Using AIRS**
NASA Grant:	**Atmospheric Composition, Inter-comparison of EOS CO Sensors**
NASA Grant:	**Tropospheric Chemistry, ARCTAS Support and Analyses**
Investigators:	Juying Warner, Research Assistant Professor, Geographical and Environmental Systems; Zigang Wei, Assistant Research Scientist, JCET; Zhibin Sun, Research Associate, JCET; Allen Chu, Associate Research Scientist, GEST/UMBC

Description of Research

Warner's projects involve the evaluations of current NASA tropospheric trace gas measurements and the developments of more accurate methods to retrieve these quantities, which are important to air quality and climate change studies. The objective is to build a bridge in understanding the differences between EOS sensors that measure the same trace gas products. The detailed aspects of the group's work can be summarized in the following areas: (a) Inter-comparison of AIRS/TES/MOPITT using current AIRS operational products; (b) similar comparisons for under cloudy conditions; (c) new trace gas products with improved accuracy using combined AIRS/TES data; (d) development of new retrievals using Rodgers formulation; (e) participation in NASA ARCTAS experiments; and (f) collaborations and support to the greater community.

Accomplishments for FY 07-08

Tropospheric CO comparisons between AIRS and MOPITT have been partly published by Warner *et al.* [2007], and this year's efforts focus on the comparisons of all the collocated CO profiles between AIRS and TES operational products for years 2006 and 2007. In general, TES are lower in the mid-troposphere by approximately 20 ppbv and higher in the lower troposphere to as much as 50 ppbv or higher. TES CO variability is significantly higher than AIRS. AIRS and TES profiles are also compared against *in situ* profiles from INTEX-B field experiments. This work will continue to include measurements from other field campaigns comprised of TC4, SAUNA, MOVES, and other AURA validation missions, as well as current and future missions such as ARCTAS.

The spatial resolution of AIRS sensor is at 15km^2; however, AIRS cloud-clear radiances that the retrieval uses are, at 45km^2, limited by the use of AMSU measurements in the cloud clearing process. To use a single view AIRS resolution is desirable to resolve tropospheric CO features with high accuracies: since the sensor lifetime for AMSU is perceived to be much shorter than AIRS, an independent method of cloud clearing or detection is needed for new AIRS retrievals. The JCET group developed a collocation scheme between AIRS and MODIS cloud masks in order to use the MODIS cloud mask directly for AIRS retrievals because AIRS and MODIS are both onboard the Aqua satellite. With the new algorithm this approach will be further tested so its strengths and limitations can be identified. This collocation scheme between AIRS and MODIS cloud mask can also be used to identify any potential cloud contamination for AIRS operational products for the purpose of validation under cloudy conditions. Part of the TES L2 products, cloud optical depth is used to identify TES cloudy pixels. The SDVs between TES and AIRS under cloudy conditions are higher than under clear conditions.

Based on the previous studies, the *a priori* selection is essential to the quality of the retrieval products, since it causes biases between sensors. Several options for AIRS retrievals have been studied: using a uniform *a priori*, AFGL or MOPITT *a priori*, and using global dynamic CO profiles, such as the retrieved CO profiles from TES. The Optimal Interpolation (generally used in data assimilation) technique is used to obtain *a priori* for AIRS for areas away from nadir. This is the group's first attempt for data interpolation in this technique to develop a 3D-dynamic *a priori* field; much more work is needed to incorporate vertical weighting using averaging kernels. They have studied a two-month-long period coincident with INTEX-B (3/1/2006-5/15/2006) and produced 3D *a priori* fields that are very promising in terms of increased accuracy for AIRS retrievals. This technique will be used not only in their new retrieval system, but also to combine the current operational products of AIRS and TES for new products with higher information content that can be used in air quality studies.

Using Rodgers method 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. The AIRS operational algorithm will be compared with the algorithm using Rodger's Maximum Likelihood formulations. The goal in developing the new algorithm is to meet all the needs of the project: instead of obtaining AIRS L-2 products of temperature, water vapor, ozone profiles and the cloud-cleared AIRS radiances from the NASA DAAC as inputs, the new and operational version of AIRS retrievals will be processed in parallel. Modules using the Maximum Likelihood inversion have been inserted into the current AIRS off-line operational system, such that all other geophysical properties required by the retrieval routines stay the same between the two algorithms except the CO inversion. The inversion methods will then change from operational to new for water vapor, temperatures, ozone, and so on, with respect to observing how the CO retrievals respond accordingly.

The group participated in the Spring and Summer 2008 ARCTAS campaigns. Five NASA, NOAA, and DOE planes were deployed to study atmospheric chemistry and aerosols over the Arctic region, significant for climate change, providing the group opportunities to validate AIRS retrievals over the Arctic region, retrievals that were previously impossible.

Objectives for FY 08-09

The CO comparisons between AIRS and TES under both clear and cloudy conditions will continue and results will be published as appropriate. Validation will include more past and ongoing NASA field measurements. Refinement of the new AIRS algorithm using Rodger's formulations will continue, and the group will compare the outputs with AIRS operational products, initially comparing the new outputs with TES measurements for selected cases based on current knowledge of the operational products of both sensors. Components will be tested that will provide improvements to AIRS retrievals not included in current AIRS operational products, such as using *a priori* from TES measurements, improved surface emissivity retrievals, improved cloud treatments, and different channel selections.

NASA Grant:	NNG05GC-79-A
NASA Grant:	AURA Validation, TES CO and O3 Validations Using AIRS
NASA Grant:	Atmospheric Composition, Inter-comparison of EOS CO Sensors
NASA Grant:	Tropospheric Chemistry, ARCTAS Support and Analyses
Task 88:	Geomagnetic Data Assimilation (NSF); Core Dynamics and the Application to Surface geodynamics Observables (NASA) *(Sponsor: W. Kuang, GSFC Code 697)*
Investigators:	Zigang Wei, JCET Visiting Assistant Scientist; Juying Warner, JCET Assistant Scientist; Weijia Kuang, JCET Fellow, GSFC, Code 697

Description of Research

In order to forecast the future changes of geomagnetic field, different kinds of geomagnetic observation models, specifically GUFM1 historical geomagnetic models and CALS7k paleo-magnetic models, which are a total of 7000 years long, were input into geodynamo model. Such observation models had different time validation and different accuracies. The JCET investigators combined them into an observation data series. Based on these observations, the data assimilation runs were carried out using 20, 40, 100, 400, 5000 and 7000 years of observations, respectively.

Wei and his fellow JCET investigators compared the differences and correlations between forecasts and observations, as well as forecast and free model runs. They were developing a new retrieval by using Rodgers algorithm. This was a totally different algorithm compared with current AIRS retrieval. They focused on comparing the variables retrieved from the new algorithm with those from MOPITT, TES and MLS, which are retrieved by Rodgers' algorithm. At the same time, the group conducted some validations and evaluations of the current NASA tropospheric trace gas measurements by comparing AIRS/TES/MOPITT products and supporting NASA ARCTAS experiments.

Accomplishments for FY 07-08

A suite of programs for analyzing assimilated geodynamo solutions were developed, which included a geomagnetic field of all components at any position for a given time. Using these tools, the group compared geomagnetic forecast results with the PGRF results over the past three decades.

The group also did geo-collocation works for the AIRS and MODIS data. The AIRS cloud qualities were studied and evaluated with MODIS cloud mask based on the collocation information. At the same time, a new inversion algorithm with Rodgers retrieval method was partly developed under the NASA grant supports, which will contribute to a new retrieval algorithm for AIRS. In order to validate the AIRS products and support ARCTAS field campaigns, the group studied CO transportation with AIRS L1 and L2 NRT data products by using trajectory models. (The results of this are detailed in Dr. Juying Warner's report.)

Objectives for FY 08-09

In the coming year, Wei's main efforts will focus on the development of the new retrieval algorithm. The coding debugging research also will be done within the next year. In addition, the JCET group will continue to run the data assimulation models and analyze the forecast results.

NOAA Grant: **Monitoring Tropospheric CO, CH4 and CO2 Profiles Using a Distributed Network of High Resolution Infrared Spectrometers (NA04 AOAR4310095)**

NASA Grant: **AIRS Trace gas retrievals validation and analysis (NNG-046-N42G)**

JPL Subcontract: **Optimization, Validation, and Integrated EOS Analysis of AIRS Trace Gas Products**

Investigators: Dr. Leonid Yurganov, Senior Research Scientist, JCET (co-PI); Dr. W. Wallace McMillan, Associate Professor, Physics (PI)

Description of Research

A goal of the first project is to complete, validate, and implement an operational algorithm for retrievals of CO_2, CH_4 and CO in the troposphere from the existing distributed network of Atmospheric Radiation Measurements (ARM) sites. Atmospheric Emission Radiance Interferometer (AERI) capability to simultaneously monitor temperature and water vapor enables some source discrimination such as CO_2 from combustion vs. biogenic processes. The demonstrated autonomous operation of the AERIs at the ARM sites argues for their eventual deployment at numerous North American Carbon Program (NACP) and U.S. Interagency Carbon Cycle Science Program (CCSP) network stations. The proposed algorithm development builds on the investigators' ongoing research of compiling CO climatology for the ARM/SGP site. This site will be used as ground truth for existing and pending space platforms. The goals of the second and third projects are validation and analysis of AIRS data. Proper validation is necessary for successful usage of these data by modelers and decision makers.

Accomplishments in FY 07-08

From June 2007 until June 2008, CO concentrations retrieved from AERI spectra for the period between 1997 and 2008 underwent an analysis, which revealed significant drawbacks in the forward model and input data. First, the assumption of negligible contribution from solar scattered light in the spectral range 2130-2200 cm-1 is invalid. An empirical regression allowed for data correction. Second, errors in archived water vapor profiles are too large, up to 20%. These water vapor errors result in up to ~ 30% of errors in retrieved CO. Simultaneous precise H_2O measurements from a microwave radiometer at the ARM site fixed the problem. Third, radiances at 2144 cm-1 calculated with the improved water vapor profiles during nighttime (without scattered solar light) do not agree with the radiances measured by AERI. This last problem is now under investigation; Yurganov hopes that using new, more up-to-date input water vapor continuum coefficients will improve this fit. Comparisons of corrected CO concentration measured by AERI and several vertical soundings by aircraft show a good agreement. Vertical integration of CO concentration achieved by the investigators' technique makes monitoring the entire boundary layer possible. Comparison of AERI data with surface continuous data sets revealed strong spikes in the latter in contrast to much smoother variations in the former.

A comprehensive analysis of CO total columns measured by MOPITT and AIRS [Yurganov *et al.,* 2008] elucidated several important issues. First, the MOPITT CO total column has a precision better than ±13%; however, the accuracy of MOPITT total column data over some continental areas drops in wintertime when the surface is covered by snow. Moreover, the MOPITT error has an upward instrumental drift of ~ 1% per year. The Version 4 of AIRS data can be used for qualitative analysis. Second, monthly mean anomalies of sources are attributed to anomalies of CO emitted by biomass burning (BB), confirmed by comparisons with an independent inventory of BB emissions [van der Werf *et al.*, 2006]. Both data sets show large variations of the BB global emissions with amplitude of up to 100 Tg per year. While fires in tropical forests of Africa and South America are strong, they do not vary much from year to year. The main contributors in the CO anomalies are Siberia, North America, and Indonesia. Indonesian fires return every second year, in 2002, 2004, and 2006. However, the record fire emissions of 1997-1998 (~ 200 Tg CO) have not been surpassed, yet. So far, continents are considered as a net sink for atmospheric carbon dioxide. Burning of continental biomass in 1997-1998 could convert the continents from a net sink to neutral area or even a weak source of carbon for the atmosphere. The results of this work open a door for permanent monitoring of BB emission using satellite CO measurements and provide an early warning for periods of catastrophic fires.

Objectives for FY 08-09

While the objectives depend to some extent on funding for new proposals, the investigators' general objectives include studying natural and/or anthropogenic pollution, cycles of tropospheric gases with respect to their influence on carbon cycle and global climate, and the integration of ground-based and space-borne measurements, ensuring long-term consistent data sets that can be used for quantitative assessments of perturbation of the carbon cycle.

NOAA Grant: **An IDEA product for GOES-R data (DG133E07CN0285)**

Investigators: Hai Zhang, Research Associate, Research Faculty; Raymond M. Hoff, Professor, Physics

Description of Research

JCET at UMBC 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. In an effort to provide more nearly continuous coverage of the continental United States, Zhang ported the MODIS Terra-based IDEA system, which overlays ground-based particulate measurements with MODIS satellite measurements of AOD, to a computer that will ultimately be an operational system for NOAA. This computer will be configured to support inclusion of the GOES-R aerosol product as the primary AOD measurement when GOES-R becomes operational. The system is currently running with current GOES AOD (GASP), which provides AOD updates on a 30-minute basis in addition to the twice daily updates provided by MODIS.

Accomplishments for FY 07-08

Infusing satellite Data into Environmental Applications (IDEA) was created through a NASA/EPA/NOAA cooperative effort and involves the near-real time dissemination of aerosol optical depth data from MODIS to the public using the UW direct broadcast capture of MODIS data. During the past year, the product was transferred from UW to NESDIS and enhanced for a pre-operational test. In addition to the MODIS AOD data from Terra, which was the only satellite data source for the original IDEA site, the MODIS AOD from Aqua and GOES Aerosol and Smoke Product (GASP) are included in the enhanced product so that it provides updates twice a day from MODIS and updates at 30-minute intervals (daytime) from GASP. Air quality forecast guidance is produced through a trajectory model initiated at locations with high AOD retrievals twice per day from MODIS and three times per day from GASP. The IDEA beta test site is located at http://www.star.nesdis.noaa.gov/smcd/spb/aq/. It is prepared to use GOES-R aerosol product from the ABI, which will have nearly the same capabilities as MODIS to generate multi-wavelength retrievals of AOD with high temporal and spatial resolutions. The product will be run at NESDIS and will be a NOAA-supported product relevant to air quality decision makers.

The system was reconfigured to accommodate satellite data acquired from NOAA's FTP server. The five IDEA components were modified to incorporate new data sources from MODIS Aqua and GASP. First, national and regional views of MODIS/GASP aerosol optical depth were modified. The RGB true color images are also plotted for MODIS as background in national views. The channel 1 reflectance is plotted for GASP where clouds are presented. GASP AOD animations are produced every day with 30-minute intervals between frames. Second, 48-hr aerosol trajectory forecasts were initiated from MODIS/GASP AOD at locations where AOD is greater than 0.4 at 50mb, 100mb, 150mb, and 200 mb above the surface level. Forecasts are issued twice for MODIS (Terra and Aqua) and three times for GASP (at 15Z, 18Z and 21Z). Third, 3-day composite data fusion animation of AOD, surface PM2.5, 850mb wind, and ABBA fire locations were modified to include AOD from Aqua and GASP. Fourth, in addition to 60-day time series, the scatter graph and the histogram of MODIS/GASP AOD and PM2.5 for every hourly PM2.5 site were added. Finally, national correlation summary between MODIS/GASP AOD and surface measurements of $PM_{2.5}$, which presents the correlation coefficients over the US map for more than 600 hourly sites over North America.

Additionally, the investigators incorporated the processes in IDEA to have a match-up of MODIS/GASP AOD and 1800 $PM_{2.5}$ sites over North America, and to map MODIS/GASP AOD to the 12x12 km^2 CMAQ grid. These processes run at midnight every day, and the data are provided to the EPA for their Airquest site.

Zhang and Hoff investigated the relationship between GASP AOD and *in situ* $PM_{2.5}$ measurements over ten EPA geographical regions and for different seasons. The GASP AOD was found to have moderate correlations with $PM_{2.5}$ in the northeast regions in all the seasons except winter. The variations of monthly averaged GASP AOD retrievals and $PM_{2.5}$ are in good agreement. The average diurnal variations of GASP AOD retrievals are found to be in agreement with those of $PM_{2.5}$ over regions 1, 2, and 3 (northeast) in the spring and in the summer, and in the afternoon in the other central and east regions (regions 4 to 7) and seasons. Compared with the MODIS AOD retrievals, GASP retrievals have lower correlation coefficients with $PM_{2.5}$ over all the EPA regions due to the less accurate AOD retrievals.

Objectives for FY 08-09

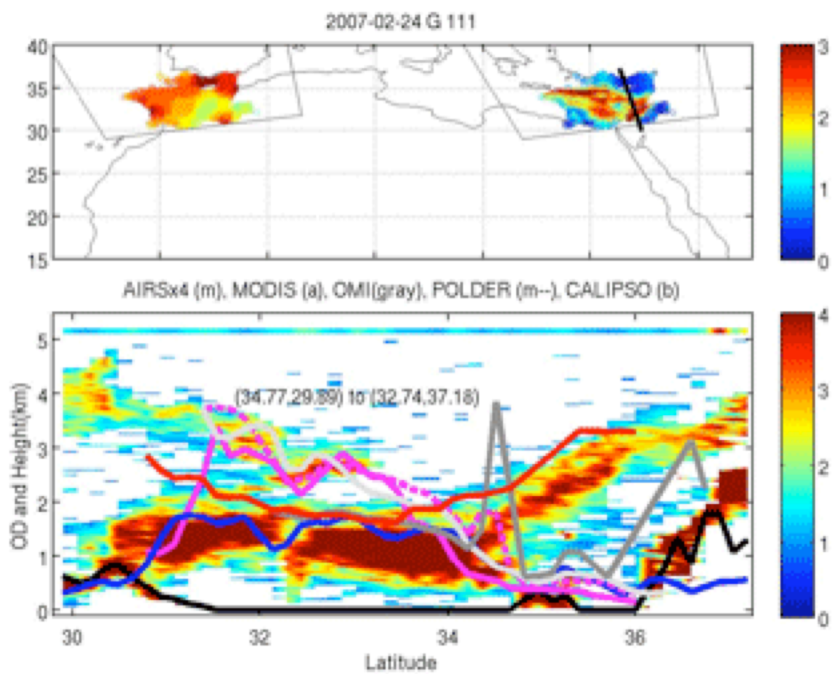
For the coming year, the JCET investigators will work with NESDIS on testing and maintaining the NESDIS IDEA product to ensure continuity in product development and supervise the delivery of the new NESDIS IDEA product. They will develop a new GOES AOD retrieval algorithm based on the MAIAC algorithm developed for MODIS, and evaluate the retrieval results. IDEA using IDL has a license problem if it is put in operation; therefore, they will rewrite and test the code for IDEA in another language (McIDAS, for example).

JCET Highlight: Dust Layer Heights and Optical Depths

Sergio DeSouza-Machado

The top panel shows the optical depths (ODs) and heights (in km) of the dust as seen by AIRS, with the magnitude indicated by the same colorbar. The optical depths in the true geographic location are on the right side of the plot, and are seen to have large variations; the CALIPSO ground track is in black. Offset horizontally to the left are the retrieved heights.

The bottom panel shows the cross section along the CALIPSO track. The axis on the left shows heights and optical depths. The black line shows the surface, with Egypt, Cyprus and Turkey on the left, middle and right. The red line is the AIRS retrieved height, placing the dust roughly at 2 km between Egypt and Cyprus, but rising to 3 km near Turkey. The high resolution CALIPSO data confirms this, as noted from the color bar on the right; this more sensitive instrument also sees a tenuous dust layer near Egypt at ~4 km. Optical depths retrieved from the A-Train instruments are also shown: AIRS (magenta), MODIS (ash), OMI (gray), POLDER (dashed magenta) and CALIPSO (blue).



NASA's A-train constellation of polar orbiting satellites pass over the same ground spot within 15 minutes of each other, carrying instruments for the Earth Observing System (EOS). The figure shows retrieved results from a duststorm observed over the Eastern Mediterranean (between Egypt and Turkey), at ~ 11:00 UTC on 02/24/2007. Generated by strong winds, mineral dust can be transported vast distances, affecting atmospheric processes and carry micronutrients and microorganisms. Most dust observations from space are from instruments with sensors in the visible band. However, infrared instruments also "see" the dust, and are sensitive to the dust height. On the A-Train, the CALIPSO lidar provides the best height resolution, but is limited to a very narrow track. The AIRS hyperspectral infrared sounder has a much wider coverage. (A related manuscript to be submitted to the *Journal of Geophysical Research* is in progress.)

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Mesoscale Atmospheric Processes
(Code 613.1)

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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**
Investigators:	Jeffrey B. Halverson, JCET Associate Director-Academics and Associate Professor of Geography; Haiyan Jiang, University of Utah
Corp. Grant:	**Prototype Electronic Learning Module for Hurricane Science (Prentice Hall Inc.)**
Investigators:	Jeffrey B. Halverson, JCET Associate Director-Academics and Associate Professor of Geography; David Stroud, GEST

Description of Research

Dr. 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 07-08

During the past year, Halverson engaged a number of undergraduate students in the study of Mid Atlantic climatology and meteorology. Undergraduates Linnette Boisvert, David Thompson and Nate Wells helped him analyze and map patterns of winter ice accumulation and tropical cyclone rainfall variation across the Mid-Atlantic region and relate these features to the orography and physiography of the region. This research culminated in the generation of an informative poster detailing the link between climatology and physiography of the Mid-Atlantic region, based on 50 years of data collected by the National Climate Data Center and NOAA's Hydrometeorological Prediction Center. The poster illustrates the characteristic patterns of seasonal temperature and precipitation variation across the Mid-Atlantic, documents a monsoon circulation east of the Appalachians, and, for the first time, illustrates the total distribution of tropical cyclone rainfall over a 15-year period in relation to topography.

UMBC graduate student Ross Dixon worked under the PI's direction to systematically examine objectively analyzed fields of various upper atmospheric meteorological parameters for 30 landfalling tropical cyclones in the Mid-Atlantic. This effort will help the investigators categorize patterns or modes of extratropical transition in the Mid-Atlantic and the dynamic and thermodynamic processes that lead to localized heavy rainfall generation.

Halverson and Dave Stroud continued to develop a prototype for scientific hurricane visualizations, animations and interactive exercises geared toward enriching the textbook-learning experience as part of their work with Pearson-Prentice Hall. Four modules are being developed describing hurricanes in terms of genesis, intensification, maturity, and decay/landfall. Each module will contain one animation of crucial dynamic processes, several visual treatments developed by NASA's Scientific Visualization Studio, and interactive calculations based on real-world data inputs.

