

Earth System Science (ESS) Graduate Student Fellowship Fellowship - ESS06

NASA has completed its evaluation of the 2006 applications to the Earth System Science (ESS) Graduate Student Fellowship Program, as well as the Graduate Student Researchers Program (GSRP) applications with specifications of both "Earth Science" and "Headquarters." A total of 181 applications were received by the Earth Science Division of the Science Mission Directorate at NASA Headquarters in response to the announcements released in September 2005. In all, over 77 universities and educational institutions from 31 States were represented.

The applications were evaluated through a two-step process: first through mail review, and then by a panel composed of members of academic institutions and research organizations as well as program managers in Earth Science at NASA Headquarters.

A total of 55 new students have been identified to receive the fellowships this year, pending acceptance by each applicant and the respective institution. The purpose of the Fellowship program is for NASA Earth Science to train a pool of highly qualified scientists in support of NASA's mission to use the vantage point of space to understand and protect our home planet. NASA understands that the future of Earth science rests with today's students, who will be tomorrow's scientists and engineers. Financial support for pursuing an advanced education obviously plays a vital role in securing the necessary talent in the education pipeline to further NASA's mission to advance Earth system science.

The 2006-2007 ESS Fellowships are given for an initial 1-year term and may be renewed annually for up to 3 years total, based on satisfactory progress as reflected in academic performance and evaluations made by faculty advisors. The amount of award is \$24,000 per annum, including \$18,000 student stipend and an allowance of up to \$6,000 consisting of \$3,000 for student expenses and \$3,000 for university expenses. The student allowance may be used to defray living expenses, tuition, fees, and other educational expenses. The university allowance may be used for tuition or travel by the faculty advisor or student in support of the student's research. Students receiving these stipends must not receive other Federal fellowship or traineeship. The names and affiliations of the recipients identified for this year and the titles of their proposals are given below.

The next announcement for the 2007-2008 ESS Fellowships will continue to be synchronized with the GSRP announcement. The release will appear at <http://nspires.nasaprs.com/external/> in September 2006 and the deadline for submission of new applications to NASA will be February 1, 2007. Queries about this program may be sent to essf@hq.nasa.gov.

Adeney, Jennifer Duke University

Remote Sensing of Essential Drivers of White Sand Systems in the Brazilian Amazon Using Landsat and MODIS

Satellite imagery reveals that, far from a biologically homogeneous expanse of humid lowland forest, the Amazon basin contains many distinct ecosystems.

White sand ecosystems occur in patches like islands in the surrounding forest. They are difficult to access and not well known, as the overwhelming majority of scientific studies are restricted to accessible areas near rivers. The few explored white sand areas contain high proportions of endemic species. The vegetation is dominated by spiny, drought-resistant plants, adapted to extreme conditions of nutrient scarcity.

White sand ecosystems have a dynamic, disturbance-driven ecology. Fires and floods are common. I will use Landsat and MODIS imagery from the years 2000-2004 to map and classify them and to quantify fire and flooding events. Specifically, I will: 1) Map white sand areas in the Brazilian states of Amazonas and Roraima. 2) Classify vegetation types within delineated areas and conduct a change detection analysis for 2000-2004. 3) Detect burn scars to quantify yearly fire events. 4) Detect flooding events and create categories of flood intensity and duration. 5) Define white sand ecosystems classes based on size, isolation, fire frequency, flood duration and vegetation classes. 6) Correlate white sand ecosystem classes with their avian communities. 7) Determine what proportion of the white sand ecosystems fall within protected areas, indigenous lands and extractive reserves. These activities will provide critical baseline information for these distinctive communities and determine which areas are most vulnerable to anthropogenic change.

Using Landsat images from Brazil's National Institute for Spatial Research (INPE), I will classify at least three white sand vegetation types. I will conduct a supervised classification with training GPS points provided by Brazil's National Institute for Amazonian Research (INPA). The MODIS Global Percent Tree Cover product will assist in delineating vegetation classes. A post classification comparison of 2000 and 2004 images will identify changes.

I will use MODIS for flood and fire detection. Although recommended for flood detection, the infrequent radar coverage will not allow the seasonal comparisons essential for this study. MODIS has frequent global coverage with red and near infrared bands (NIR, 1 and 2 respectively) at a 250m resolution. Band 2 can distinguish surface water from vegetation or sand. As tree cover is sparse in much of the white sand areas, the composite surface reflectance product, MOD09, should be adequate for detecting surface water.

Using MODIS products for fire and burn scar detection is well established. While hot pixels are sometimes missed, burned areas persist for days and can be detected with surface reflectance data from visible and NIR bands. I will map burn scars at a 250m resolution.

I will use multivariate clustering techniques to define white sand ecosystem classes. Inputs will include size and isolation of patches, vegetation classes, frequency of fires and flooding, and number of consecutive days without rainfall. I will correlate white sand classes with field data on soil, vegetation and avian communities, and map predicted classes onto the landscape using a classification tree (CART). Finally, I will use GIS to map the proportion of white sand areas that currently fall within protected areas and indigenous territories.

This project addresses a little-studied Amazonian system that has relevance for regional scale biodiversity and fire regimes. It exemplifies NASA's goals of using remote sensing to explore fundamental questions in ecology and ecosystem function. The overall goal is to enhance our understanding of these unusual, disturbance driven 'forest island' habitats with their high rates of endemism in the larger context of the Amazon basin.

Barnes, Christopher South Dakota State University

United States Land Cover Land Use Change, Albedo and Radiative Forcing: Past and Potential Climate Implications

This hypothesis driven research will address the recent recommendation made by the National Research Council for regional forcing studies to better understand climatic responses to land cover land use (LCLU) changes. New satellite derived LCLU change and albedo data for the conterminous US will be used to study the impact of land cover change 1980-2000 on albedo and surface radiative forcing. Taking advantage of the spatial LCLU data sampling, sample

level results will be scaled up within ecoregions to provide a US wide quantitative estimate of the impact of contemporary LCLU change on albedo and radiative forcing.

The research will seek to address (confirm or negate) the following four hypotheses:

#1: Over the last 20 years LCLU change across the conterminous United States has led to a mean net positive albedo increase and a consequent albedo-related cooling.

#2: Current rates of LCLU change imply future net albedo increases and associated albedo-related cooling effects.

#3: Observed changes in albedo and radiative forcing due to LCLU change are greater than those due to inter-annual variability.

#4: There are large regional disparities in LCLU change and so large regional disparities in albedo change and radiative forcing, modifying the outcomes of hypotheses #1-3 at regional scale.

Whether hypotheses #1-3 are true is an open research issue. Certainly Houghton et al, (2001) and Govindasamy et al. (2001) suggest that human land surface activities on a regional scale have indicated an increase in surface albedo and a subsequent cooling due to albedo change. However, recent U.S. Land Cover Trends Project results find that in the southeastern United States 2.1 million acres of cropland were converted to forest for the period 1973 - 2000 (Loveland et al., 2002).

Forests generally have lower albedo than cropland, and so, in the absence of snow (Betts 2000), arable to forest conversion, may have resulted in a decrease in surface albedo and thus a net albedo-related warming in the southeastern United States. Across the U.S. it is likely that there is no single profile of change, rather there are varying pulses affected by clusters of change agents (Loveland et al., 2002). This argues strongly for a regional analysis (hypothesis 4) as continental averages may mask regional differences.

Hypothesis #2 will be considered in a statistical sense, considering only contemporary LCLU change rates and albedo and land cover data. This is worthy of interest as it is unclear even what the current rates suggest for the future. Furthermore, future predictions of LCLU change may not be reliable, primarily because statistical

LCLU change trend data may not capture future changes in the driving forces of LCLU change, such as economic and policy modifications acting at varying scales.

For these reasons, incorporation of a two-way feedback between future land cover and climate acting to modify future potential land cover will not be examined.

Hypothesis #3 posits the important question that anthropogenic changes are greater than 'natural' variability. In addressing this hypothesis, the assumption is made that there is a sufficient satellite data record to characterize the 'natural' variability. Permanent changes e.g., urbanization, will be examined first, and then less permanent changes e.g., forest clearing-fallow-forestation will be examined. The veracity of this hypothesis is likely to vary regionally as the type and phenology of vegetation and land cover, and so albedo, varies across the climatic zones of the conterminous U.S.

The proposed research is a direct contribution to the NASA Earth Science research focus on Climate Variability and Change.

Campbell, John University of Iowa
Simultaneous Chemical Transport Inversion of CO₂ and CO Signal: Data Analysis with MOTPITT CO Columns

Casey, Sean Texas A&M University
The Frequency of Tropical Precipitation as Observed by the TRMM PR and ICESat/GLAS

Clouds in the tropics can be grouped into three categories: shallow clouds with cloud-height tops near 2 km above the surface, congestus clouds with tops near the freezing level, and deep clouds capped by the tropopause. This trimodal distribution is visible in cloud data from the Geoscience Laser Altimeter System (GLAS), carried aboard the Ice, Cloud, and land Elevation Satellite (ICESat), as well as precipitation data from the Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR). By combining data from these two satellites, initial analysis indicates that overall, less than half of all clouds are precipitating at any one time, with deep clouds showing the highest Precipitating Cloud Fraction (PCF). The proposed research intends to study concurrent scans between ICESat and the TRMM satellite to further report on the fraction of clouds that contain precipitation observable by the PR. In addition, ground radar data will be compared with GLAS overpasses to enhance PCF statistics

Cavanaugh, Kyle University of California at Santa Barbara
Remote Sensing of Kelp Habitats in the Santa Barbara Channel Using SPOT Imagery

Forests of giant kelp (*Macrocystis pyrifera*), found along the shallow rocky areas of the Santa Barbara Channel, are some of the most productive marine ecosystems in the world. The structure of kelp lends itself to aerial mapping; however, very few recent studies have used satellite mapping to calculate kelp coverage and none have done this with high spatial and temporal resolution. Through a partnership with Terra Image USA, UC Santa Barbara has the unique opportunity to access multiple dates of imagery of the Santa Barbara Channel from May of 2004 to the present. Using this imagery, we can create maps of kelp canopy coverage on a monthly basis and use them to understand the forcing of the kelp ecosystem by oceanographic processes on various spatial and temporal scales. We will parameterize predictive statistical and demographic models of kelp dynamics to predict changes in regional populations resulting from environmental forcing such as long term climate change. This work builds on existing projects at UCSB including the Santa Barbara Coastal LTER and the NASA supported Plumes and Blooms ocean color study.

Cetinic, Ivona University of Southern California
Harmful Algal Blooms in an Urbanized Coastal Ocean - Application of Remote Sensing for Understanding, Characterization and Prediction

Harmful Algal Blooms (HABs) are recurring events in the coastal ocean, and local economies that depend on beach and coastal use are often adversely affected by these events. This proposal outlines a multidisciplinary approach for the investigation of HABs in the coastal Southern California region that utilizes *Lingulodinium polyedra* as a model organism. High resolution field datasets will be coupled with multi-sensor satellite data. Species specific optical signatures (absorbance, backscattering) measured in situ and in the laboratory, can be used to calculate species specific water-leaving radiance that can be linked to remote sensing. By distinguishing natural from human induced

factors that govern initiation and maintenance of a HAB, and utilization of remote sensing species specific patterns, successful models of HAB prediction can be developed.

Christman, Zachary Clark University

Disaggregating Phenological Variation from Discrete Land-Cover Change in the Rio Lerma-Chapala Watershed, Mexico

Remotely-sensed imagery, as vegetation indices or classified products, can effectively be used to monitor changes in land cover through time over broad areas. Interannual and interseasonal phenological variation can mask the signal of human-induced land-cover change, creating errors in precision regarding the location and quantity of vegetation conversion. By assessing rates and patterns of phenological variation over the period 1981-2007, I will create and validate land-cover products that accurately reflect the amount of anthropogenic land-cover change throughout the Río Lerma-Chapala watershed of Central México, to aid and evaluate conservation efforts in the region, including the Monarch Butterfly Biosphere Reserve.

Connelly, Brandon University of Colorado at Boulder

Uptake of Organics by Thin Sulfuric Acid/Ammonium Sulfate Films: The Kinetics of Acid-Catalyzed Secondary Organic Formation

It is now recognized that liquid and solid aerosol particles have a strong impact on atmospheric chemistry, global climate, and air quality.¹ A key finding in the last decade is that almost all tropospheric particles are internal mixtures of many components, with organics comprising 50% or more of the particle mass.^{3,4} Recent studies suggest that acid-catalyzed chemical reactions may play an important role in the uptake process. In this proposal, I plan to carry out laboratory studies of hexanal, methylglyoxal, and isoprene uptake by sulfuric acid and ammonium sulfate to further our understanding of how organics become incorporated into aerosol particles.

