Hurricane Field Experiment
Abstracts of selected proposals.
(NNH09ZDA001N)

For more than a decade, the NASA Convection and Moisture EXperiment (CAMEX) series of field campaigns have provided a wealth of new research findings into the genesis, intensity change, and 3-D multiscale structure of tropical cyclones in the Atlantic, Gulf of Mexico and Eastern Pacific ocean basins. The CAMEX sequence (CAMEX-3, 1998; CAMEX-4, 2001; TCSP, 2005; NAMMA, 2006) has also consistently provided a test-bed for new remote sensing technologies for satellite and aircraft platforms, retrieval algorithms, and predictive model developments. The scientific focus on intensity change is particularly timely in light of the current heightened era of Atlantic-basin storm activity and the continuing challenges of accurately forecasting tropical cyclone intensity. As part of ROSES 2008, NASA selected a team of investigators to use NASA satellite and field campaign data as part of a Hurricane Science Research Program, with the goal to conduct basic research on problems related to the formation and intensification of hurricanes.

Inherent to the topic of storm formation and intensification are questions related to the structure and evolution of clouds and precipitation and their links to the kinematic and thermodynamic characteristics of the initial disturbance, the more mature wind system, and the surrounding environment. Of particular relevance to NASA are remotely sensed estimates of wind, temperature, and water (in all of its phases) and their validation via direct measurements of their distributions.

This opportunity relates to the conduct of a new field experiment in 2010, the Genesis and Rapid Intensification Processes (GRIP) experiment, to better understand how tropical storms form and develop into major hurricanes. NASA plans to use the DC-8 and the Global Hawk Unmanned Airborne System (UAS) and is soliciting proposals for instruments that can achieve the specified measurement requirements.

NASA received a total of 26 proposals in response to this NRA and has selected 11 of these for funding at the present time.

Richard Blakeslee/NASA Marshall Space Flight Center
Lightning and Electric Field Measurements during the Genesis and Rapid Intensification Processes (GRIP) Experiment

The Genesis and Rapid Intensification Processes (GRIP) experiment is next in the series of Convection and Moisture Experiment (CAMEX) investigations. During GRIP, comprehensive datasets will be collected by NASA and collaborating agencies. These measurements will yield high spatial and temporal information to improve the understanding and prediction of the genesis, intensity, structure, motion, rainfall potential, and landfall impacts of tropical cloud systems. This mission also serves as a test-bed for new remote sensing technologies for satellite and aircraft platforms, retrieval

algorithms, and predictive models. During GRIP, the processes associated with intensification will receive special attention.

Lightning and electrical storm observations have been an integral and highly relevant component of CAMEX. What makes lightning observations particularly relevant to GRIP is the growing evidence that changes or bursts in lightning activity precede intensity changes in these storms. Yet while lightning bursts may be precursors to storm intensity changes, they are not sufficient to indicate whether strengthening or weakening will occur. Improving understanding of the lightning connection and its predictive capability will be a special focus of the proposed investigation.

We propose that a Lightning Instrument Package (LIP) be flown on the Global Hawk as a facility instrument. The Global Hawk will be integrated with a complementary suite of instruments that will provide an unprecedented and detailed view of tropical cyclone development and evolution needed to address key science objectives in GRIP. The Global Hawk provides a new observing paradigm with its capability to remain over storms for long periods. Now, instead of ¿snapshots,¿ a ¿video¿ (i.e., animation rather than a photograph) of the storm¿s behavior will be acquired, more quickly yielding detailed insights of the cause and effect processes at work.

We request support for aircraft integration, acquisition and analysis of LIP data, and collaboration with the scientific and validation investigations afterwards.

Paul Bui/NASA Ames Research Center
***In Situ* Pressure, Temperature and 3D Winds on NASA DC-8**

We plan to deploy the NASA Ames Meteorological Measurement System (MMS) on the NASA DC-8 to measure accurate in situ pressure, temperature, three-dimensional wind, and turbulence. The DC-8 MMS had participated in past hurricane field studies during CAMEX-3, CAMEX-4, and NAMMA. The instrument provides science quality state parameters, specifically addressed in the announcement (in situ T, p, winds).