Objectives for FY 08-09

The research during this period will 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.

Two manuscripts are under preparation. The first, a paper devoted to the climate of the Mid Atlantic region, is based on the poster described in the Accomplishments (above). The second will detail the process of tropical cyclone extratropical transition and heavy rainfall generation in the Mid-Atlantic, based on computations being completed by graduate student Ross Dixon.

Work is also underway to establish a mesoscale research framework for assessing the impact of severe summer storms (thunderstorms containing heavy rain, damaging wind, hail and lightning) in the D.C.-Baltimore urban corridor. UMBC has partnered with the NASA Marshall Space Flight Center to install sophisticated lightning detection equipment as part of the D.C. Lightning Mapping Array (LMA). The LMA will allow high time and space resolution assessment of severe storm generation, evolution and movement, as well as detailed 3D mapping of lightning strikes. This dataset will be paired with precipitation intensity mapping provided by the regional network of NWS and FAA Doppler weather radars. Favored locations of storm genesis, movement and intensification will be placed in the context of terrain-induced surface boundaries, such as those generated by the urban "heat island" effect, Chesapeake Bay breeze and mountain-valley circulations.

Task 89:	**Modeling of Rainfall Statistics from Satellite and Ground Based Remote Sensing Measurements (NNG05GQ79A)** *(Sponsor: T. Bell, GSFC Code 613.2)*
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 Code 613.2

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 data sets 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 and Special Sensor Microwave/Imager (SSM/I); and, a quantitative generalization of the commonly used least-squares method of determining the coefficients of a linear regression of satellite vs. ground data, in connection with the validation problem for satellite measurements which takes into account the spatio-temporal correlation between the two variables.

Accomplishments for FY 07-08

In his Ph.D. dissertation JCET graduate student Dr. Ravi Siddani has studied the statistics of gridded radar data from the Tropical Ocean Global Atmosphere - Coupled Ocean-Atmosphere Response Experiment (TOGA-COARE). His study has led to the discovery of a new family of probability distributions belonging to the general class of the so-called infinitely divisible distributions, which accurately describes the scale dependence of the full hierarchy of moments of spatially averaged rain rate field [Kundu and Siddani 2007]. In this respect it supersedes the previously used stochastic dynamical model [Bell and Kundu 1996, Kundu and Bell 2003, 2006], which was limited to the second moment statistics. The moments of the rain rate data aggregated at various spatial scales were found to exhibit nontrivial power law scaling, known as multiscaling or multifractal behavior. The scaling exponents describing this observed power law dependence of the moments agree well with those estimated from the probability model. The new distribution arises naturally from a hierarchical clustering model of precipitation. In this statistical model, the nonzero part of the spatial rain rate field is represented by a multiplicative random process in which precipitation is supposed to occur in clusters spatially organized in a hierarchical manner. The number of sub-clusters in a cluster at each level in the hierarchy is a random variable obeying log-Poisson statistics. Scaling properties of the rain field are reflected in the dependence of the distribution parameters on the spatial averaging scale. While the model captures the scaling behavior of the spatial statistics at the scale of radar observations (2 – 128 km), it is possible that the clustering phenomenon persists down to much smaller scales. A multi-year gridded data set based on spatially averaged radar data from the TRMM ground validation (GV) site in Melbourne, Florida provides an excellent testing ground for the model.

The above-mentioned probability describes the statistical properties of the rain field after the zeroes of rainfall are "factored out" from the data. The distribution of the zeroes themselves represents an important aspect of rain, namely its intermittent nature. The probability of occurrence of zeroes in rainfall is also dependent on the space-time averaging scale. A preliminary exploration based on the TOGA-COARE and TRMM GV radar datasets carried out by Dr. Siddani exhibited a near-power law depenence on the limited range of spatial scales accessible to ground radar measurements. In order to gain access to a larger range of scales, attention was redirected to time averaged rainfall data available from rain gauges. Using the time-averaged precipitation data from a network of 300+ tipping bucket gauges located in Central and South Florida as part of the TRMM GV program, a study of the temporal scale dependence of rainfall intermittence was conducted. The study resulted in a simple 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 decades 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. In order to explore the behavior at small scales where the tipping bucket gauges are unreliable, a current work in collaboration with Dr. Ali Tokay of JCET focuses on rain data from various disdrometers which provide more accurate and detailed information about the small time scale behavior of precipitation.

Objectives for FY 08-09

In the coming year, the immediate goals are to obtain a probabilistic model of time-averaged precipitation based on different types of disdrometer and gauge measurements, including the multi-year rain data from the TRMM GV sites; to seek a physical basis for the new distribution in terms of an underlying stochastic process that leads to clustering of rain at various scales; to examine spatial statistics of TRMM PR (Precipitation Radar)-derived rain data and test the model predictions with regard to the multiscaling behavior; and, finally, to pursue the problem of generalizing the standard least-squares formulation of the linear regression of satellite vs. ground radar or rain gauge estimates by properly taking into account both the individual variances of the dependent and the independent variables as well as their mutual covariance described by the investigators' stochastic dynamical model [Bell and Kundu 1996].

Task 28: **Research Support For Precipitation Science** ***(Sponsor: E. Smith, GSFC Code 613.1)***

Task 109: **Research Support for Goddard Earth Sciences Data and Information Services Center Hurricane portal** ***(Sponsor: G. Lepoutkh, GSFC Code 610.2)***

Investigator: Amita V. Mehta, Research Assistant Professor, Geography and Environmental Systems; Eric Smith, GSFC Code 613.1; Gregory Lepoutkh, GSFC Code 610.2

Description of Research

The main objective of this research has been on retrieval, observational analysis, and modeling of precipitation with the focus on the Gulf of Mexico - Caribbean Sea (GM-CS) basin. Additionally, this research includes the provision of precipitation, dynamical, and thermodynamical parameters for Atlantic and GM-CS tropical cyclones for the past five years through the Goddard Hurricane portal (http://disc.sci.gsfc.nasa.gov/hurricane). Under this task, Cloud Dynamics and Radiation Database System (CDRD), a project for improved rain retrievals from microwave radiometers and radars flying onboard current and future satellites has been carried out. Under CDRD, the University of Wisconsin Nonhydrostatic Modeling System (UW-NMS) has been used to simulate different rain systems, including hurricanes and severe extra-tropical storms, over the GM-CS basin and Mediterranean Sea (Med) basin. The simulated rain-rate profiles, associated microphysical, dynamical, and thermodynamical parameters, and calculated brightness temperatures (TBs) at TRMM, AMSR, and SSMIS radiometer frequencies from these parameters have been collected into an extensive database. An experimental Bayesian algorithm has been developed which uses a subset of the CDRD database to obtain rain retrieval solutions from TRMM TB measurements over the GM-CS and Med regions. Moreover, analyses of TRMM-based rainfall over Med and Asian monsoon regions have been carried out.

Accomplishments in FY 07-08

An inter-comparison project was initiated to assess the accuracy and uncertainty of the CDRD-based simulated TBs. This is necessary because CDRD-based TBs will be a critical component in precipitation retrieval scheme being developed for current and future microwave radiometers. For this purpose, three different microwave radiative transfer models were used to calculate TBs at TRMM Microwave Imager frequencies. The calculated TBs are currently being inter-compared to examine their spread which can be attributed to the differences in radiative transfer modeling techniques. A paper describing the CDRD concept is being finalized.

In addition, analyses of precipitation properties and precipitation propagation features over Med were conducted based on TRMM measurements for contrasting over-sea processes to over-continent processes. A paper based on this study has been accepted for publication in *Advances in Geosciences*.

Furthermore, an analysis of TRMM measurements was carried out to understand slope-flow and mesoscale convective system (MCS) influences on diurnal propagation of rain systems downstream of seven (7) north-south aligned mountain ranges over the world. A paper based on this study is being revised for submission. Also, an analysis of TRMM measurements and NCEP reanalysis products was carried out to diagnose space-time precipitation properties of Indian Summer Monsoons and possibilities and limitations for event sequence forecasting of monsoon rainfall. Results of this study were presented at the International Monsoon Conference in July 2007.

Additional activities include the creation of archives of sea level pressure, and multi-level zonal and meridional winds for the hurricane seasons of 2004-2007 for visual analysis through Goddard's Hurricane portal. A procedure to obtain along-track average quantities such as rain, winds, and sea level pressure for hurricanes/tropical storms was developed. Results of this activity were presented at the American Geophysical Union meeting in December 2007 by the GES-DISC (Goddard Earth Sciences Data and Information Services Center) Interactive Online Visualization and Analysis Infrastructure (GIOVANNI) team members.

Objectives for FY 08-09

Mehta's main objectives for the next year are to continue CDRD in its final phase, including finalizing the database over GM-CS and Med basins and testing the algorithm for rain retrievals based on CDRD; to continue the analysis of CDRD to understand the water budget of the GMCS basin and its influence on the warm season rainfall over the central US and its variability; to develop a new CDRD database for the Asian monsoon region; and, to continue analyzing TRMM measurements, operational reanalysis datasets, and UW-NMS model simulations to understand rain characteristics over GM-CS, Med, and Asian monsoon regions. Additionally, the PI will demonstrate the capabilities of the Goddard Hurricane portal in hurricane research via paper and poster presentations in relevant meetings.

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: W. Adler, UMCP/ESSIC)*
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)**
Investigators:	William S. Olson, Research Associate Professor, Physics; Robert Adler, UMCP/ESSIC; Wei-Kuo Tao, GSFC, Code 613.1; Mircea Grecu UMBC/GEST; Chung-Lin Shie, UMBC/GEST; Arthur Hou, GSFC, Code 610.1; Gail S. Jackson, GSFC, Code 614.6; Mei Han, UMBC/GEST

Description of Research

This group's emphasis is mainly 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 Ku-band radar (Tropical Rainfall Measuring Mission or TRMM), Ku + Ka band radar (Global Precipitation Measurement mission or GPM), and W-band radar (CloudSat mission) in conjunction with a range of passive microwave multispectral observations. Regarding precipitation, Olson's team aims to improve the representations of ice and mixed-phase precipitation in combined radar/passive microwave algorithms. The relationship between latent heating vertical distributions and spaceborne radar estimates of surface rain rate, echo top, and convective/stratiform classification is a related area of study, with implications for understanding the earth's water and energy cycles.

Accomplishments in FY 07-08

The GPM core mission observatory (anticipated launch date: mid-2013) will include both spaceborne radar (Ku and Ka bands) and a range of passive microwave radiometer channels (10 – 183 GHz). These channels will provide the "best" estimates of precipitation and latent heating vertical profiles, which, in turn, will be used to cross-calibrate radiometer-only profile estimates from an international fleet of radiometers flying in complementary orbits.

This past year, Olson was chosen to lead the US team to develop a combined radar-radiometer algorithm for precipitation and latent heating that would be applied to the GPM core instruments. After a team of investigators was assembled, a general plan was developed for this algorithm, emphasizing both modular algorithm construction and physical consistency with integrated GPM radar-only and radiometer-only algorithms.

Also under GPM, working groups were developed to address current weaknesses in satellite precipitation algorithms. The PI gathered 14 investigators to study uncertainties in the modeled ice and mixed-phase precipitation physics represented in combined radar-radiometer algorithms. Based upon the use of airborne radar and radiometer measurements and *in situ* observations from the Wakasa Bay and TC4 field campaigns, they developed a plan to test the physical models incorporated in these algorithms to evaluate their consistency. An ensemble filtering method, developed in 2008, will be used to "fit" the physical models to all coincident field observations simultaneously; this method contains the necessary architecture to include statistical constraints on the fit parameters and provide information on the data sensitivities and error statistics of the fit parameters.

This past year also saw the final surge to develop a latent heating algorithm based upon TRMM Microwave Imager (TMI) observations, an effort supported by NASA's Energy and Water cycle Study (NEWS). Significant algorithm improvements were achieved by correcting for biases of the cloud-resolving model simulations used to calibrate the algorithm. Afterward, analyzed atmospheric density profiles were used to properly normalize the vertical latent heating profiles with respect to surface rain rates. The resulting latent heating algorithm was used to generate multi-year records, which were combined with satellite estimates of radiative heating from Tristan L'Ecuyer (Colorado State University) to produce the first satellite estimates of total diabatic heating. Preliminary studies of the Madden-Julian Oscillation and tropical forcing of drought/flood conditions over the south-central US were carried out using the TRMM heating estimates.

Software previously developed by the investigators to calculate upwelling microwave radiances and radar reflectivities based upon cloud-resolving model simulations was used to study the consistency of cold frontal rainband simulations performed by Dr. Mei Han (GEST). Different model microphysical schemes were tested, of which a subset resulted in near-consistency of model-based and TRMM-observed radiances and reflectivities.

Objectives for FY 08-09

Olson's team will further refine plans for Ku+Ka+passive microwave estimation of precipitation and latent heating. In the next half-year, a draft algorithm theoretical basis document will be prepared, and the algorithm working group charged with studying ice and mixed-phase precipitation physics will implement their testing plan, with results on the validity of ice-phase precipitation physical models expected in that timeframe. TMI latent and total diabatic heating estimates derived from the first 10 years of TRMM operations (1998-2007) will be archived, and the latent heating estimation methodology and procedures for combining latent and radiative heating estimates will be documented in the literature. Initial studies of the sensitivity of narrow cold-frontal rainband simulations to microphysical parameterizations will be documented.

NASA Grant:	**Measurements of the Hydrometeor Size Distribution through Surface based Instruments (NNX 07AF45G)**
NASA Grant:	**Improved Ground Validation Rain Estimates at Kwajalein and Central Florida for Comparison to and Validation of TRMM and Other Satellite Estimates (NNX 07EJ50C)**
Task 34:	**A proposed Mid-Latitude Coastal Ground Validation Site for the NASA Precipitation Measurement Mission** ***(Sponsor: M. Schwaller, GSFC Code 420.2)***
Investigator:	Ali Tokay, Research Associate Professor, Affiliated Associate Professor

Description of Research

The leading objective of the study is to provide better validation products for the Precipitation Measurement Mission in which the inconsistency between the radar and radiometer-based precipitation retrieval algorithms is often attributed to the lack of knowledge of the physics of the precipitation. In that regard, the measurements of the particle size distribution in rain, snow, and mixed regime can be analyzed for different precipitation systems. The mathematical form of the size distribution may then be extracted for a particular precipitation system. For snow, the density of the particles or at least bulk density should be known. The ongoing research deals with these physical aspects of precipitation including its small-scale variability and measurement accuracy.

Accomplishments for FY 07-08

Considering the time-height ambiguity between the precipitation measuring instruments, the ground-based disdrometer reflectivities were compared to the vertically pointing S- and K-band radar reflectivities. The agreement between the radars was better than the comparison of collocated disdrometers. The size of the measuring volume plays an important role in rainfall statistics. The vertical variability of reflectivity was also studied in the content of variations in coefficients and exponents of reflectivity rain rate (Z-R) relations where rainfall was determined from disdrometer and reflectivity was taken from radar measurements. Peter Hartmann of Bonn University, Germany conducted this study during his visit to JCET, received his diploma in 2007, and continued working on this project during the past year [Tokay *et al.*, 2008].

A study regarding the performance of operational rain gauges was re-evaluated and a first draft of a manuscript is about to be completed. As a follow-up study, the Multi-sensor Precipitation Estimate (MPE), an operational product, was evaluated using rain gauge networks in the Mid-Atlantic region. Since the gauges are not part of the MPE, they provide an independent source of evaluation. The comparions were done on hourly, three-hourly, six-hourly, daily, and monthly time scales. The results showed that the MPE provides a reasonable estimate of rainfall in the test region. This segment of the study was done by

Boone Larson of the University of Louisiana-Lafayette. Mr. Larson received his master's degree in Spring 2007.

Considerable progress was made on the analysis of the snowfall measurements that were collected during the Canadian Cloudsat/CALIPSO validation project (C3vp) field campaign in winter 2006-07. The size distributions of snowflakes were compared between the various optical disdrometers. The fall velocity size parameter relations were derived for each instturment in each case. The snow density was investigated through bulk density and density size parameter relations. The relations between the snow intensity and radar reflectivity was derived for different snow density relations. This segment of the study was conducted by Elke Rusteiemer of the University of Bonn, Germany.

Three major precipitation systems — tropical cyclones, frontal showers, and sea-breeze induced precipitation — identified through synaptic analysis showed distinct size distribution characteristics in Florida. The parameters of the size distribution were derived at 40 dBZ for each storm for cloud modeling and precipitation retrieval algorithms. The presence of more small and less large drops in tropical cyclones than in frontal and sea-breeze storms at a given reflectivity were evident and has a pronounced influence on forecast models.

Objectives for FY 08-09

Tokay is expected to submit a journal paper on the comparison of the operational and specialty rain gauges in the Mid-Atlantic region. The follow-up study of the evaluation of the operational rainfall product will also be completed within a year. Additional snow size distribution observations from C3vp became available and a more complete study of the comparison of size distribution will be done this winter. The characterstics of raindrop size distribution will be examined through a new data set from Houston, Texas. The new data set will also be used to compare the radar and disdrometer reflectivities at two different ranges.

Climate and Radiation
(Code 613.2)

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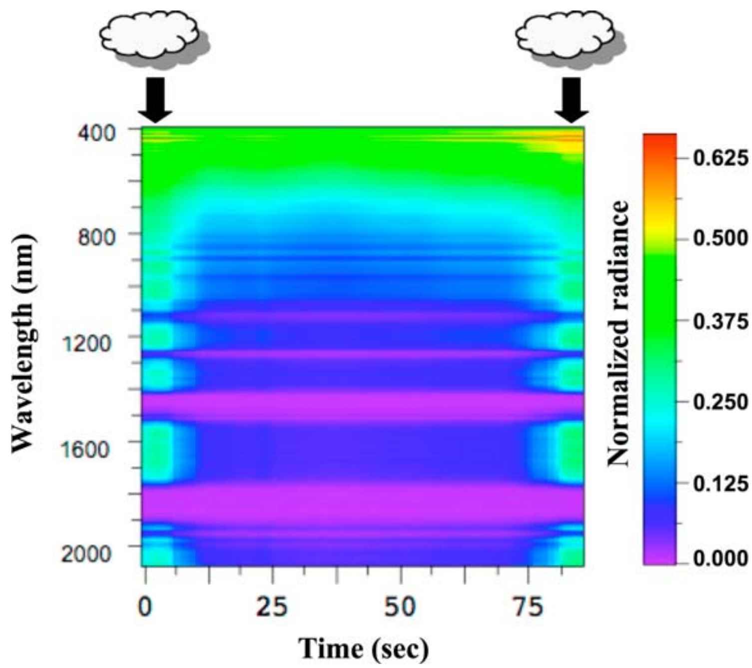
JCET Highlight: Studying the transition zone between cloud-free and cloudy regions using the ARM Shortwave Spectrometer

Christine Chiu

Although to a casual observer clouds appear to have distinct boundaries, distinguishing between cloud-free and cloudy air from remote sensing observations has been difficult. This problem has major climatic consequences, in particular for studying how aerosols directly and indirectly impact radiation, cloud formation and lifetime. One-second-resolution zenith radiance measurements from the Atmospheric Radiation Measurement (ARM) program's new shortwave spectrometer provide a unique opportunity to analyze the transition zone between cloudy and cloud-free regions. With rich data that contain 418 wavelengths in visible and near infrared spectral regions, we can advance our understanding of physical processes in the transition zone, such as activation and evaporation of cloud droplets and humidification of aerosols (see image).



Radiant energy spectra measured by the ARM Shortwave Spectrometer between two cumulus clouds. The data are presented in a wavelength versus time plot for 86 seconds and, at each wavelength, the radiance has been normalized by the value at the top of atmosphere. The spectral signature shows two cumulus clouds during the first and last 5 to 8 seconds of the plot, and clear sky is evident about 15 seconds away from these periods. However, the measurements in the intervening period (5 to 12 s and 75 to 82 s) are difficult to classify and, depending on the remote sensing criterion used for cloud detection, would be called either cloudy or cloud-free.

Reference: Chiu, J. C., A. Marshak, Y. Knyazikhin, P. Pilewskie, and W. J. Wiscombe, 2008: Physical interpretation of the spectral radiative signature in the transition zone between cloud-free and cloudy regions. *Atmos. Chem. Phys. Disc.* (accepted).

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NASA Grant:	**Studies of 3D-cloud optical depth from small to very large values (NNG06GC17G)**
Investigators:	J.-Y. Christine Chiu, Assistant Research Professor, JCET; Alexander Marshak, JCET Fellow, NASA/GSFC, Code 613.2; Warren Wiscombe, NASA/GSFC, Code 613.2

Description of Research

This project focuses on cloud-radiation processes in a general 3D cloud situation, with particular emphasis on cloud optical depth, effective cloud droplet size, and cloud fraction. These three cloud optical properties are the most fundamental parameters that determine how much solar radiation is reflected back to space, and how much infrared radiation goes towards the surface. Chiu and her group retrieve cloud properties mainly using ground-based zenith radiance measurements from the Department of Energy Atmospheric Radiation Measurement (ARM) program, NASA Aerosol Robotic Network (AERONET), and NASA Micropulse Lidar Network (MPLNET). Measurements are taken at operational sites in different climate regimes, as well as various field campaigns that address issues such as orographic precipitation and aersosol indirect effects. They show that lidars can retrieve cloud optical depth not just for thin clouds but for all clouds. The JCET investigators also study the transition between cloud-free and cloudy areas using high spectral and temporal zenith radiance data.

Accomplishments for FY 07-08

Although to the casual observer clouds appear to have distinct boundaries, to define them from remote-sensed measurements is difficult. One-second-resolution zenith radiance measurements from the Atmospheric Radiation Measurement program's new shortwave spectrometer (SWS) provide a unique opportunity to analyze the transition zone between cloudy and cloud-free air, which has considerable bearing on the aerosol indirect effect. In the transition zone, a remarkable linear relationship has been found between the sum and difference of radiances at 870 and 1640 nm wavelengths. The intercept of the relationship is determined primarily by aerosol properties, the slope by cloud properties. This linearity can be predicted from simple theoretical considerations; furthermore, it supports the hypothesis of inhomogeneous mixing, whereby optical depth increases as a cloud is approached but the effective drop size remains unchanged. In addition, the width of transition zones from SWS data is in the range of 50–150 m, which differs from the width in satellite observations (a few kilometers) and in airborne lidar data (1–2 km). Analyzing spectral behavior of the overhead radiance measured by the SWS helps the group to learn more about radiative properties of aerosols and clouds, including optical depth, particle and droplet sizes. Knowledge of aerosol and cloud properties corresponding to SWS-observed radiative signatures will advance the investigators' understanding of physical processes, such as evaporation and activation of cloud droplets, rising humidity, and humidification of aerosols as well as modeling aerosol-cloud interactions and predicting cloud evolutions.