Crosman, Erik University of Utah

Weather and Climate Variations Associated with the Great Salt Lake

A research study is proposed to assess the interactions between Great Salt Lake surface temperature and the atmosphere on temporal scales ranging from days to years. Lake surface temperature will be obtained several times per day using Moderate Resolution Imaging Spectroradiometer (MODIS) thermal imagery from 2000-present. The satellite data will be compared against surface weather station data, atmospheric soundings, and the North American Regional Reanalyses (NARRs) from the National Center for Environmental Prediction. These comparisons will increase understanding of the extent to which lake surface temperature variations affect local weather and climate, and the extent to which these variations are controlled by regional forcing by the atmosphere on daily to interannual time scales.

The results of this research may be relevant to other climatically sensitive lake systems to analyze global trends in lake state(s). In addition, the Great Salt Lake serves as an excellent remote sensing laboratory due to significant and documented variations in its physical characteristics (temperature, salinity, turbidity, water color, surface foam) that affect upwelling radiation over a broad spectrum. This research is also likely to engender broad scientific interest in many disciplines as a result of the complex interrelationships between weather and climate and the GSL ecosystem.

Dasgupta, Swarvanu George Mason University

Multi-Sensor Approach for Monitoring Fire Risk in the Wildland Urban Interface

A new technique based on the physical variable of pre-ignition energy is proposed for assessing fire risk in the grassland Wildland-Urban-Interface. The physical basis lends meaning, a site and season independent applicability, possibilities for computing spread rates and ignition probabilities, features contemporary fire risk indices usually lack. The method requires estimates of grass moisture content and temperature. A constrained radiative-transfer inversion scheme on MODIS NIR-SWIR reflectances which reduces solution ambiguity is suggested for grass moisture retrieval, while MODIS land surface temperature/emissivity products are explored for retrieving grass temperature. Subpixel urban contamination of the MODIS reflective and thermal signals over a grassland-urban-interface pixel is suggested to be corrected using periodic estimates of urban influence from high spatial resolution ASTER. A dynamic fire risk environment demands high temporal resolution. Keeping this in mind the potential accuracy of real time pre-ignition retrievals and its implications for fire-spread predictions are to be thoroughly examined.

Davis, Sean University of Colorado

Comparison of In Situ and Remotely Sensed Measurements of Cirrus Cloud Properties

I propose to compare in-situ measurements of cirrus cloud ice water path and optical depth with satellite retrievals from the Atmospheric Infrared Sounder (AIRS) aboard the NASA Aqua satellite and the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the NASA Terra and Aqua satellites. My instrument, along with several others, has measured cirrus cloud properties from aboard the NASA WB-57 aircraft during two recent field campaigns. Included in these measurements are water vapor, cirrus ice water content, particle size distributions and habit, extinction coefficient, and meteorological parameters. During both of these field campaigns, flight patterns were coordinated with satellite overpasses of Terra and Aqua in a way which makes the in-situ data amenable to comparison with the satellite data.

My first goal is to assess the accuracy of in-situ measurements of cirrus cloud properties made during these field campaigns and use this knowledge to evaluate the ability of satellite retrieval algorithms to accurately retrieve cirrus properties. Specifically, I will compare measurements of cirrus cloud ice water content from three different instruments aboard the WB-57, one of which I have developed as part of my graduate school work in collaboration with Prof. Linnea Avallone at the University of Colorado. Cirrus cloud ice water content can be vertically integrated to calculate cirrus ice water path (IWP), which is measured by MODIS and will attempt to be measured by AIRS. I will then compare the in-situ ice water path (IWP) to IWP measured by MODIS and AIRS. This comparison will provide a key test of the MODIS/AIRS retrieval algorithms.

Secondly, I will work to improve these satellite retrievals by using aircraft measurements as input to radiative transfer models. In collaboration with one of the developers of the MODIS cirrus retrieval, I will develop a cirrus retrieval that is suited for midlatitudes which will be complimentary to the retrieval previously developed for the tropics. The resulting improvement of satellite retrievals of cirrus properties will aid in increasing our understanding of the global distribution and climate impact of cirrus clouds. I will collaborate with the AIRS retrieval team, which is currently in the process of developing an algorithm for cirrus detection and IWP measurements.

In summary, I will synthesize data from two field campaigns and two satellite platforms to improve satellite measurements of cirrus cloud properties. The accurate measurement and monitoring of

cirrus properties from satellite platforms is important for improving “prediction of Earth system change”, and is relevant to NASA’s goal “to understand and protect our home planet by using the view from space to study the Earth system and improve prediction of Earth system change.”

Deeb, Elias University of Utah

Measuring Snow Water Equivalent Using Interferometric Synthetic Aperture Radar (InSAR)

Water is essential to human life; and in the global movement of water, snow water storage plays a crucial role. For over a billion people, seasonal snow pack and glaciers are the primary source of drinkable water. Models use certain measures, most importantly snow water equivalent (SWE), to monitor the role of snow pack in the hydrologic cycle. These models are valuable in water resource management, flood hazard assessment, and climate-change impact studies. Manual snow sampling and meteorological stations located throughout a hydrologic basin collect point samples of SWE to assist in the modeling of this phenomenon. However, due to the high variability of snow cover in both time and space, these point sample measurements do not adequately characterize SWE across even a single hydrological basin.

In general, remote sensing applications have been developed to address the inadequate spatial and temporal distribution of data currently available. More specifically, radar remote sensing shows considerable advantages when studying snow compared to visible, near-infrared, and even passive microwave sensors. Since radars are an active remote sensing system (e.g. supplying their own illumination), this allows for the acquisition of data through cloud cover, without the need for solar illumination (e.g. can operate at night), and with much higher spatial resolution than passive microwave remote sensing (e.g. 25 m, opposed to 25 km).

Based on the limited spatial coverage of SWE point samples and the ability of radar remote sensing to help resolve this limitation, Interferometric Synthetic Aperture Radar (InSAR) to measure SWE has been previously presented. This theory is based on the refraction of the radar signal in the snow pack being a function of snow depth and density. Fundamentally, the amount of refraction can be measured by the interferometric phase difference between two SAR acquisitions spanning a snow event. The proposed research fully investigates the use of InSAR to measure SWE for dry snow. A time series of change in SWE maps has been generated using this technique for the Kuparuk watershed, North Slope, Alaska. Despite promising results, there is need for better validation on the ground. Continuation of this effort is proposed identifying where satellite data, ground-based measurements, and snow precipitation events overlap with a detailed plan of validating results.

Specific data sets have been identified where the above search criteria has been met. These study areas include differing snow pack conditions from the Canadian prairie, Pacific Northwest, and Rocky Mountain regions of North America. Once change in SWE maps have been generated using the InSAR technique, the validation plan includes comparison of these results to meteorological point samples of SWE measurements, estimates of SWE derived from passive microwave methods, and model output of SWE from tools such as SNODAS. Based on the validation results, further study areas will be identified using the search criteria previously explained. Portable radars will also be used to measure the change in radar backscatter including phase changes after precipitation and redistribution of snow by wind. These experiments will measure the phase change from 2-18 GHz due to changes in SWE and metamorphic snow processes.

The ability of using InSAR to measure changes in SWE at a much finer resolution than passive microwave remote sensing is a significant reward of this research. Developing this remote sensing technique and employing a detailed validation plan will be the main objective of this endeavor.

NASA scientists were one the first members of the scientific community to develop the use of interferometry to look at changes on Earth. There exists a vast archive of InSAR data suitable for these means, and furthering the technique towards new applications is an important interest identified by many key members of the current scientific community.

Eckmann, Ted University of California Santa Barbara

Validating Retrievals of Subpixel Fire Sizes and Temperatures from MODIS to Improve Understanding and Monitoring of Fires

The sizes and temperatures of fires strongly influence how they spread, the amount and chemistry of their trace gas and aerosol emissions, and their effects on ecosystems. Unfortunately, current remote sensing products leave large uncertainties in measurements of fire sizes and temperatures. However, preliminary results show that multiple endmember spectral mixture analysis (MESMA) can retrieve subpixel fire sizes and temperatures from MODIS and other sensors, and overcome many limitations of existing methods for pixel-level and subpixel fire measurements.

This proposal describes a plan for exploring the following questions: 1) How effectively can MESMA retrieve subpixel fire sizes and temperatures from MODIS and other sensors? 2) How does MESMA compare to other methods for retrieving fire properties? 3) How can subpixel fire retrievals improve initialization and validation of fire spread models? 4) How sensitive are these subpixel retrievals and fire models to various inputs, how accurate are they, and how could they enhance scientific understanding of fires and their roles within the Earth system?

The proposed research will use images of fires acquired simultaneously by MODIS and higher-resolution sensors, along with in-situ sources, to validate MESMA and other methods for retrieving fire properties. These retrievals will then be used to initialize and validate fire spread models. Analysis of soils and vegetation at burn sites from this study, using high-resolution images and in-situ measurements, will explore potential uses of the methods for measuring and modeling fires developed by this research, such as relating fire temperatures to post-fire ecosystem recovery.

Direct broadcast receivers can supply processed MODIS images that are sometimes just a few minutes old, and all processing steps to be developed by this research for measuring and modeling fires could be automated. This research will thus provide methods that could potentially be used for operational fire spread forecasting in many areas worldwide. This could support decision-making by the United States Forest Service and many other agencies, improve fire management, and help to reduce some hazards that fires pose to property and health. The methods developed by this research for improving measurements and modeling of fires could also be applied to many fires from several years of archived global MODIS data. This could enhance scientific understanding of fires, and improve estimates and forecasts of trace gas and aerosol emissions, ecosystem disturbance, and land-cover change due to fires, which are important drivers of change in the Earth system. Results from this research could thus contribute towards many goals in NASA's Earth Science Enterprise Strategy and Earth Science Applications Plan in several focus areas and applications of national priority, such as "atmospheric composition," "carbon cycle and ecosystems," "air quality," and "disaster management."

Fugal, Jacob Michigan Technological University

Improving Validation of MODIS Cloud Ice Crystal Data Products Using the HOLODEC Instrument

MODIS instruments aboard the Terra and Aqua satellites are used to infer cloud physical properties including ice crystal mean effective size. Confidence in such measurements rely on validations of in situ measurements taken from standard aircraft instruments such the PMS 2DC and 2DP probes. Due to inherent systematic errors, these probes have large uncertainties of small (< order 100 micrometer extent) ice crystal number densities. The new HOLODEC (Holographic Detector for Clouds) probe, flown in August and September 2003 during the IDEAS 3 project over northeastern Colorado has a well defined sample volume, and an ability to detect ice crystal shattering by examining the particles' 3--D positions in the sample volume. It is proposed to process existing HOLODEC ice cloud holograms, measure ice crystal number densities and size distributions, and make a quantitative estimate of the measurement bias of other standard probes.

Galford, Gillian Brown University

Biogeochemical Consequences of Land-Use Transitions Along Brazil's Agricultural Frontier

In the last half-decade, the southwestern Brazilian Amazon has begun rapid transformation from natural vegetation and pastures to mechanized agriculture (MA) with significant impacts on regional biogeochemistry. Quantifying land use transitions and modeling biogeochemical consequences are critical. Greenhouse gas fluxes (CO₂ and N₂O) from MA depend on crop type, management regime, and other biophysical parameters. In Mato Grosso and Rondônia states, I will use MODIS and remote sensing tools to delineate major crop types of MA - soybean, maize, rice, millet, and cotton. Remote sensing information and new biogeochemical field data will be used to improve and iteratively test the process-based Terrestrial Ecosystems Model (TEM). I will use georeferenced databases of model drivers such as temperature, precipitation, and soil type to apply the model at regional scales. The improved TEM will estimate regional fluxes of CO₂ and N₂O associated with agricultural intensification to determine the biogeochemical impacts of land cover change.

Hence, Deanna University of Washington

Tropical Cyclone Structure as Seen by the TRMM PR and Recent Field Campaigns

The proposed research seeks to understand the role that the spiral rainbands have in the inner dynamics of hurricanes, but especially the inner rainbands connecting to the convective ring of clouds known as the eyewall. Previous radar observations have shown that these rainbands consist of a combination of convective cells and stratiform echoes. Convective cells are pockets of high reflectivity on the radar that have winds marked by convergence at lower levels, strong updrafts, and divergence at upper levels. Stratiform precipitation is marked by relative horizontal uniformity in reflectivity, convergence in the winds at midlevels, and a distinct layer of melting ice particles falling from upper levels. The distribution of convective and stratiform structures has important implications for the dynamics of the hurricane. Therefore this study has three main objectives: 1) to statistically analyze TRMM satellite Precipitation Radar (PR) data on the structure of eyewalls and rainbands; 2) to use airborne Doppler radar data to determine the wind structure of the eyewalls and rainband; 3) to use numerical modeling to interpret the observations dynamically in terms of how eyewall and rainband potential vorticity (PV) affects intensity changes of tropical cyclones.

