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NOAA Intensity Forecasting Experiment (IFEX): A Multi-year Framework for NOAA Tropical Cyclone Research

1. Statement of Need

One of the key activities in NOAA's Strategic Plan Mission Goal 3 ("Reduce Society's Risks from Weather and Water Impacts") is to improve the understanding and prediction of tropical cyclones (TCs). The National Centers for Environmental Prediction (NCEP) Tropical Prediction Center (TPC) is responsible for forecasting tropical cyclones in the Atlantic and East Pacific basins, while the Environmental Modeling Center (EMC) provides NWP guidance for the forecasters. Together they have made great strides in improving forecasts of TC track. With support from the research community, forecast errors of TC track have decreased by about 50% over the past 30 years. However, there has been much less improvement in forecasts of TC intensity and rainfall. The lack of improvement in intensity and rainfall forecasting is largely the result of deficiencies in routinely collecting inner-core data and assimilating it into the modeling system, limitations in the numerical models themselves, and gaps in our understanding of the physics of TCs and their interaction with the environment. Accurate forecasts will rely heavily on the use of improved numerical modeling systems, which in turn will rely on accurate observational datasets for assimilation and validation.

The next-generation TC model, the Hurricane Weather Research and Forecasting model (HWRF) currently under development at EMC and anticipated to become operational in 2007. The HWRF will run at high resolution (≈10 km grid length initially), using improved data assimilation techniques and physical parameterizations. Such a configuration holds the hope of improving our understanding and forecasting of tropical cyclone track, intensity, structure, and rainfall. In order to realize such improvements, however, new data assimilation techniques must be developed and refined, physical parameterizations must be improved and adapted for TC environments, and the models must be reliably evaluated against detailed observations from a variety of TCs and their surrounding environments.

2. Overview of Framework

To conduct the research necessary to address the issues raised above, NOAA has proposed an experiment designed to improve operational forecasts of TC intensity, called the Intensity Forecasting EXperiment (IFEX). The goals of this experiment have been developed through a partnership involving NOAA's Hurricane Research Division (HRD), TPC, and EMC. The goals of IFEX are stated as a set of requirements and recommendations for the collection of data that will directly aid in the development and improvement of operational forecasting models. They are listed below:

- Collect observations throughout the life cycle of a TC for the development of a 3-D variational assimilation of the hurricane core circulation.
- Collect observations of the atmosphere and ocean in and around the storm scale circulation that can be used to develop an evaluation and validation package for the high resolution HWRF.
- Collect observations in a variety of atmospheric/oceanic conditions (e.g. atmospheric shear and humidity environments, oceanic warm core eddies) to assess the influence of these features on observed and model TC intensity and structure changes.

- Improve understanding and develop improved model representations of sea spray/surface flux effects on boundary layer structure and microphysics, especially in the core and rainbands. Develop techniques for evaluating ocean vertical mixing parameterizations against observed data.
- Improve the understanding of the phase changes of moisture.
- Determine the storm intensity and structure change during decay over cold water.

A unique, and critical, aspect of IFEX is the focus on providing measurements of TCs at all stages of their life cycle, from pre-genesis to intensification and subsequent landfall, decay over water, or extratropical transition. The focus of hurricane research flights during the past 25 years has been on mature storms, leading to a dataset biased toward these types of systems. The strategy of observing the entire life cycle of a TC is new and unique, and it will provide invaluable information, particularly in sparsely observed environments. The ability to target multiple basins provides greater flexibility for observing TCs at different stages of their life cycle. For example, the eastern North Pacific is an ideal location for genesis studies, since that region has the highest frequency of tropical cyclogenesis per unit area in the world. The western Atlantic, Caribbean Sea, and Gulf of Mexico are ideally suited for studying storms during their mature, landfalling, and extratropical transition stages of their lifecycle, while the eastern North Atlantic would again be a possible site for measurements during the tropical cyclogenesis stage. Since it is unlikely that all of these basins would be covered in a single season, the goals of IFEX are relevant over a multi-year timeframe and can take advantage of a multitude of proposed experiments to enhance the data collected for use in model development. A list of planned experiments is provided below. Figure 1 provides a timeline of the lifecycle of a TC and the portions of the lifecycle that will be covered by each experiment and each ocean basin.