Chiu and her group participated in the ARM Mobile Facility (AMF) Convective and Orographically-induced Precipitation Study (COPS) campaign at the Black Forest area during March-December 2007. This international campaign aimed to improve the quantitative precipitation forecasting, particularly in orographic precipitation. The COPS region is associated with significant amounts of deep convective and cumulus clouds in summertime, which is a major challenge for remote sensing of cloud properties. To test the group's retrieval method, several data sets have been used, including zenith radiance measurements from the ARM two-channel narrow-field-of-view radiometer (2NFOV), a sunphotometer operated in a cloud mode, a multifilter rotating shadowband radiometer, and microwave radiometers. Cloud retrieval products are cloud optical depth, effective droplet size, and cloud fractions. Preliminary validations against retrievals from other instruments have shown good agreement. The 2NFOV is currently deployed in China and taking measurements for the study of aerosol indirect effects.

Chiu's group's retrieval method that uses two-channel radiances at wavelengths of 675 and 870 nm has been successfully applied to AERONET data. Operational products of cloud optical depth and cloud fraction are provided but not public available yet. Further validations against others are undergoing.

Collaboration with MPLNET continues, aiming to provide operational cloud optical depth product. Optical depths of thin clouds are retrieved from active lidar returned signals, while thick clouds are retrieved from passive solar background light. Because the relationship between solar background light and optical depth is not monotonic, the group's retrieval technique requires knowledge of beam block status to distinguish thin and thick clouds. MPLNET has provided preliminary beam block flags, and data for the Goddard site have been tested. (Chiu's group's technique used here was selected for inclusion in the FY07 ARM Annual Report.)

Objectives for FY 08-09

More detailed model simulations will be conducted to understand how SWS spectral signatures change with aerosol and cloud properties in the transition zone between cloud-free and cloudy areas. Measurements collected in China from the 2NFOV and sunphotometer will be analyzed. Retrievals of cloud properties will be provided and used for studies of aerosol indirect effect. Chiu and her group will participate in the ARM Routine AVP Clouds with Low Optical Water Depths (CLOWD) Optical Radiative Observations (RACORO) field campaign. During the campaign, the AVP will conduct routine flights at the Oklahoma site to sample low-altitude liquid-water clouds in the boundary layer. This will collect representative statistics of cloud microphysical properties and help to validate the group's retrieval method. Collaboration with AERONET and MPLNET will continue. Retrievals will be monitored and collected to investigate performance for each site. The investigators aim to make cloud optical depth retrievals publicly available soon.

USGS Grant: **Cloud Detection and Avoidance for the Landsat Data Continuity Mission**

DOE Grant: **Evaluation of General Circulation Model (GCM) Column Radiation Models**

Investigators: Lazaros Oreopoulos, Research Associate Professor, Physics; Tamás Várnai, Research Assistant Professor, Physics

Description of Research

The investigator's research focuses on development of new efficient cloud and radiation parameterizations for inhomogeneous atmospheres suitable for implementation in GCMs, intercomparison of GCM RT models, and analysis of satellite, airborne, and ground-based measurement for studies of cloud masking, cloud variability, and cloud-aerosol interactions. The common goal of all the above research elements is to advance the understanding of the complex nature of clouds and its effects on the propagation of radiation in terrestrial atmospheres, the atmospheric and surface energy budgets, and, ultimately, global climate.

Accomplishments for FY 07-08

Oreopoulos and JCET fellow S. Platnick adopted an approach where satellite retrievals can be used to estimate the radiative response or sensitivity to some specified change in cloud droplet number ("cloud albedo susceptibility"). An alternative method to calculate albedo perturbations based on relative (rather than fixed) changes in cloud droplet number density was introduced. In addition to in-depth theoretical calculations [Platnick and Oreopoulos, 2008], select MODIS Level-2 (orbital swath) and four months of Level-3 (1° gridded) cloud optical thickness and effective radius data were used to estimate susceptibility [Oreopoulos and Platnick, 2008]. A uniform droplet number density increase of 10% under constant liquid water conditions, was found to result in a susceptibility forcing (increase in reflected solar flux at the top of the atmosphere) of about1.5 Wm^{-2}.

The investigator has also completed the most extensive hitherto estimates of the plane-parallel homogeneous (PPH) SWCRF bias for both liquid and ice clouds by combining four months of MODIS Level-3 cloud products with a broadband radiative transfer model. The absolute value of global SWCRF bias of liquid clouds at the top of the atmosphere was ~6 Wm^{-2} for MODIS overpass times while the SWCRF bias for ice clouds was smaller in absolute terms by ~0.7 Wm^{-2}. Marine clouds of both phases were characterized by larger (more negative) SWCRF biases than continental clouds. Morning–afternoon differences in SWCRF bias were much more pronounced for ice than liquid clouds, reaching about ~15% (stronger negative biases in the afternoon) on global scales, with virtually all contribution to the difference coming from land areas. The global magnitude of the SWCRF bias for clouds of both phases is collectively about 4 Wm^{-2} for diurnal averages exceeding many of the well-studied radiative forcings.

With the aid of collaborator Dr. Várnai, the investigator examined the performance of simplified versions of Landsat-7's Automated Cloud Cover Assessment (ACCA) algorithm on ~200 Landsat-7 scenes and on ~ 450 MODIS images. The main focus of the study, aided also by simulations with a RT tool, was to identify the thresholds of the so-called "cirrus band" in the future Landsat, which would allow us to recover the clouds missed by the absence of the thermal band. In another Landsat study with JCET fellow I. Koren and other colleagues, the investigator showed that in shallow cumulus cloud fields the separation into clear and cloudy skies is resolution dependent and misclassifications lead to large errors in the estimated aerosol direct radiative forcing. This occurs because at any resolution, a significant fraction of the clouds are missed, and their properties are assigned to the apparent cloud-free optical properties. It was also found that the largest contribution to the total cloud reflectance comes from the smallest clouds [Koren *et al.*, 2008].

During the reporting period, a major effort was the development of the CIRC observation-based Phase I cases and the CIRC website (http://circ.gsfc.nasa.gov), which was launched on June 4, 2008. The Phase I reference dataset consists of five clear-sky cases with a range of precipitable water loadings and two overcast homogeneous (optically) thick and thin liquid cloud cases. The reference calculations come from runs with line-by-line radiation codes.

Finally, two modeling efforts conducted collaboratively in the past year are reported here: a new formulation of GCM cloud overlap with Gaussian copulas that improves simulation of non-linear processes such as radiative transfer [Norris *et al.*, 2008]; and a study that uses the NASA Global Modeling Initiative 3-D chemical transport model for assessments of indirect forcing and its sensitivity to the treatments of aerosol, aerosol-cloud interactions and meteorological fields [Sotiropoulou, *et al.*, 2008].

Objectives for FY 08-09

Future research directions will be largely determined by the outcome of funding requests made during the reporting period. Possible projects include parameterizations of aerosol optical properties for the GEOS-5 GCM, incorporation of copulas and stochastic RT in that model, parameterizations of the copula parameters from satellite and ground-based cloud condensate retrievals, and development of CIRC Phase II. In addition, Oreopoulos will continue to fulfill his obligations as a member of the Landsat Science Team by advising on all issues related to cloud detection and prediction that may affect the Landsat Data Continuity Mission.

Task 72:	**Retrieval of cloud and sea ice properties from THOR lidar measurements** ***(Sponsor: R. Cahalan, GSFC Code 613.2)***
NASA Grant:	**I3RC workshops and 3D community tools applied to assessments and improvements of cloud retrievals from Terra, Aqua, and THOR offbeam data (621-30-86 and 622-42-57)**
Investigator:	Tamás Várnai, Research Assistant Professor, Physics

Description of Research

The overall goal of this research is to improve understanding of 3D radiative processes that occur in clouds, snow and sea ice. Várnai's work focuses on three areas in particular: first, it investigates the uncertainties that 3D-radiative processes cause in satellite retrievals of cloud optical thickness and aerosol properties near clouds; second, it explores a new retrieval technique that determines the structure of snow, sea ice, and highly opaque clouds by observing the way 3D multiple scattering spreads out the returning lidar pulses; third, it brings improvements to the 3D radiative transfer tools available to the research community by coordinating model intercomparisons, providing on-line resources, and organizing workshops on 3D radiative transfer.

Accomplishments for FY 07-08

This year Várnai expanded the scope of his research to 3D radiative processes that affect satellite retrievals of aerosol properties in the vicinity of clouds. A statistical analysis of MODIS observations over the North-East Atlantic Ocean revealed that the brightness of satellite images systematically increases near clouds. To understand this increase, the investigator examined the effects of instrument imperfections, as well as the dependence of the observed increase on wavelength and on the thickness and direction of nearby clouds. The results indicated that a large portion of the observed increase is caused by the 3D process of clouds scattering sunlight toward nearby cloud-free areas.

He also examined whether simultaneous observations from multiple view directions (*e.g.*, by MISR, the Multiangle Imaging SpectroRadiometer onboard the Terra satellite) can improve cloud optical thickness retrievals. For stratocumulus clouds, using data from multiple views reduced the uncertainty of single-view retrievals by up to 40%. Though the improvements were less pronounced for cumulus clouds, the methodology used in multi-view retrievals still offered clear benefits over the standard plane-parallel method even in single-view retrievals [Evans *et al.*, 2008].

Várnai and his group also continued their statistical analysis of 3D radiative processes in a year-long global dataset of MODIS cloud products. In order to estimate 3D influences in MODIS retrievals of cloud optical thickness, further progress was made toward combining the observations with 3D radiative simulations for a wide variety of cloudy scenes.

The JCET investigator and his group continued exploring the benefits of offbeam multiview lidars that can detect photons returning from increasingly wide rings around a spot illuminated by a laser beam. This year they performed ground-based field experiments in order to examine the potential for airborne THOR (THickness from Offbeam Returns) lidar observations of snow and sea ice thickness. After designing and building the necessary equipment, they took observations over snow fields at several locations in Maryland and Pennsylvania. The results confirmed their theoretical prediction [Várnai and Cahalan, 2007] that the bright area around a single illuminated spot grows systematically with snow thickness, and they showed that, despite the large amount of absorbing aerosol embedded in the snow in this region, halo-observations can still reveal the thickness of thin and moderately thick snow covers. This suggests that fairly minor upgrades could enable the group's cloud-observing instrument to provide valuable snow thickness measurements.

Finally, the group further advanced the third phase of the I3RC (Intercomparison of 3D Radiative Codes) project. In particular, they completed a detailed intercomparison of results from twelve 3D radiative transfer models from around the world, which allowed them to establish reference results when numerous models agreed, and analyze some differences between various modeling techniques as well. Results from this intercomparison were discussed at a well-attended international conference. In addition, Várnai and his group expanded the I3RC web site (http://i3rc.gsfc.nasa.gov) and improved its online resources for the 3D radiative transfer community, including databases on relevant publications and publicly available radiation and cloud models.

Objectives for FY 08-09

Next year the JCET investigators plan to expand their work—which until now focused on 3D radiative effects in remote sensing—to examine 3D effects in dynamical cloud simulations. First, they will create a database of 3D cloud structures and corresponding radiation fields; second, they will use this database for developing a parameterization that is fast enough to allow 3D radiative calculations of even high-resolution dynamical models of cloud development. In addition, they plan to continue exploring the 3D radiative effects through which clouds influence aerosol measurements near them. In particular, they plan to combine their observation statistics with radiative simulations in order to estimate the effects on aerosol optical thickness and particle size retrievals.

Várnai and his group also intend to continue working on combining satellite data on clouds with theoretical simulations, with the goal of establishing relationships between easily observable features such as cloud texture and 3D influences on cloud optical thickness retrievals. Also, they plan to expand the scope of THOR lidar measurements by exploring THOR's potential for measuring vertical profiles of optical properties in stratiform clouds.

Finally, the JCET investigators will make further improvements to the I3RC website, so that it provides additional resources for the 3D community. The planned upgrades include an online 3D radiative transfer calculator and an online test bed suitable for future model evaluation.

Atmospheric Chemistry and Dynamics
(Code 613.3)

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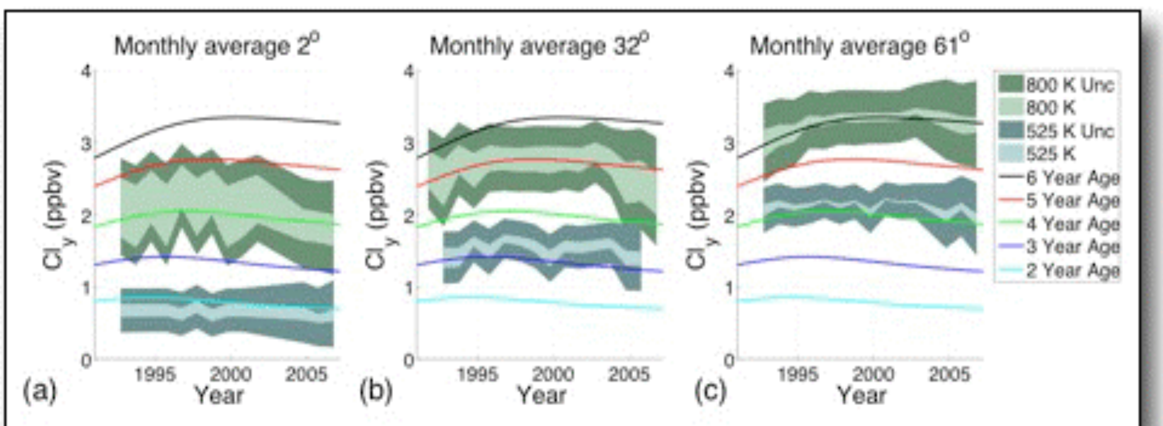
JCET Highlight: Variations in Stratospheric Inorganic Chlorine Between 1991 and 2006

David Lary

So how quickly will the ozone hole recover? This depends on how quickly the chlorine content (Cl_y) of the atmosphere will decline. The ozone hole forms over the Antarctic each southern spring (September and October). The extremely small ozone amounts in the ozone hole are there because of chemical reactions of ozone with chlorine. This chlorine originates largely from industrially produced chlorofluorocarbon (CFC) compounds. An international agreement, the Montreal Protocol, is drastically reducing the amount of chlorine-containing compounds that we are releasing into the atmosphere.

To be able to attribute changes in stratospheric ozone to changes in chlorine we need to know the distribution of atmospheric chlorine. However, due to a lack of continuous observations of all the key chlorine gases, producing a continuous time series of stratospheric chlorine has not been achieved to date. We have for the first time devised a technique to make a 17-year time series for stratospheric chlorine that uses the long time series of HCl observations made from several space borne instruments and a neural network. The neural networks allow us to both inter-calibrate the various HCl instruments and to infer the total amount of atmospheric chlorine from HCl. These new estimates of Cl_y provide a much needed critical test for current global models that currently predict significant differences in both Cl_y and ozone recovery. These models exhibit differences in their projection of the recovery time and our chlorine content time series will help separate the good from the bad in these projections. (This article was chosen as a NASA Aura Mission Science Highlight and a NASA GSFC Atmospheric Chemistry and Dynamics Branch highlighted publication.)



Panels (a) to (c) show time series of total chlorine (Cly) for October at ~20 km (525 K isentropic surface) and at ~30 km (800 K). In each case the dark shaded range represents the total uncertainty in our estimate of Cly. The inner light shading depicts the uncertainty on Cly due to the inter-instrument bias in HCl. Overlaid are lines showing the Cly based on age of air calculations Newman et al. (2006).

Reference: Lary, D.J, A. Douglass, D. Waugh, R. Stolarski, P. Newman, and H. Mussa, "Variations in Stratospheric Cl_y Between 1991 and the present", *Geophysical Research Letters*, 34(21), Article Number: L21811.

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NASA IPA: **Intergovernmental Personnel Act (IPA) Assignment to the NASA HQ Science Mission Directorate's Research and Analysis Program, Program Manager and Scientist**

Investigator: Ernest Hilsenrath, Professor of Practice

Description of Research

Mr. Hilsenrath is an IPA detailed to NASA Headquarters, where his responsibilities include the formulation and implementation of various elements NASA's Science Mission Directorate's (SMD) Earth Science Division to include the Atmospheric Composition Focus Group in collaboration with the Atmospheric Chemistry Modeling and Analysis Program, Upper Atmosphere Research Program, Tropospheric Chemistry Program and the SMD Applications Division. He participates in scientific research solicitation and selection through the ROSES program and the initiation of research grants with selected principal investigators. He is the Program Scientist for Aura mission responsible for overseeing the mission operations and science outputs. He also coordinates and participates with international groups consisting of representatives of international space agencies and represents NASA interests in international forums through collaboration of flight missions and research programs.

Accomplishments for FY 07-08

Hilsenrath participated in the ROSES 07 selection process, conducted program site review at JPL, maintained Program databases and budgets for ACMAP and the Aura mission, and developed priorities and strategies for FY09. He also participated in Program Management for Atmospheric Composition Modeling and Data Analysis Program (ACMAP), and he began the Senior Review process for the Aura mission.

Also during the past year, Hilsenrath chaired the CEOS Constellation concept for international collaboration and coordination of Atmospheric Composition satellite missions and conducted second workshop. Additionally, three demonstration projects on air quality and aviation hazards using international satellite data were formulated and are underdevelopment.

The JCET investigator provided ongoing support for NASA's SMD Earth Science program with Congressional and Administration inquiries and NASA strategic planning, and he participated in the US Climate Change Science Program Working Group on Atmospheric Composition.

Objectives for FY 08-09

Going forward, Hilsenrath will develop the ROSES 09 solicitation for Atmospheric Composition Modeling and Data Analysis Program and follow up with the review and selection process. He will track the progress of NASA-selected Atmospheric Composition Principal Investigators and service their grants, and continue the development of ACMAP priorities and complimentary budgets. Additionally, he plans to participate in the Aura mission Senior Review, and continue the development of CEOS Atmospheric Composition Constellation Concept by engaging international partners. He will conduct a third workshop on long-term data sets and climate predictions at GISS in October 2008, continue to support NASA's Atmospheric Composition Focus Area to the US Climate Change Science Program, as well as provide on-going support to NASA's SMD Earth Science program for Congressional and Administration inquiries and NASA's strategic planning.

NASA Grant:	**The Swift Neurological Acceleration of Atmospheric Photochemistry and Aerosol Calculations [SNAPA]: Development and Application to Atmospheric Chemistry and Aerosol Simulations with a Focus on UT/LS Ozone.**
NASA Grant:	**Validation of Non-Coincident Trace Species Measured by AURA Using Trajectory Mapping and Statistical Analysis**
NASA Grant:	**An Objectively Optimized Sensor Web**
NASA Grant:	**A General Framework and System Prototype for the Self-Adaptive Earth Predictive Systems (SEPS) for Atmospheric Chemistry - Dynamic Coupling Sensor Web with Earth System Models**
NASA Grant:	**Assimilation of Chemical Constituents for Evaluation and Intercomparison of Aura Observations: (ACEi-Aura**
NASA Grant:	**Validation of Non-Coincident Chemical Trace Species Measured by AURA Using Trajectory Mapping and Statistical Analysis**
Investigator:	David Lary

Description of Research
The research is split into two main areas: the validation of earth observation data, in particular the observations made from the NASA Aura satellite, and the development of the next generation of autonomous earth observing systems. For the first, the JCET investigator has taken validation to the next level by using multi-variate non-linear neural network algorithms to cross-calibrate sensors and effectively account for inter-instrument bias. This greatly facilitates the use and fusion of multiple datasets to address key scientific issues, for example, ozone depletion. The second component of the research is based on a variety of distributed assets that form a 'sensor web'.

Accomplishments for FY 07-08
Six papers were published during the reporting period; one of these papers, "Variations in stratospheric inorganic chlorine between 1991 and 2006" [Lary *et al.*, 2007], was chosen as both a NASA Aura mission Science highlight and as a highlight for the annual report of the NASA/GSFC Atmospheric Chemistry and Dynamics Branch. It represents the first time that a nearly two-decade record of atmospheric chlorine has been compiled, dealing with the particularly tricky issue of inter-instrument data biases.

Another paper entitled "Data Assimilation and Objectively Optimized Earth Observation" [Lary and Koratkar, 2007] was both an invited Royal Society vision article, specially commended by the editor, and an invited contribution to the National Academies Press CD-ROM containing the two National Research Council reports Earth Science and Applications from Space: Urgent Needs and Opportunities to Serve the Nation and National Imperatives for the Next Decade and Beyond.

A third paper by Lary, "An objectively optimized earth observing system", was an invited contribution and outlined the operation of Lary's autonomous sensor web observation direction system. The result of a two-month NASA summer internship, the student paper "A method to determine the spatial resolution required to observe air quality from space" [Loughner, *et al.*, 2007] was aimed at addressing the spatial observing requirements for future air quality remote sensing platforms.

"Space-based measurements of HCl: Inter-comparison and historical context" [Lary and Aulov, 2008] gives details of an inter-comparison of remotely sensed HCl observations made over the last two decades. It outlines the nature of the inter-instrument biases and how these can be accounted for. The paper "Neural Networks as a Tool for Constructing Continuous NDVI Time Series from AVHRR and MODIS" [Brown *et al.*, 2008] describes a methodology for cross-calibrating vegetation indices from AVHRR and MODIS to form a seamless time series. This is useful for a variety of applications from eco-system models to decision support tools for famine relief.

Over the past year, Lary also made several teaching contributions, including the 2007 PHYS440/660 Computational Physics course; supervision of UMBC Graduate Student Andy Rickert who is enrolled for a masters in atmospheric physics entitled "Neural Network in Atmospheric Physics: Application to Lorenz-Mie Theory"; and supervision of UMBC PhD Student Oleg Aulov for a project entitled "Objectively Optimized Earth Observation."