To achieve these objectives, the proposed research will analyze TRMM PR data from 69 storms in the 1998-2005 Atlantic hurricane seasons. The data have been converted into a database viewable by

the NCAR Zebra visualization software. I will statistically quantify the results of objective 1) by using a combination of tools including an algorithm that distinguishes convective precipitation from stratiform precipitation, contoured frequency diagrams that display frequency of occurrence of radar reflectivity echo by height, and interactive horizontal and vertical cross-sections created in Zebra. Analyzed airborne Doppler radar data obtained during the Tropical Cloud Systems and Processes (TCSP) experiment and the Hurricane Rainband and Intensity Change Experiment (RAINEX) will be compared with the eyewall and rainband data of the TRMM PR. For objective 2), Doppler analysis of the airborne radar data will be used to retrieve the wind structures within a subset of these features. High-resolution numerical modeling of the 2005 storms extend the TRMM PR and airborne observations to provide a dynamically-based evaluation of the working hypotheses arising from the TRMM PR, TCSP, and RAINEX analyses for objective 3). The author's preliminary analysis suggests that the principal hypotheses to be tested will be:

- * The inner rainbands consist of the structure proposed by previous studies in that the upwind sections of the inner rainbands are primarily convective cells, but downwind the rainband becomes increasingly stratiform.

- * Asymmetries in the eyewall tilt indicate a lack of wind balance within certain sectors of the cyclone.

- * The degree of tilt and circular symmetry of rainbands indicates their degree of tendency toward eyewall-like structure, and potential secondary eyewall formation.

- * As suggested by theory, the PV generated and concentrated within midlevels of stratiform regions of rainbands travels inward, leading to cyclone intensification.

Satellite observations are pivotal to future improvement of the understanding and prediction of hurricane intensity changes. Using TRMM PR and field campaign data, this study will lead to a better interpretation of satellite data and hence to better understanding, modeling and prediction, of the structure of hurricanes and their changes in intensity. Consistent with NASA's vision to improve life here, and the mission to understand and protect our home planet, improving forecasting of intensity changes will further NASA's goal of improving overall hurricane forecasting capabilities as well as supporting the decision-making processes involving mitigation of storm impacts.

Hilburn, Isaac Massachusetts Institute of Technology
Paleomagnetism of the NAI Deep Time Drilling Program Core: Characterization of the Geomagnetic Field Behavior on the Early Earth

NASA's National Astrobiology Institute, Deep Time Drilling Program (NAI-DTDP) core, which samples 3.5-2.4 billion year old volcanic and sedimentary rocks from the Pilbara and Hamersley regions, Western Australia, offers the opportunity to address two controversial subjects in the geosciences - the nature of the geomagnetic field and the emergence of terrestrial atmospheric oxygen on the early Earth. A combination of standard paleomagnetic techniques with optical petrology and the new ultra high resolution SQUID microscope may yield the oldest yet found magnetic remanences and reversals, and new paleomagnetic constraints upon the presence of oxygen in late Archean and earliest Paleoproterozoic sedimentary rocks sampled by the NAI-DTDP core.

Hitchcock, Bryan Portland State University

Antarctic Peninsula Glacier Response to Environmental Change: Remote Observation and Numerical Simulation

Outlet glaciers along the Antarctic Peninsula have recently undergone rapid change in conjunction with ice shelf disintegration. The dynamical connection between ice shelves and the glaciers that feed them may be capable of producing a strong and quick mechanism for the transfer of water stored as ice on land into the ocean. The central questions of this proposed research are, why do some glaciers accelerate dramatically in the wake of ice shelf collapse and does climate warming play a direct role in the observed changes in glacier flow? The ice dynamical processes currently at work in the Antarctic Peninsula are likely relevant to much larger systems that could yield a significant impact on global sea-level.

The work proposed here will use a combination of remotely-sensed data sets and numerical models of glacier ice flow to understand the physical processes at work in the observed speed-ups of the Larsen area glaciers in response to ice shelf disintegration. Observational data will derive from a suite of remote sensors, including GLAS, MODIS, ASTER, the QuickSCAT scatterometer, and LandsAT 7. This work addresses the NASA objectives of developing models that can be applied to retrospective and future studies of climate variability and change and to utilize state-of-the-art measurements and advanced modeling techniques to understand and predict changes on the Earth's surface.

Remotely-sensed data sets will be used to accomplish a variety of tasks. We are using, and will continue to use image correlation with ASTER and Landsat scenes to measure glacier surface velocity over as many intervals as possible. The goal is to capture both annual and seasonal variations in ice flow. We have begun monitoring glacier terminus position using the MODIS image archive at the National Snow and Ice Data Center. That effort will continue throughout the proposed research project. Meltwater at the glacier bed is known to lead to increased speeds, thus we have an interest in obtaining precise timing of the melt season. Gridded daily QuickSAT observations for Antarctica from the Scatterometer Climate Record Pathfinder at Brigham Young University will be used to identify the onset and end of the melt season. Together, this suite of observations will be used to guide numerical model development and experiment design.

A new numerical model of the coupled outlet glacier and ice shelf system will be built for this project. The model will improve upon prior work in that it will solve the full set 3D of stress balance equations. This is important because the stress boundary conditions change in space, resulting in spatial variations in the relative importance of stress gradient terms in the balance equations. The model design must not make a priori decisions about these terms but should instead respond to changes in boundary conditions. This approach affords the best opportunity to correctly simulate changes in glacier system response to environmental change.

Holloway, Christopher University of California Los Angeles

Profiles of Tropical Temperature and Humidity Variations in AIRS, In Situ, and Climate Model Data

This project seeks to understand the effects of convection on large-scale tropical climate by investigating vertical structures of temperature and moisture variations. One preliminary goal is to determine the degree to which temperature and moisture variations are coherent throughout the tropical troposphere. The extent to which these quantities are vertically coherent allows conceptual and model simplifications assuming fewer vertical degrees of freedom. A second, related objective is to test quasi-equilibrium theory, which connects small-scale tropical deep convection with large-scale

forcing of vertical instability, and thus vertical structure. Quasi-equilibrium theory will be tested at many time and space scales, in part to better quantify the minimum scale that it is still relatively useful. Comparisons will be made between the vertical structures generated by convective parameterizations in various climate models with those found in observations, leading to a better understanding of the ability of those parameterizations and models to simulate tropical climate.

The coherence of vertical perturbations and the extent to which they follow quasi-equilibrium theory will be tested by regressions of various quantities at different vertical levels on vertically averaged temperature and moisture, using Atmospheric Infrared Sounder (AIRS) satellite data extensively, as well as the National Centers for Environmental Prediction / National Center for Atmospheric Research (NCEP/NCAR) and European Reanalysis Agency (ERA-40) reanalyses, Tropical Rainfall Measuring Mission (TRMM) moisture and precipitation data, and radiosonde data. In addition, moisture and precipitation will be used to mask these regressions in order to test the analyses for varying amounts of convection and humidity. These observational results will be compared to results from Global Climate Models (GCMs) in order to evaluate model parameterizations based on their ability to reproduce observed vertical structure.

This research will help further NASA's goal of understanding climate change and variability by investigating the ability of GCM convective parameterizations to represent the large-scale effects of convection via quasi-equilibrium theory. Furthermore, this study has made and will continue to make extensive use of AIRS temperature and humidity data and allow for intercomparisons of AIRS with other observations, including TRMM moisture data, and of AIRS version 3 with AIRS version 4.

Huang, Yi Princeton University

Diagnostic Investigation of Satellite-Observed and Model-Simulated Spectral Longwave Radiances: Spectral Signatures of External (Natural, Anthropogenic) Climate Forcings and Internal Variability

Satellite-observed and climate model-simulated radiances will be analyzed to diagnose the major factors affecting the spectral distribution of the outgoing longwave radiation (OLR). First, a global perspective, including seasonal and interannual changes, will be obtained from observations, which will be used to assess the climate model simulations. Through comparisons of the observed spectra with those from different categories of atmospheric data, as obtained from reanalyses and climate model simulations, and utilizing highly accurate radiative transfer models, we will identify model (and observational) deficiencies that contribute to the biases in the modeled spectra. Then, with the various external forcings (natural: solar, volcano; anthropogenic: well-mixed gases, ozone, aerosols and land-use change) being added to the climate model integrations in a sequential manner, we will investigate the effects due to the different forcings (and their associated feedbacks) upon the OLR spectra. Also, effects due to internally-generated variations, such as sea surface temperature changes, will be examined. Based on the hypothesis that feedbacks by water vapor, temperature and clouds will differ for the different forcings, we will test whether there a significant footprint in the spectral features exists due to specific forcings. This will yield insights on the influence of the various climate variables (forcing and/or feedback) upon the present-day OLR spectra, as well as provide information on how the spectral features may be expected to evolve due to the changes in forcings and feedback mechanisms in the decades ahead.

This work seeks the use of remote sensing data in process studies and Earth system modeling, and will primarily support the NASA focus area of Climate Variability and Change.

Ihara, Chie Columbia University

The Impacts of El Niño Phases on the Indian Summer Monsoon Rainfall

The all-India summer monsoon rainfall (hereafter referred to as ISMR) defined as the rainfall received during the summer monsoon season (June through September) over India is important to the agriculture and related economic activities of the region. El Niño Southern Oscillation is one of the most important external forcing on ISMR. It is said that El Niño/La Niña is linked to deficit/excess of summer monsoon rainfall. However, the state of ENSO cycles does not always explain the interannual variability of ISMR. We have found in our preliminary work that the evolution phases of ENSO have different impacts on ISMR; in particular, a protracted El Niño is linked to above normal and normal ISMR associated with warmer Indian Ocean. During our diagnostic study of the historical long record from 1881 to 1998, we realized that it is necessary to pursue 1) the analysis of three dimensional data to understand the dynamical mechanisms of our results; 2) studies using reliable water-related data, which is feasible only after the advent of satellite observations.

We propose research regarding the El Niño evolution phases and ISMR which aims to depict the climate conditions associated with different ENSO evolution phases, and attempts to understand physical mechanisms regarding this association. Our research consists of three different periods; from 1949 to 2004 using reanalysis products, from 1979 to 2004 using satellite based precipitation dataset, and the case studies of 2002, 2003 and 2004 using recent satellite data, which is important for understanding the characteristics of available data. We attempt to understand the shift of large scale circulation and precipitation distribution induced by different types of ENSO evolution. We then try to characterize evolutions of rainfall distribution using GPCP precipitation data (1979-), TRMM (2002, 2003, 2004) and reanalysis data (1949-) in accordance with the evolution of the SST over the eastern Pacific and atmospheric circulations over the Indian Ocean. In our preliminary work, we used rainfall data averaged over all of India and the entire monsoon season, but these averaged data smoothed out some features that might offer an important insight for understanding the mechanism. The next step of our research is examining the stability of the atmosphere associated with different El Niño phases. Our main attempt here is to examine our working hypothesis that the tropospheric temperature is already warmer than usual during rapid rise El Niño although the ocean remains to be cold because of the larger thermal inertia of the ocean compare to the atmosphere, while during protracted El Niño, the Indian Ocean is already warm up and the atmosphere is not as stable as during rapid rise El Niño events.

Jana, Raghavendra Texas A&M University

Use of Satellite Data for Soil Parameter Estimation in Rio Grande Basin

The Rio Grande is one of the major rivers of the North American continent and is a predominant source of water - residential, commercial, recreational, ecological and agricultural, for the state of New Mexico. Unfortunately, over the years, there has been a steady decrease in the flow in the Rio Grande basin due to drought and over-appropriation of water. State and federal scientific agencies have embarked on an effort to characterize the river basin area using multi-scale/resolution hydro-climatic modeling. The model includes surface and subsurface flow components. Since critical input parameters into the model are the soil hydraulic properties such as porosity, residual soil water content and saturated and relative hydraulic conductivities at multiple scales, techniques to estimate these properties for various spatial resolutions and across the basin must be developed. Estimation of soil hydraulic parameters from remotely sensed land parameter data is a novel approach to address this need. The objective of this study is to derive multi-scale values for soil hydraulic parameters such as porosity, residual water content, saturated hydraulic conductivity and relative hydraulic conductivity, in the Rio Grande basin using remotely sensed land surface data from AQUA and

TERRA satellites by employing Bayesian and Monte Carlo simulation techniques with artificial neural networks. This innovative application of ANN in hydrology will handle pedo-transfer functions and scaling of parameters simultaneously. An Artificial Neural Network (ANN) is an information processing tool that is inspired by the way brain neurons process information. It is composed of a large number of interconnected processing elements, called neurons, working together to solve specific problems. ANN's, like people, learn by example. In this study, the ANN analysis will be carried out using the Neural Network Toolbox of MATLABTM software. Custom-built training algorithms will be adopted in this study if necessary. Conventional ANN training searches for a single optimum weight vector that can best describe the relationship and give the best fit to the observed target data. Bayesian training, on the other hand, attempts to update the weight vector with information available in the data. The resulting numerical integration equations will be solved using sophisticated statistical tools like Markov chain Monte Carlo method. The Bayesian ANN will be trained with data (e.g., soil moisture, temperature, vegetation, soil texture) from one resolution and then asked to predict values for soil hydraulic parameters (e.g., saturated hydraulic conductivity) at a different scale. This is a new application of ANN and will result in development of suitable pedo-transfer functions that are scale-independent. Hence, values for the soil parameters can be obtained interchangeably between scales. I propose to use AMSR-E's surface soil moisture derivative, temperature and topology data from ASTER and vegetation data from MODIS sensor at coarse resolution. Point scale data from the Rio Grande basin along with SSURGO data form the fine resolution dataset. The ANN output - scaled soil hydraulic parameter values - from the proposed research can be used to substantiate the sparsely available measured data being used in the hydrologic models, especially at higher resolutions. This in turn will help answer such questions as the effect of vegetation change on the basin-scale water balance and effect of climate change on the rainfall partitioning at the land-surface. Better decisions can then be made with regard to water allocation disputes, water banking and water management. These applications are in line with NASA's objectives of utilizing remote sensing data in process understanding in energy and water cycle research, and in addressing the water balance and water budgeting issues.

