Joint Hurricane Testbed Final Report for Year 1
September 1, 2005-May 1, 2006
Updated July 10, 2006 (see Section 5 below)

Project title: *Improved Statistical Intensity Forecast Models*
Principal Investigators: John Knaff, Mark DeMaria and John Kaplan
Affiliation: Knaff (CIRA), DeMaria (NESDIS) and Kaplan (OAR)
Project dates: September 2005-May 2007
TPC Point of Contacts: Lixion Avila, Chris Sisko and Eric Blake

Note: This final report was submitted 3 months early to re-align the project with the NOAA grant cycle.

1. Background Information

This project is to improve statistical intensity forecast models by 1) incorporation of a new formulation of the inland decay component in the SHIPS model, 2) evaluate new methods for the evaluation of the vertical wind shear in SHIPS, and 3) improve the rapid intensity index (RII) by utilization of a discriminate analysis method that would weight the input parameters to provide the optimal separation of the rapid and non-rapidly intensifying tropical cyclones. The timeline and deliverables for this project are listed below in the Appendix.

2. Accomplishments

1) New decay model

The new decay model was implemented in SHIPS at the beginning of the 2005 season. This new model reduces the decay rate over islands and other narrow landmasses to eliminate a bias that was prevalent in the original version. The new decay model was included in the operational SHIPS in 2005, based upon re-runs of the 2001-2004 seasons, all of which showed neutral or positive impact. To determine the impact on the real-time runs, the 2005 Atlantic and east Pacific forecasts were re-run with the new and old versions of the decay model. The re-runs were needed to make the comparison exact because it is not always possible to exactly reproduce everything that can happen in real time. The 2005 Atlantic season was ideal for this evaluation because of the large sample size, and the large number of storms impacted by land.

Figure 1 shows the improvement (reduction in mean absolute error) of the 2005 Atlantic SHIPS forecasts for the entire sample of storms. The new decay model improved the forecasts at every forecast internal, with the maximum impact at 96 hours. The improvement at most time periods was statistically significant at the 95% level. Similar, but slightly smaller, improvements were seen in the reruns of the 2004 Atlantic forecasts with the new decay model.

The east Pacific storms were also re-run with the new and old decay model. The new decay model had little impact on the east Pacific forecasts because so few cases were impacted by land. The differences in the forecast errors with the new and old decay models were less than 0.7% at all forecast intervals, and none of the differences were statistically significant.

The new decay model has been implemented on the IBM is ready to be run in 2006. Thus, the part of the project is essential completed.