Lary was elected to the GSFC Science Directors Council, where he played a leading role in coordinating and compiling a report for Laurie Leshin, Deputy Director for Science and Technology at NASA GSFC on recruiting and retaining staff. Additionally, David was cited as part of a NASA group achievement award.

Objectives for FY 08-09

The research over the coming year will be split into three main areas: first, the validation of earth observation data, in particular the observations made from the NASA Aura satellite; second, the development of the next generation of autonomous earth observing system, based on a variety of distributed assets that form a 'sensor web'; and third, the compilation and use of a boundary layer aerosol product for health applications produced from an intelligent fusion of CALIPSO, MODIS, OMI, and MISR data.

Hydrospheric and Biospheric Sciences (Code 614x)

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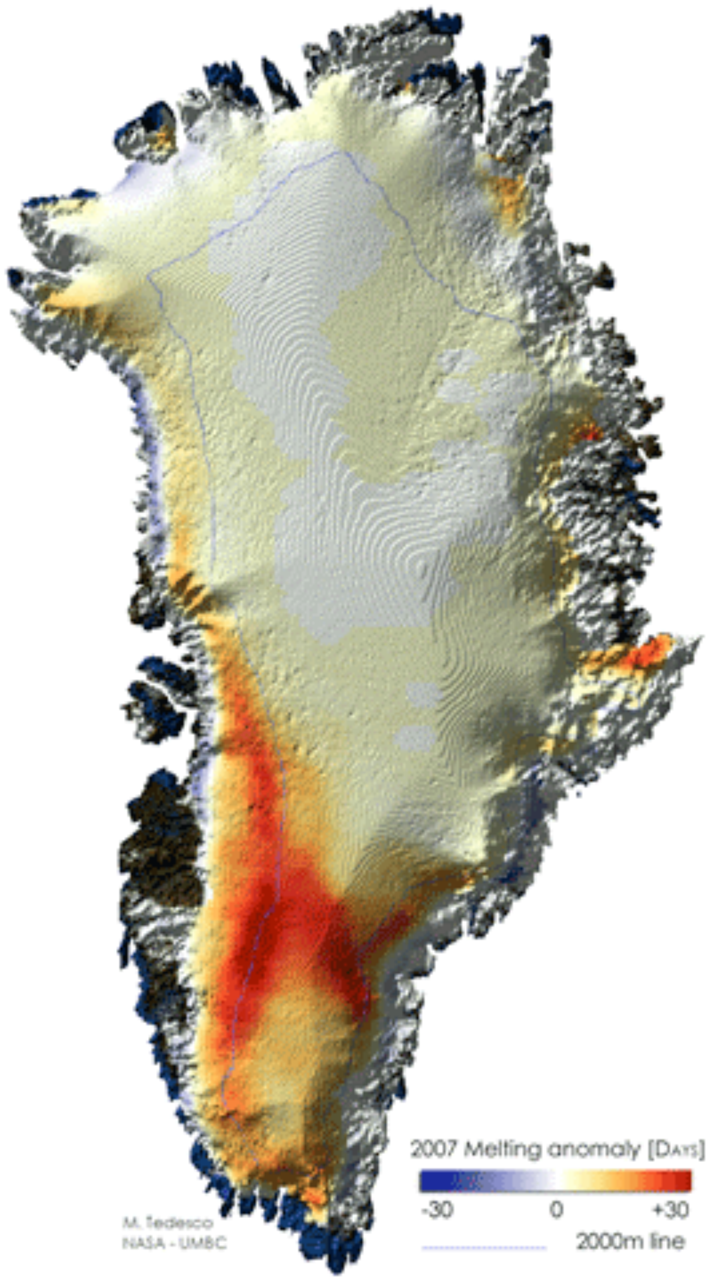
JCET Highlight: The 2007 Greenland Melting Anomaly

Investigator: Marco Tedesco, JCET Fellow

Microwave data from the Special Sensor Microwave Imaging radiometer was used to create this image of the 2007 Greenland melting anomaly, which reflects the difference between the number of melting days occurring in 2007 and the average number of melting days during the period 1988 – 2006.



Reference: M. Tedesco, A new record in 2007 for melting in Greenland, *EOS*, Vol. 88, No. 39, 25 Sept. 2007, p. 383

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Task 71:	**NASA Terrestrial Ecosystems, Spectral Bio-Indicators of Ecosystem Photosynthetic Light Use Efficiency** ***(Sponsor: E. Middleton, GSFC Code 614.4)***
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/Goddard Space Flight Center, Greenbelt, MD

Description of Research

Scientists today are faced with the important issue of balancing the global carbon cycle and determining the major carbon (C) sources and sinks within the Earth's system. Current remote sensing methods do not provide accurate estimates of vegetation physiological status and C-sequestration potential. Within the EO1-Hyperion data intercalibration and analysis effort, the goal is to compare existing land cover products and suggest new ones, as well as to address vegetation types and functions. Initiated in Spring 2007, this effort will use the only available spaceborne spectrometer (EO1 Hyperion) to contribute to the comparisons of current data products, generated by multiple and frequently disparate systems. Datasets and comparisons will be produced for core EOS sites and made available for use in calibrating long-term data records, required for understanding climate dynamics and change.

Recent studies related to the spectral bio-indicators of an ecosystem's health have demonstrated that, when compared to results using traditional wide band (>20 nm) reflectance, superior results can be achieved with narrow band visible/near-infrared spectral reflectance analyses for remote assessment of vegetation types and conditions. New studies are critical to define the optimal narrow band information required for future hyperspectral satellites used to monitor ecosystem health. The investigators are evaluating high-spectral resolution reflectance data obtained for vegetation over a range of functional types (species, phenology, and stress conditions) to establish which spectral algorithms perform rigorously, with respect to correlation to photosynthetic function and efficiency. From various field measurement projects conducted by the investigators and through collaborations with other investigators, reflectance data which has contemporaneous photosynthetic data is being assembled; in particular, the reduction or enhancement in photosynthetic efficiency resulting from environmentally induced physiologic stress and nitrogen application is being characterized.

Flux and environmental data, compiled from tower sites representing a range of ecosystems and provided by AmeriFlux collaborators, are also being evaluated. Using several radiative transfer modeling tools and atmospheric correction modules, the investigators are evaluating the high performance of candidate spectral bio-indices for remote sensing application at ecosystem scales at the AmeriFlux and intensive sites. The best-performing spectral bio-indices will be applied to available hyperspectral remote sensing data over selected test sites.

The fluorescence research team's goal 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. Understanding the connection between the global C and N cycles is essential to successfully interpret current and future feedbacks between the atmosphere and the terrestrial biome. Current strategies for monitoring vegetation status from satellites rely on spectral reflectance, which provide estimates of vegetation vigor related to chlorophyll content; but fluorescence from vegetation can relate inversely to photosynthetic efficiency and directly to chlorophyll concentration. Using new technologies and methods, further exploration is necessary to measure and monitor how environmental stress affects photosynthetic dysfunction. Fluorescence offers a non-destructive, fast alternative with diagnostic potential for early detection of changes and disturbances in the photosynthetic system. Campbell's team expects to validate the use of active fluorescence for monitoring vegetation stress, and to show the use of passive fluorescence as an innovative remote sensing carbon sequestration monitoring capability.

Accomplishments for FY 07-08:

The group assessed contributions of fluorescence to the reflectance of crop and tree species, on a range of C3 and C4 species under a full range of environmental stress regimes. They also compared the use of spectral ratios computed from CF emission measurements and the reflectance ratios for detecting vegetation at the leaf and canopy levels. The research produced new algorithms and recommendations for cost-effective remote sensing techniques for assessing vegetation physiological conditions.

The PI was involved with processing and analyzing the 2006 and 2007 reflectance (R) and fluorescence (F) data, and comparatively evaluating biophysical measurements and the R and F trends in the datasets, and a manuscript has been drafted for a peer-reviewed publication. In addition she participated in the collection of new 2007 and 2008 spectral R, F and biophysical data. The PI also organized and participated in the CEOS/WGCV28 Plenary meeting in Sanya, China, and she took part in the IGARSS08 conference. In Fall 2007, she taught the course "Remote Sensing of Environment" (GES 481/681) at UMBC.

Objectives for FY 08-09:

Campbell's specific interests and/or objectives include spectral analyses and assessments for the development of methods (algorithms, measurement techniques) for vegetation stress assessments and land cover change detection; the development of new EO1-Hyperion products to assess vegetation physiology; the assessment of potential for using solar-induced ChlF to estimate vegetation photosynthetic efficiency for several vegetation species; and the review of the requirements to build a sensor to measure solar ChlF. She will continue to participate in and facilitate the discussions for determining spectroscopy requirements for a future hyperspectral mission, and provide logistical team support.

Task 31:	**MODIS Light Use Efficiency** *(Sponsor: J. Irons, GSFC Code 613.0)*
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
Task 97:	**LEDAPS: a Landsat reanalysis project** *(Sponsor: J. Masek, GSFC Code 614.4)*
Investigator:	Forrest G. Hall

Description of Research

Within the past year, the MODIS BIOPHYS project under Task 31 has been completed. Hall's goal was to develop physically-based approaches to the retrieval of biophysical parameter data using multi-spectral, angle and date MODIS data. This project included Dr. K. F. Huemmrich and Dr. Derek Peddle as Co-I's and Dr. Qingyuan Zhang as a post-doctoral fellow.

The MODIS Light Use Efficiency effort continues to be focused on the remote sensing of an ecosystem's primary production using narrow-band spectral sensors, specifically investigating the use of the Photochemical Reflectance Index to quantify vegetation light use efficiency. Hall collaborated on this effort with Dr. Hank Margolis, PI of the major Canadian effort to study terrestrial ecosystems, and Dr. Andy Black, Dr. Nicholas Coops and Mr. Thomas Hilker of the University of British Columbia.

Hall also participated in activities with both the ICEsat II and the DESDynI Mission Formulation teams over this reporting period. The DESDynI Mission formulation team is headed by Dr. Diane Wickland, Terrestrial Ecosytems Program Manager of NASA Headquarters. The ICEsat II team is headed by Dr. Sealy Martin of NASA Headquarters. Both mission activities are in response to the National Research Council Earth Sciences Decadal Survey.

Finally, Hall also continued his participation in LEDAPS, an effort to process the last 30 years of the GeoCover Landsat data set to surface reflectance and use that data set to measure forest disturbance and recovery rates over North America.

Accomplishments in FY 07-08

Under the MODIS BIOPHYS project, an algorithm to retrieve biophysical parameters has been developed, tested and validated for both Landsat and MODIS data, resulting in subsequent publications (Peddle *et al.,* 2007a, Peddle *et al.,* 2007b, Soenen *et al.,* in press-a, Soenen *et al.,* in press-b). With respect to MODIS Light Use Efficiency, Hall's group has demonstrated that the MODIS 531 nm band is sensitive to variations in the photosynthetic uptake of carbon dioxide; thus, MODIS can be used to measure plant light use efficiency, a major missing variable in satellite monitoring of the carbon water and energy cycle. Hall's group believes that demonstrating this capability from space is an important breakthrough, since scaling results were previously only obtained at the leaf and canopy level from aircraft. Several publications have resulted from this effort (Hall *et al.* 2008, Hilker *et al.* 2008a, Hilker *et al.* 2008b, Drolet *et al.*, in press.)

Hall attended two ICEsat II mission formulation meetings, chaired breakout groups and wrote the vegetation section drafts for the ICEsat II report. He also participated in weekly telecons with the DESdynI team and attended two workshops 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. He has prepared a draft of a DESDynI measurement requirement document and a draft paper articulating the measurement requirements, science justification, and state-of-the-art technology to be submitted to *Remote Sensing of Environment*.

Hall continued his involvement with the website established to provide Landsat 5 and 7 GeoGover Landsat images to surface reflectance for the decades of the 80s, 90s and 00's for North America (available for download by anyone at no cost). The technology is now being transferred to USGS for operational products. Hall's team began to apply Landsat Biophys to the reprocessed data sets to produce disturbance images, and a publication has resulted from this activity (Masek *et al.*, 2008).

Objectives for FY 08-09

Two of three main activities for the coming year will be the continuation of algorithm development for biophysical variable retrievals and development of the DESDynI mission. A new proposal, written in collaboration with colleagues at Boston University, was funded; the focus of this new effort (and the third main activity) is to include lidar data, along with multi-angle MISR data and hyperspectral data, to improve the retrievals of vegetation biophysical parameters. Hall has also been funded by the GSFC Mission Formulation Team to support the development of the DESDynI mission. Finally, he will be writing new proposals to continue the light use efficiency work.

Task 79:	**Spectral Bio-Indicators of Ecosystem Photosynthetic Efficiency** ***(Sponsor: J. Irons, GSFC Code 613.0)***
Investigators:	K. F. Huemmrich, Research Assistant Professor, JCET; E. Middleton, PI, GSFC Code 614.1; P. Entcheva-Campbell, JCET; C. Daughtry, USDA/ARS; G. Parker, Smithsonian Environmental Research Center; L. Corp, Science Systems and Applications, Inc.
Task 86:	**North American Forest Disturbance and Regrowth Since 1972** ***(Sponsor: J. Irons, GSFC Code 613.0)***
Investigators:	K. F. Huemmrich, Research Assistant Professor, JCET; J. Masek, PI, GSFC Code 614.1
Task 95:	**Direct Satellite Inference of Ecosystem Light Use Efficiency for Carbon Exchange using MODIS on Terra and Aqua and Spectral Bio-Indicators of Ecosystem Photosynthetic Efficiency** ***(Sponsor: E. Middleton, GSFC Code 614.1)***
Investigators:	K. F. Huemmrich, Research Assistant Professor, JCET; E. Middleton, PI, GSFC Code 614.1; F. Hall, JCET; R. Knox, GSFC Code 614.4; H. Margolis, Univ. Laval

Description of Research

Huemmrich's research focuses on developing 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.

Canopy reflectance models 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 used to monitor ecosystem carbon exchange. Measurements made at leaf-level can be used in models combining canopy reflectance models with photosynthesis models, in order to simulate the relationship between canopy reflectance and photosynthesis. These relationships can also be explored at a canopy level using canopy-level reflectance measurements combined with ecosystem carbon flux measurements from flux towers.

Accomplishments for FY 07-08

To determine landscape characteristics for the North American Forest Disturbance project, a canopy reflectance model was run in the forward-mode multiple times, varying the inputs over the range of possible values. The reflectance values output by the model, and all input values, are stored in look up tables (LUT). Given observed reflectance values, the LUT is searched to find modeled reflectance values that match. Associated with the modeled reflectances are the inputs that describe the vegetation characteristics along with a measure of uncertainty. The derived vegetation characteristic data are used to study spatial and temporal patterns of disturbance and regrowth. Tests have been performed in boreal forests, as well as forests in the Southeastern US.

Using ground- and satellite-based observations for a number of different ecosystem types, the investigators studied the use of narrow spectral bands to detect plant stress and relate that to ecosystem carbon exchange. The satellite approach uses narrow MODIS spectral bands intended for ocean studies over land, a novel use of MODIS data requiring the development of a new processing stream, as the ocean bands have not been processed over land. They have focused on forests in Canada and are collaborating with scientists in the Canadian Carbon Program. The group has shown that an index using two MODIS 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, the amount of shadows in the sensor's field of view can affect the interpretation of the reflectance index.

To further examine vegetation spectral reflectance changes associated with stress in a more detailed manner, field experiments were conducted where reflectance and carbon exchange were measured in conjunction with whole canopy reflectance and carbon exchange measurements. In conjunction with Smithsonian and Department of Agriculture scientists, this fieldwork is being performed on tulip poplar trees and in a cornfield. Hyperspectral reflectance data has been collected at multiple times diurnally in a cornfield; 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, the investigators are lifted up in a basket suspended from a crane. Canopy structure has been shown to be important in determining the light environment of plant canopies, and has an effect on the overall productivity of vegetation and the manner in which it responds to stress conditions.

Objectives for FY 08-09

Work will continue on remote sensing of plant stress, and Huemmrich will complete his analysis using MODIS data to detect light use efficiency for multiple forest types. His group will create models of vegetation canopy radiative transfer dynamically linked to leaf level photosynthesis and stress response, which will provide a physical link between the leaf- and canopy-level observations. He plans to expand the use of multiple forward-mode modeling of canopies to detect vegetation biophysical characteristics, and to encourage the use of this technique to detect vegetation disturbance throughout North America. The PI will continue to develop research activities that monitor changes in high latitude ecosystems, and begin work on the use of remote sensing for biodiversity, linking biodiversity with ecosystem processes. Additionally, he will examine the use of high temporal frequency reflectance data in describing vegetation seasonality and temporal patterns of carbon flux.

Task 87:	**Passive and active microwave retrievals of frozen and melting precipitation hydrometeors (Sponsor: J. Wang, GSFC Code 614.6)**
NASA Grant:	**Retrieval Algorithm Development for Precipitating Snow Detection and Estimation using High Frequency Observations NASA (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), JCET & University of Wisconsin; Gail Skofronick-Jackson (PI), GSFC Code 613.3; James W. Wang, NASA GSFC; William Olson, NASA GSFC; Mircea Grecu, GEST.

Description of Research

Research has primarily focused on improving multi-sensor microwave retrievals of cold-cloud precipitation. The main goal is to obtain a higher quality retrieval of precipitation properties, such as particle size distribution, particle density, precipitation rate, and particle shape. To achieve this goal, a novel, new forward model was developed to simulate the radiative and physical properties of a steady-state 1-D column of the atmosphere and surface.

A retrieval technique has also been developed that utilizes co-located satellite or aircraft-based dual-frequency radar observations to more accurately assess particle size distribution properties. As an additional constraint to the above retrieval technique, passive microwave brightness temperature simulations, using the forward model, are compared to co-located observations of passive microwave brightness temperatures. This allows for a relatively fine-tuned selection of retrieved precipitation properties, which are consistent with the entire set of observations and physical relationships present in simulations.

Accomplishments for FY 07-08

In December 2007, at the University of Wisconsin, Johnson successfully defended his Ph.D. dissertation entitled “Multi-frequency passive microwave and dual-frequency radar remote sensing of snowfall”. This represents the culmination of a multi-year project designed to accurately simulate a 1-D column of a precipitating atmosphere, and simulate the multi-channel passive microwave brightness temperatures and vertical profile of radar reflectivity for the 1-D column. This “forward model” also allowed his group to create a retrieval technique based on the inversion of the model; that is, given the passive microwave brightness temperatures and radar reflectivity, what are the physical properties of the precipitating cloud? Case studies were performed using data from the 2003 Wakasa Bay field experiment. This research has been presented at several conferences and Johnson has been invited to give presentations on the research as well.

Johnson also supervised a graduate student, Anne Kramer, who is working in his group on field campaign data and snowflake shape properties; the snow shape research is part of a larger ongoing project designed to better understand the influence of snow particle shape on the observed radar and radiometer reflectivities. Substantial progress has been made in this research, and the results are being prepared for publication. Additionally, Johnson has developed a heuristic model for melting individual snowflakes, to be used to compute the microwave properties of more physically realistic particle shapes.

Other research topics involved extending the work from his dissertation to include rainfall cases (melting snow), estimating land surface emissivity for precipitation retrievals over land, ongoing participation in the Centre for Atmospheric Research Experiments (CARE) CloudSat/Calipso validation program C3VP, with respect to assisting his civil servant sponsor (Gail Skofronick-Jackson) with retrieval and forward modeling efforts.

This past year, Johnson became a member of the Global Precipitation Mission (GPM) combined radar/radiometer algorithm development team, whose members are tasked with developing the standard GPM algorithm for combined retrievals. He is also an active member of the ice/mixed phase working group and the precipitation detection working group; both operate in support of the GPM project. In order to facilitate collaboration among the group, Johnson developed a “wiki”, which allows members to actively interact and share information. He is also supplying critical portions of his research to the combined effort, which will eventually become part of the retrieval algorithms for GPM.

Johnson’s research work as a Co-I on two funded proposals continues, as the group converges toward a final research product for snowfall detection using high frequency passive microwave observations, and also with a 94 GHz W band space-based radar (onboard the CloudSat satellite). When research is completed in early 2009, they will begin to publish the results.

Finally, in addition to attending the MicroRad 2008 conference in Florence, Italy and the 2nd International Workshop on Space-based Snowfall Measurement in Colorado, he has also been an active reviewer for the *Journal of Applied Meteorology and Climatology* (JAMC).

Objectives for FY 08-09

Additional rainfall case studies from the dissertation work will be conducted, as well as testing of optimal-estimation techniques to improve retrieval and error characterization. Johnson’s group will continue their comparison of spherical particles with more realistic shape model and properties (e.g., using the discrete dipole approximation). He will also simulate melting particles more realistically for use in the melting layer of the forward model. Regarding over-land retrievals, they plan to improve land surface emissivity, radar cross-sections, and their understanding of terrain influences on the retrievals.

Johnson’s primary objective in the coming year is to develop GPM-era combined GMI/PR2 radar retrieval algorithm(s) for light rain and snow over both land and ocean, and progress 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, retrieval over land and ocean of both rain and snowfall.

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Heliophysics Division
Solar System Division
(Code 670-699)

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USRA Subcontract: Olympus Mons – NASA Mars Data Analysis Program, (2094-03)

NSF Grant: **An investigation of progressive failure in landslides in the area affected by the 8th October 2005 Earthquake in Pakistan. (NSF SGER)**

World Bank Grant: Vilcanota Valley Slope Monitoring for Flash Flood Prevention (0000002683)

Investigator: Mark Bulmer, Research Associate Professor, Geography and Environmental Systems

Description of Research

Current research interests include 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. Work on these various projects has been funded through the NASA Solid Earth and Natural Hazards Program, NASA Mars Data Analysis Program, NASA Mars Fundamental Research Program, NASA RADARSAT-1 ADRO 2 Program, NSF (International Programs, NSF VIP K-16, and NSF Small Exploration and Research Grants), DRU RADARSAT-1, ESA AO-3, Maryland Industrial Partnerships Program, Royal Geographical Society and National Geographic. Additionally, the PI taught undergraduate classes, including Planetary Geology, Natural Hazards and Process Geomorphology.