Stephen Durden/Jet Propulsion Laboratory
Dual-Frequency Airborne Radar Observations of Tropical Weather Systems in GRIP 2010

The GRIP experiment has the goal of improved understanding of how tropical storms form and develop into major hurricanes. An airborne instrument important to the objectives of the GRIP experiment is the dual-frequency Airborne Precipitation Radar (APR-2). The APR-2 observations during the GRIP field campaign would consist of the vertical structure of rain reflectivity at 13.4 and 35.6 GHz, and at both co-polarization and cross-polarization, as well as vertical Doppler measurements and cross-wind measurements. Such a comprehensive set of radar observables will be extremely valuable for detailed studies of the processes, microphysics and dynamics of tropical cyclones, as well as weaker systems that are associated with tropical cyclone formation. APR-2 has flown on the NASA DC-8 aircraft in four previous experiments. The APR-2

set of retrieval algorithms has been enriched during and after the NAMMA and TC4 campaigns to satisfy the requests of the science team specific to hurricanes and tropical weather. In addition to collection of data during GRIP and real-time processing of that data, we will produce a complete quality-controlled APR-2 data set for archive. The data set to be produced for the GRIP campaign will include not only calibrated measurements, but also a set of retrievals of macro and microphysical quantities. This work is proposed to be conducted as Fundamental Research.

Michael Goodman/NASA Marshall Space Flight Center
GRIP IT: Collaboration Portal, Decision Support and Data Management Information Technology for the GRIP Field Experiment

The Genesis and Rapid Intensification Processes (GRIP) field experiment, planned for the summer of 2010, is being designed to measure hurricane formation and growth through satellite, aircraft and surface remote sensing. A wide variety of instrumentation will be deployed to the Atlantic basin to observe and gather data on hurricanes and foster the research to better understand their lifecycle. The proposed GRIP Information Technology (GRIP IT) system will be key to the success of the field experiment, providing end-to-end data and information management for relevant surface, airborne, and space-based instruments, as well as project coordination tools to support the 2010 GRIP campaign in the pre-experiment planning, field experiment execution, and post-experiment analysis stages. Although this proposal is neither an instrument nor a research proposal per se, it does provide a vital component for GRIP research since it fundamentally supports the community-wide research efforts towards understanding how tropical storms form and develop into major hurricanes. GRIP IT will consist of:

* Collaboration Portal for mission planning and coordination, providing interactive web collaboration tools such as blogs, wiki and chat sessions;

* Decision Support for aircraft and experiment asset situational awareness via the Real Time Mission Monitor (RTMM);

* Active Data Stewardship for GRIP data at the Global Hydrology Resource Center, providing for science data product collection, archival, dissemination and user assistance to support field experiment planning and operations, and post-experiment data analysis.

The GRIP IT team, comprising investigators from NASA/Marshall Space Flight Center (MSFC) and the University of Alabama in Huntsville (UAHuntsville), has contributed to numerous NASA field campaigns in various roles dating to the mid 1990s, providing data management and project coordination tools for CAMEX, ACES, TCSP and NAMMA campaigns. For the ACES and NAMMA campaigns, the team developed, evolved and deployed the RTMM, which has been used in several subsequent field experiments in 2007 and 2008. While there will be no RTMM development costs borne by the GRIP IT project, we are proposing GRIP IT-specific RTMM configuration and in-the-field support activities.

We propose to leverage previous field program data systems to design, implement and operate a web-accessible information management system that will support all aspects of the GRIP experiment. The GRIP IT team will also provide technical and operational support to the GRIP science team throughout the mission life cycle. We propose to deploy the equivalent of three people, two to Florida and one to Dryden, to support both RTMM and GRIP data collection and management, and to update software systems as needed in response to evolving situations in the field.

GRIP IT will have linkages to other tropical cyclone data sources and be aligned with the Tropical Cyclone Interactive Data Exchange and Access System (TC-IDEAS) that is jointly being developed and operated by the Jet Propulsion Laboratory (JPL) and MSFC in support of the larger Hurricane Science Research Program.