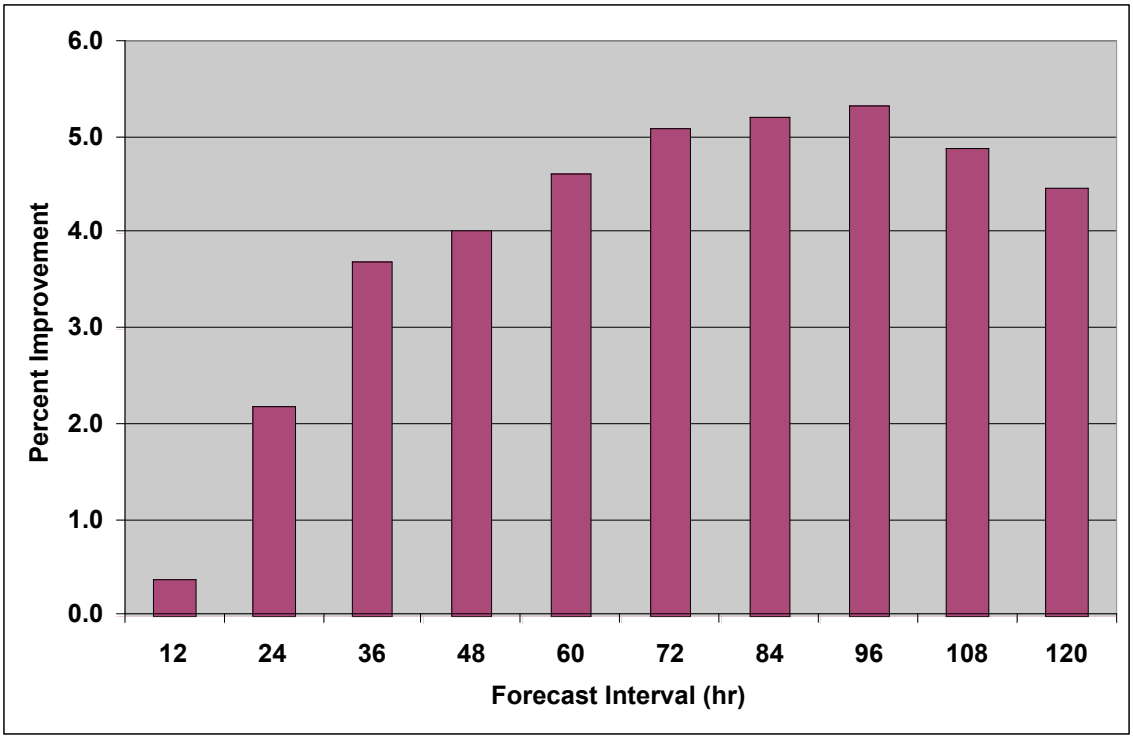

Figure 1. The improvements in the 2005 Atlantic SHIPS forecasts due to the inclusion of the new decay model. The sample includes all of the 2005 SHIPS forecasts, including those not affected by land.

2) New method for evaluating vertical shear in SHIPS

The SHIPS model averages the winds over an annulus from 200 to 800 km from the storm center. This large area is used to account for potential differences between the official forecast track (used in SHIPS) and the track of the storm in the NCEP GFS model. In order to test smaller or non-circular averaging areas (for example, an elliptical area with the major axis oriented along the storm motion), the storm circulation must first be removed. Two methods for removing the storm circulation were proposed. The first involves removing the symmetric storm circulation, and the second involves a "Laplacian filter" where the wind fields inside a specified radius centered on the model storm location are replaced by solutions of $\Lambda^2 u = \Lambda^2 v = 0$. Preliminary testing of the vortex

removal methods has begun, and this code is being incorporated into the part of the SHIPS routine that performs the model diagnostics.

Figure 2 shows an example of the 850 hPa wind field from the 108 hour GFS forecast for Hurricane Frances staring from 06 UTC on 27 August 2004 before and after the vortex removal procedure (the first type). The model storm center was located just to the west of Puerto Rico, but the official NHC forecast utilized by SHIPS was about 500 km to the NE of the Puerto Rico at this time. Thus, GFS representation of Frances had a large impact on the vertical shear calculation. This effect would be greatly reduced if the wind field with the storm removed was utilized.

This work will continue in Year 2 according the schedule shown in the Appendix. We expect to have a real-time parallel version of SHIPS with an alternate shear calculation (the version that performs best in the re-runs of the 2005 season) ready by the start of the main part of the 2006 hurricane season (Aug. 1st) for forecaster evaluation.