Accomplishments in FY 07-08

As part of on-going research as a Co-I on this first grant, which pertains to Olympus Mons, new image and topography data over Olympus Mons and the surrounding aureoles has been continually compiled into a GIS environment and assigned a common coordinate system. A digital elevation model will be created from HRSC using stereographic techniques that allow for a higher density sampling of elevation points than is possible in the MOLA 128 degree/pixel data. Shaded relief, color coded elevation and slope gradient maps have continually been amended to include new data, providing the base for a geomorphologic mapping of the aureoles and volcanic edifice. Results were presented at the 2007 Lunar and Planetary Conference and the American Geophysical Union Spring Conference. A proposal submitted to the Mars Fundamental Research Program to examine optimal ways of obtaining topography data on Mars using laser scanning has been selected for funding. Further examination of the presence of streaks in aureole units has continued and a manuscript has been submitted for review. The dimensions and morphologies of streaks have been re-examined using newly available HiRISE images, allowing for a detailed examination of published emplacement models.

In January 2006, Bulmer was invited by the Director of the Pakistan Geological Survey, Islamabad to examine the landslides associated with the 8th October 2005 Earthquake in Pakistan. The official death toll is 87,300, with landslides being responsible for about 20,000 fatalities. In response to the request from the GSP for an assessment of data collection systems that could be deployed in Kashmir, a new low-cost, long duration, low maintenance, day and night operation slope movement data collection technique (SENTINEL) was designed at the University of Maryland, Baltimore County by Bulmer and Farquhar. This is based upon the comparison of time series digital photography of markers affixed to slopes. Results from a preliminary deployment of this system were published as the lead article in *EOS*. The SENTINEL system has been further refined and calibrated using two sites around the UMBC campus. Camera systems have successfully been carried on a helium balloon, radio-controlled helicopter and fixed-wing aircraft. Image mosaics and calibrated images have been presented to the Baltimore County Department of Public Works and the civil engineering subcontractor The Robert B. Balter Company.

The objective of Bulmer's third project is to identify appropriate protocols to monitor hazardous slope movements (a) within Mach Picchu Pueblo, (b) along the road up to Machu Picchu, and (c) along the rail line. The PI seeks to identify appropriate techniques to: (i) determine if the surface movements of natural and managed slopes differ according to their geology, aspect and gradient; (ii) identify community-based strategies to manage or mitigate landslide hazards, including structural and non-structural measures; (iii) determine if the surface movements of disturbed cut slopes (such as those associated with construction) differ from those of natural slopes; (iv) determine if the surface movements of disturbed slopes carrying heavy rail or road traffic differ from similar slopes without active roads or railways; (v) determine the institutional capacity requirements of the different possible methods in setting up an early warning/hazard mitigation system, with a view to selecting one that will be sustainable over the long term; and (vi) identify, in partnership with the relevant stakeholders, the appropriate strategies to manage or mitigate landslide hazards, including structural and non-structural measures. The first of three field deployments has been conducted and an initial report completed, which contains recommendations for reducing the town's vulnerability to large rocks falling onto MPP and/or the rail line, flash flooding of MPP by any one of its three rivers, and mudflows and landslides. Based on their initial assessment, the PI and his group recommend technical characterization of all three types of threats, plus a series of risk reduction projects in partnership with the appropriate local stakeholders.

Objectives for FY 2008-2009

Proposals will be submitted to NSF Earth Sciences, NASA Mars Data Analysis and Army Research Programs.

Task 84: **Numerical Modeling Historical Martian Dynamo** ***(Sponsor: W. Kuang, GSFC Code 698)***

Investigators: Weiyuan Jiang, Research Assistant Professor, JCET/UMBC; Weijia Kuang, JCET Fellow, Code 698, GSFC

Description of Research

One of the most important findings of the Mars Global Surveyor (MGS) mission is strong crustal magnetization in the highland crust of the Martian southern hemisphere (e.g. Acuña *et al.* 1998, 2001). On the other hand, little crustal magnetization is found in other areas of Mars, in particular the Hellas and Argyre impact basins. These observational evidences suggest that Mars once had an active dynamo in its early stages of evolution.

While geophysical exploration of Mars' interior structures (e.g., seismic/geodetic information on the core) can help differentiate these scenarios, critical information should also include the three following components: the amount of gravitational energy that could be released in the core in the secular cooling of Mars; the minimum gravitational energy for an active core dynamo; and, the impact of the size of the inner core on the annihilation of the Martian dynamo. Currently, the second and third criteria can best (perhaps only) be obtained via an extensive numerical modeling effort: using self-consistent numerical dynamo models to investigate systematically the convection and the generation of the magnetic field in Mars' core. In particular, numerical modeling can help specify the energy budget necessary to operate a dynamo with various scenarios of the Martian core (*e.g.*, the Martian core with various possible parameters). In their research, the JCET investigators used the MoSST to simulate the process of annihilation of the Mars dynamo and to explore the properties of the magnetic field and the convective flow in the core.

Accomplishments in FY 07-08

The investigators have carried out the numerical simulations for the reverse process with ricb = 0.35. The Rayleigh number Rth decreases from Rth = 15000 (when a strong field dynamo exists [7]) to Rth = 2400. It shows that the magnetic field changes the strongest magnetization in the Noachian-aged southern highland (Whaler and Purucker, 2005) dramatically around the subcritical domain, while the variation is relatively small at the supercritical domain.

The numerical results show that the dynamo volume also changes dramatically around the subcritical domain, while the deviation from the mean dynamo volume is relatively small at the supercritical domain.

The numerical results show the distribution of the generation and the decay of the magnetic field are well mixed and it is hard to separate those special domains.

Objectives for FY 08-09

First, Jiang and Kuang intend to use numerical simulations to understand whether the subcritical dynamo state could exist for a variety of core properties; in particular, they intend to identify whether such a subcritical dynamo is achievable for different sizes of the inner core.

Second, they intend to investigate how the dynamo state evolves from one that generates and maintains a stable, nearly axial-dipole magnetic field (at Mars' surface) to one with a low-latitude, dipolar, frequently reversing magnetic field for different sizes of the inner core.

Based on the results from the first and second investigations, the team intends to investigate potential measurable magnetic properties from numerical models that can be used to interpret current and future Mars observations, thus furthering their understanding of the dynamical processes in Mars' interior and its evolution history from combined model simulation and observation analysis.

NASA Grant:	Dynamics of eastern Mediterranean, Sea Level and altimetry Calibration-validation (DynMSLaC) (NNG05GO31G)
NURI Grant:	Current and Future Satellite Mission Data Analysis for Global Gravity Field Modeling and Reference Frame Implementation (NMA201-01-2008)
NASA Grant:	Understanding Sea Level Variations: Reference Frame, Data Analysis, and Modeling (NRA-03-OES-03 funding Tasks 85 & 90)
NASA Grant:	Current and Future Satellite Mission Data Analysis for Global Gravity Field Modeling and Reference Frame Implementation (SENH-0126-0180)
NASA Grant:	GRACE applications for TRF development and fundamental physics tests (NNH06ZDA001N-GRACE)
Task 33:	Space Geodesy Applications to Earth Sciences *(Sponsor: H. Frey, GSFC Code 698.0)*
Task 105:	Design and Optimization of NASA's Future Space Geodetic Networks in Support of GGOS *(Sponsor: H. Frey, GSFC Code 698.0)*
Investigators:	Erricos C. Pavlis, Research Associate Professor, Physics, JCET; Magdalena Kuzmicz-Cieslak, Research Associate, JCET; Glynn Hulley, Research Assistant, Physics, UMBC; Keith Evans, Research Analyst, JCET; Peter Hinkey, undergraduate student assistant, UMBC.

Description of Research

Pavlis's research focuses on the application of SLR, VLBI, GPS, and altimetry techniques and data analyses in Earth science covering many - often overlapping - areas. His team leads in the analysis of SLR, VLBI and GPS data for the development and maintenance of global terrestrial reference frames and mean sea level time series. Pavlis chairs the Int. Laser Ranging Service's (ILRS) Analysis Working Group and Refraction Study Group. Additionally, Hulley and Pavlis co-authored a chapter in IERS' Conventions 2003 living document (http://tai.bipm.org/iers/convupdt/convupdt.html), describing the newly adopted state-of-the-art procedures for atmospheric corrections in laser ranging. Their time series of long-wavelength temporal variations of terrestrial gravity are widely used. The group leads an international team to optimally design NASA's future space geodetic tracking networks. They've established and presently operate two facilities for sea level monitoring, altimeter calibration, and environmental observation for weather, oceanography and climate research.

Accomplishments for FY 07-08

Pavlis's group updated their database of temporal variations for all harmonics up to degree and order (60,60) from the latest GRACE project release (R04). A reanalysis of the entire 1976-2008 SLR data set is continuing, with new bias models agreed by the ILRS AWG. A daily product of weekly-arc analyses has been initiated, with a by-product being a daily QC report on the tracking network.

The group's GAVDOS activities under the OSTM program has a second facilty, KASTELI, on the north coast of mainland Crete, now completed and awaiting power for the Cal/Val phase for JASON-2. Both sites are now instrumented so that they can participate in the Int. GNSS Service (IGS) with METEOSAT transmission packages as well as wireless connections. Pavlis and his team were awarded a new four-year NASA grant to continue these activities and expand the Eastern Mediterranean Altimetry Calibration Network (e-MACnet).

They collaborated with an international group seeking an improved measurement of the relativistic "frame-dragging" effect. The Italian Space Agency (ASI) accepted their joint proposal for a geodetic-quality SLR satellite (LARES); the tentative launch date is early 2009. As GRACE ST members, the group won a 3-year NASA grant to apply also towards studies associated with LARES.

Work on the Mean Sea Level (MSL) project focused on accuracy assessment of the team's knowledge of the geocenter and quantified the implications in terms of MSL variability. Results were presented at the 2008 European Geosciences Union general assembly. Work now focuses on the development of simulation techniques for further validation and the study of the error budget associated with MSL determination and its long- and short-term variations. One year of simulated SLR and VLBI data was used for four different size networks to scope the optimal size of the Int. Terrestrial Reference Frame (ITRF).

Objectives for FY 08-09

Pavlis's team will continue to extend their analysis of GRACE data for temporal variations of gravity and test them in the reanalysis of SLR data in preparation for a new ITRF. As an ILRS Analysis Center, they will continue to operate their automated weekly and daily data analysis and quality control, and generate annual contributions. This year operations will be extended to include more SLR targets, and re-processing of historical data will be completed, extending the record to the early years of SLR tracking (ca. mid-1970s). Precise orbits determined during these analyses will be made public through the group's own web site and submitted to the ILRS Pilot Project, starting in July 2008.

The group will continue their project GAVDOS collaboration with their European partners and the routine operation of the JCET facilities on Gavdos and Kasteli. The GAVDOS site will be relocated to its final permanent location in September 2008. The group's local database will be expanded to include JASON-2 data and results.

All activities and products are documented and disseminated via a web site that is continuously expanded and upgraded according to the needs of the various projects it supports.

NASA Grant:	NNG05GC-79-A
NASA Grant:	AURA Validation, TES CO and O3 Validations Using AIRS
NASA Grant:	Atmospheric Composition, Inter-comparison of EOS CO Sensors
NASA Grant:	Tropospheric Chemistry, ARCTAS Support and Analyses
Task 88:	Geomagnetic Data Assimilation (NSF); Core Dynamics and The Application to Surface geodynamics Observables (NASA) *(Sponsor: W. Kuang, GSFC Code 698)*
Investigators:	Zigang Wei, JCET Visiting Assistant Scientist; Juying Warner, JCET Assistant Scientist; Weijia Kuang, JCET Fellow, GSFC, Code 698

Description of Research

In order to forecast the future changes of the geomagnetic field, there are different kinds of geomagnetic observation models. GUFM1 historical geomagnetic models and CALS7k paleo-magnetic models, which total 7000 years old, were input into the group's geodynamo model. Such observation models had different time validations and different accuracies. The JCET investigators combined them into an observation data series. Based on these observations, the data assimilation runs were carried out using 20, 40, 100, 400, 5000 and 7000 years of observations.

Wei's team compared the differences and correlations between forecasts and observations as well as forecasts and free model runs. The JCET investigators are developing a new AIRS retrieval by using Rodgers algorithm, a totally different method compared with current AIRS retrievals. The group focused on comparing the variables retrieved from the new algorithm with those from MOPITT, TES and MLS, which are also retrieved by Rodgers' algorithm. Simultaneously, they conducted some validations and evaluations of the current NASA tropospheric trace gas measurements by comparing AIRS/TES/MOPITT products and NASA-supported ARCTAS experiments.

Accomplishments for FY 07-08

A suite of programs for analyzing assimilated geodynamo solutions were developed, which included geomagnetic fields of all components at any position for any given time. Using these tools, the team compared geomagnetic forecast results with the PGRF results over the past three decades.

The JCET investigators performed geo-collocation works for the AIRS and MODIS data. The AIRS cloud qualities were studied and evaluated with MODIS cloud mask based on the co-location information. At the same time, a new inversion algorithm with Rodgers retrieval method was partly developed under the NASA grant support, which will contribute to a new retrieval algorithm for AIRS. In order to validate AIRS products and support ARCTAS field campaigns, the team studied CO transportation with AIRS L1 and L2 NRT data products by using trajectory models. (The detailed accomplishments for these parts of the investigators' work can be found in Dr. Juying Warner's annual report.)

Objectives for FY 08-09

In the coming year, emphasis will be on the development of the new retrieval algorithm. The coding debugging works also will be carried out this year. In addition, the group will continue to run the data assimulation models and analyze the forecast results.

III. Supporting Information

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III.3 Publications Submitted for Review

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Bulmer, M.H., T. Farquhar, and M. Roshan (2007), Effective use of Fiducial-based photogrammetry for tracking large scale outdoor motion, *J. Exp. Eng. Techs*, submitted.

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Bulmer, M.H., S. Anderson, T. Gregg, and L. S. Glaze (2008), Blocky Lava Flow Characterization and Emplacement at Sabancaya Volcano, Peru, *J. Geophys. Res. – Earth*, submitted.

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

Beckley, B. D., N. P. Zelensky, F. G. Lemoine, S. B. Luthcke, R. D. Ray, G. T. Mitchum, S. D. Jacob, E. C. Pavlis (2008), Assessment of current estimates of global and regional mean sea level trends from TOPEX and Jason-1 altimetry based on revised reference frame and orbits, EGU2008-A-10261, EGU 2008, Vienna, Austria, 13 – 18 April.

Beller, D., A. Griswold, M. H. Bulmer, and P. J. McGovern (2007), An examination of slope streak emplacement using new HiRise Data. NASA Intern Poster Session, Goddard Space Flight Center, Greenbelt, MD.

Beller, D., A. Griswold, M. H. Bulmer, and P. J. McGovern (2007), Examination of Martian slope streak emplacement, Tenth Annual Summer Undergraduate Research Fest, College of Natural and Mathematical Sciences, University of Maryland, Baltimore County, 8 August.

Boy, J.-P., P. Gégout, J. Hinderer, S. B. Luthcke, E. C. Pavlis, D. D. Rowlands (2008), Atmospheric loading effects on time-variable gravity and surface displacements (solicited), EGU2008-A-06309, EGU 2008, Vienna, Austria, 13 – 18 April.

Bulmer, M. H. (2007), Annual progress report on NSF Grant entitled "An investigation of progressive failure in landslides in the area affected by the 8th October 2005 Earthquake in Pakistan", p.4.

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Bulmer, M. H. (2007), Examination of Olympus Mons Aureole deposits, Annual report to Lunar and Planetary Institute, USRA Subcontract to UMBC of NASA MDAP Grant NNG05GQ71G, Studies of volcanic growth, spreading and collapse on Mars, p.4.

Bulmer, M. H. (2007), Future Employment Manning the Base Surveillance Capability, RMLY G3-100/1 p.8.

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Campbell, P. (2008), Attended the Joint Workshop on NASA Terrestrial Ecology, Biodiversity and Related Applied Sciences College Park, MD. 2008 NASA Carbon Cycle and Ecosystems Joint Science Workshop; Adelphi, Maryland; April 28–May 2.

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Carn, S. A., et al. (2007), Direct sampling of tropospheric volcanic plumes in Ecuador and Colombia during TC4, Aura Science Team Meeting, Pasadena, CA, 1-5 October.

Carn, S. A., J. Wang, N. A. Krotkov, K. Yang, and A. J. Krueger (2008), "Using A-Train synergy to determine the potential impact of volcanic degassing on climate" OMI Science Team Meeting, Helsinki, Finland, June 24 – 27.

Chiu, J. C., A. Marshak, W. Wiscombe, S. C. Valencia, and E. J. Welton (2007), Studying thick clouds with ground-based lidars, presented at The Gordon Research Conference, New London, New Hampshire, 30 July.

Chiu, J. C., A. Marshak, W. Wiscombe, P. Pilewskie, and S. Kittelman (2007), Cloud property retrievals from the shortwave spectrometer, presented at the 2007 joint ARM Radiative Processes / Aerosol Working group meeting, Madison, Wisconsin, 17–19 September.

Chiu, J. C., A. Marshak, Y. Knyazikhin, and W. Wiscombe (2008), Integrated cloud optical properties from zenith radiance measurements collected during the ARM COPS experiment, presented at the 18th ARM Science Team Meeting, Norfolk, Virginia, 10–14 March.

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DeWinter, J. L., et al. (2007), Utilization of NASA MODerate Resolution Imaging Spectroradiometer (MODIS) Derived Aerosol Optical Depth (AOD) for Trends Analysis Over the United States-Canada Border Region, American Geophysical Union, Fall Meeting, San Francisco, CA, 10-14 December.

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Engel-Cox, J., E. Zell, S. Weber, R. M. Hoff, and H. Zhang (2008), Applications of the Three-Dimensional Air Quality System to Western U.S. Air Quality: Smog Blog, Smog Stories, and AirQuest, AAAR/AWMA Visibility Conference, Paper #88, Moab, Utah, 28 April – 2 May.

Evans, K, W. McMillan, G. Sachse, G. Diskin, and C. Barnet (2007), Validation of AIRS v5.0.14.0 CO Retrievals From INTEX-A and B, *Eos. Trans. AGU*, Fall Meet. Suppl., Abstract A33A-0824, San Francisco, CA, 10-14 December.

Farquhar, T., and M. H. Bulmer (2007), Distributed Sensing of Hazardous Geophysical Flows (SENSEI), MIPS Project Final Report, Contract Agreement #3619, p.9.

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Grecu, M., W. S. Olson, C.-L. Shie, and W.-K. Tao (2007), A Radiometer-Based Latent Heating Estimation Method, Trained Using PR Observations, Fifth TRMM Latent Heating Workshop, Annapolis, MD, 27 – 28 August.

Grecu, M. and W. S. Olson (2008), TRMM Combined Radar-Radiometer Precipitation Retrievals to Support Radiometer-Only Retrieval Algorithms, 3rd TRMM NASA/JAXA International Science Conference, Las Vegas, NV, 4 – 8 February.

Griswold, A., M. H. Bulmer, D. Beller, and P. J. McGovern (2007), An examination of the Olympus Mons Aureoles, NASA Intern Poster Session, Goddard Space Flight Center, Greenbelt, MD.

Griswold, J., M. H. Bulmer, D. Beller, and P. J. McGovern (2008), An examination of Olympus Mons aureoles, 39th Lunar and Planetary Science Conference, Houston, TX, #2239.

Han, M., S. A. Braun, W. Olson, P. O. G. Persson, J.-W. Bao (2007), An Evaluation of Cloud Microphysics Schemes in a Mesoscale Model Using Microwave Measurements, American Meteorological Society 12th Conference on Mesoscale Processes, Waterville Valley, NH, 6 – 9 August.

Han, M., S. A. Braun, and W. S. Olson (2008), An Evaluation of the Microphysical Parameterizations in the MM5 Mesoscale Model, 3rd TRMM NASA/JAXA International Science Conference, Las Vegas, NV, 4 – 8 February.

Hannon, S., L. Strow, S. D. Souza-Machado, and H. Motteler (2007), Deriving Climate Level Trends with Infrared Hyperspectral Data, AGU Fall Meeting Abstracts, pp. A4.

Hilsenrath, E. (2008), The CEOS Atmospheric Composition Constellation (ACC), an Integrated Observing System, AGU, Ft. Lauderdale, FL, May.

Hilsenrath, E., J. Langen, and C. Zehner (2007), The Atmospheric Composition Constellation: A proposed example of Integrated Earth Observing System for GEOSS, IGARSS 2007 Barcelona, 23 July.

Hoff, R. M. (2007), CALIPSO Observations of the Long-Range Transport of Smoke, Department of Geography and Environmental Engineering Seminar, Johns Hopkins University, Baltimore, MD, 4 December.

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Hoff, R. M., and H. Zhang (2008), IDEA Product Enhancements for the GOES-R Era, Presentation at NOAA NESDIS, 18 January.

Hoff, R. M., G. Pappalardo, and J. Boesenberg (2008), The GAW Atmospheric Lidar Observations Network (GALION), Paper 5.2, Symposium on Recent Developments in Atmospheric Applications of Radar and Lidar, AMS Annual Meeting, New Orleans, LA, 21-24 January (INVITED).

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Huemmrich, K. F. (2007), Linking Fluxes with Remote Sensing in Field Studies, AGU Fall Meeting, San Francisco, CA, 12 December.

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Huff, A. K., J. Engel-Cox, and R. M. Hoff (2008), Use of NASA Three-Dimensional Air Quality System (3D-AQS) Remote Sensing Data for Air Quality Forecasting, US EPA National Air Quality Conference, Marriott Portland Downtown Waterfront, Portland, Oregon, 6-9 April.

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Irion, F. W., C. Barnet, M. T. Chahine, N. J. Livesey, W. W. McMillan, and G. B. Osterman (2007), AIRS Version 5 Trace Gas Retrievals, *Eos. Trans. AGU*, Fall Meet. Suppl., Abstract A21B-0437.

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Jordan, N., and R. Hoff (2007), Employing A-Train Sensors for Assessing Biomass Burning, Paper P30, A-Train Symposium, Lille, France, October 21-24.

