White Paper Abstract: Ocean Observations 09 Theme 3c (Ocean Hazards)

Targeted Ocean Measurements For Tropical Cyclone Intensity Forecasting

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Ocean mixed layer and sea surface temperature (SST) variability has been shown to impact tropical cyclone (TC) intensity changes in both observations and coupled model simulations. The focus of these modeling efforts has been on the cold wake structure and the negative feedback to the atmosphere due to decreased SST and reduced air-sea fluxes. The mechanism primarily responsible for the observed ocean cooling is shear-induced mixing events across the mixed layer base; however as the TC slows down, upwelling of cooler water from the thermocline contributes to strong cooling. When a TC moves over an existing cold ocean eddy, the negative feedback will be significantly enhanced as SSTs have been shown to significantly decrease. The net result of this feedback is to weaken TC's. By contrast, in complex ocean regimes containing warm features, the oceanic response is considerably weaker due to: 1) deeper warm layers (defined here as temperatures of more than 26^{o}C) of more than 100 m; and, 2) strong background currents preclude the development of vigorous near-inertial currents (and shears). This less negative feedback implies there is more sustained heat and moisture flux to the atmosphere boundary layer. TC's Katrina and Rita (three weeks later) are two examples of this feedback as they moved over the Gulf of Mexico's Loop Current and intensified to category 5 status in 2005. Such oceanic impacts on TC intensity have global consequences.

Accurate initialization of ocean features associated with large horizontal differences in SST and oceanic heat content (OHC) is necessary for the ocean model to predict the rate and pattern of SST cooling during TC passage. Ocean hindcasts that assimilate sea surface height (SSH), SST, sea surface salinity, and vertical structure from profiling floats (e.g., Global Ocean Data Assimilation Experiment) can provide consistent fields for this initialization; the oceanic and coupled models require targeted ocean measurements in storm-based coordinates to examine model parameterizations under high wind conditions. Given inherent ocean sampling issues, realistic ocean and coupled model simulations can also provide guidance on where to deploy instrumentation to optimize the aircraft sampling strategies. Temperature and salinity structure measurements are needed for these detailed model comparisons in examining the upper ocean structure changes induced by TC passage. Since integrated thermal structure (OHC) is now input into the Statistical Hurricane Intensity Prediction Scheme in the Atlantic and Eastern Pacific Oceans (see above website), these comparisons must also be made to satellite-derived fields. Current profile measurements are of particular importance both to assess mixing parameterizations and verify that coupled models realistically close the air-sea momentum budget (Frances, 2004). Thus, ocean profiles must be routinely acquired to improve the oceanic and coupled models at the National Centers responsible for issuing TC intensity forecasts.

To address these basic and scientific concerns, targeted ocean measurements are needed from several platforms such as subsurface floats (including currents), drifting buoys equipped with thermistor chains, and aircraft expendables. Lagrangian floats and drifters provide the evolutionary phases of the oceanic response embedded in grided, synoptic snapshots from expendables (Gustav, Ike in 2008). When these targeted measurement approaches are combined as in recent measurement campaigns, they provide unprecedented detail of the mesoscale oceanic response to TCs embedded within the regional-scale satellite measurements. That is, multi-dimensional ocean analyses (surface through the seasonal thermocline) derived from these data are crucial to evaluating oceanic and coupled model performance (including parameterization schemes). Novel measurement approaches to augment satellite fields in other basins must also be explored in assessing oceanic impacts on TC intensity. Thus, this comprehensive approach of improved initialization schemes and targeted measurement approaches has important implications for the global coastal communities who rely on the most advanced forecast systems to prepare for TC landfall.