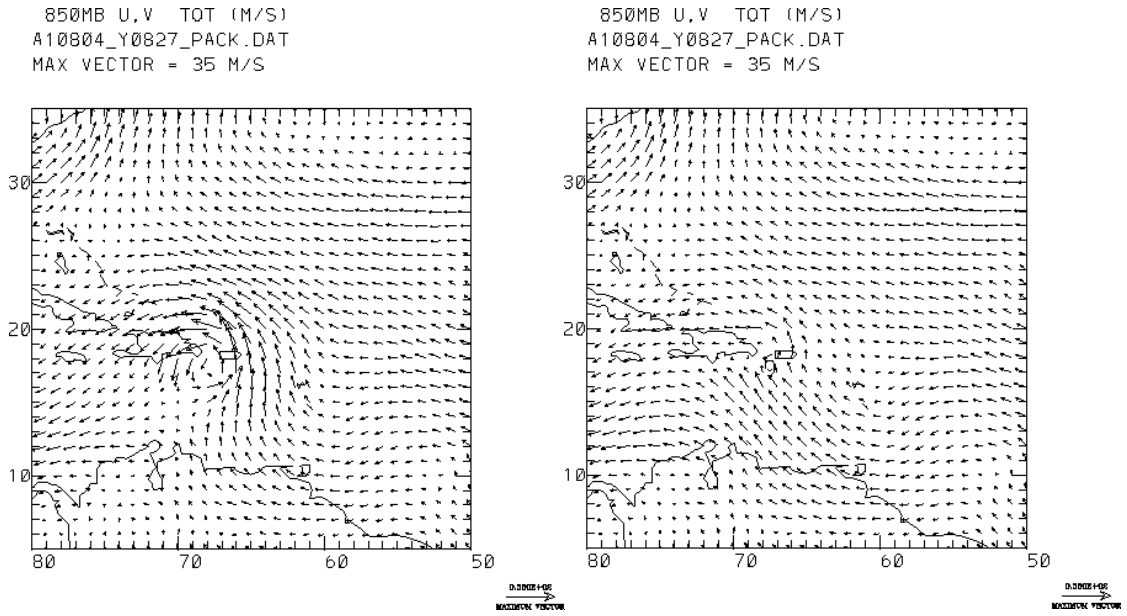

Figure 2. The 850 hPa wind field from the GFS for the 108 h forecast starting from 27 Aug 2004 for hurricane Frances. The left panel shows the original field and the right panel shows the field after application of the vortex removal procedure.

3) Improved Rapid Intensity Index

J. Kaplan visited CIRA in mid-April and considerable progress on the discriminant analysis (DA) version of the RII was made. The DA software available from the IMSL library was adapted to the RII development code, and the performance relative to the operational RII was evaluated for the dependent sample. In the operational RII, the seven scaled inputs are equally weighted, while the DA chooses optimal weights that best separate the rapid intensifying cases from the non-rapid intensifiers.

Figure 3 show the input weights for the operational (all equal) and DA versions of the RII for the Atlantic and east Pacific. In the Atlantic, the potential and SST terms are treated much differently than in the equally weighted version. In the east Pacific, the discriminant weights are all positive, but do vary in magnitude by about a factor two.

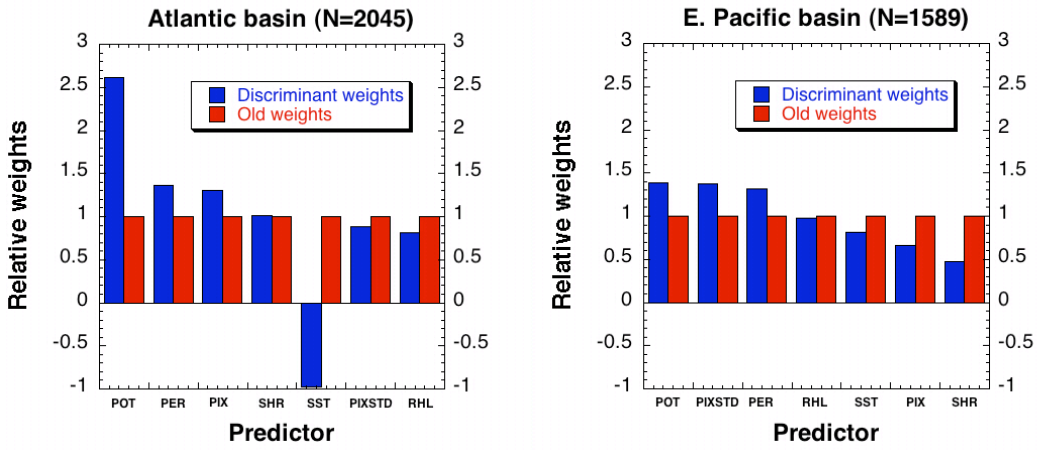

Figure 3. The input weights for the operational (red) and discriminant analysis (blue) versions of the RII for the Atlantic (left) and east Pacific (right) dependent samples (1995-2004).

The Brier skill score (relative to a climatological rapid intensity probability) for the operational and DA RII were calculated for the dependent sample, as shown in Fig. 4. Results show that the DA version has a higher Brier skill score, with the larger improvement in the Atlantic version. This result is consistent with the fact that the DA adjusted the weights relative the operational version more in the Atlantic than in the east Pacific. The DA version of the RII will be run in parallel during the 2006 season for comparison with the operational version.