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Krotkov, N. A. (2007), Poster titled "What have we learned about global SO_2 sources with OMI data?", Aura Science Team Meeting, Pasadena, CA, 1-5 October.

Krotkov, N. A., K. Yang, A. J. Krueger, and S. A. Carn (2008), "Current and future OMI SO_2 algorithms", OMI Science Team Meeting, Helsinki, Finland, 24-27 June.

Krueger, A. S. (2007), Presentation entitled "NOAA/NASA Satellite Data for Volcanic Aviation Hazards", the 2nd virtual Atmospheric Composition Constellation Workshop, Darmstadt, Germany, 12-14 September. (Download presentation from: ftp://gp16.ssd.nesdis.noaa.gov/pub/volcano/ACC_Workshop2_Volcano_Final.ppt.)

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L'Ecuyer, T. S., Z. Luo, G. L. Stephens, W. Olson, M. Grecu, X. Jiang, D. Waliser, and A. Tompkins (2007), Applications of TRMM-Based Estimates of Atmospheric Radiative Heating Profiles, NASA Energy and Water cycle Study (NEWS) Principal Investigator Meeting, Huntsville, AL, 19 – 21 September.

Lary, D. (2007), Variations in Stratospheric Inorganic Chlorine Between 1991 and 2006, 14th Conference on Middle Atmosphere, Portland, Oregon, 20-24 August.

Lary, D. (2007), Session 7 Stratospheric Chemistry and Ozone Recovery Posters, The First Multi-Constituent Kalman Filter Analysis of Atmospheric Chemistry from 1991-2007, 14th Conference on Middle Atmosphere, Portland, Oregon, 20-24 August.

Lary, D. (2007), Linking NASA Satellite-Based Environmental Data with Environmental Exposures and Health Outcomes in Theater of War Key Technologies for Collecting, Processing, and Sharing NASA Satellite Data, US Army Center for Health Promotion and Preventive Medicine, Environmental Medicine Program, Aberdeen Proving Grounds, MD, 28 November (INVITED).

Lary, D. (2007), Using Neural Networks for Instrument Cross-Calibration, AGU Fall Meeting, *Eos Trans. AGU, 88*(52), Fall Meet. Suppl., Abstract A11E-07, San Francisco, CA, 10–14 December (INVITED).

Lary, D. (2008), Automating Classification of Satellite Imagery for Environmental Exposure Assessment in Cancer Epidemiology, The Michigan League, University of Michigan, Ann Arbor, MI, 14-15 January (INVITED).

Lary, D. (2008), Noble seminar, Atmospheric Physics Seminar Series, University of Toronto, 21 January (INVITED).

Lary, D. (2008), NASA HIRDLS Science Team Meeting, Boulder, Colorado, 30-31 January (INVITED).

Lary, D. (2008), SORCE (Solar Radiation and Climate Experiment) Science Meeting, La Posada de Santa Fe Resort & Spa, Santa Fe, New Mexico, 5-7 February (INVITED and commended by Organizing Committee).

Lary, D. (2008), NASA Observation System Sensitivity Experiment (OSSE) Meeting, Harvard University, 27 March (INVITED).

Lary, D. (2008), NASA Earth Science Technology Office (ESTO) Sensor Web PI Meeting, Florida, 1-2 April (INVITED).

Lemoine, F, N. Zelensky, E. Pavlis, D. Rowlands, D. Chinn, B. Beckley, and J.-P. Boy (2008), Impact of Modelling Improvements on POD for TOPEX/Poseidon and Jason, EGU2008-A-11368, EGU 2008, Vienna, Austria, 13–18 April.

Marshak, A., J. C. Chiu, Y. Knyazikhin, W. Wiscombe, and P. Pilewskie (2008), Studying the transition from cloudy to clear skies using the ARM shortwave spectrometer, presented at the 18th ARM Science Team Meeting, Norfolk, Virginia, 10–14 March.

McCann, K. (2008), A New Approach to the CALIPSO Feature Finder based on Image Processing Techniques, presented to the NASA/Langley Calipso Team, February.

McCann, K., S. DeSouza-Machado, L. Strow, B. Imbiriba, K. McCann, and R. Hoff (2007), Retrieving Dust Optical Properties using AIRS and CALIPSO, Paper P16, A-Train Symposium, Lille, France, 21-24 October.

McCann, K., R. Hoff, S. DeSouza-Machado, B. Imbiriba, and M. Vaughan (2007), The Use of the CALIPSO/CALIOP lidar to Retrieve the Extinction and Optical Depth of Saharan and Asian Dust Plumes, Paper P38, A-Train Symposium, Lille, France, 21-24 October.

McGovern, P.J., J. K. Morgan, M. H. Bulmer, and J. R. Smith (2007), Studies of volcanic growth, spreading and collapse on Mars, Annual progress report for Year-2 NASA MDAP Grant NNG05GQ71G, pp.9.

McMillan, W. W., G. Osterman, K. Evans, R. Hoff, F. W. Irion, N. Livesay, K. Pickering, L. Sparling, D. Wicks, and L. Yurganov (2007), A-Train Tropospheric Chemistry Observations on 30 August 2006 over the 2006 TexAQS/GoMACCS Study Area, NASA Aura Science Team Meeting, Pasadena, CA, 2-5 October.

McMillan, W. W., and L. Yurganov (2007), Global Climatology of Tropospheric CO from the Atmospheric InfraRed Sounder (AIRS): Interannual Variations in Emissions from Indonesia, *Eos Trans. AGU, 88*(52), Fall Meet. Suppl., Abstract A11C-0601, San Francisco, CA, 10-14 December.

McMillan, W. W., L. Yurganov, K. Evans, and C. Barnet (2008), Global Climatology of Tropospheric CO from the Atmospheric InfraRed Sounder (AIRS), 88th Annual Meeting of the American Meteorological Society, 20th Climate Conference, Abstract 5B.3, New Orleans, LA, 20-24 January.

McMillan, W. W., and L. Yurganov (2008), Local, Regional, and Global Views of Tropospheric Carbon Monoxide from the Atmospheric InfraRed Sounder (AIRS) onboard the Aqua Satellite, SPIE Defense+Security Meeting, Conference 6966-40, Orlando, FL, 18 March.

McMillan, W. W., and L. Yurganov (2008), Local, regional, and global views of tropospheric carbon monoxide from the Atmospheric Infrared Sounder (AIRS), Proceedings of SPIE, 6966, *Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XIV*, eds. Sylvia S. Shen, Paul E. Lewis, 696615 (Apr. 11, 2008), doi:10.1117/12.776983.

McMillan, W. W., K. Evans, L. Yurganov, R. C. Wilson, G. Sachse, G. Diskin, and M. Fischer (2008), v5.0.14.0 CO Validation Update, NASA AIRS Science Team Meeting, Pasadena, CA, 16 April.

McMillan, W. W., et al. (2008), AIRS Global Mid-Tropospheric CO_2 and CO: Sensitivity to Surface Sources and Transport, NASA Carbon Cycle and Ecosystems Joint Science Workshop, Poster #350, Adelphi, MD, 28 April – 2 May.

McMillan, W. W., et al. (2008), Air Quality Observations from the A-Train: A Synergistic View, *Eos. Trans. AGU*, Spring Meet. Suppl., Abstract U21A-04, Fort Lauderdale, FL, 27-29 May.

McMillan, W. W., K. Evans, L. Yurganov, R. C. Wilson, G. Sachse, G. Diskin, C. Barnet, and E. Maddy (2008), Validation of AIRS CO Retrievals for Air Quality and Transport

Assessments, *Eos. Trans. AGU*, Spring Meet. Suppl., Abstract A33A-12, Fort Lauderdale, FL, 27-29 May.

Mehta, A. V., and E. A. Smith (2007), Monsoon Rain over India from TRMM and NMS Cloud Resolving Model, paper presented at Celebrating the Monsoon: An international Monsoon conference, Bangalore, India, 24-28 July.

Mertikas, S. P., E. C. Pavlis, X. Frantzis, A. Tripolitsiotis, S. Bouros, and S. Karasavidis (2007), A Permanent GPS Array in Crete and the Calibration/Validation Facility for Satellite Radar Altimeters, EUREF-2007 Symposium, London, England, 6-9 June.

Olson, W. S., M. Grecu, C.-L. Shie, T. L'Ecuyer, D. E. Waliser, X. Jiang, J.-L. Li, A. Tompkins, and W.-K. Tao (2007), Evaluation and Integration of Global Latent Heating Distributions from a PR-Trained Radiometer Algorithm, NASA Energy and Water cycle Study (NEWS) Principal Investigator Meeting, Huntsville, AL, 19 – 21 September.

Olson, W. S., M. Grecu, C.-L. Shie, and W.-K. Tao (2007), Latent Heating Estimates from TRMM, US CLIVAR MJO Workshop: New Approaches to Meet the Challenge of the Madden-Julian Oscillation, Irvine, CA, 5 – 7 November.

Olson, W. S., M. Grecu, C.-L. Shie, T. L'Ecuyer, D. E. Waliser, X. Jiang, J.-L. Li, B. Tian, A. Tompkins, and W.-K. Tao (2008), Global Applications of Remotely-Sensed Latent Heating Distributions from a PR-Trained Radiometer Algorithm, 3rd TRMM NASA/JAXA International Science Conference, Las Vegas, NV, 4 – 8 February.

Oreopoulos, L. (2007), CIRC progress, presented at the ARM Joint RPWG and AWG Meeting, Madison, WI, 17-19 September.

Oreopoulos, L. (2007), An update on CIRC, presented at the GEWEX Radiation Panel Meeting, Buzios, Brazil, 9-12 October.

Oreopoulos, L. (2008), A primer on 1.38 μm cloud detection, presented at the 3rd Landsat Science Team Meeting, Sioux Falls, SD, 8-10 January.

Oreopoulos, L., E. Mlawer, J. Delamere, and T. Shippert (2008), Comparison of RT codes via BBHRP, presented at the 18th ARM Science Team Meeting, Norfolk, VA, 10 -14 March.

Oreopoulos, L., E. Mlawer, J. Delamere, and T. Shippert (2008), Goals and objectives of CIRC, presented at the 18th ARM Science Team Meeting, Norfolk, VA, 10 -14 March.

Oreopoulos, L., E. Mlawer, T. Shippert, and J. Delamere (2008), Evaluating BBHRP radiative flux closure under cloudy conditions with a "shadow" dataset, presented at the 18th ARM Science Team Meeting, Norfolk, VA, 10 -14 March.

Pagano, T. S., H. H. Aumann, S. E. Broberg, D. A. Elliott, K. Overoye, and L. L. Strow (2007), AIRS Pre-flight Calibration and In Orbit Validation, AGU Fall Meeting Abstracts, pp. B305.

Pavlis, E. C. (2007), SLR-based evaluation and validation studies of candidate ITRF2005 products, *Proceedings of 15th Int. Laser Workshop*, John Luck (ed.), Geosciences Australia, Canberra.

Pavlis, E. C. (2007), The Global SLR Network and the origin and scale of the TRF in the GGOS era, P*roceedings of 15th Int. Laser Workshop,* John Luck (ed.), pp. 159-166, Geosciences Australia, Canberra.

Pavlis, E. C. (2007), ILRS contributions to near-realtime EOP series, Journées 2007 "Systèmes de référence spatio-temporels", Paris Observatory, Meudon, France, 17-19 September.

Pavlis, E. C. (2007), Towards an improved ILRS TRF contribution, BIPM - Pavillon de Breteuil, Sèvres, France, 20-21 September.

Pavlis, E. C. (2007), Center of mass offset for SLR s/c - Some practical aspects, ILRS Technical Workshop, Grasse, France, 25-28 September.

Pavlis, E. C. (2007), Some ideas about the extension of the ILRS products in the near future, ILRS Technical Workshop, Grasse, France, 25-28 September.

Pavlis, E. C. (2007), The Origin and Scale of the Terrestrial Reference Frame From Laser Ranging, *Eos Trans. AGU, 88*(52), Fall Meet. Suppl., Abstract G41A-05, San Francisco, CA, 10-14 December (INVITED).

Pavlis, E. C. (2008), Weekly SLR series of ‘TRF origin’-geocenter variations, EGU2008-A-05380, EGU 2008, Vienna, Austria, 13 – 18 April.

Pavlis, E. C. (2008), SLR and Global Reference Frames over the Next Decade NAS NRC Panel on National Requirements for Precision Geodetic Infrastructure, University of Colorado at Boulder, Boulder, Colorado, 11-13 June (INVITED).

Pavlis, E. C (2008), Designing the Next Generation Global Geodetic Networks for GGOS IAG International Symposium Gravity, Geoid and Earth Observation 2008, Chania, Crete, Greece, 23-27 June. (SOLICITED)

Pavlis, E. C., I. Ciufolini, and R. König (2007), Recent Results from SLR Experiments in Fundamental Physics, *Proceedings of 15th Int. Laser Workshop*, John Luck (ed.), Geosciences Australia, Canberra.

Pavlis, E. C., and V. Luceri (2007), Reanalysis and extension of the ILRS weekly solutions: Towards an ILRS-TRF, IUGG XXIV General Assembly, Perugia, Italy, 2–11 July.

Pavlis, E. C., and S. P. Mertikas (2007), JASON-1 absolute calibration results from the eastern Mediterranean GAVDOS project, IUGG XXIV General Assembly, Perugia, Italy, 2–11 July.

Pavlis, E. C., J. C. Ries, D. S. MacMillan, M. Kuzmicz-Cieslak, C. Ma, and D. D. Rowlands (2007), Design of next generation global geodetic networks to support GGOS, IUGG XXIV General Assembly, Perugia, Italy, 2 – 11 July.

Pavlis, E. C., and M. Kuzmicz-Cieslak (2007), First experience with the new CRD ILRS NP data format, ILRS Technical Workshop, Grasse, France, 25-28 September.

Pavlis, E. C., and M. Kuzmicz-Cieslak (2007), Quality control of ILRS data and products, ILRS Technical Workshop, Grasse, France, 25-28 September.

Pavlis, E. C., V. Mendes, and G. Hulley, (2008), Tropospheric Model: Optical Techniques, in *IERS Conventions 2003*, G. Petit and B. Luzum eds., *IERS Technical 32*, online version: http://tai.bipm.org/iers/convupdt/convupdt.html, Paris, France, 2008.

Pavlis, E. C., J. C. Ries, D. S. MacMillan, M. Kuzmicz-Cieslak, C. Ma, and D. D. Rowlands (2007), Design a global geodetic network to support GGOS, ILRS Technical Workshop, Grasse, France, 25-28 September.

Pavlis, E. C., J. C. Ries, D. S. MacMillan, M. Kuzmicz-Cieslak, C. Ma, and D. D. Rowlands (2007), Design a global geodetic network to support GGOS, ESA 2007 International Geohazards Week, ESRIN, Frascati, Italy, 5-9 November.

Pavlis, E. C., J. C. Ries, D. S. MacMillan, M. Kuzmicz-Cieslak, C. Ma, and D. D. Rowlands (2007), Design a global geodetic network to support GGOS, *Eos Trans. AGU, 88*(52), Fall Meet. Suppl., Abstract G32A-07, San Francisco, CA, 10-14 December.

Pavlis, E. C., and S. P. Mertikas (2008), Absolute calibration of the JASON-1 altimeter from the GAVDOS project, EGU2008-A-05391, EGU 2008, Vienna, Austria, 13 – 18 April.

Pavlis, E. C., and S. P. Mertikas (2008), GAVDOS Project contributions to the Mediterranean Tsunami Warning System, EGU2008-A-05397, EGU 2008, Vienna, Austria, 13 – 18 April.

Pavlis, E. C., and S. P. Mertikas (2008), Absolute altimeter calibration, sea-level monitoring and tectonics from project GAVDOS, IAG International Symposium Gravity, Geoid and Earth Observation 2008, Chania, Crete, Greece, 23-27 June.

Prados, A. I., G. Leptoukh, E. J. Alston, and I. N. Sokolik (2007), Assessing U.S Air Quality Using CALIPSO and MODIS Data via Giovanni, American Geophysical Union 2007 Fall Meeting, San Francisco, 10-14 December.

Prados, A. I., G. Leptoukh, A. Savtchenko, A. Gopalan, J. Johnson, and S. Ahmad (2008), Assessment of U.S Particulate Air Quality using remote sensing and EPA surface aerosol data via Giovanni, EPA 2008 National Air Quality Conference, Portland Oregon, 7-9 April.

Prados, A., G. Leptoukh, G. Labow, S. Lloyd, A. SavtchenKo, A. Gopalan, J. Johnson (2008), Assessing U.S. particulate air quality using MODIS, OMI, Calipso and Surface $PM_{2.5}$ measurements via Giovanni, Proc. Joint Assembly American Geophysical Union, Fort Lauderdale, Florida, 27-30 May.

Prados, A. I., G. Leptoukh, and A. Chen (2008), Using Giovanni for 3D-Visualization of Air Quality Data, Workshop on 3-Dimensional Scientific Visualization of Air Quality, Univ. of Maryland Baltimore County, 2-3 June.

Salemi, A., et al. (2007), A-Train Tropospheric Chemistry Observations on 30 August 2006 over the 2006 TexAQS/GoMACCS Study Area, American Geophysical Union, Fall Meeting, San Francisco, CA, 10-14 December.

Salemi, A., et al. (2007), A-Train Tropospheric Chemistry Observations on 30 August 2006 over the 2006 TexAQS/GoMACCS Study Area, *Eos Trans. AGU, 88*(52), Fall Meet. Suppl., Abstract A53H-06.

Schoeberl, M., et al. (2007), Session 5 General Middle Atmosphere, QBO and Annual Cycle Variations in Tropical Lower Stratosphere Trace Gases from HALOE and Aura MLS Observations, 14th Conference on Middle Atmosphere, Portland, Oregon, 20-24 August.

Stohl, A., et al. (2007), Long-range transport of air pollution into the Arctic, *Eos. Trans. AGU*, Fall Meet. Suppl., Abstract A44C-01.

Strow, L., and S. Hannon (2007), A Four-Year Global Climatology of Mid-Tropospheric Carbon Dioxide from AIRS, AGU Fall Meeting Abstracts, pp. F6.

Swanson, G., and G. Serafino (2007), Use of Volcanic Sulfur Dioxide Satellite Observations for Operational Monitoring of Volcanic Activity, Workshop on Global Support to Aviation Control, Toulouse, France, 26-27 November.

Tangborn, A., I. Stajner, S. Pawson, M. Buchwitz, I. Khlystova, J. Burrows, and R. Hudman (2007), Assessing model errors through the assimilation of SCIAMACHY total column observations, AGU fall meeting, San Francisco, CA, 10-14 December.

Tangborn, A. I. Stajner, S. Pawson, M. Buchwitz, I. Khlystova, and J. Burrows (2008), Assimilation of SCIAMACHY total Column observations, AMS annual meeting, New Orleans, LA, 20-24 January.

Tangborn, A. (2008), Assimilation of VORCORE polar balloons, BIRS workshop on mathematical advancement in data assimilation, Banff, Canada, 3-8 February.

Tangborn, A., and W. Kuang (2008), Estimating error statistics in geomagnetic data assimilation, EGU joint assembly, Vienna, Austria, 19-24 April.

Tangborn, A., and W. Kuang (2008), Ensemble forecasting of geomagnetic fields, SEDI symposium, Kunming, China, 26-30 July.

Ungar, S., P. Campbell, M. Rast, and C. Cao (2007), Data quality guidelines for GEOSS consideration – The CEOS Working Group on Calibration and Validation, IGARSS'07.

Várnai, T., and R. F. Cahalan (2007), Potential for offbeam lidar measurements of snow and sea ice thickness, XXIV General Assembly of the International Union of Geodesy and Geophysics (IUGG), Perugia, Italy, 11 July.

Várnai, T., A. Marshak, and R. F. Cahalan (2007), Phase 3 of the Intercomparison of 3D radiative codes (I3RC) project, XXIV General Assembly of the International Union of Geodesy and Geophysics (IUGG), Perugia, Italy, 11 July.

Várnai, T., A. Marshak, and P. Chambon (2007), Climatology of 3D radiative effects in Collection 5 MODIS data, XXIV General Assembly of the International Union of Geodesy and Geophysics (IUGG), Perugia, Italy, 11 July.

Vicente, G. (2007), The NOAA Near Real-time OMI-SO2 Cloud Visualization and Product Distribution System, AGU Fall Meeting, San Francisco, CA, 10-14 December.

Waliser, D. E., X. Jiang, J.-L. Li, B. Tian, W. S. Olson, M. Grecu, W.-K. Tao, S. E. Lang, A. M. Tompkins, and T. S. L'Ecuyer (2008), Characterizing the Vertical Latent Heating Structure of the MJO using TRMM, American Meteorological Society 20th Conference on Climate Variability and Change, New Orleans, LA, 20-24 January.

Wall, K., T. Salemi, W. W. McMillan, K. Evans, M. Fromm, and R. Hoff (2007), A-Train Observations of Pyrocumulonimbus Events, American Geophysical Union, Fall Meeting, San Francisco, CA, 10-14 December.

Wall, K., W. W. McMillan, K. Evans, M. Fromm, R. Hoff, and O. Torres (2007), A-Train Observations of Pyrocumulonimbus Events, *Eos. Trans. AGU*, Fall Meet. Suppl., Abstract A33A-0836.

Warner, J., et al. (2007), Update of TES Validation using AIRS, TES science team meeting, Boston, MA, 8-11 September.

Warner, J., Z. Sun, C. Barnet, A. Tangborn, M. Luo, and G. Sachse (2007), Combining AIRS and TES CO Measurements, AIRS science team fall meeting, Greenbelt, MD, September.

Warner, J., C. Barnet, A. Tangborn, Z. Sun, M. Luo, and G. Sachse (2007), Combining AIRS and TES CO Measurements for Air Quality Studies, AURA science team meeting, Pasadena, CA, October.

Warner, J., Z. Sun, Z. Wei, C. Barnet, A. Tangborn, M. Luo, and G. Sachse (2007), Combining AIRS and TES CO Measurements, AGU 2007 Fall meeting, San Francisco, CA, 10-15 December.

Weldegaber, M. H., B. B. Demoz, L. Sparling, R. M. Hoff, and S. Chiao (2007), Investigation of Convective Initiation Along a Dryline Using Observations and Numerical Weather Prediction Model, American Geophysical Union, Fall Meeting, San Francisco, CA, 10-14 December.