Jayaram, Vikram The University of Texas at El Paso

Optimum Band Selection Techniques Under Hyperspectral Image Analysis for Material Identification

In most Hyperspectral processing algorithms the distance metrics is still the most widely used similarity measure between two material spectra. The spectral angle mapper (SAM) and the minimum Euclidean distance (MED) are some of the common distance metrics. However, these deterministic metrics do not have the capability to measure spectral properties inherent in a single pixel vector. Our research shall address this problem by incorporating a stochastic description of the pixel vectors. We will introduce stochastic distance metrics based on hidden Markov models (HMM) and spectral information distance (SID). We will further derive an engine that iteratively select the bands in a way that maximizes our distance metrics. We shall extend our study of optimum band selection by incorporating the more realistic Gaussian modeling of the spectral signature and evaluating some of the statistical best band selection methods from the multispectral to the hyperspectral domain. Our goal is to achieve enhanced class separability among similar material spectra although using fewer number of spectral dimensions.

Kang, Do Hyuk Duke University

Characterization of the Physical Properties of the Snowpack at Very High-Resolution Using RF Wireless Networks and Downscaling of Satellite-Based Estimates of Snow Water Equivalent

The goal of this proposal is to characterize the statistical structure of the space-time variability of the physical properties of the snowpack within an area consistent with the pixel resolution expected from a future ESSP mission dedicated to snow measurement (e.g. Cold Land Processes Mission in NASA's Terrestrial Hydrology Program). Ultimately, the objective is to design and test a downscaling methodology that can use the sub-grid scale statistical information to improve remote sensing estimates of snow water equivalent (SWE) at scales relevant for hydrological applications (10's to 100's of meters). Here, we propose an intense field experiment relying on nested Radio-Frequency (RF) Wireless Grids consisting of distributed Vector Signal Generators (VSGs) transmitting in the 300 kHz to 10 GHz frequency range (UHF and lower-range of the SHF bands) to central pods equipped with Vector Signal Analyzers (VSAs) to monitor the evolution of snow accumulation and snow-pack properties continuously at high spatial resolution (100 m or less). This requires the development of an estimation algorithm to estimate snow dielectric properties, snow density, and volume fraction of snow (VF) from the time-of-travel, amplitude and phase modification of the multi-channel RF signals as they propagate through the snow-pack. To obtain data for calibration and validation of this algorithm, the proposed field experiment will also include conventional snow measurements including snow core extraction for laboratory measurement of snow dielectric properties, grain morphology, VF and SWE, snow stratigraphy using a snow sounding probe, snow depth from sonic rangefinders, and SWE from gamma-ray sensors. The field experiment will be conducted at the field site maintained by University of North Dakota (UND) in Grand Forks. The area is large enough to accommodate this sampling strategy and five stations equipped with gamma ray loggers is already in place due to ongoing collaboration between Duke University and UND. Finally, downscaling of existing satellite-based estimates of snow obtained from snow products from MODIS, AMSR-E, SSM/I and AMSU instruments will be investigated using the downscaling algorithm developed by Kim and Barros (2002) modified to incorporate the sub-grid scale statistics of snow-pack heterogeneity obtained through our field experiment.

Kao, Hsun-Ying University of California Irvine

Investigations of ENSO Persistence Barrier in Ocean Heat Content Using Satellite Observations and Ocean Data Assimilation Products

It is well known that ENSO predictions are less successful through the spring. This spring barrier has been suggested the result from the weak persistence of ENSO sea surface temperature (SST) anomalies. It has been shown that ocean heat content (OHC) could help overcome the spring barrier problem because its persistence barrier occurs during a different season from that of the SST persistence barrier. However, dynamics that control the OHC persistence barrier and its phase lag with the SST barrier are not fully understood. Sea surface height collected by TOPEX/Poseidon and JASON, together with subsurface ocean structure information derived from data assimilation projects, will improve understanding of OHC anomalies during ENSO. Using these datasets, this project will (1) examine the changes of OHC persistence barrier and its phase lag with the SST persistence barrier over the past 20 years and (2) determine the physical mechanisms that control the OHC persistence barrier, its phase lag with the SST barrier, and their decadal variations. The proposed investigations will be conducted in view of current ENSO theories. These understandings will help improve utilization of OHC information for ENSO prediction, and will contribute to the development of a unified ENSO theory. This project represents a unique application of remote sensing and data assimilation products in climate research and application.

Kerns, Brandon University of Utah

Are There Systematic and Distinctive Convective Signatures in Pre-Tropical Cyclone Disturbances?

To support NASA's research objective to develop the technological and observational capacity to improve daily and extreme weather forecasting, we propose to analyze passive microwave satellite data for pre-tropical cyclone disturbances and for non-developing disturbances. This would be the first time these data have been used systematically to study pre-tropical cyclone and non-developing disturbances in several ocean basins and years.

The disturbances will be tracked with band-pass filtered ERA40 Reanalysis, and the wave-scale dynamical properties noted. The satellite-derived statistical properties of pre-tropical cyclone precipitation features, such as convective intensity and location relative to the center, will be determined for pre-tropical cyclone disturbances and non-developing disturbances. This allows us to assess the relative importance of large-scale dynamical control and to test the prevalence of intense convective bursts, and the intensity and location of this convection.

Kopacz, Monika Harvard University

Constraining CO Sources and CO₂ Surface Fluxes Using Satellite Observations and a 4-Dimensional Variational Data Assimilation Technique

I propose to apply a 4-dimensional variational (4D-var) assimilation technique to constrain CO sources and CO₂ surface fluxes with high spatial and temporal resolution from satellite observations of atmospheric concentrations. I have recently developed for that purpose an adjoint of the GEOS-Chem global chemical transport model (CTM). I will use it in a first phase 4D-var application to synthesize satellite observations of CO from MOPITT and AIRS to estimate anthropogenic CO sources from Asia (providing a check against previous studies) and natural sources from boreal forest fires in North America (offering in particular constraints on injection heights). I will apply it in a second phase to develop a capability for constraining CO₂ surface fluxes using future observations from NASA's Orbiting Carbon Observatory (OCO) satellite mission; this work will be conducted in collaboration with the Chemical Data Assimilation Group at NASA/GMAO.

Kopczynski, Sarah Lehigh University

AMSR-E Derived Snowmelt and Implications for Glacial Hydrology, Alaska

Impetus: Glacial discharge is characterized by an abrupt snowmelt-induced stream-flow increase, termed "spring event," purported to trigger seasonal opening of the subglacial plumbing. Studies at many glaciers observe this spring event, followed by transitions in sediment and geochemistry records (proxies of subglacial plumbing behavior), suggesting drainage system evolution. However, no study has yet provided a "cause and effect" model temporally linking snowmelt, spring event, and subglacial plumbing transitions. This work advances NASA ESS goals by understanding cryospheric consequences of climate forcings.

Objectives: My proposed research will address this critical gap so we can better understand mechanisms driving subglacial hydrology, a very important, yet "primitively" understood regime (Flowers 2002). I will accomplish this by the innovative combination of a rare high-resolution field dataset at Matanuska Glacier, AK and correlations to passive-microwave-detected glacier snowmelt

from the Defense Meteorological Satellite Program Special Sensor Microwave Imager (SSM/I) and NASA's higher resolution Advanced Microwave Scanning Radiometer for EOS (AMSR-E). My specific research goals are to:

1) develop detailed observations and a conceptual model linking passive microwave satellite based snowmelt, glacial discharge spring event and subglacial evolution at Matanuska Glacier, and

2) demonstrate portability of concept through validation at other Alaskan glaciers.

1) Matanuska Model: I will apply a snowmelt algorithm developed by Ramage (2002) to daily passive microwave SSM/I and AMSR-E observations to predict the onset of the spring-event at Matanuska. At Matanuska we have highly detailed records of hourly discharge, suspended sediment, geochemistry and meteorology extending back to 1993, to be used as proxies of subglacial drainage system behavior. While studies at other glaciers observe the spring event over one or two seasons and report trends in subglacial proxy data consistent with physical changes of plumbing structure following the spring event, this new Matanuska study will be the first to provide a "cause and effect" model temporally linking snowmelt, to spring event, to subglacial plumbing transitions.

2) Portable Results: In order for these results to be meaningful to the broader scientific community, I will validate the Matanuska-based model at other Alaskan glaciers large enough to be detected by SSM/I and AMSR-E sensors, and glacial discharge records long enough to be comparable with satellite data. This work will culminate in a new algorithm to predict the timing of the glacial spring events, and thus, timing of subglacial plumbing evolutions.

Significance to NASA Earth System Science Goals: My proposed work will contribute to Water and Energy Cycle goals through enhanced understanding of changes in global water reserves due to variations in glacial snowmelt timing. Covering 10% of Earth and storing 75% of our freshwater, glaciers are critical global freshwater reservoirs. My work will broaden our understanding of glaciological responses and hydrological consequences imposed by seasonal to inter-annual climate variations. My results can help understand how glacial hydraulics impact large floods, such as the storm-induced 1995 flood affecting Matanuska Glacier and the Cook Inlet area, causing over \$10M in damage. Moreover, because subglacial hydrology variations are directly tied to rates of atmospheric CO₂ drawdown (Sharp et al 1995), we can advance NASA's Climate Variability and Change goals by this research linking temporally resolved glacier melt observations to subglacial activity.

Li, Jilu The University of Kansas Center for Research Inc.

Design and Development of Complementary-Coded Pulse Radar for Ice Measurement

Radars can measure ice thickness and map internal layers using remote sensing technology. The shape and depth of internal layers provide information about accumulation and flow history and help to make more accurate calculations of ice-sheet mass balance (net gain or loss of ice) that are essential to accurate estimation of sea-level rise. None of the existing radars is capable of mapping internal layers near the ice bed. This is because of lack of radar sensitivity to map weak returns from deep internal layers. Range sidelobes of a traditional pulse compression radar limit the radar's sensitivity and hence its ability to map internal layers close to the bed. A complementary-coded pulse radar is proposed to be developed and applied to map the internal layers near the bed.

Short pulses with high peak power are needed for both long-range detection and fine range resolution. It is difficult to generate high-peak power pulses. For this reason, the technique of pulse

compression is used, in which long coded pulses are transmitted and received pulses are compressed (decoded) to obtain short pulses to obtain fine resolution. The pulse compression can be implemented by using a digital matched filter. An artifact of pulse compression is range sidelobes that extend over a duration equal to the time duration of the long pulse on both sides of the compressed pulse main lobe. The range sidelobes of strong ice bed echoes will mask the returns from internal layers near the bed. Complementary codes introduced by Golay are therefore employed to eliminate or reduce the sidelobes so that the internal layers near the ice bed can be detected. The sidelobe cancellation or reduction could be achieved with complementary codes because the autocorrelation function of each code has a main lobe located at the center, and the sidelobes of two codes are opposed each other so that when summed together the sidelobes are cancelled and the peak of the main lobe is doubled.

I have developed a simulation model with ADS to verify side lobe cancellation for the ideal case and to study the effects of signal waveform phase shift and amplitude imbalance that may be caused by hardware on the side lobe level. I also have constructed a radar using laboratory test equipment to study the performance of side lobe cancellation with complementary coded pulses. Based on preliminary computer simulation and laboratory experiment results, the amplitude imbalance of the signal waveform would be the challenge in the radar development. I will develop a prototype of a complementary-coded radar according to the simulation, experimentation and experience from previous ice radar designs and developments. Measurements can be made in the laboratory with the prototype to decide the signal distortion and peak side lobe level at each stage of the radar so that calibration algorithms can be developed. For instance, for linear components, the calibration may be achieved by finding their transfer functions. Finally, the integrated radar will be taken to ice core sites such as GISP and GRIP in Greenland and the new deep WAIS core site in Antarctica to carry out field tests. A well-known target is to be chosen as the calibration target to identify the system corrections and then apply the corrections to other targets to map the internal layers near the ice bed. The whole system will be evaluated by carefully analyzing the data from field tests.

