**NOAA Joint Hurricane Testbed Project**
**Mid-year progress report**

A New Secondary Eyewall Formation Index: Transition to Operations and Quantification of Associated Intensity Changes

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Year-one timeline:

1. August 3, 2009 - Project begins
2. Convert the MatLab code to FORTRAN
3. Transition the present prototype model onto the JHT computing platform with the intention of having the model operational before the onset of the 2010 hurricane season. Modifications are needed to use SHIPS to include an additional GOES-based feature.
4. February 1, 2010 - Mid-year report due
5. March 2010 – Present work at the Interdepartmental Hurricane Conference
6. April 1, 2010 – Year two renewal proposal due
7. Aug 3, 2010 –Year one ends/ year one progress report due

Progress by relevant timeline item:

**Item 2:**

Most of the MatLab code has been converted to FORTRAN. Subroutines have been completed that perform all of the fundamental calculations of the Bayes probabilistic model. We still need to modify this code for the specific requirements of accessing the SHIPS input and output files. We've been working with Mark DeMaria on gaining access to the additional SHIPS input data required to run the model in its full form. With one exception (described below), the model will only require access to the standard SHIPS predictors. Predictors that SHIPS may no longer use can still be easily "switched on" so that our model can access them.

The one additional input data source that our model will need access to is the GOES IR brightness temperature profiles used by SHIPS to create the GOES-based predictors. These profiles are needed to calculate the principal components used as features in our model. Since SHIPS already ingests and analyzes these data, we will just need to add some code to access them. Calculation of the PCs then requires only a few vector dot products.

**Item 3:**

In mid-September, Matt Sitkowski visited NHC where he presented a formal overview of our model to management and forecasters, and worked with Jose Salazar to set up an account on the JHT server and outline the optimum procedures for getting the model operational before the onset of the 2010 hurricane season. It was agreed upon, with James Franklin's and Mark DeMaria's approval, that the algorithm be added directly to the SHIPS model processing with its output appended to the *ships.txt* file. This is analogous to the procedures used for outputting the Annular Hurricane Index and we will follow this streamlined procedural template. Mark DeMaria has very recently provided us with the SHIPS model FORTRAN source code so that we can begin this process. We are working on compiling the code right now.

**Item 5:**

Details of this progress report will be presented by Jim Kossin at the 64$^{th}$ Interdepartmental Hurricane Conference.

**Informal report on early progress on year-two tasks:**

The next major task of this two-year proposal is to utilize low-level aircraft reconnaissance data to quantify the intensity and structure changes associated with secondary eyewall formation. At present, there have only been case studies, and no general climatology of these changes exists. We had found in our earlier work that best track data are too smoothed to adequately capture these deviations, which can be large and rapid. Consequently, a significant challenge of this task, and one that is highly labor intensive, is the collection and processing of the large existing archives of raw data from the NOAA WP-3D and Air Force C-130 aircraft. It's probably defensible to say that the need for this represents a very real travesty in that such a large record of such useful data has remained largely unprocessed for so many years. To mitigate this, Matt Sitkowski has been working on the problem. We just chain him to his desk and give him water and a potato or two a day, and a bit of coal for his office stove when his fingers get too numb with cold to type. Here are a few highlights of what we've accomplished so far:

1) NOAA WP-3D flight-level data were collected from HRD online sources, and USAF C-130 data were generously provided by John Knaff. The 10-second data are interpolated to 1-second data to form a roughly homogeneous dataset.

2) Storm center positions were obtained from HRD *trak* files. These files were created using aircraft wind observations. A series of spline curves were then applied to optimally fit the various fixes into a continuous curve. Storm center fixes are listed roughly every two minutes.

3) Using code provided by Chris Rozoff, raw flight-level data were combined with two-minute fixes to calculate storm centered tangential and radial winds. A weighted mean was then applied and winds were divided into 0.5 km bins out to 200km from storm center. An example of the resulting profiles in Rita (2005) is shown in Fig. 1.

4) We're estimating that ~2,500 radial legs will be created when all available data are obtained and quality control is complete. We're still trying to fill in gaps in the data and HRD *trak* files. The data are scattered around various places, the data format is remarkably variable, and this has been an arduous process, but we are making good progress. Table 1 shows what we've processed so far (more than 600 radial leg pairs, or 1200 radial legs). Initial composite analyses of nine pre- and post-secondary eyewall events are very encouraging and show clear signals in the intensity and wind structure changes. Metrics like inertial stability and integrated kinetic energy (IKE) are being calculated, and modified Rankine and Holland profiles are being fitted to the data. The evolutions of these metrics are being explored during the formation of a secondary eyewall.