Jeffrey Halverson/Joint Center for Earth System Technology
In Situ Measurement of Meteorological State Variables Using Dropsonde On the NASA DC-8 and Global Hawk During NASA-GRIP, and Composite Analysis of a Large Dropsonde Database

The NCAR-designed GPS dropwindsonde is proven technology that provides in situ vertical profiles of temperature, humidity, pressure and winds within tropical cyclones and their environment. The instrument has been used successfully on the NASA DC-8 in past field campaigns and the data analyses have been used in numerous publications. Here, the PI proposes to serve as NASA Dropsonde Scientist for the DC-8 and Global Hawk. In the past the PI has served as Dropsonde Scientist during TOGA COARE, CAMEX-3, CAMEX-4 and NAMMA and a Mission Scientist during TCSP and NAMMA. This proposal budgets for installation and rental of the NCAR dropsonde system on the DC-8 and 100 DC-8 dropsondes for NASA GRIP. The proposal assumes NOAA will take the lead in furnishing the dropsonde system and expendables for Global Hawk.

Following the field phase of GRIP in summer-fall 2010, the PI proposes to work with NCAR in analyzing an unprecedented dataset of nearly 12,000 dropsondes collected in tropical cyclones over a 12-year period by NOAA, NASA and the USAF aircraft. The goal of this analysis will be to construct composite structures of vertical thermodynamic and wind profiles in the eye, eyewall and rain band regions according to geographic region and storm intensity category. This will help elucidate the detailed structure of storms in terms of the warm anomaly, convective instability, vortex structure, low level jets and wind shear effects on storm asymmetry for an unusually large and diverse sample of tropical cyclones. It may also offer clues about storm intensity trends in the present warming environment.

Andrew Heymsfield/University Corporation for Atmospheric Research
Microphysical Observations in Support of the Genesis and Rapid Intensification Processes (GRIP) Experiment

We propose to investigate and characterize the microphysical properties of the liquid and ice hydrometeors in the cloudy regions of Atlantic Hurricanes from the NASA DC-8 aircraft during the Genesis and Rapid Intensification Processes (GRIP, 2010) Experiment. We will measure the size distributions and habits, cloud water and rain liquid water contents, ice water contents, precipitation rates and extinction coefficients, and estimate the radar reflectivities. Our primary interest is in the rain and mixed-phase regions and our secondary interest in the ice regions.

We will make a comprehensive set of measurements of hydrometeor properties, including the size distributions of sub-micron through to centimeter particles from which estimates of the liquid and ice water contents will be made, and of the hydrometeor shapes. The instruments we are proposing for the DC-8 include a multi-probe Cloud and Aerosol Particle Spectrometer (CAPS), a hot-wire liquid water content probe on the CAPS, precipitation imaging probe (PIP) with a hot wire, and a Rosemount icing sensor. These probes flew successfully during previous NASA research experiments. Because of uncertainty in acquiring a CVI probe to directly measure the condensed water content, it is proposed as an option.

A graduate student at Howard University will be funded through this proposal. Interactions with the NASA Langley and JPL co-investigators will yield quantitative estimates of the uncertainties of our particle size distribution measurements and derived moments' extinction coefficient and radar reflectivity. Our preliminary processed data and later products will be archived. Emphasis will be given to collaborations with investigators on algorithm development and validation with our in-situ measurements. Through our involvement as Co-PIs in the NSF PREDICT (PRE-Depression Investigation of Cloud-systems in the Tropics) field campaign proposed for the about same period as GRIP, we seek to share microphysical observations across the two field programs.

Gerald Heymsfield/Goddard Space Flight Center
Studies of Tropical Cyclones During GRIP Using NASA High-Altitude Radar

Wind measurements are crucial for understanding and forecasting tropical storms since they are closely tied to the overall dynamics of the storm. The spatial and temporal resolution and availability of such measurements must be improved if hurricane intensity forecasting is to improve. The recent introduction of the high-altitude Global Hawk UAS to the NASA science community has resulted in development of new sensors, one of which is the High-Altitude Imaging Wind and Rain Profiler (HIWRAP) funded by the NASA Instrument Incubator Program (IIP). HIWRAP is a conical scan radar that will measure horizontal wind vectors within clouds and precipitation, and ocean surface winds in clear to light rain situations. HIWRAP is in an integration and testing phase and test flights are planned on the NASA WB-57 and Global Hawk prior to the GRIP field effort (pre-GRIP).