The outcome of my work will be a radar capable of mapping the ice layers near the ice bed with side lobes 60 dB below the main lobe. The ice data collected by the radar will help the glaciologists to make more accurate estimations of the contribution of polar ice sheets to sea level rise. This will help NASA to achieve its objective to improve remote sensing technology and capability and to fulfill its mission to understand and protect our home planet.

Lipscomb, Monica The University of North Carolina at Chapel Hill

Urban Landscape Patterns: Impacts on Hydrologic Processes and Nitrogen Pollution

I propose to examine the impact of neighborhood design on stormwater runoff to streams with the policy aim of reducing flash-floods and pollutant transport to receiving water bodies. For a range of rainfall conditions, I will investigate the cumulative impacts of location and spatial arrangement of impervious surfaces on stormwater flows within rapidly urbanizing suburban watersheds near Baltimore, MD. While many scientific studies have described the ecological impact of increasing imperviousness, little has been discerned regarding impacts of location and pattern of development; as a result, no spatial guidance is included in stormwater planning manual, TR-55. Equipped with a background in urban planning and geographic skillsets, including hydrologic modeling and satellite image analysis, I intend to fill this gap in planning knowledge by:

*Determining advantageous location and design of neighborhoods to reduce surface runoff;

- *Developing pattern metrics to apply to satellite imagery or site development plans to predict runoff and nitrogen pollution, and target sensitive areas for preservation or mitigation efforts;
- *Developing improved estimates of soil moisture based on remotely sensed data;
- *Enhancing our understanding of landcover impacts on water cycle disruptions and effective water management strategies;
- *Determining whether pattern of development can compensate for forest area loss.

Upon successful completion of this research, I will complete and defend my dissertation in geography, and publish several refereed journal articles. Upon graduation, I intend to become a professor, continue my research at the interface of human and environmental systems, and inspire the next generation of scientists to carry out policy-relevant urban ecological work.

Methods:

To examine the advantageous neighborhood designs for reducing runoff:

- *I will generate synthetic landcovers with varying locations and arrangements of impervious surfaces, and evaluate each scenario with a hydrological model to determine the runoff and nitrogen loads under varying rainfall conditions.

- *Pattern metrics will be applied to quantify the configuration of computer-generated landcover arrangements.

- *Statistical analyses will be used to discern relationships between the pattern metrics and the modeled outcomes of these varying landscape scenarios.

- *To develop pattern metrics to target hydrologically sensitive areas:

- *I will apply pattern metrics to classified Emerge and Landsat imagery and compare their correlation with measured stream discharge and nitrogen runoff data.

To improve estimates of soil moisture:

- *A combination of the multi-resolution valley bottom flatness terrain index and the temperature vegetation dryness index will be calculated using a suite of remotely sensed datasets: LiDAR DEM, MODIS, ASTER, and AMSR-E. These indices will be used to estimate the influence of subsurface infrastructure on soil moisture fluctuations in urban environments.

Significance to NASA:

This research addresses NASA Earth Science objectives by examining how water cycling processes change in urbanized areas and the associated consequences. Nitrogen pollution triggered by these water cycle disruptions stimulate algal blooms in coastal estuaries, which adversely effect water quality, animal and plant communities, local economies, and human health. Thus, researching solutions to flash-flooding and nonpoint source pollution in urban areas holds great potential societal benefit. This research will provide a basis for using land cover data to characterize shifts in the urban water and energy cycle. The pattern recognition metrics developed in this study can be applied to satellite imagery to estimate water fluxes in urban environments and stream response to land cover

changes. The resulting metrics and neighborhood design recommendations can be used by policymakers for water management applications and advanced stewardship of Earth's water resources.

Loomis, Bryant University of Colorado at Boulder
Development of a Follow-On Gravity Mission to GRACE

The goal of this investigation is to help develop a follow-on gravity mission to GRACE and evaluate its scientific performance. Such a mission would build on and improve the results of the current Gravity Recovery and Climate Experiment (GRACE). In October 2003, work began at the University of Colorado at Boulder and Ball Aerospace Technologies Corp. to develop an interferometric laser ranging system. This highly accurate ranging system will significantly improve the resolution to which the Earth's gravity field can be recovered from a satellite mission similar to GRACE, thus benefiting many areas of Earth systems research. The proposed work seeks to perform a full simulation of the follow-on mission and analyze its ability to recover the time-varying gravity field.

The GRACE measurements are used to estimate the Earth's gravity field in 30-day increments to a spatial resolution of ~400 km. The monthly gravity field estimates are used to study temporal mass variations on global and regional scales. Knowledge of the Earth's time-varying gravity field is beneficial to many areas of scientific research, including hydrology, oceanography, glaciology, geodesy, solid Earth science, and orbit determination.

One of the limitations to the spatial resolution of the estimated gravity field is the noise of the satellite-to-satellite ranging instrument. GRACE employs a microwave ranging device with an accuracy of ~1 micron/s. The interferometer will be capable of determining the range-rate to an accuracy of ~1 nm/s. The goal is that a satellite gravity mission equipped with the interferometer would improve the spatial resolution from ~400 km to ~100 km for 1 cm water equivalent accuracy. The ability to model the time-dependent variations in the gravity field with an improved spatial resolution will enable new achievements in each of the mentioned areas of research.

Our team has developed the error budget for the interferometer with laboratory testing of the instrument. To date, simplified simulations of a follow-on mission have been performed considering only the instrument noise. These results show an approximate three order of magnitude reduction in the spherical harmonic errors as compared to GRACE.

It is necessary to perform a full simulation of the GRACE follow-on mission in which all significant sources of error are considered. For this a regional gravity estimation technique will be used. This technique is advantageous for many reasons. Specifically it is less computationally intense than the numerical method where a full set of spherical harmonics is estimated. This will allow the gravity field errors to be estimated to a spatial resolution of 100 km. Simulations will be performed using GEODYN, the orbit determination software package provided by Goddard Space Flight Center.

Currently, members of the GRACE Science Team believe that the largest source of error to the GRACE mission is temporal aliasing. Aliasing is caused by un-modeled short period gravity variations due to ocean tides, atmospheric pressure, and other effects. These short period signals alias into the monthly gravity field estimates provided by the GRACE mission. The extent to which the results are affected is dependent on how well these processes can be modeled and removed from the signal, and how much data is needed to generate a gravity solution. It will be necessary to investigate how temporal aliasing would affect the results of a GRACE follow-on mission and whether the use of

the regional estimation technique could mitigate its affects.

The work will include an evaluation of how variations in the orbital parameters affect the performance of a follow-on mission. Also, an investigation into how the GRACE follow-on mission will benefit Earth systems research will be performed.

Loughner, Christopher University of Maryland College Park

How Do Changes to the Urban Environment Affect Precipitation and Air Quality?

Objective:

The proposed project will answer the question, "How do changes to the urban environment affect precipitation and air quality?" A regional model and ground-, aircraft-, and satellite-based observations will be used to address the following four questions:

Are weekday/weekend differences in aerosol/trace gas emissions evident in satellite measurements of aerosol and trace gas concentrations?

What is the effect of these differences on air quality and precipitation distribution?

Are model calculated changes to these distributions consistent with ground, aircraft, and satellite measurements?

How sensitive are air quality and precipitation to land surface characteristics, especially the amount and type of tree cover?

NASA Aura, Aqua, and Terra satellite data and ground based observations will be used to determine if there are weekday/weekend statistical significances in aerosols, trace gases, and precipitation patterns. Weather Research and Forecasting model with integrated chemistry (WRF-chem) simulations of precipitation and air quality events in an East Coast city will be performed and evaluated with in-situ, satellite, and ground based observations. Additional simulations will be performed with altered anthropogenic emissions and added tree species to investigate how these changes in the urban environment affect precipitation and air quality.

Method:

The OMI, TES and MODIS space based instruments and ground based observations will be used to investigate if there is a weekday/weekend effect of air quality and precipitation. WRF-chem simulations for precipitation and air quality events for an East Coast city will be performed with (1) weekday anthropogenic emissions and land surface coverage, (2) weekday anthropogenic emissions with more trees planted in the city, (3) weekend anthropogenic emissions and current land surface coverage, and (4) weekend anthropogenic emissions with more trees in the domain. Multiple simulations with added tree species in the domain will be performed to represent different types of US tree species. Land surface characteristics in the modeling domain will be adjusted to account for added tree species in the domain. The WRF-chem simulation with standard land surface coverage will be evaluated with NASA satellite, ground based, and aircraft observations. Air quality and precipitation distributions in and downwind of the city of interest will be compared for each of these simulations.

Significance:

Urbanization is increasing throughout the globe. A change in precipitation rates downwind of a city may affect humans and the hydrologic cycle. Also, changes in anthropogenic and biogenic emissions may have health impacts. The proposed project is in-line with the NASA mission statement "to understand and protect our home planet" by learning how humans change the hydrologic cycle and air quality in and downwind of cities due to changes in the urban environment.

Maue, Ryan Florida State University

Coupled Atmosphere-Ocean Dynamics of Southern Ocean Cyclones

Southern Ocean cyclone evolution from an observational and forecasting standpoint is poorly understood on a case-to-case basis and in term of interannual variability. Furthermore, little is known about the impact of air-sea interactions on non-tropical systems especially in the Southern Hemisphere (Ren et al. 2004). This project aims to better understand the dynamic interactions between cyclones and the ocean surface including transfers of momentum, heat, and moisture (through sensible and latent heat fluxes) that lead to a distinct mature cyclone structure. It is hypothesized that surface fluxes during early extratropical cyclogenesis serve as a critical forcing mechanism leading to a bifurcation in cyclone structure: cold-core or warm core seclusion. It is the latter, warm-core seclusions, which undergo extreme intensification, develop hurricane force winds and deep central pressures, and large areas of intense rainfall. Just as tropical cyclones are critically important to the poleward transfer of heat and moisture, the meridional transfers of heat and moisture associated with Southern Ocean warm seclusion cyclones are as well, but have not been quantified explicitly or put into the perspective of interannual variability.

This project will involve both numerical modeling experiments and considerable use of NASA satellite remote sensing observations both for verification and analysis. The PI in this research has had considerable experience with mesoscale modeling of both tropical and extratropical cyclones as well as the utilization of QuikSCAT surface winds, AMSU radiances, and sea surface temperature (SST) observations. These observational tools are essential to calculating accurate surface fluxes (Bourassa et al. 2005) and forcing the ocean component of a coupled mesoscale model (i.e. Morey et al. 2005). The PI also has experience with singular vector (SV) decomposition techniques (Maue et al. 2005) that identify optimal growth structures along a forecast trajectory. These optimal perturbations have not been investigated with respect to the bifurcation of cyclone structure during early cyclogenesis.

Minson, Sarah California Institute of Technology

Combined InSAR and Seismic Studies of Rupture Dynamics and Fault Zone Rheology

I propose to use geodetic imaging and seismic data from large earthquakes to study anelastic deformation in Earth's upper crust. Faults are themselves anelastic features, and slip surfaces are generally surrounded by damage zones. It is not known how and when these damage zones form. Preliminary investigation of the 1992 Landers earthquake reveals evidence of near-fault deformation which may be the result of anelastic processes. We will develop tools to combine multiple data sets to both study the deformation field from large earthquakes and interseismic strain as well as to improve the near-fault accuracy of current space imaging techniques. Our goal is to first identify deformation in damage zones, and then to determine whether such deformation is due to elastic strain on preexisting weaknesses or new anelastic deformation.

Nicholson, David University of Washington

Combining Altimetry, Scatterometry and Ocean Color with In Situ Seaglider Measurements to Quantify and Investigate Biological Oxygen Production

We propose to determine carbon export, the marine biological pump, remotely using a combination of satellite data products and in situ measurements made by Seagliders. This approach will first be demonstrated at the Pacific Ocean time series site near Hawaii where Seaglider data has provided a 4-D field of oxygen (O₂), temperature (T) and salinity (S) in a 50 km by 50 km by 1000 meter deep study volume over a period of a year. Quikscat winds and XX surface currents will be used in conjunction with Seaglider data to drive circulation and mass fluxes of O₂, T and S in a surface ocean model. The model results will be compared with TOPEX/Poseidon and ERS altimetry along with MODIS ocean color to relate ocean color to export production and investigate the importance of mesoscale variability in driving biological oxygen production.