**Table 1: NOAA WP-3D and USAF C-130 data processed so far.**

| | Sorties | Radial Leg Pairs | Radial Leg Pairs within ±18 hr of SEF |
|---|---|---|---|
| 2002 Isidore | 18 | 62 | 9 |
| 2002 Lili | 23 | 76 | 18 |
| 2003 Fabian | 10 | 23 | 10 |
| 2003 Isabel | 21 | 62 | 23 |
| 2004 Charley | 9 | 38 | 17 |
| 2004 Frances | 25 | 85 | 44 |
| 2004 Jeanne | 10 | 23 | 12 |
| 2005 Dennis | 19 | 57 | 23 |
| 2005 Emily | 18 | 58 | 24 |
| 2005 Katrina | 13 | 62 | 37 |
| 2005 Rita | 15 | 68 | 33 |
| 2005 Wilma | 17 | 55 | 18 |

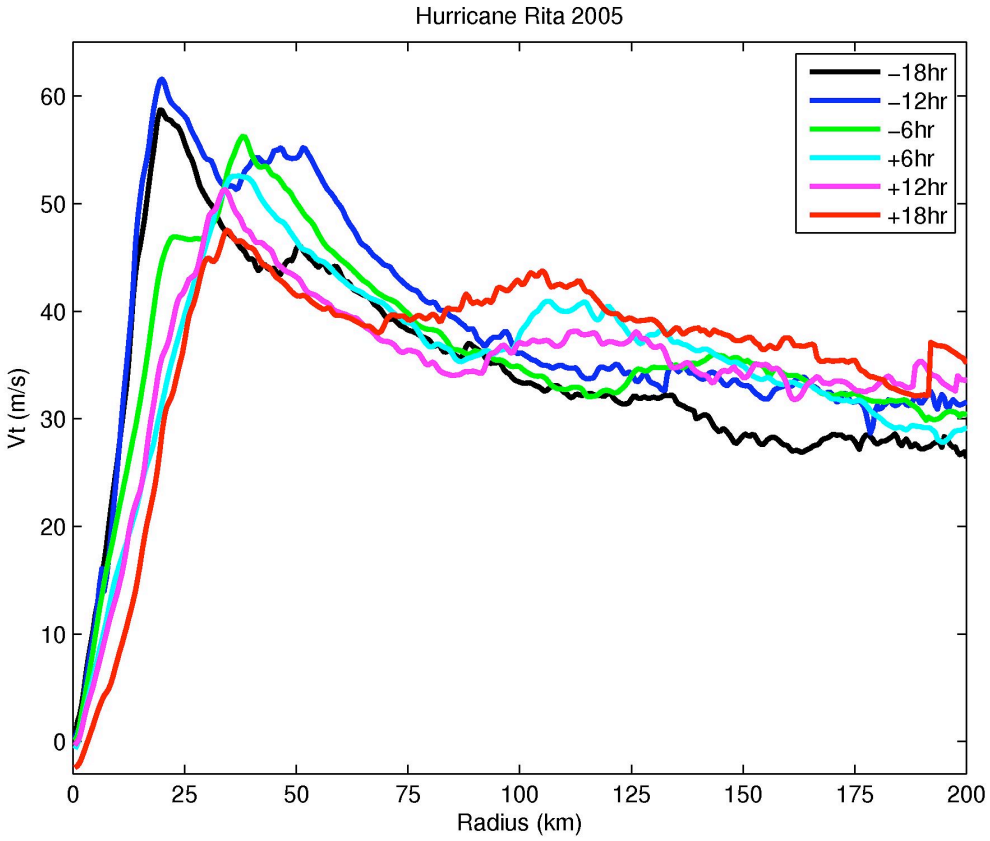


**Figure 1: Evolution of 6-hour composite tangential wind profiles calculated from raw USAF C-130 data during a secondary eyewall event in Hurricane Rita (2005). While the peak intensity decreases more than 10 m $s^{-1}$ during the event, the RMW moves outward and the outer winds increase, which increases the integrated kinetic energy (IKE) by about 40%.**