Emphasis of this proposal will be on understanding tropical cyclone genesis and intensification using the HIWRAP instrument on the Global Hawk. The goals are to a)

prepare HIWRAP for the GRIP field effort taking into account results from prior test flights (WB-57 and pre-GRIP), b) participate in the field portion of GRIP with HIWRAP on the Global Hawk, c) provide post-campaign data processing, including data calibration, reflectivity and horizontal wind maps, and d) improve the wind retrieval software and algorithms, e) produce and archive data and products for distribution to other scientists, and f) produce high quality research papers addressing key GRIP science questions .

Syed Ismail/NASA Langley Research Center
LASE Measurements of Water Vapor and Aerosol Profiles and Cloud Distributions During the GRIP Field Experiment

The LASE (Lidar Atmospheric Sensing Experiment) system onboard the NASA DC-8 will be used for remote measurements of water vapor and aerosol profiles and cloud distributions as part of the GRIP (Genesis and Rapid Intensification Processes) experiment. These measurements will be used to address questions related to the formation and intensification of hurricanes in the Atlantic Ocean. LASE will provide information to characterize the moisture (low-to-mid level and dry air), thermodynamic environment, the Saharan Air Layer (SAL), cloud development, and environmental stability conditions. These variables will be used to study their influence on storm development during GRIP. LASE data from the CAMEX-3&4 field experiments were used in the past to demonstrate the impact of high spatial resolution water vapor measurements on improving hurricane track and intensity forecasts. LASE measurements from NAMMA are being used in a number of ongoing studies related to the development of African Easterly Waves (AEWs) and the role of the SAL in the intensification of AEWs. The LASE measurements proposed for GRIP represent an opportunity to provide self-calibrated, continuous, high resolution water vapor profiles under daylight conditions in storm environments. The data obtained by LASE on the DC-8 will be combined with other available observations, such as from dropsondes/radiosondes, other aircraft and satellites to retrieve more advanced data products like relative humidity, aerosol extinction profiles, and aerosol optical depth to conduct basic research related to hurricane development. LASE measurements will also be used in the validation studies of ¿A-Train¿ satellites including CALIPSO and Aqua.

We propose to provide observations during the first year, and carry out analysis activities during years 2 and 3. During the first year we will optimize the LASE system for GRIP; assist in mission and flight planning activities; deploy LASE on the NASA DC-8 aircraft during GRIP; provide real-time, quicklook water vapor, aerosol, and cloud distribution data along the aircraft flight track during each flight to assist in the planning and execution of the mission; provide a full set of preliminary digital and image data at the end of the field phase; provide and archive a complete set of quality controlled data after the field mission at a date specified by the GRIP protocol; and initiate the interpretation of the LASE measurements. In the second and third years, we will combine the LASE and DC-8 remote sensing and in situ data with other GRIP (e.g., NOAA dropsondes) and satellite (e.g., MODIS, AIRS) datasets to characterize the airmass and thermodynamic structure of the events and their evolution. We will work with the NASA Hurricane Research Science Team as needed to assimilate the LASE and GRIP moisture

measurements to assess their impacts on short range forecast sensitivity experiments, and use the LASE and GRIP data along with satellite (METEOSAT, GOES, SSMI. MODIS, AIRS, CALIPSO) data sets to characterize the environment and its influence on the evolution of Tropical Cyclones. We will present results of the research at science conferences and prepare manuscripts for publication in the third year.