Perring, Anne University of California Berkeley

On the Effects of Organic Nitrate Formation on Regional and Global Ozone and Nox

NO_x (NO + NO₂) is an important component of photochemical smog and a major precursor to ozone. In parallel with its role in O₃ production, NO_x undergoes reactions to form peroxy nitrates (ΣPNs), alkyl and multifunctional nitrates (ΣANs) and HNO₃. These higher oxides can be transported on a continental to global scale, convert back to NO_x and lead to ozone production in far removed locations. Alternatively, they can be removed from the gas phase through deposition to the surface or accumulation on aerosols. A thorough understanding of the cycles by which oxidized nitrogen is transformed and transported on both the regional and global scale is essential to accurate atmospheric models and to the enactment of sound environmental policies and regulations concerning air quality, especially those aimed at controlling tropospheric ozone. Also, a mechanistic model capable of explaining global NO_x is essential to the interpretation of OMI and SCHIAMACHY satellite measurements.

There has recently been increased interest in the production of ΣANs as they have been observed to be a much larger portion of NO_y (NO_y = NO_x + ΣPNs + ΣANs + HNO₃ + HN03 + ...) than previously thought. Also, hydroxy-alkyl nitrates (a subset of ΣANs resulting from reactions between alkenes and OH in the presence of O₂) are predicted to be very water-soluble and thus could represent a reactive nitrogen sink of comparable importance to that of HNO₃. The proposed research focuses on the use of airborne field data to help us understand the role of ΣANs in global and regional ozone production and in the NO_y budget and aims to address the following questions:

During the summer of 2004 observations of NO₂, ΣPNs and ΣANs were made aboard the NASA DC-8 aircraft as part of a two-phase experiment known as INTEX-NA. NO₂ was measured using Laser Induced Fluorescence (LIF). ΣPNs, ΣANs and HNO₃ were detected through thermal dissociation (TD) to NO₂ and a companion radical followed by LIF. These measurements represent the first extensive characterization of total alkyl nitrates in the free troposphere. Comparisons were made between these observations and model results of vertical AN profiles. The model agreed reasonably well with the observations in the boundary layer but was an order of magnitude low in the free troposphere. Correlations between total alkyl nitrates and other products of hydrocarbon oxidation, such as formaldehyde, were used to place constraints on alkyl nitrate yields in the boundary layer.

Further measurements will be made during INTEX-B, the second phase of the experiment. These measurements will allow us to evaluate the role of ΣANs in global transport of NO_x and NO_y and the effect of their formation as a chain termination event in the O₃ production cycle.

Peterson, Markus Michigan State University

Integrating Remotely-Sensed Imagery and Social Surveys for Sustainability: The Case of US/Mexico Borderlands

This project will evaluate the effects of NAFTA on primary productivity and land use in the Lower Rio Grande Valley (LRGV; along the Texas/Mexico border), discover publicly perceived threats to sustainability, identify key attributes associated with public participation in land use planning, and model spatio-temporal dynamics of human-environment relationships under different policy scenarios. To achieve the objectives, I will use systems modeling to integrate remotely sensed data, household survey results, government records, and U.S. census data. The systems model will include statistical models of social processes and landscape changes. Results will provide information for improving environmental sustainability, democracy, policy, and quality of life for people in the LRGV. Findings should facilitate identification of priority areas for land acquisition to protect endangered species, and explicate linkages between social and environmental systems in trans-boundary contexts. Finally, the systems model will facilitate scaling up the project to support national and global decision making in similar trans-boundary contexts.

Racoviteanu, Adina University of Colorado

Remote Sensing, GIS and Field Techniques for Studying Glacier Changes in the Indian Himalayas: A Multi-Scale Approach Using ASTER Data

Glaciers in mid-latitude areas of the world are important for water resources and sensitive indicators of changes in climate. There is a paucity of field-based measurements of glacier mass balance in high-mountain areas of Asia because of the difficulty of conducting field campaigns in rugged terrain, lack of logistical support and political or cultural conflicts. This limits our understanding of the alpine glacial response to climate variability. Remote sensing data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument shows promise in filling existing gaps in field-based glacial measurements. A multi-scale approach will be used to test the suitability of ASTER images for glacier change detection from the basin scale to the regional scale in the Western Indian Himalayas. Specific objectives of the proposed research are: 1) to use a combination of remote sensing and traditional glaciologic methods to estimate glacier mass-balance at the Chhota Shigri glacier; 2) to construct an ASTER-based geospatial glacier inventory that will facilitate analysis of glacier changes at the regional scale; and 3) to understand spatial patterns of glacier fluctuations in relation to regional climatic variability across the entire Himalayan mountain range.

ASTER imagery will be used to extract digital elevation data using automated stereo auto-correlation procedures and ground control points, and to produce glacier outlines using various image classification algorithms. Geographic information systems (GIS) tools will be used to extract key glacier parameters (slope, aspect, length, area-elevation distribution curve, equilibrium line altitude and accumulation-area-ratio). At the regional scale, I will test the hypothesis that within the same climatologic region, the rate of glacier change is a function of glacier size, area-altitude distribution, orientation, slope and debris-cover. At the mountain-range scale, I will test the hypothesis that different monsoon patterns in the Western and Eastern Himalayas govern the fluctuations of glaciers in these two regions. Selection of the Indian Himalayas by a joint international team of scientists to conduct long-term glacial research will provide the opportunity for logistical support and new collaborators.

The proposed research relates directly to NASA's goal of understanding the changing Earth's climate system and its implications. In the short-term, climate-induced changes in glacial melt may provide a surplus of water at down-gradient locations, but in the long-term, increased glacial melt will lead to depletion of the amount of freshwater, posing a threat for severe water shortages to hundreds of millions of people. Second, water from glacier runoff is the main source for hydroelectric power generation in the Himalayas. Changing water resources will pose the need for planning and operation of new mini and micro hydroelectric stations. Third, climatic changes may increase the potential for glacier-related hazards such as glacial lake outburst floods (GLOFs), ice avalanches and debris flows.

The present research seeks to understand these glacial responses by (1) providing established methods to detect glacier changes in a timely manner using remote sensing; (2) monitoring the evolution of glaciers and the formation of new pro-glacial and supra-glacial lakes; (3) providing the scientific community with new glacial datasets stored in the GLIMS Glacier Database at the National Snow and Ice Data Center in Boulder, CO, that will ensure continuous monitoring of glaciers worldwide.

Reifel, Kristen University of Southern California

Investigating the Role of Stormwater Runoff on Coastal Phytoplankton Community Structure in Southern California

Urbanization within the Los Angeles region has resulted in increased stormwater inputs to the coast. Stormwater runoff creates distinct plumes that are easily detected by their low salinity and high turbidity signatures. Several aspects of these plumes have been studied, such as increases in contaminants and human pathogens, but few studies have attempted to directly test the links between stormwater plumes and changes in the phytoplankton community. Shifts in the phytoplankton community have great potential to alter the functioning of coastal foodwebs. In addition, it is unknown how long and far these stormwater plumes may travel once they are formed, thus their effects may extend well beyond their local discharge region. By using a combination of in situ measurements and satellite imagery, I will investigate the links between stormwater plume formation and shifts in phytoplankton community structure, as well as the spatial and temporal extents of plumes and their effects.

Ruddell, Benjamin University of Illinois at Urbana-Champaign

Data Mining of Co-Evolving Variables for Understanding Multi-Scale Dependencies in Remote-Sensing Data

Ecology, hydrology and climate form a complex system where the feedbacks and interconnections between parts mean that small and seemingly isolated changes can have significant effects on the whole system. Recognition of the complexity of natural systems coincides with breakthroughs in network theory, which provides the theoretical framework needed to quantify the structure and behavior of complex systems. This research hypothesizes that data-driven methods can be used to derive ecological-climatic feedback networks and simulate the complex nonlinear dynamics of those networks. Entropy-based information metrics methods will be used for identification of relationships from this spatio-temporal, eco-climatic data milieu obtained from satellite observations. The objective of this research is to develop entropy-based data mining/knowledge discovery techniques using satellite remote sensing data to identify dependencies between spatially distributed co-evolving variables that will allow us to construct the network of dependency relationships and model their dynamical evolution.

Saenz, Benjamin Stanford University

Multi-Decadal, Multi-Sensor Investigation of Primary Production Within the Antarctic Ice Pack

Increasing evidence suggests the yearly growth and decline of polar sea ice, combined with biological cycles of carbon uptake by photosynthetic organisms, may allow the polar oceans to act as sinks for atmospheric CO₂. Under the rectification hypothesis (Yager et al. 1995), biological production of organic carbon in the sea ice and water column contributes to undersaturation of CO₂ in surface waters of polar seas. This, combined with the capping action of sea ice, traps CO₂ within the water column, effectively removing this greenhouse gas from the atmosphere. Using modeling and remote sensing tools, Arrigo and van Dijken (submitted) recently confirmed that areas of the Southern Ocean indeed act as sinks for CO₂ via this mechanism. However, the contribution of sea ice algae to CO₂ drawdown during the approximately eight months of ice cover in these regions is not known.

Sea ice represents one of the largest ecotypes on earth, seasonally covering one sixth of the world's oceans. Sea ice algae, although subjected to dramatic environmental variation, can be very abundant and are an integral component of polar marine ecosystems. As sea ice algal growth is primarily regulated by nutrients and salinity gradients in the ice, the richest sea ice communities typically form on the bottom of ice floes where exchange of seawater is greatest. Algae contained in the ice play a role in carbon sequestration by reducing CO₂ in surface waters before the sea ice retreats and through bursts of export production as the ice pack melts. Furthermore, seasonal release of sea ice algae during melting may 'seed' the water column, thereby precipitating the annual bloom of phytoplankton in polar regions that sustains polar ecosystems and contributes the bulk of CO₂ drawdown.

We will develop a sea ice ecosystem model in order to investigate primary production in Antarctic pack ice, and to investigate the role of ice algae in the carbon budget of the Southern Ocean. Arrigo (1997) used an ecosystem model to estimate annual production that was forced by remotely-sensed environmental data, however recent advances in sensor technology will allow us to more accurately estimate the variability in the ice environment. We will make use of the AMSR/E sensor suite on the AQUA mission, using derived products such as ice type and thickness, snow over ice thickness, temperature at the snow-ice interface, and ice movement vectors in order to characterize the habitat available to ice algae. Known properties of sea ice physics allow prediction of temperature, salinity, and available nutrients and solar radiation based upon these satellite measurements. These new measurements will allow our model to incorporate the bottom-ice community, which is able to reach high rates of production and to potentially effect CO₂ drawdown. To investigate the period before the AQUA mission, we plan to use more simple formulations to extrapolate ice variability using the previous generation SSM/I sensor data, thereby increasing our environmental ice record to almost two decades. Using the ice ecosystem model will allow us to examine interannual and inter-decadal trends in Antarctic sea ice primary production, and how it is related to documented rapid changes in the Antarctic climate.

Development of our sea ice ecosystem model fits within the Earth Science focus of the NASA Science Mission Directorate. Through use of sensors on the AQUA mission, a sea ice ecosystem model will improve understanding carbon flux in an area with the potential to be one of the largest sinks of anthropogenic CO₂. The projected rise in Antarctic temperature due to global warming is expected to increase precipitation over the region. By adjusting environmental parameters such as snowfall and ice growth rates to fit these predicted changes in the Antarctic climate, we hope use this

model to forecast how climate change will impact sea ice primary production and related carbon flux in the Southern Ocean.

Scheidt, Stephen University of Pittsburgh

Using Multi-Sensor Data Fusion to Estimate Dust Aerosol Composition and Its Affect on Longwave Radiative Forcing

This research proposes a unique remote sensing approach which combines data from multiple NASA sensors in order to better understand a forcing on the Earth's radiative energy budget. Specifically, the geologic processes operating in eolian (desert) systems are examined in its impact on the atmosphere. This directly applies to the NASA goal: "to better understand the Earth system and apply Earth system science to improve prediction of climate, weather, and natural hazards." This work is designed to address key questions in the focus area of Atmospheric Composition in the ESE Research Strategy Report in order to improve the predictive ability of assessment models on climate impact and air quality. It is known that changes in the flux of dust aerosols (specifically silicate minerals) from the central Sahara Desert affect the variability of the radiant energy budget. Arabian dust can cause reduced temperatures in Australia as well as the northern hemisphere. Other researchers have shown regional warming effect over the Sahara due to a dusty atmosphere which impedes the longwave infrared radiant energy flux (Zhang and Christopher, 2003). This variability of radiant energy over the Sahara and the North Atlantic caused by dust emissions and their transport could act as a forcing for local weather as well as increasing the possibility of western Atlantic hurricanes. Although there are numerous studies examining the larger scale patterns of weather and even dust plumes, very few studies have been conducted into the affects at smaller spatial scales. This research proposes to use a combination of NASA data sets and data fusion techniques to address specifically the atmosphere - land surface interaction. First, the spatial distribution and mineralogy of the dust source regions must be documented for known source regions. With ASTER, we have the ability to map the composition and radiative properties at high spatial and spectral resolution over large areas of the Sahara. Quantitative calibration techniques have been developed which allow for numerous 60 km ASTER scenes to be mosaiced, radiometrically balanced, and normalized (Scheidt et al., 2006). The result is a seamless, self-consistent map of surface emissivity, from which the composition, quantity, and temporal trends in silicate dust emission can be modeled. Only ASTER has the spatial and spectral resolution in the TIR region to enable this level of quantification. Second, the larger-scale spatial and temporal variations of dust composition in the atmosphere must be addressed. Using data from TES, CERES, MODIS and MISR, the dust cloud and radiant energy flux will be tracked over time and with respect to dust emission source location and composition. The fundamental hypothesis will be address how dust sources have different radiative properties (emissivity), and once emitted into the atmosphere how these will affect the variability of the radiant flux of energy in the atmosphere.