Whiteman, D. N., et al. (2008), The Water Vapor Variability - Satellite/Sondes (WAVES) Field Campaigns, 24th International Laser Radar Conference, Boulder, Colorado, 23-27 June.

Wicks, D. E., W. W. McMillan, G. Osterman, N. Livesey, E. Browell, and F. W. Irion (2007), A-Train Observations of Stratosphere-Troposphere Exchange During 2006, *Eos. Trans. AGU*, Fall Meet. Suppl., Abstract A21E-0774.

Willis, P., J.C. Ries, L. Soudarin, N. Zelensky, F.G. Lemoine, E.C. Pavlis, and H. Fagard (2008), DPOD2005: Realization of a DORIS terrestrial reference frame for precise orbit determination, 37th COSPAR Scientific Assembly Montreal, Canada.

Wilson, R. C., L. Yurganov, W. W. McMillan, P. Novelli, M. Fischer, and S. Biraud (2007), Ground-based Remote Sensing of Carbon Trace Gases: Validation of AERI CO Retrievals and Validation of Satellite CO Observations, *Eos. Trans. AGU*, Fall Meet. Suppl., Abstract B43D-1602.

Yang, Y., A. Marshak, J. C. Chiu, W. Wiscombe, and A. B. Davis (2007), A method of studying thick clouds with space-borne lidars, with applications to GLAS, presented at The Gordon Research Conference, New London, New Hampshire, 30 July.

Yang, Y., A. Marshak, T. Várnai, J. Spinhirne, S. Palm, C. Chiu, W. Wiscombe, A. Davis, and W. Hart (2008), Impact of atmospheric multiple scattering on laser altimetry: A Revisit, GLAS Science Team Meeting, Boulder, CO, 26 March.

Yang, K., N. A. Krotkov, A. J. Krueger, and S. A. Carn (2008), Iterative Retrieval of Sulfur Dioxide from Large Volcanic Eruptions, OMI Science Team Meeting, Helsinki, Finland, 24-27 June.

Yang, K., N. A. Krotkov, J. Joiner, P. K. Bhartia, R. McPeters, A. Vasilkov, D. Haffner, S. Taylor, A. J. Krueger, and E. Chiou (2008), Satellite Ozone Retrieval with Improved Radiative Cloud Pressure, Quadrennial Ozone Symposium, Tromso, Norway, 29 June – 5 July.

Yurganov, L., and W. W. McMillan (2007), Comparison of MOPITT (Terra), AIRS (Aqua), and TES (Aura) CO total column products and impact of wild fires, NASA Aura Science Team Meeting, Pasadena, CA, 2-5 October.

Yurganov, L., W. McMillan, A. Dzhola, E. Grechko, N. Jones, G. van der Werf, P. Wennberg, and K. Evans (2007), Interannual variations of carbon monoxide global burden measured by MOPITT and AIRS; assessments of total carbon emitted by wild fires, *Eos. Trans. AGU*, *88*(52), Fall Meet. Suppl., Abstract A13D-1513.

Yurganov, L., W. McMillan, A. Dzhola, and E. Grechko (2008), Tropospheric CO interannual variations as a proxy for emissions from boreal forest fires, United States North American Carbon Program (NACP) Investigators Meeting, Colorado Springs, CO, 22-24 January.

Yurganov, L., and W. McMillan (2008), Ground- and space-based spectrometers for monitoring biomass burning emissions, Joint Canada-Mexico-USA Carbon Program Planning Meeting, Colorado Springs, CO, 25-26 January.

Zhang, H., R. M. Hoff, S. Kondragunta, I. Laszlo, and A. Wimmers (2008), An enhanced IDEA product with GOES AOD, Paper P1.80, 5th GOES Users' Conference, American Meteorological Society Annual Meeting, New Orleans, LA, 21-24 January.

Zhang, H., R. M. Hoff, and S. Kondragunta (2008), Application of satellite aerosol measurements to air quality monitoring and forecasting, GOES-R User Meeting, Madison, Wisconsin, 23-26 June.

Zhang, H., R. Hoff, K. McCann, P. Ciren, S. Kondragunta, and A. Prados (2008), Influence of the ozone and water vapor on the GOES Aerosol and Smoke Product (GASP) retrieval, *NOAA Technical Report NESDIS 128*.

Zhang, L., D. J. Jacob, K. W. Bowman, D. A. Jaffe, F. Boersma, and W. W. McMillan (2007), Recent increases in Asian emissions and consequences for transpacific ozone pollution in the United States: INTEX-B and Aura observations, *Eos. Trans. AGU*, Fall Meet. Suppl., Abstract A53H-04.

Zhou, D. K., X. Liu, A. M. Larar, W. L. Smith, P. Schlüssel, P. Yang, and L. Strow (2007), Atmospheric and surface/cloud parameters retrieved from satellite hyperspectral infrared sounder measurements, AGU Fall Meeting Abstracts, pp. B425+.

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III.5 Courses Taught

GES 110: *Physical Geography* — An introduction to Earth systems science, examining the major systems on the planet including atmosphere, cryosphere, hydrosphere and geosphere. The course also provides an introduction to the remote sensing of Earth using satellite technology. (Taught by Jeff Halverson, Fall 2007)

GES 311: *Weather and Climate* — This class covers fundamentals of meteorology including atmospheric radiation, cloud microphysics, weather analysis and severe weather, global circulation and global climate. The daily weather briefing was 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 Ali Tokay, Fall 2007)

GES 400A: *Severe Storms And Their Socioeconomic Impact* — This course examines large, high impact cyclonic storms (Nor'easters and hurricanes) that impact the Mid Atlantic Region. The course describes the physics behind the storms, discusses storms of historical significance, and examines the impact in terms of human vulnerability, risk and hazard mitigation (Taught by Jeff Halverson, Spring 2008)

GES 481/681: *Remote Sensing of Environment* — An introduction to image analysis and interpretation for mapping/monitoring the earth’s surficial environments from multispectral satellite images. Lectures will cover theories and principles of remote sensing. Laboratory exercises will provide hands-on experience in the use of computers and software for image analysis, interpretation, and classification applied to multispectral satellite image data. Environmental applications include wetland delineation, forest mapping, and land use land cover, and urban sprawl analysis. (Taught by Petya Campbell, Fall 2007)

PHYS 220: *Introduction to Computational Physics* — This course provides an introduction to the basic methods of computational physics, as well as an overview of recent progress in several areas of scientific computing. Deals with basic computational tools and routines, covering differential equations, spectral analysis and matrix operations. Advanced topics covered include Monte Carlo simulations, lattice gas methods, molecular dynamics and symbolic computing. (Taught by Kevin McCann, Spring 2008)

PHYS 340L: *Electronics for Scientists* — This is a basic lecture and laboratory course in electronics. Properties of semiconductor devices and their combinations in amplifiers, oscillators, timers, switching circuits, digital circuits, and electronic instruments in common use in the scientific laboratory. (Taught by Wallace McMillan, Spring 2008)

PHYS 440/640: *Computational Physics* — An introduction to computational methods used in physics. It introduces the use of computers for data analysis, problem solving, modeling and visualization. The topics covered include; linear equations; interpolation; zeros and roots;

least squares; quadrature; ordinary differential equations; Fourier analysis; random numbers; eigenvalues and singular values; and partial differential equations. (Taught by David Lary, Fall 2007)

PHYS 440/640: *Computational Physics* — The following topics were covered: the application of computers and numerical methods to physics models. Boundary value problems, Monte Carlo techniques and modeling (Taught by Kevin McCann, Spring 2008)

PHYS 622: *Atmospheric Physics II* — This course on physical meteorology covers the basics of atmospheric aerosols and clouds, and an introduction to atmospheric radiative transfer. The course discusses the typical properties of aerosols and clouds, as well as some of the most important physical processes associated with them, for example precipitation formation. The lectures also cover the impact of aerosols, clouds, and radiation on climate and weather. (Co-taught by Tamás Varnai and Wallace McMillan, Spring 2008; Ali Tokay, Guest Lecturer, Spring 2008)

PHYS 707: *Advanced Electromagnetic Theory* — This course covers boundary-value problems, derivation of macroscopic properties, plasma physics, radiation from moving charges, advance topics in radiation, wave guides and cavities. (Taught by Kevin McCann, Fall 2007)

PHYS 722: *Atmospheric Remote Sensing* — This graduate course focuses on techniques for the passive and active remote sensing of the state and composition of the Earth's atmosphere. Contents of ths course include: introduction to the measurement of radiation and the design of passive and active instruments; theoretical background and algorithmic considerations for the remote sensing of aerosol and cloud properties, atmospheric profiles of temperature, humidity and trace gas concentration and the state and composition of the surface. (Co-taught by J.-C. Chiu and Ray Hoff, Spring 2008)

III.6 Colloquia and Seminars

Chiu, J. C. (2007), Remote sensing of cloud properties using ground-based zenith radiance measurements, seminar given at the Electrical Engineering Department, University of Maryland, Baltimore County, Baltimore, MD, 28 September.

Johnson, B. T., G. Skofronick-Jackson, and G. W. Petty (2007), Passive microwave and dual-frequency radar remote sensing of frozen precipitation, University of Maryland Baltimore County, Joint Center for Earth Systems Technology (UMBC/JCET), 11 July.

Johnson, B. T., G. Skofronick-Jackson, and G.W. Petty (2007), Multi-frequency passive microwave and dual-frequency radar remote sensing of snowfall, University of Wisconsin, Madison, WI, 10 December.

McMillan, W. W. (2007), A-Train Tropospheric Chemistry Observations on 30 August 2006 over the 2006 TexAQS/GoMACCS Study Area, contributed talk at the NASA Aura Science Team Meeting, Pasadena, CA, 2-5 October.

McMillan, W. W., and D. E. Wicks (2007), Observations of Stratosphere-Troposphere Exchange from the A-Train Suite in 2006 During INTEX-B, contributed poster by D. E. Wicks and presented by W. McMillan at the NASA Aura Science Team Meeting, Pasadena, CA, 2-5 October.

McMillan, W. W., and L. Yurganov (2007), Comparison of MOPITT (Terra), AIRS (Aqua), and TES (Aura) CO total column products and impact of wild fires, contributed poster by L. Yurganov and presented by W. McMillan at the NASA Aura Science Team Meeting, Pasadena, CA, 2-5 October.

McMillan, W. W. (2007), A-Train Tropospheric Chemistry Observations on 30 August 2006 over the 2006 TexAQS/GoMACCS Study Area, invited talk at the NASA AIRS Science Team Meeting, Greenbelt, MD, 10 October.

McMillan, W.W. (2008), v5.0.14.0 CO Validation Update, invited talk at the NASA AIRS Science Team Meeting, Pasadena, CA, 16 April.

Oreopoulos, L. (2008), How MODIS observations can be used to quantify cloud heterogeneity and susceptibility, invited talk at National Observatory of Athens, 8 November.

Oreopoulos, L. (2008), Characterizing cloud inhomogeneity and susceptibility from MODIS measurements, invited talk at University of Athens, 14 November.

Tangborn, A. (2008), Assessing model errors through the assimilation of SCIAMACHY total column CO, Dept. of Atmospheric and Ocean Sciences, University of Maryland – College Park, 22 February.

Tangborn, A. (2008), Wavelets in timeseries analysis, Lectures in METEO 630 class, Department of Meteorology, University of Maryland, College Park, 7 May.

Warner, J. (2008), Affiliation seminar at GEST/UMBC: Title: Global Measurements of Atmospheric Trace Gases for Climate and Air Quality Studies, April.

Warner, J. (2008), 20-25 daily presentations at ARCTAS field planning meeting: Title: AIRS Update and Analyses for ARCTAS, March – April and June – July

III.7 Patents and Invention Disclosures

Bulmer, M. (2008), Method for Defining the Optimal Layout of a Wireless Radio-ranging Network for Slope Motion Detection. Farquhar and Bulmer. UMBC 2550TF. Received Mar 12 2008.

Bulmer, M. (2008), Method for Learning the Physical Geography of Bodies in the Solar System Through the use of Map Puzzles and Cards Created From Real Spacecraft Data. Bulmer and Bussey. Received Jun 9 2008.

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III.8 Proposals Submitted by JCET Members

Proposal Title	Funding Agency	PI	CO-I(s)	Status
Aerosol processing by deep convection and the radiative effect of its anvil cirrus and outflow	DOE	X. Li (GEST)	Koren, Várnai	Pending
Improving assessments of cloud radiative forcing via model intercomparison and a novel subgrid cloud parameterization scheme optimized with ARM data	DOE	Oreopoulos		Pending
Parameterization and analysis of 3-D solar radiative transfer in clouds	DOE	Várnai		Funded
Photosynthetic light use efficiency: Quantifying diurnal and seasonal carbon dynamics in cornfields	DOE	Middleton (GSFC)	Campbell	Awarded
Optimization, Validation, and Integrated EOS Analysis of AIRS Trace Gas Products	JPL	McMillan		Awarded
A global model study of emissions and long-range transport of aerosols and trace gases using Terra and Aqua satellite data	NASA	Chin (GSFC)	McMillan	Awarded
A Long-Term Precipitation Dataset with Uncertainty Information	NASA	Kummerow (Colorado St. Univ.)	Olson, Grecu	Awarded
Assimilation of A-Train satellite data for constraining a new PDF-based cloud parameterization in GEOS-5	NASA	da Silva (GSFC)	Oreopoulos	Pending
Cloud susceptibility derived from MODIS observations as a tool for assessing the indirect aerosol effect on global and regional scales	NASA	Oreopoulos	Platnick	Not Awarded

Proposal Title	Funding Agency	PI	CO-I(s)	Status
Combining field observations, satellite data, and model predictions to predict distributions of keystone species and related organisms from local to continental scales	NASA	L. Vierling (Univ. of Idaho)	Huemmrich	Pending
Continuation of I3RC with applications to THOR cloud data analysis	NASA	Cahalan (GSFC)	Marshak, Várnai	Funded
Integration of Geomagnetic Observations to Numerical Geodynamo Model and Applications to surface Geodynamic Observables	NASA	Kuang (GSFC)	Tangborn	Pending
Investigation of global biomass burning emissions using CO as a proxy; validation and reconciliation of MOPITT AIRS, TES, and IASI CO data using remote sensing spectrometers	NASA	Yurganov	McMillan	Pending
Mapping ecosystem light-use efficiency using satellite data	NASA	Huemmrich		Not Awarded
Microphysical and Radiative Parameterizations of Aerosol-Cloud Interactions for Assessing Aerosol-Climate Connections with NASA GEOS-5 GCM Simulations	NASA	Y. Sud (GSFC)	Oreopoulos, Bacmeister (GEST)	Pending
North American high latitude land cover and carbon exchange	NASA	Huemmrich		Not Awarded
The role of canopy structure and incoming par regimes in regulating carbon uptake dynamics in forests	NASA	E. Middleton (GSFC)	Huemmrich	Not Awarded
Can Tropical Cyclones Influence Warm Season Precipitation over the US by Altering Water Budget over the Gulf of Mexico and Caribbean Sea Basins?	NASA	Mehta		Pending

Proposal Title	Funding Agency	PI	CO-I(s)	Status
Historical Rendition of Mediterranean Water Cycle based on Earth Satellite Measurements	NASA	E. Smith (GSFC)	Mehta	Awarded
A common Framework for Studying tropical cyclones and their Environment	NASA	Leptoukh (GSFC)	Mehta	Not Awarded
Investigating Relationships Between Eyewall Replacement, Intensification, and Precipitation Production in Atlantic Hurricanes Using Satellite/Aircraft Observations and GFS Model Analyses	NASA	E. Smith (GSFC)	Mehta	Awarded
Multiscale Analysis of Tropical Storm Hot Tower and Warm Core Interactions Using Field Campaign Observations	NASA	Heymsfield (GSFC)	Halverson, Tian	Pending
The Study of the Spatial and Temporal Variability of Stratosphere-Troposphere Exchange with Global Integrated A-Train Observations	NASA-NESSF08	McMillan		Not Awarded
Explaining Role of Tropical Storms & Hurricanes on Water Balance within Gulf of Mexico-Caribbean Sea Basin as Determined by Unified Water Budget Satellite Retrieval System	NASA	Mehta		Awarded
Investigations of Ice Particles in Hurricane Hot Towers	NASA	Skofronick-Jackson (GSFC)	Johnson	Pending
Retrieval Algorithm Development for Precipitating Snow Detection and Estimation using High Frequency Observations	NASA	Skofronick-Jackson (GSFC)	Johnson, Olson, Grecu	Awarded

Proposal Title	Funding Agency	PI	CO-I(s)	Status
Retrievals of Precipitating Snow and Light Rain Using Synergistic Multi-Sensor Active and Passive Observations 05-CldSat-CAL-0040 NNH05ZDA001N-CCST	NASA	Skofronick-Jackson (GSFC)	Johnson, Olson	Awarded
Optimization of NASA's Next Generation Global Geodetic Networks (71000 CPU hours)	NASA	Pavlis		Awarded
NASA Giovanni support for HTAP	NASA	Leptoukh (GSFC)	Prados	Awarded
Design and Optimization of NASA's Future Space Geodetic Networks in Support of GGOS	NASA	Pavlis		Awarded
Atmospheric Carbon Mapper (ACM)	NASA	T. Kampe (Ball Aerospace & Tech)	Warner	Not Awarded
Constraining Long Range Transport of CO by Assimilating AIRS and IASI CO Observations	NASA	Tangborn	McMillan, Jacob	Pending
Optimally Combined Tropospheric CO from the A-Train Satellites for Model Validations and Transport Studies	NASA	Warner		Pending
Topography data on Mars: Optimizing its collection and application using laser scanning	NASA	Bulmer		Awarded
A-Train and IASI CO and O_3 Observations and Near-Real-Time Assimilation Tests for ARCTAS Flight Planning and Post-Mission Analysis	NASA	McMillan		Not Awarded
Building an integrated view of Terra, Aqua, and Aura trace gas products: global modeling and detailed case study investigations	NASA	McMillan		Not Awarded

Proposal Title	Funding Agency	PI	CO-I(s)	Status
Constraining long range transport of CO by assimilating AIRS and IASI CO observations	NASA	Tangborn	McMillan	Pending
Geostationary Imaging Fabry-Perot Spectrometer-Infrared (GIFS-IR): Science, Retrievals, and Validation Support for JHU APL GIFS-IR CO Instrument	NASA	McMillan	Yurganov	Not Awarded
Investigating the 3-Dimensional Structure of Stratospheric-Tropospheric Exchange Events Through an Integrated Analysis of MLS, TES, OMI, and AIRS Retrievals	NASA	McMillan		Not Awarded
Investigation of global biomass burning emissions using CO as a proxy; validation and reconciliation of MOPITT AIRS, TES, and IASI CO data using remote sensing spectrometers	NASA	Yurganov	McMillan	Pending
The Baltimore-Washington AERI Experiment (B-WAX): Ground-based measurements of ozone and carbon monoxide tropospheric columns in the Baltimore-Washington corridor for satellite validation and air quality studies	NASA	McMillan	Yurganov	Pending
Validation of satellite based tropospheric T, Q, O_3 and CO measurements using AERI, ozonesonde, airborne measurements and chemical/meteorological analyses	NASA	McMillan	Yurganov	Pending
Airborne Fraunhofer Line Discriminator for Ecosystem Carbon Studies (AFLD-EC)	NASA	Heaps (GSFC)	Campbell	Awarded
Atmospheric Delay Computations for NASA's Next Generation Geodetic Networks - The RADICAL	NASA	Pavlis		Not Awarded

Proposal Title	Funding Agency	PI	CO-I(s)	Status
Service				
Eastern Mediterranean Altimeter Calibration Network -- e-MACnet	NASA	Pavlis		Awarded
Focusing GGOS for Geodynamic, Climate Change, and Sea Level Studies	NASA	Pavlis		Pending
Geodetic Reference Antenna in Space (GRASP)	NASA	Pavlis		Pending
Global Sea Level in a Changing Climate: Reference Frames, Data Analysis, and Interpretation	NASA	Pavlis		Awarded
GRACE Applications for TRF Development and Fundamental Physics tests	NASA	Pavlis		Awarded
Improved ground validation rain estimates at Kwajalein, RMI and Melbourne, Florida for comparison and validation to TRMM and Other Satellite Estimates.	NASA	Tokay		Awarded
Measurements of the hydrometeors size distribution through surface based instruments.	NASA	Tokay		Awarded
Orbital and rotational dynamics of the Moon with sub-centimeter lunar laser ranging	NASA	Pavlis		Not Awarded
Quantitative Error Characterizations of TRMM and GPM Rainfall Products for Climate Studies and Validation	NASA	T. Bell (GSFC)	Kundu	Awarded
The Role of Canopy Structure and Incoming PAR Regimes in Regulating Carbon Uptake Dynamics in Forests	NASA	Middleton (GSFC)	Campbell, Huemmrich, Q. Zhang (GEST)	Awarded

Proposal Title	Funding Agency	PI	CO-I(s)	Status
Impact of Siberian forest fires on USA and Europe: view from satellites and from ground	NATO	Yurganov		Pending
Current and Future Satellite Mission Data Analysis for Global Gravity Field Modeling and Reference Frame Implementation.	NIMA	Pavlis		Awarded
An IDEA product for GOES-R data	NOAA	Zhang		Pending
Dynamics of eastern Mediterranean, Sea Level and altimetry Calibration-validation (DynMSLaC)	NRA	Pavlis		Awarded
Understanding Sea Level Variations: Reference Frame, Data Analysis, and Modeling	NRA	Ray	Pavlis	Awarded
A Hybrid Ensemble Geomagnetic Data Assimilation System	NSF	Tangborn	Kuang	Not awarded
Collaborative Research: Lagrangian assimilation of long lived Antarctic balloons	NSF	Tangborn		Pending
CSEDI Collaborative Research: Variational Approaches to Geomagnetic Data Assimilation	NSF	Tangborn	Kuang	Awarded
Detecting and understanding vegetation change over time in open-canopied Arctic ecosystems	NSF	Gamon (Cal State - L.A.)	Huemmrich	Not Awarded
Investigation of free tropospheric pollutants entering US from Asia using a ground-based spectrometer at the Mt. Bachelor Observatory, satellite data, and model calculations	NSF	Yurganov	McMillan	Pending
Progressive Movement of Natural Versus Engineered Slopes,	NSF	Bulmer		Not Awarded

Proposal Title	Funding Agency	PI	CO-I(s)	Status
Pursuant to the Kashmir Earthquake				
US-Russia Planning Visit: North Asian Sources of Greenhouse Gases: Collaborative Research Using Ground – and Space-Based Instruments	NSF	Yurganov	McMillan	Awarded
Landslide Risk Assessment and Mitigation Study in the Villcanota Valley, Peru	World Bank	Bulmer		Awarded
Vilcanota Valley Slope Monitoring for Flash Flood Prevention	World Bank	Bulmer		Awarded

III.9 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 14 years of experience in earth and planetary research. His research interests are in the area of mass movement dynamics, both on Earth and the terrestrial planets, combining field measurements with remotely sensed data. He has led or participated in over 22 major field tests and campaigns. He is the author of journal articles, technical reports, conference proceedings papers, and educational videos for middle-school students, and has given numerous public presentations of his work. Dr. Bulmer obtained a Bachelor of Science degree in Geography at University of London, King's College in 1990 and a Ph.D. in Astronomy & Physics (Planetary Volcanology) at University College London in 1994. He has conducted research at the NASA Jet Propulsion Laboratory and Goddard Space Flight Center, and the Smithsonian National Air and Space Museum. He serves on the American Geophysical Union Tellers Committee and the Landslide Working Group of the Committee for Earth Observing Satellites. He has received grants from NASA, ESA, CSA, ISA, NSF, National Geographic, Royal Geographical Society, Smithsonian Institution and Radarsat International. He has peer review roles at NASA and NSF and has held memberships in four scientific societies.