Michael Kavaya/NASA Langley Research Center
Vertical Profiles of Horizontal Winds From the DC-8 Using a Pulsed Coherent Doppler Wind Lidar System

We propose to measure the vertical profiles of vector horizontal wind from the DC-8 as it flies in the vicinity of hurricanes in the NASA SMD Genesis and Rapid Intensification Processes (GRIP) campaign of 2010. The vertical profiles will extend from the DC-8 altitude less the minimum range (~ 300 m), down to the earth's surface. The wind velocity's magnitude and direction will be determined to high accuracy, usually below 1 m/s error. The instrument will be a 2-micron, pulsed, coherent-detection, Doppler wind lidar system. It is currently being developed for the DC-8 under existing funding. The wind vectors will be referenced in time and in space with respect to the DC-8 and the earth's surface. The spatial reference will include altitude above ground and compass heading. Several aspects of the wind measurements will be displayed in real time on board the DC-8. More processing products will occur after landing. Coplots of the wind data with other geophysical parameters will be done. These may be provided to us by other campaign investigators, or obtained from orbiting assets. New science products will be investigated through data fusion. The data will be compared to existing theories of hurricane processes. The proposed effort will be very significant to NASA for 1) understanding of hurricanes through this specific campaign, and 2) demonstration of wind measurement technology and technique in preparation of the NRC Decadal Survey 3-D Winds space mission.

Tiruvalam Krishnamurti/Florida State University
Field Phase Forecasting for GRIP

The key central objective of this proposal is to provide forecasting support, using the best available research tools, during the field phase of GRIP. Research on rapid intensification of hurricanes and genesis of hurricanes are central themes of GRIP and our laboratory is currently being supported by NASA for research in these areas. Our participation in the field phase also helps in data acquisition for the field phase that would support the research of the science team and other user scientists who would benefit from GRIP.

During the field phase, our two graduate students will develop a day-to-day preparation and dissemination of daily weather including mesoscale details for the guidance of flight planning for the NASA DC-10 and Global Hawks. These forecasts are geared to both phenomenological issues related to storm intensity changes, what to observe, where and which observational platforms to use, and also to provide the best possible suggestions on the flight planning for the aircraft of GRIP for the next mission. This task requires both scientific knowledge of storms and also includes development of flight strategies.

The field phase is central to the success of the central objectives of GRIP. We need to monitor weather disturbances at critical places in space and time to provide an understanding of the hurricane intensity during its life cycle. The data sets developed from multiple aircraft and from satellites will be shared by the science team members and the scientists at-large who will eventually share these data sets and their findings. In the past we have passed-on both field phase forecasts and flight plans arising from our forecasts to NASA MSFC who have archived all our findings. The present experiment (GRIP) will be handled in a very similar and thorough manner for the success of this NASA enterprise.

Bjorn Lambrigtsen/Jet Propulsion Laboratory

Assessing the Thermodynamic and Convective Structure of Tropical Cyclones with the HAMSR Microwave Sounder

Our observational objective is to determine the thermodynamic state of the atmosphere - through the distribution of temperature, water vapor, and cloud liquid and ice - and the structure and intensity of convection - through the distribution of scattering, reflectivity and precipitation - in the GRIP campaign. These measurements will be obtained with the High Altitude MMIC Sounding Radiometer (HAMSR), a microwave sounder developed at JPL that has participated in a number of successful hurricane field campaigns since 2001 and has been reconfigured, as "UAV-HAMSR", for the Global Hawk. The thermodynamic quantities form the backdrop for the cloud, convection and precipitation processes that will be studied during this experiment and are crucial for the understanding of cyclogenesis and intensification; the other parameters are direct measures of the convective processes. We will produce measurements of sufficient resolution to allow even small convective cells to be mapped out. Our measurement system - intended to operate from the Global Hawk platform - is the most advanced of its kind, has a proven track record, and will provide observations that are more accurate and on a much finer spatial scale than is possible from space or from the ground. The raw measurements will be calibrated and made available to other investigators soon after the field operations. We will subsequently use them to derive atmospheric parameters and use those to characterize the state of the atmosphere in and around hurricanes and pre-genesis convective systems.

After the field campaign We will use HAMSR observations in combination with data from other airborne and satellite instruments to compare against ensembles of high-resolution model simulations to determine the set of model assumptions that produce the most realistic hurricane forecasts. We will use these most realistic hurricane simulations to study the hurricane processes associated with storm genesis and evolution.

This work is proposed to be conducted as Fundamental Research.