Schiek, Cara University of Texas at El Paso

3-D Surface and Subsurface Deformation Modeling of Fuego Volcano, Guatemala Using ASTER, ERS 1/2, and Gravity Data

Fuego volcano, Guatemala has been erupting since 2002. Smoke, gas, and ash plumes, seismic activity, sporadic explosions, and lava flows have characterized this on-going eruption. I propose an investigation that will describe the deformation processes coupled with this eruption. This project uses two geodetic data sets to determine inflation and deflation rates of the Fuego volcano. Imageodesy using ASTER images will be used for determining horizontal displacements. InSAR using ERS data will be used to determine the vertical displacements. Using vector addition, the

horizontal and vertical displacements will be integrated to produce a 3-D surface deformation map of Fuego. These surface deformation maps will be compared to changes in gravity data (e.g. field measurements) in order to link surface deformation patterns to subsurface processes. This will be the first time InSAR and imageodesy will be combined to produce a 3-D surface deformation map.

Sheldon, Sage University of Maryland

Estimating North American Carbon Using ICESat Observations

NASA's Carbon Cycle and Ecosystems Roadmap has set as its highest priority the balancing of North America's carbon budget to facilitate carbon management in the coming decades. The Roadmap calls for the development and implementation of remote sensing technology and modeling to quantify biomass, carbon fluxes, and other phenomena to reach this goal. In particular, NASA has identified the need for better characterization of the 3D structure of vegetation to initialize carbon models and validate their outputs at policy-relevant spatial and temporal scales. The recent availability of consistent, global observations of land surface vegetation from the ICESat mission, along with other remote sensing data sets now allows for the creation of continental scale forest structure maps that will greatly improve carbon modeling efforts. The overall objective of this proposal is to quantify and characterize the spatial variability of forest structure, successional state, and biomass over the United States using ICESat, other remote sensing data, and United States Forest Inventory and Analysis (FIA) data. In particular it seeks to answer the following questions:

1. What is the relationship between ICESat observations and FIA forest structure data across the United States at various spatial scales?
2. How can ICESat data be fused with other remotely sensed data to provide finer resolution estimates of structure?
3. Can information on climate, soils, and topography be combined with structural data, such as canopy height, to infer successional state?

To answer these questions, the following research plan will be implemented. First, existing ICESat observations will be gridded at various scales to produce maps having mean height and variability for each grid cell. Next, the relationship between FIA summaries of biomass and ICESat heights will be developed. The second phase of this research will develop and use remote sensing fusion methods to produce finer resolution distributions of forest height to overcome the limited spatial coverage of ICESat data. In particular SRTM, passive optical, and multi-angle observations will be used for fusion exploration. Fusion results will be validated against high spatial resolution canopy structure maps produced by airborne lidar for various regions. The last part of this research will explore methods for using ICESat and fused datasets of forest structure to infer successional state. The covariation of heights with soils, climate data, and topographic position will be examined using decision trees and FIA summary data of age-class structure. The output of this research will be maps of height, biomass and successional state, not otherwise available, which will subsequently be used as part of other research to initialize a height-structured ecosystem model to predict carbon stocks and fluxes for the United States.

Sobolowski, Stefan Columbia University in the City of New York

Linkages Between North American Climate, Atmospheric Wave Dynamics and Land Surface Boundaries

Developing a clearer understanding of the means by which surface boundary forcings influence intraseasonal – interannual climate is essential for improving regional- hemispheric climate prediction. The objective of this study is to identify physically-based mechanisms by which snow anomalies over western North America (NA) may influence regional climate phenomena such as the Pacific North American (PNA) pattern and the North American Monsoon System (NAMS). The central hypothesis is that continental snow anomalies, surface orography and dynamic stationary wave dynamics combine to facilitate snow – climate linkages. Western NA is characterized by interannually variable snow cover and a large mountain chain that influences the quasi-stationary tropospheric waves that govern the regional climate of the western US and Canada. Previous research demonstrates that a similar combination of these features in Siberia initiates a teleconnection pathway relating autumn snow anomalies and the subsequent winter season phase of the Arctic Oscillation (AO). It is reasonable to hypothesize that analogous linkages occur in western NA. Atmospheric general circulation model (GCM) experiments with prescribed snow/ orographic forcings will be performed in conjunction with a complementary suite of snow/ orography forced regional climate model (RCM) experiments. Dynamical snow-climate linkages will be diagnosed and analyzed from these models using stationary wave modeling tools and statistical methods. Reanalysis and remotely sensed data sets will be similarly diagnosed in order to discern any hypothesized snow-forced climate signal from observed data; this to confirm and refine the model- based results. The novelty of the approach lies in the examination of atmospheric wave dynamics and orography as a means to discern the physical mechanisms involved in North American snow – climate linkages. By shifting from the traditional foci of land surface – atmosphere interactions (i.e. soil moisture thermodynamics) the proposed research offers a fresh perspective and will contribute towards improved predictions of regional climate variations. Further, the proposed research will benefit various sectors of society in addition to contributing to NASA’s earth science research mission objectives.

Swan, Chantal The Regents of the University of California

Cycling of Colored Dissolved Organic Matter in the Open Ocean: Application of Photolysis Measurements to Global Satellite Observations

The proposed work is an integration of laboratory process studies with global remote-sensing data concerning open-ocean colored dissolved organic matter (CDOM). UVR photolysis of CDOM drives the global ocean surface distribution of CDOM seen from satellite. Light absorption by CDOM dominates UVR flux in the upper ocean, moderating photobiological processes and photochemistry of trace gases. Characteristics of CDOM relating to light exposure are observed in the ocean interior, and a quantitative understanding of photolysis will advance the potential utility of CDOM as a remotely-sensed ocean tracer. I propose experimental determinations of apparent quantum yield of CDOM photolysis on open-ocean samples and immediate application of these measurements to global CDOM data derived from NASA ocean color. Through this method, rates of photolytic loss, net production by bioremineralization, and seasonal entrainment of CDOM will be quantified such that an annual mixed layer budget for open-ocean CDOM is established.

Swatantran, Anuradha University of Maryland College Park

Mapping Habitat for the Ivory-Billed Woodpecker and the California Spotted Owl: A Multi-Sensor Fusion Approach

Multi-sensor fusion is a powerful and promising approach towards optimizing existing remote sensing capabilities for habitat mapping, one of the important research areas in NASA's Carbon and Ecosystems Roadmap. This is because habitat structure is multi-dimensional and none of the available remote sensing data can completely derive it. Lidar data provides this vertical forest structure required for habitat studies but is sparse and expensive to acquire over large areas. An appropriate strategy would be to use multi sensor fusion of Lidar with other easily available and affordable satellite data to derive forest structure.

The primary goal of this study is to explore multi sensor fusion for mapping potential habitats for the Ivory-billed Woodpecker and California Spotted Owl. These objectives will be achieved by answering the following research questions

- (1) How can Lidar, radar, hyperspectral, multi angle and other data be fused to derive forest structure important for habitat characterization? (e.g. canopy height, foliar diversity, biomass, canopy cover and functional type)
- (2) What is the efficacy of operational approaches to habitat characterization using currently available space-based sensors?
- (3) How robust are the fusion methods for habitat mapping for the two species of birds in dissimilar environments?

Existing and new methods of spatial and statistical modeling will be applied to fuse Lidar with multispectral, hyperspectral, and radar data. This study will also assess the efficacy of operational approaches to habitat characterization using currently available space based sensors. Fusion results for the two dissimilar bird habitats will be analyzed for effectiveness and robustness of methods used. Multidimensional habitat structure maps from this study are expected to aid further discovery efforts for the woodpecker and guide conservation activities for the spotted owl.

Two sites have been selected for this study. The Arkansas Ivory-billed Woodpecker habitat and the Sierra Nevada California Spotted Owl habitat. Available multispectral data like Landsat ETM, SRTM radar data, AVIRIS or Hyperion hyperspectral data, multi angle MISR and AIRMISR, ICESAT and LVIS Lidar have been acquired. The lower Mississippi habitat area for the woodpecker will be acquired and flown this June as a part of a cooperative experiment between the University of Maryland, the US fish and Wildlife Services, the USGS and NASA.

This study is expected to result in improved understanding and development of fusion techniques of Lidar with other available remote sensing data. In particular it will help define possible operational approaches for mapping habitat over large areas using existing NASA space-based data, as well as ground and commercial remote sensing data.

The results of the study are expected to be helpful to researchers/ecologists working on mapping and conserving habitats for the Ivory billed Woodpecker by providing habitat information at various scales. Detailed forest structure maps from Lidar would be provided as well as broad scale landscape level forest structure maps using multi sensor fusion.

Toro Farmer, Gerardo University of Southern California

Monitoring Sediment Resuspension in Coral Reefs and Seagrass Beds with Modis and ASTER Sensors

High concentrations of resuspended sediments reduce the survival of species inhabiting coral reefs and seagrass beds all around the world. I propose to demonstrate how MODIS moderate resolution and ASTER sensors can be applied to monitoring such threats in a case study of the Northern Lagoon of Bermuda Island. Specifically, with the support of the Bermuda Biodiversity Project, Bermuda Zoological Society, I propose to 1) use in-situ instruments for measuring inherent and apparent water column optical properties, as well as suspended sediment concentrations, at different distances from navigation channels and at different times of the year; and 2) to integrate remotely sensed measurements in order to develop an algorithm for mapping and investigating spatial-temporal variations in the amount of resuspended materials threatening coralline organisms. This work will facilitate improve future monitoring and management of coralline ecosystems in the study area, as well as in other coastal ecosystems.

Villarini, Gabriele University of Iowa

Propagation of Uncertainty in Rainfall Estimates from Remote Sensors in Spatio-Temporal Hydrologic Models

Worldwide, many catastrophic events are triggered by rainfall. Prediction of these rainfall-induced events, which could ultimately save many lives and minimize damage, requires accurate estimation of rainfall quantities with sufficiently high global resolution in space and time as well as models of the transformation of rain water into flooding, debris flow, landslides, and other water cycle processes. Global remote sensing observations of rainfall and other land and atmospheric processes collected using satellite platforms offer an unprecedented opportunity to develop and study predictive models of the water cycle at global, regional, and local scales. The key objectives of this proposal are the investigation and modeling of the uncertainties associated with the estimation of rainfall by remote sensors and their propagation through spatio-temporal hydrologic models.

Despite vigorous research on the use of satellite and radar remote sensors for rainfall estimation, several key questions regarding the accuracy of these estimates remain unanswered. Quantitative use of satellite-based rainfall estimates in predictive models of rainfall-induced hazards, as well as in other processes of the hydrologic cycle, requires an assessment of the uncertainty of these estimates. Only then will users of the satellite be able to provide information that will enable optimal decision making in risk-based frameworks. Additionally, while prediction of stream flow, flooding in particular, may not be sensitive to errors in rainfall estimates in some situations, it may be highly sensitive to even small errors under other circumstances. Furthermore, some situations such as flash flood prediction require high resolution rainfall estimates in space and time over fairly small spatial scales. For these situations, the satellite-provided rainfall may have to be disaggregated in order to accurately make predictions, which requires use of space-time models of rainfall. The previously underexamined effects of uncertainty in satellite-based estimates on the performance of these models need to be studied extensively.

The general strategy for achieving this proposal's objectives necessitates the use of observations that would "close the scale gap." Ground-based weather radars provide observations of rainfall with much higher space and time resolution than satellite systems. However, radar observations of rainfall are also subject to uncertainties that require more extensive investigation and mathematical description. Such modeling requires use of in-situ direct observations of rainfall with research grade specialized networks of rain gauges and disdrometers. Several years of data from these measuring

devices have been organized and are ready for evaluation. Combined analysis of rain gauge, radar, and satellite data will lead to mathematical models of the uncertainties of satellite-provided rainfall maps. The resulting description will account for the effects of different rainfall regimes and space and time scales, allowing the propagation of uncertainty through hydrologic models to be investigated via simulation experiments.