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. Campbell joined NASA as 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. She started work in this direction as a post-doctoral research associate of Dr. Middleton at NASA/GSFC, and later continued as a Prime Investigator on a small grant for Exploratory Research (funded by the National Science Foundation). At GSFC she participates in NASA's "Light Use Efficiency and Carbon Science" research led by Dr. Middleton and has participated in the development of the satellite hyperspectral mission's Flora/SpectraSat for vegetation assessment led by Drs. Ungar and Asner. Currently, she is 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. She is also participating 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 within the Department of Geography. As the current Technical Secretariat of the Working Group on Calibration and Validation of the Committee on Earth Observation Satellites (CEOS/WGCV), under the chairmanship of Dr. C. Cao (NOAA), she follows with interest the plans for new satellite capabilities of various agencies and would like to contribute to the efforts on data calibration, product development, validation and inter-comparison.

Dr. Simon A. Carn received a BA in Earth Science from Oxford University, UK, in 1993, and a DEA (the French equivalent of an MS) in Volcanology from Université Blaise Pascal, Clermont-Ferrand, France, in 1994. He received a PhD in Volcanology in 1999 from the Department of Earth Sciences, Cambridge University (UK), for research on volcanism in Indonesia. From 2000-2001 he worked as a volcanologist on the active volcanic island of Montserrat (West Indies). In 2001 he joined JCET at UMBC to work on remote sensing of volcanic sulfur dioxide (SO_2) emissions using UV satellite data from the NASA Total Ozone Mapping Spectrometer (TOMS) missions and since 2004 from the Ozone Monitoring Instrument (OMI) on the EOS/Aura spacecraft. His main research interests are satellite- and ground-based UV/IR data analysis applied to studies of volcanic degassing, eruption monitoring, and air pollution monitoring. Dr. Carn has led or participated in field campaigns at active volcanoes in Indonesia, Guatemala, Democratic Republic of Congo, Chile, Papua New Guinea and Italy. He was an Assistant Research Scientist in JCET, serving as PI for validation of OMI SO_2 data from the Aura satellite.

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 received a B.S. and M.S. in Chemistry from the University of Puerto Rico in 1995 and 2004, respectively. He expects to receive his Ph.D. in 2008, also from the University of Puerto Rico, for his dissertation work entitled "Observations and Modeling of Sporadic Metal Layers over the Arecibo Observatory". Since November 2006, he has been a Research Associate at JCET. 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 four 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. in Math/Physics 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 CO_2 P/R linemixing and water continuum corrections. His current research work is on retrievals of dust heights and optical depths, and trace gas retrievals.

Dr. Forrest Hall has been active in the field of remote sensing since 1972 and has been at NASA's GSFC since 1985. He is Senior Research Scientist at JCET UMBC. Dr. Hall has an undergraduate degree in Mechanical Engineering from the University of Texas, and M.S. and Ph.D. degrees 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.

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).

Mr. Ernest Hilsenrath received his BS in Physics at the George Washington University in 1961 and did graduate work at the American University until 1963. He began his career at the National Bureau of Standards (now the National Institutes of Standards and Technology) in 1958 and joined NASA in 1962 at the Goddard Space Flight Center. After retiring from NASA in August 2005, he was appointed to UMBC JCET (also in August 2005). During his career at NASA, he developed and conducted several instruments to measure ozone on aircraft, balloons and sounding rockets. He developed and managed a calibration facility at GSFC which was used as a reference standard for calibrating US and international BUV type instruments, including TOMS, SBUV/2, SCIAMACHY, OMI, and GOME-2. He was the Principal Investigator for the Shuttle-borne SBUV (SSBUV), which flew eight times to provide in-orbit calibration for the NOAA SBUV/2 instruments, and he was Principal Investigator for several analysis tasks for validation ozone data from TOMS, POESS and Envisat. He was also the Co-Principal Investigator for the first instrument to measure stratospheric limb scattering from the Shuttle using a CCD detector, which imaged the Earth's limb on the detector. This technique was selected for the NPOESS ozone profile monitoring instrument. He has published over 50 papers in refereed literature dealing with instrument calibration and performance and ozone climatology. He has chaired and served on several US and international panels for establishing ozone monitoring requirements and establishing CAL/VAL requirements for future stratospheric monitoring instruments. NASA has awarded Mr. Hilsenrath six Group Achievement Awards and seven individual awards, including the NASA Exceptional Medal.

Dr. R. M. Hoff is a Professor of Physics at the University of Maryland, Baltimore County. He is also Director of the Joint Center for Earth Systems Technology. Dr. Hoff has 33 years of experience in atmospheric research. His research interests are in the optical properties of aerosols and gases in the atmosphere. Dr. Hoff has been central in formulating major research programs on Differential Absorption, airborne and spaceborne lidar, volcanic emissions, atmospheric transport of toxic chemicals to the Great Lakes, atmospheric visibility, Arctic Haze, and dispersion of pollutants. He has led or participated in over 20 major field experiments. He is the author of 83 journal articles and book chapters, 94 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 was a member of a proponent team for a spaceborne Differential Absorption Lidar (DIAL) involving NASA, the Canadian Space Agency and the Meteorological Service of Canada. 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, and he is Chair of the NASA Applied Sciences Advisory Panel. He has had committee and peer review roles at NASA, EPA, Environment Canada, and the European Economic Community. He has held memberships in six scientific societies and served as Chairman of committees for those societies.

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, and 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 received his B.Sc. degree in 1997 from the Universidade Federal do Par´a (UFPA) -Bel´em, Brazil. In 1999, he received his M.Sc. degree in Theoretical Physics from the Instituto de Fisica Te´orica (IFT) -S˜ao Paulo, Brazil. In 2007, he received his Ph.D. in Physics from the University of Maryland at College Park (UMCP). His research was on numerical simulation of binary black hole collision and gravitational wave extraction. Since Fall 2006, he has been a Research Associate at the Joint Center for Earth Systems Technology (JCET) at the University of Maryland Baltimore County (UMBC), in Baltimore, MD. His research interests are on remote sensing studies of atmospheric trace gases retrieval, trace gases climate record, climate change and numerical modeling.

Dr. Weiyuan Jiang received a B.S. degree in Applied Mechanics and a M.S. degree in Fluid Mechanics from Fudan University, Shanghai in 1993 and 1996, respectively. He worked at the Shanghai Institute of Applied Mathematics and Mechanics, Shanghai University for two years. He received his Ph.D in 2004 from Clarkson University, where he worked on the instability of multi-layer fluid motion at the Department of Mechanical and Aeronautical Engineering. He subsequently joined JCET at UMBC as a Research Associate. His research interests range from instabilities of fluid motion, film coating, computational fluid dynamics, parallel computation and geodynamo. His research is currently focused on the time-variable gravity caused by large-scale mass redistribution of the mantle and the parallel computation on the MoSST (Modular, Scalable, Self-consistent, Three-dimensional) core dynamics model and the Martian historical dynamo. He is currently a Research Assistant Professor affiliated with UMBC's Department of Mechanical Engineering.

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 Mission (GPM) science objectives. He is also a member of the GPM combined radar/radiometer algorithm development team, and is actively involved in developing improved retrieval algorithms for snowfall using passive microwave and radar remote sensing methods.

Dr. Arlin J. Krueger received his undergraduate degree in Physics from the University of Minnesota in 1955 and his Ph.D. degree in Atmospheric Sciences from Colorado State University in 1984. He began his career in 1959 at the Naval Weapons Center, China Lake, California, where he developed balloon and rocket instruments and techniques for ozone measurements. He joined GSFC in 1969, initially serving as technical officer on the Nimbus-4 backscatter UV experiment, where a new method for remote sensing of total ozone from satellites was tested. Based on this experience he proposed an instrument for mapping of total ozone, the Total Ozone

Mapping Spectrometer (TOMS) instrument, for flight on the Nimbus-7 satellite. Following its launch in 1978, he investigated many applications of the TOMS total ozone data and developed a new technique for mapping volcanic sulfur dioxide clouds. He was awarded the NASA Exceptional Scientific Achievement Medal in 1991, the University of Maryland Elkins Professorship of Physics in 2000, and the NASA Exceptional Service Medal in 2001. Dr Krueger served as sensor scientist for the Nimbus-7 TOMS, instrument scientist on the Meteor 3/TOMS (launched on August 15, 1991), and the Earth Probe TOMS (launched in July 1996), and as principal investigator on the ADEOS/TOMS (launched in August 1996). He was the principal investigator of the VOLCAM Mission, which was selected as an Alternate ESSP mission. Dr Krueger is a member of the William T. Pecora Award-winning NASA TOMS science team and the EOS Aura OMI science team.

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; during 1982-85 he was an instructor at the University of Utah, Salt Lake City. In

1985 he joined the Department of Physics and Astronomy at Ohio University, Athens as an 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 problems. 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. David J. Lary received a First Class Double Honors B.Sc. in Physics and Chemistry from King's College London (1987) with the Sambrooke Exhibition Prize in Natural Science, and a Ph.D. in Atmospheric Chemistry from the University of Cambridge, Churchill College (1991). His thesis described the first chemical scheme for the ECMWF numerical weather prediction model. He was awarded a Royal Society University Research Fellowship in 1996 at Cambridge University. From 1998 to 2000 Dr. Lary held a joint position at Cambridge and the University of Tel-Aviv as a senior lecturer and Alon fellow. In 2000 the chief scientific adviser to the British Prime Minister and Head of the British Office of Science and Technology, Professor Sir David King, recommended Dr. Lary to be appointed as a Cambridge University lecturer in Chemical Informatics. In 2001, he joined UMBC/GEST as the first distinguished Goddard fellow in earth science at the invitation of Richard Rood. Dr. Lary's automatic code generation software, AutoChem, has received five NASA awards. He is currently involved with NASA Aura validation using probability distribution functions and chemical data assimilation, neural networks for accelerating atmospheric models, the use of Earth Observing data for health and policy applications, and the optimal design of Earth Observing Systems. The thread running through all the research is atmospheric chemistry, and the use of observation and automation to facilitate scientific discovery.

Dr. J. Vanderlei Martins has received a Bachelor's degree in Physics in 1991, a Master's degree in Physics/Nuclear Applied Physics in 1994, and a Ph.D. in Physics/Applied Physics in 1999 from the University of Sao Paulo (USP), Brazil. He joined the Group of Air Pollution Studies at the Institute of Physics (USP) in 1990, and conducted research in environmental and atmospheric applied physics. In particular, he developed analytical nuclear techniques using particle accelerators for material analysis, including aerosols and tree-rings, and participated in several ground-based and aircraft field experiments studying properties of aerosols from biomass burning and biogenic emissions. He was a member of the University of Washington, Department of Atmospheric Sciences' Cloud and Aerosols Research Group, from November 1995 to August 1996, and of the 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 at international conferences, the most recent being on the spectral absorption properties of aerosol particles, and on the measurement of the vertical profile of cloud microphysical and thermodynamic properties. He served as elected member of the International Radiation Commission from 2001-2008. In 2006 he assumed an Associate Professor position in the Department of Physics of the University of Maryland Baltimore County, while keeping his affiliation with the Joint Center for Earth Systems Technology.

Dr. Kevin J. McCann is a Research Associate Professor in JCET and is affiliated with the Physics Department at UMBC. Dr. McCann is engaged in research to use LIDAR to measure atmospheric aerosols to help estimate pollution levels. Dr. McCann has worked for over 20 years in the field of theoretical and experimental underwater acoustics at the Johns Hopkins University Applied Physics Laboratory (JHU/APL). Prior to APL, he had been working on theoretical atomic and molecular collisions and atom/molecule surface interactions at Georgia Tech and the University of Virginia. This work was directed at an understanding of the collision cross sections that are relevant in the interstellar medium and, to some extent, planetary atmospheres. Dr. McCann received all three of his college degrees from Georgia Tech and did his Ph.D. dissertation work (1974) with Dr. Ray Flannery there on atomic collision processes. Dr. McCann has published over 50 refereed journal articles in the areas of atomic and molecular collisions and acoustic propagation.

Dr. W. Wallace McMillan is an Associate Professor of Physics at UMBC, Director of UMBC's Atmospheric Physics Graduate Program, and a JCET Fellow. His research activities focus on tropospheric chemistry and dynamics of carbon monoxide (CO); observations of upper tropospheric water vapor; and the validation of satellite remote sensed atmospheric parameters. Dr. McMillan has developed an extensive familiarity with air- and ground-based FTIR spectra, including the BBAERI and BNAERI instruments in his Atmospheric Remote-sensing Facility (ARF), and has participated in several NASA field experiments. Prior to coming to UMBC, Dr. McMillan spent two years in the Laboratory for Extraterrestrial Physics at NASA Goddard Space Flight Center as a National Research Council Postdoctoral Fellow with the Mars Observer thermal emission spectrometer team. He is an active member of the American Geophysical Union (AGU) and the Optical Society of America (OSA). Dr. McMillan received his Ph.D. in Earth and Planetary Sciences from The Johns Hopkins University in 1992 for studies of the chemistry and dynamics of the stratosphere of Uranus. He earned a Masters degree from JHU in 1990, and graduated cum laude, Phi Beta Kappa with a B.S. in Physics from Rhodes College in 1985.

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 has been working in the 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 interests and expertise are in satellite remote sensing of geophysical parameters and their analysis to understand climate and its variability.

Dr. Howard Motteler received his B.S. degree in Mathematics from the University of Puget Sound, Tacoma, WA in 1980, M.S degree in Computer Science from Purdue University, West Lafayette IN in 1982, and Ph. D. degree in Computer Science from the University of Maryland at College Park in 1987. He was a Research Associate at JCET/UMBC where his research interests were in the areas of scientific computation and applications in atmospheric science, including passive infrared and microwave sounding and radiative transfer calculations.

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 and latent heating distributions into global models. His current work involves the adaptation of cloud microphysics/radiative models for simulating spaceborne passive microwave, radar, and infrared observations in support of TRMM and GPM mission research.

Dr. Lazaros Oreopoulos (a.k.a Lazaros Oraiopoulos) received his B. Sc. in Physics with honors from Aristotle's University of Thessaloniki, Greece in 1989. He received M. Sc. (1992) and Ph. D. (1996) degrees from McGill University, Montreal. After working for a year as a Research Scientist for the Cloud Physics Research Division of the Meteorological Service of Canada, he was offered a postdoctoral fellowship from the National Science and Engineering and Research Council of Canada, but chose instead to join JCET in October 1997. Soon thereafter he established an affiliation with the UMBC Department of Physics, where he regularly teaches a graduate course on atmospheric radiation. Dr. Oreopoulos served as the leader of the JCET Radiation Focus Group for three years. He currently holds the rank of Research Associate Professor and leads research on the modeling and remote sensing of clouds, cloud-aerosol interactions, and three-dimensional radiative transfer. He is a member of the Landsat and ARM Science Teams.

Dr. Erricos C. Pavlis received his Dipl. Ing. from the Nat. Tech. Univ. of Athens, Greece in 1975, and his PhD in Geodetic Science from The Ohio State Univ., Columbus, Ohio. Dr. Pavlis is currently a Research Associate Professor, Physics, at the University of Maryland, Baltimore County, doing research for NASA, EU and the NGA.

He participated in the LAGEOS, LAGEOS 2, the Crustal Dynamics and WEGENER Projects, the TOPEX/POSEIDON and JASON Missions, and the development of EGM96. Currently he is a science team member of GRACE and OST missions, and a co-PI of the LARES mission, vice-chairman of COSPAR's Panel on Satellite Dynamics, member of GGOS Steering Committee, IERS Directing Board, ILRS's Governing Board, Central Bureau and Coordinator for Analysis and Modeling, chairman of the ILRS Refraction Study group, IAG's Subcommission 1.4 Working Group 1.4.4, and Associate Editor of the journal *Celestial Mechanics and Dynamical Astronomy*. He is also co-author of a chapter ("Terrestrial Reference Frames") of the revised *Explanatory Supplement to the Astronomical Almanac*.

Dr. Ana I. Prados received her B.A in Physics and Chemistry from the University of Florida in 1992, and her Ph.D in Chemistry from the University of Maryland, College Park in 2000 where her major research was in-situ measurements and modeling of U.S air pollutants. She joined JCET in October 2005 and her primary research focus is in the area of remote sensing of aerosols and air quality applications. She currently works on the integration of in-situ and remote sensing data for air quality applications at the Goddard Earth Sciences Data and Information Services Center (GES DISC) via the Giovanni online tool for remote sensing data exploration and visualization.

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 his B.S. degree in Physics from the University of Maryland Baltimore County in 1974 and his M.S. and Ph.D. degrees in Physics from the University of Maryland, College Park in 1977 and 1981, respectively. He is currently a Research Professor in the Department of Physics at the University of Maryland Baltimore County. His research interests include molecular spectroscopy, especially spectral line shapes, and radiative transfer, and atmospheric remote sensing. He is a Member of the NASA AIRS and NPP (CrIS Sensor) science teams, and a Co-Investigator on EUMETSAT's IASI sounder on the new METOP platform.

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. These include atmospheric constituent data assimilation for the carbon cycle (SCIAMACHY and MOPITT), assimilation of polar wind observations using data from the VORCORE balloon experiments and solid earth data assimilation in which geomagnetic field observations are assimilated into a geodynamo model. He is currently a Research Associate Professor and is affiliated with the Department of Mathematics at UMBC, where he teaches graduate courses in data assimilation, computational fluid dynamics and wavelet transform methods.

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. Dr. Tokay was a research associate through the National Research Council Fellowship between 1993 and 1995. He then joined Saint Louis University as an assistant professor in 1995 and the University of Maryland Baltimore County (UMBC) as a research assistant scientist in 1997. He later was promoted to research assistant professor and became a research associate professor in 2007. Dr. Tokay was a principal investigator during a series of field campaigns under the NASA Tropical Rainfall Measuring Mission. He has taught a number of undergraduate and graduate courses at both Saint Louis University and UMBC. Dr. Tokay mentored 12 undergraduate and five graduate students, and was an advisor of a M.S. student who graduated in 1998. Dr. Tokay is an Affiliated Associate Professor of the Department of Geography and Environmental Sciences and a Research Assistant Professor of the Joint Center for Earth Systems Technology at UMBC. Dr. Tokay is also a member of NASA's precipitation science team.

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 in 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 estimating the influence of cloud heterogeneities on operational MODIS (Moderate Resolution Imaging Spectroradiometer) cloud property retrievals and develops cloud property retrieval algorithms for the 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 the Atmospheric Chemistry Division until she joined the Joint Center for Earth Systems Technology at the University of Maryland Baltimore County in 2004. Since 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 atmospheric chemistry and remote sensing algorithms and techniques, and has received 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. 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). For many years he has been using grating spectrometers for atmospheric research in Moscow and St. Petersburg (Russia). He studied total column and surface CO abundances in 1995-1996 at the Geophysical Institute, UAF, 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 41 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, where he conducts 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.

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III.10 Table 1: JCET Faculty (as of September 30, 2008)

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	Faculty Research Assistant	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. Arlin Krueger	Research Professor	Physics
Dr. Prasun Kundu	Research Associate Professor	Physics
Dr. Magdalena Kuzmicz-Cieslak	Research Associate	Research Faculty
Dr. David Lary	Research Professor	Physics

NAME	TITLE	AFFILIATION
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. Lazaros Oreopoulos	Research Associate Professor	Physics
Dr. Erricos Pavlis	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 Associate Professor	Physics
Dr. Juying Warner	Research Assistant Professor	Geography and Environmental Systems
Dr. Zigang Wei	Assistant Research Scientist	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.11 Table 2: JCET Fellows (as of September 30, 2008)

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. Chintan Patel	UMBC CSEE
Dr. Steven Platnick	NASA GSFC
Dr. James Plusqellic	UMBC CSEE
Dr. Marcos Sirota	Sigma Space Corporation
Dr. Lynn Sparling	UMBC Physics
Dr. David Starr	NASA GSFC
Dr. Larrabee Strow	UMBC Physics
Dr. Marco Tedesco	NASA GSFC
Dr. Omar Torres	UMBC Physics
Dr. David Whiteman	NASA GSFC

III.12 Table 3: JCET Associate Staff (as of September 30, 2008)

NAME	TITLE
Mr. Dominic Cieslak	Engineer
Mr. Keith Evans	Research Analyst

III.13 Table 4: JCET Administrative Staff (as of September 30, 2008)

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

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
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
WAVES	Water Vapor Validation Experiments
WMO	World Meteorological Organization
WVIOP	Water Vapor Intensive Operations Period
Z	Radar Reflectivity Factor