Professor Ryan Torn
Department of Atmospheric and Environmental Sciences

Sponsor: National Science Foundation (NSF)
Amount: $278,595
Dates: September 1, 2009 – August 31, 2012

Collaborative Research: Ensemble-Based Predictability, Sensitivity and Data Assimilation in PREDICT

This collaborative research project between the University of Miami and the University at Albany focuses on the prediction and processes inherent to the genesis of tropical cyclones (TCs), in support of the proposed NSF Pre-Depression Investigation of Cloud-systems in the Tropics (PREDICT) field experiment. TC genesis is a *multi-scale* problem, in which a synoptic-scale precursor disturbance such as a tropical wave often exists as the source from which convective cloud clusters organize themselves into rotating mesoscale complex, culminating in a tropical depression. The overarching goal of this proposal is to explore the dynamics, observability and predictability of this process, with the following objectives:

1. To diagnose the dominant sensitivities and influence of observations on TC genesis on synoptic, meso- and convective scales.
2. To provide a seamless real-time ensemble prediction, adaptive sampling and data assimilation capability for use in mission planning during PREDICT.
3. To provide high-resolution, convection-resolving numerical model output for other PREDICT PIs for their hypothesis testing.

The central scientific hypothesis of this project is that the initialization of the synoptic-scale, pre-depression wave trough is most essential for the accurate modeling of TC genesis. It is this disturbance in which the critical layer, which acts to shield an incipient rotating disturbance from wind shear and dry air intrusion, is hypothesized to exist. To investigate this and other hypotheses, an ensemble-based framework based on the THORPEX Interactive Grand Global Ensemble (TIGGE), the Weather Research and Forecasting (WRF) model and an ensemble Kalman filter will be prepared in Year 1 for real-time prediction during the field experiment (mid-Year 2). Ensemble-based techniques such as ensemble sensitivity and the ensemble transform Kalman filter will be used to diagnose the important physical processes, and the associated scales and variables that need to be sampled to optimally curtail prediction errors. The remainder of Year 2 and all of Year 3 will be devoted to analysis, including a convective-scale reanalysis that will include all data collected during the field campaign and can be used by other PREDICT PIs for their research.

The intellectual merit of the proposed research lies in the potential to advance our understanding of the processes and predictability associated with TC genesis, via multi-scale, multi-faceted ensembles that are unprecedented in a field campaign on tropical cyclones. The related facets are focused both on science (e.g. processes that curtail predictability, growth rates of errors within different scales) and applications (e.g. advanced data assimilation, optimal observation selection).

The broader impacts of the proposed activity are that improved probabilistic predictions of TC genesis, and therefore intensity change, wind and rainfall structure at landfall will be possible. Such predictions will be improved via advanced ensemble-based data assimilation, sensitivity and adaptive sampling guidance, and diagnosis of dominant errors. Two graduate students will be trained to run models that capture inner-core processes within TCs and address unsolved issues related to their predictability. Furthermore, data and results will be shared between the research and operational communities.