Because NASA recognizes the importance of rainfall estimation, as evidenced by the Tropical Rainfall Measuring Mission and Global Precipitation Measurement satellites, the proposed study is fundamentally important for NASA and its Earth Science program. However, quantitative use of the satellite-based observations on ground-level rainfall hinges on our ability to quantify the accuracy of these observations. This has been a difficult challenge because any study addressing these issues requires background in numerous disciplines including atmospheric and hydrologic sciences, statistical and mathematical modeling, and informational technology. The proposed study offers a concrete and important step towards comprehensively addressing the propagation of uncertainty in rainfall estimation from remote sensors.

Wawrzyniak, Geoffrey Purdue University

An Error Analysis of GNSS-R Derived Roughness Corrections to Salinity Retrievals from Passive Microwave Radiometry

This study will assess the utility of reflected Global Navigation Satellite System (GNSS-R) signals in ocean remote sensing. Specifically, it will evaluate the use of GNSS-R measurements for the correction of roughness effects in sea surface salinity (SSS) retrievals from passive microwave radiometers. Noisy GNSS-R waveforms, as would be collected by a low Earth orbiting receiver, coincident with brightness temperatures from a passive microwave radiometer, will be simulated. Retrieval algorithms previously developed for aircraft use will be modified to estimate the ocean surface slope statistics from these waveforms. These components will be integrated into a complete simulation of the GNSS-R measurement that will take in model wave spectra and truth SSS values and generate simulated, noisy, SSS retrievals (corrected for surface roughness). For comparison, a simulation of scatterometer-based roughness corrections will also be developed using identical input conditions. A Monte Carlo method will then be applied, in which the complete simulation will be run, generating ensembles of simulated SSS retrievals. Statistics for the SSS retrieval error could then be numerically computed from these ensembles.

The significance of the proposed work will be to evaluate a potential alternative, or a possible complement, to the scatterometer for meeting the very stringent requirement on microwave brightness temperature measurement. Findings of this study could impact the approach taken in future SSS missions. Since SSS affects the water and energy cycle, which in turn affects climate variability and change, this project addresses these two focus areas of NASA's Earth Science research.

White, Benjamin University of Maryland

Conservation or Degradation: The Impact of Land Cover Change on the "Outstanding Universal Value" of World Heritage Sites

The proposed research will provide an assessment of current natural, forested sites and will provide a methodology for their continued assessment. The research will develop and validate a remote sensing - based methodology for assessing the "state of conservation" for the world's forested heritage sites. The goal of the research is to utilize Earth observation systems to assess land cover

change in and around heritage sites and, in so doing, characterize the integrity of the Site's Outstanding Universal Value. The research follows three distinct steps: remote sensing methods and assessment, in-situ research and integration of results.

The key research questions to be addressed are:

- Based on remotely sensed observations, how is OUV being degraded in and around forested natural heritage sites?
- To what extent do in-situ findings validate or contribute to remotely sensed assessments of OUV degradation?
- Based on the above, what constitutes a comprehensive, scalable and reliable methodology for assessing OUV?

The NASA focus area for the research is Carbon Cycle and Ecosystems. The use of NASA Earth observing instruments for the conservation of heritage and the mitigation of degradation will further the NASA goal of "understanding and protecting our home planet" and better characterizing "change in terrestrial ecosystems of identified relevance".

Brief Summary:

The extent to which human systems impact terrestrial biodiversity is a hotly debated issue and one whose complexity we are only just beginning to fathom. It is apparent that increasing rates of species extinctions, degradation of ecosystem services and a decrease in overall biodiversity bear a direct relationship to the human alteration of the landscape. The Millennium Ecosystem Assessment confirmed this assertion, finding that the greatest cause of biodiversity loss was land cover conversion.

International agreements for the protection of species and habitats are one method we have developed to counteract the above trends. The UNESCO World Heritage Convention is one of the foremost such agreements. The Convention is designed to safeguard the world's most unique ecological and biological assets, yet there is a general lack of information as to its ongoing performance. In order to maintain confidence in the World Heritage Convention as a mechanism for the preservation and conservation of natural heritage sites, it is necessary to establish the effectiveness of the Convention in meeting its goals as outlined by UNESCO.

Based on in-depth site assessments, the proposed research develops a remote sensing methodology to examine trends in the land cover in and around heritage sites that may have altered the "outstanding universal value" of the site since its inscription in the Convention. Remote sensing is uniquely suited to this task due to its ability to characterize site trends and integrity over the long-term, the verifiability of findings and a relative independence from issues such as sovereignty which have traditionally proven detrimental to many in-situ efforts. The primary remote sensing inputs will be land cover change, fragmentation, fire occurrence and infrastructure development. The research will still draw upon input from managers and will require qualitative in-situ assessments of degradation levels. The proposed research will develop and validate a remote sensing - based methodology for assessing the "state of conservation" for the world's forested, natural heritage sites. The goal of the research is to utilize Earth observation systems to assess land cover change degradation in and around heritage sites and, in so doing, characterize the integrity of the Site's Outstanding Universal Value. The research follows three distinct steps: remote sensing methods and assessment, in-situ research and integration of results.

Xu, Li University of Utah

Integrating MODIS and TRMM Satellite Data with In-Situ Chinese Station Data to Study the Impact of Tibetan Winter Snow on Asian Summer Precipitation and Northern Hemisphere Atmospheric Circulation

The Tibetan Plateau plays important roles in determining the formation and variation of regional weather and climate in east and south Asia, as well as atmospheric circulation in the Northern Hemisphere in general. However, the study of climatic impact of Tibetan Plateau has been relatively limited in the past. This is partly due to lack of the remotely sensed observational data over the Tibetan Plateau, and also because of the difficulties in exchanging the data between Chinese and western scholars.

With this fellowship proposal, we plan to undertake a first research effort to integrate multi-year (2000-present) NASA MODIS snow cover and TRMM rainfall data with in situ Chinese station data, including the snow data from 60 Chinese ground-observing snow stations over the Tibetan Plateau and 2200 ground-based meteorological stations over Chinese continent, to achieve the following research components:

- 1) Evaluate the MODIS snow cover estimates using in situ Chinese snow data from 60 ground-based snow stations over the Tibetan Plateau.
- 2) Incorporate MODIS snow cover estimates and in situ Chinese ground-based snow station data to obtain a database with multi-year winter snow cover and depth over the Tibetan Plateau.
- 3) Integrate the obtained multi-year winter snow database with TRMM precipitation estimates (cover global tropics and sub-tropics) and 2200 ground-based Chinese meteorological station data to study the relationship between the Tibetan winter (November to February) snow cover and Asian summer (June to August) precipitation.
- 4) Assimilate the snow data into state-of-the-art Community Climate System Model (CCSM) to further study the impact of winter Tibetan snow cover on Asian summer precipitation. Specific attention will be paid to general circulation associated with Asian monsoon activities. In addition, we will further explore impact of Tibetan snow cover on the global atmospheric circulation in general. The possible relationship between Tibetan snow cover on Northern American atmospheric circulation will be specifically investigated.

It is anticipated the study from this proposed activities could fill gaps of our knowledge regarding to the weather and climate impact from the Tibetan Plateau.

Yin, Grace Northwestern University

Heterogeneous Organic Oxidation Reactions Relevant to Tropospheric Chemistry

Aerosols coated with unsaturated organic molecules can be oxidized by tropospheric ozone, influencing their cloud forming properties and surface chemistry. I propose to study oxidation reactions between ozone and tailor-made organic surfaces containing various olefins, specifically biogenic terpenes and their derivatives commonly found in the lower atmosphere attached to silica surfaces via amid coupling. I will characterize the surface-bound species using the surface-specific spectroscopy broadband sum frequency generation (SFG). By exposing the substrates to

atmospherically relevant ozone levels and tracking the surface reactions in real time, I will obtain kinetic, spectroscopic, and thermodynamic reaction parameters, including reaction probabilities (γ), that will help reduce the uncertainties currently associated with the role of aerosols in cloud formation and climate change. Furthermore, this work will yield a mechanistic understanding of heterogeneous atmospheric reactions on a molecular level similar to the level of accuracy now available in gas phase chemistry.

Zelinka, Mark University of Washington

Tropical Convection and the Distribution of Upper Tropospheric Relative Humidity

The sensitivity of the climate to changes in Earth's energy budget caused by rising concentrations of greenhouse gases represents one of the most important topics in Earth system science, and science in general. Even a relatively small radiative perturbation like that caused by increased carbon dioxide levels in the atmosphere can be strongly amplified by the presence of various feedback mechanisms in the climate system, the most important of which is the water vapor feedback. The bulk of Earth's energy emission to space occurs in the dry regions of the tropics, where air is gently subsiding. Numerous studies have shown that increases in relative humidity at upper levels in these regions cause a greater reduction in energy emission than increases at lower levels; thus more heat is trapped in the atmosphere when upper level relative humidity increases. Throughout the tropics, water vapor is brought to the upper atmosphere by moisture transport away from tall cumulonimbus clouds. Our primary objective in this study is to examine the relationship between the intensity of convection in these cumulonimbus clouds and the vertical distribution of relative humidity in the surrounding regions.

We will assess how different measures of convective intensity (e.g., precipitation rate, depth of convection, area of convection) are interrelated and how each individually affects the distribution of upper tropospheric relative humidity. Additionally, we will separate the changes in relative humidity into those due to changes in temperature and those due to changes in water vapor mixing ratio. We will also analyze these relationships in the context of different background environments (i.e., different regions of the tropical oceans).

To do this, we will use retrievals of column-integrated water vapor, cloud liquid water, and rain rate from the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) satellite and retrievals of water vapor mixing ratio, temperature, cloud fraction, cloud top temperature, and cloud top pressure from the Atmospheric Infrared Sounder (AIRS). Both instruments are on the polar orbiting Aqua satellite, which was launched on May 4, 2002. Using the entire period of observations from these instruments, we will determine statistical relationships between several measures of convective intensity and their individual effects on the vertical distribution of relative humidity in 10° by 10° regions in the tropics. Areas with precipitation rates above a certain threshold will be used as a proxy for areas of vigorous convection, and combinations of cloud liquid water with cloud top temperature or cloud top pressure will be used as proxies for the depth of convection. These, in addition to magnitude of rain rate are all valid measures of convective intensity. Simultaneous retrievals of temperature and water vapor from AMSR-E and AIRS give us a tremendous dataset from which to assess statistical relationships.

Understanding how the distribution of relative humidity in the tropics is affected by deep convection is imperative for understanding the energy budget of the tropics, and of the entire planet. Without this knowledge, great uncertainty will remain in the possible responses of the climate system to changes. At a time when the concentration of anthropogenic greenhouse gases in the atmosphere is increasing and significant changes in climate are evident, it is of critical importance to constrain the

magnitude of the water vapor feedback. This effort is made possible by the powerful set of tools that NASA has provided for observing the Earth. Through the knowledge gained in this study, uncertainties in models stemming from inadequate understanding of atmospheric processes can be reduced, thereby improving our ability to address climate change. Thus we will make progress in advancing NASA's mission to understand and protect our home planet.

Zhang, Li The Ohio State University

Understanding Dynamic Processes of Water Quality in Lake Erie from MODIS Time-Series Data

The availability of MODIS data, which have higher spatial resolution and the better spectral resolution than the SeaWiFS sensor, could improve the accuracy of measuring water quality in Lake Erie. In addition, the multiple spatial resolution (250 m, 500 m, 1000 m) and high temporal resolution (twice daily) image data for the Lake Erie area enables better retrieval of the temporal and spatial distribution of suspended sediments, algal blooms, as well as other containments in Lake Erie. It is promising to improve accuracy for retrieving water quality by using hierarchal spatial and spectral characteristic of MODIS data.

For Case 2 water, the optical properties of chlorophyll-a are affected by the coexistence of suspended sediment concentration, but covariation does not exist for suspended sediment concentration and chlorophyll-a. It is possible to improve the accuracy of retrieving the water quality, if both the suspended sediment concentration and chlorophyll-a concentration can be derived simultaneously by considering the optical affects from suspended sediment concentration when retrieving the chlorophyll-a concentration.

The overall goal for the proposal is to develop a model that is suitable for inland waters (Case 2 water) to predict suspended sediment and chlorophyll-a concentration and their distribution using MODIS data. The twice daily MODIS time series images will be utilized to map and analyze the spatial and temporal variation of suspended sediment concentration and chlorophyll-a concentration to understand the dynamic processes in Lake Erie. The research results will contribute to the understanding of recent increases in toxic algal blooms in the Great Lakes and for providing solutions to water quality control and management of the Great Lakes ecosystem.

Specific objectives include:

1. Examination of the existing MODIS algorithms/models in water quality analysis.
2. Development of an optimization model to simultaneously predict the suspended sediment and chlorophyll-a concentration.
3. Evaluation of the spatial temporal variation of water quality in terms of suspended sediment and chlorophyll-a concentration taking advantage of the spatial and spectral characteristics of the MODIS data.