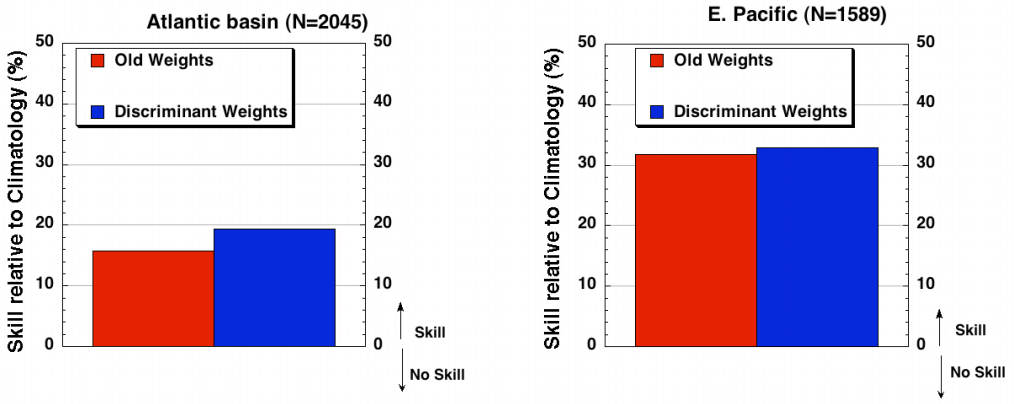

Figure 4. The Brier skill score for the dependent sample of RII forecasts with the operational (red) and DA (blue) weights.

2. Things not Completed/Pending Items:

This project is basically on track, taking into account that this report is being prepared three months early. The new decay model work is essentially complete, and the parallel version of SHIPS with the modified shear and the discriminant analysis RII will be ready for operational testing during the 2006 hurricane season.

3. Things that did not succeed.

It remains to be seen if the new shear calculation and discriminant analysis RII provide improved forecasts during the operational tests in 2006.

4. Plans for Year 2

The project will continue according to the schedule listed in the Appendix. Further progress will be reported by M. DeMaria at the Interdepartmental Hurricane Conference in March of 2007.

5. Updates to the Final Report for May 1-July 10, 2006

In late May of 2006, the parallel version of the discriminant analysis version of the rapid intensity index was implemented on the NCEP IBM. It has been run for all the operational forecasts in 2006 so far, and the results are being saved for post-season evaluation.

Some minor modifications to east Pacific SHIPS and the RII (operational and parallel versions) were made to accommodate the change from GOES-10 to GOES-11 in June of 2006.

Work on the parallel version of SHIPS with the revised vertical shear calculation is continuing. The most challenging aspect of this problem is the determination of the location of the storm center in the NCEP GFS analysis for the vortex removal or filtering routine. A new robust method that uses a variational principle to find the location at 850 hPa that minimizes the symmetric tangential wind averaged from 0 to 600 km was developed, and is being tested on cases from the 2002 to 2005 seasons, where the GFS forecast fields have been archived. This aspect of the procedure is crucial because the removal of tangential winds at the wrong location would adversely affect the shear calculation and SHIPS forecast. A set of rules are being developed where the vortex removal technique is only applied when there is a high confidence in the center-tracking routines. Preliminary results indicate that the center can be accurately tracked about 95% of the time. The parallel version of SHIPS with the revised shear calculation is still on track for implementation on the NCEP IBM by August of 2006, for real-time evaluation.

No changes were needed to the timeline in the Appendix, other than to indicate that the June 2006 task was completed.

Appendix

Year-two project timeline and deliverables:

Jun 2006 - Begin real-time testing of discriminant analysis version of RII (completed)
Aug 2006 - Begin real-time testing of parallel version of SHIPS with optimized shear
Dec 2006 – Provide year 2 progress report
Jan 2007 – Perform verification and analysis of parallel SHIPS and RII and adjust code accordingly
Mar 2007 – Report progress at the IHC
May 2007 – Finalize SHIPS and RII for 2007 season depending on outcome of 2006 tests and JHT/TPC feedback
May 2007 Provide year 2 final report