Year 2005

- Tropical Cloud Systems and Processes (TCSP; NASA) – NASA, in partnership with NOAA, set as one of its primary goals to increase the overall understanding of tropical cyclone genesis, intensity change, motion, and rainfall by identifying remote sensing measurements and modeling requirements for improved hurricane predictability; and to validate the performance of NASA space-borne sensors to accurately monitor the short-term impacts and long-term trends of tropical storms and hurricanes. An overview of this experiment can be found at http://research.hq.nasa.gov/code_y/nra/current/NNH04ZYS003N/index.html.
- Second Tropical Experiment in Mexico (TEXMEX II; NSF) – The goal of TEXMEX II is to improve the understanding of tropical cyclogenesis by studying the dynamic and thermodynamic changes that incipient tropical cyclones undergo during the genesis process. An overview of this experiment can be found at ftp://ftp.aoml.noaa.gov//hrd/pub/rogers/HFP/TEXMEXII.pdf.
- Rainband and Intensity Experiment (RAINEX; NSF) – The aim of RAINEX is to investigate the role that the interactions between a tropical cyclone's inner core and rainbands play in determining the intensity change of mature storms. An overview of this experiment can be found at ftp://ftp.aoml.noaa.gov/hrd/pub/rogers/HFP/RAINEX.pdf.
- Ocean Winds and Rain Experiment (Ocean Winds; NOAA) – The goal of this experiment is to further our understanding of the ocean surface wind vector retrievals in high wind

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speed conditions and in the presence of rain for all wind speeds from microwave remote-sensing measurements.

Year 2006

- African Multidisciplinary Monsoon Analyses (AMMA) -- The AMMA campaign is planned for the 2006 Atlantic hurricane season (http://www.joss.ucar.edu/amma/). Key TC-related science objectives during AMMA include improving our understanding of the processes that influence the relationship between African easterly waves and convection, determining the relative roles of dynamics and aerosols on MCSs and lightning, gain a better understanding of the processes that influence the fate of AEWs and embedded MCSs downstream of West Africa, and assessing the role of the Saharan Air Layer on TC intensity change.
- Ocean Winds and Rain Experiment – see previous year's description

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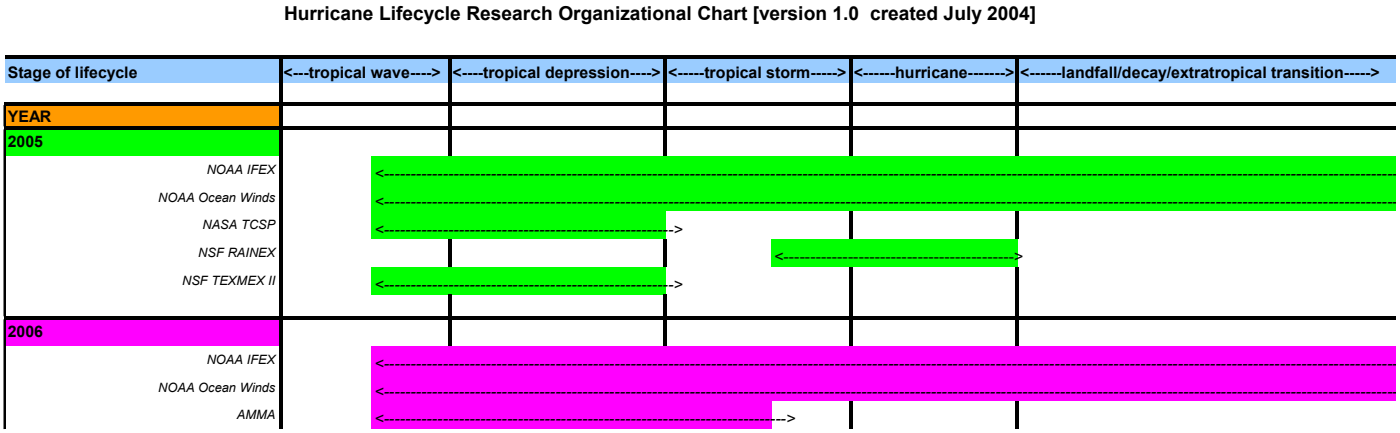

Figure 1. Time line of the life cycle of a tropical cyclone and the portions of the life cycle that will be covered by the proposed experiments.