NOAA Joint Hurricane Testbed (JHT)
Annual Report, Year 1

Date:	Sep 30, 2014
Reporting Period:	September 1, 2013 – August 31, 2014
Project Title:	Upgrades to the Operational Monte Carlo Wind Speed Probability Program
Principal Investigator:	Andrea Schumacher, CIRA / Colorado State University
Award Period:	September 1, 2013 – August 31, 2015

1. Long-term Objectives and Specific Plans to Achieve Them:

This project seeks to complete a number of upgrades to the current Monte Carlo wind speed probability model (hereafter MC model), many of which are based on NHC feedback over the past few hurricane seasons. Specific plans to improve the MC model include replacing the linear forecast interpolation scheme with a more precise spline fit scheme, applying a bias correction to the model track error statistics to provide consistency between NHC's uncertainty products, and applying a bias correction to the radii-CLIPER used by the MC model to improve the accuracy of the wind speed probabilities for exceptionally small or large (e.g. 2012's Hurricane Sandy) tropical cyclones. Additionally, several additions to the MC model will be completed such as estimates of the arrival and departure times of 34/50/64 kt winds, an integrated GPCE parameter, and wind speed probabilities beyond 5 days (proposed to 7 days). Finally, the error statistic generation code will be consolidated into a single streamlined version that will reduce the time needed to update the MC model statistics each year.

2. Year 1 Accomplishments:

a. Replaced linear forecast interpolation scheme with spline fit scheme

The starting point for the MC model is the NHC official track and intensity forecasts, which are available at 12 h intervals to 48 h and 24 h intervals from 48 to 120 h. A linear interpolation is used to obtain track and intensity between the forecast times. Verification statistics (DeMaria et al. 2009) show that the errors are larger for the times between the NHC forecast points, and an eastward bias is introduced for re-curving cyclones. This is especially problematic for storms close to the U.S. east coast, but just offshore, because it leads to an underestimate of the probabilities at the coast.

To correct this problem, the linear interpolation scheme was replaced with a spline fit. Figure 1 shows the Brier scores and threat scores (averaged over all probability thresholds) calculated for all 2013 Atlantic tropical cyclones. Overall, replacing the linear time interpolation scheme with a spline fit has very little impact on the basin verification statistics. The impact this fix has on wind speed probabilities can best be seen by examining the case of a tropical cyclone forecast to recurve. Figure 2 shows the difference between the forecast track and corresponding wind speed probabilities using linear interpolation (left) and the spline fit (center) for Hurricane Earl when it was forecast to recurve along the U.S. east coast. The spline fit methodology appears to be correcting the eastward bias in this case, providing a more realistic interpolated track forecast after 48 hours. The corresponding 34-kt wind speed probabilities along the North Carolina coast increase from 50-60% with the linear interpolation scheme to 70-80%.

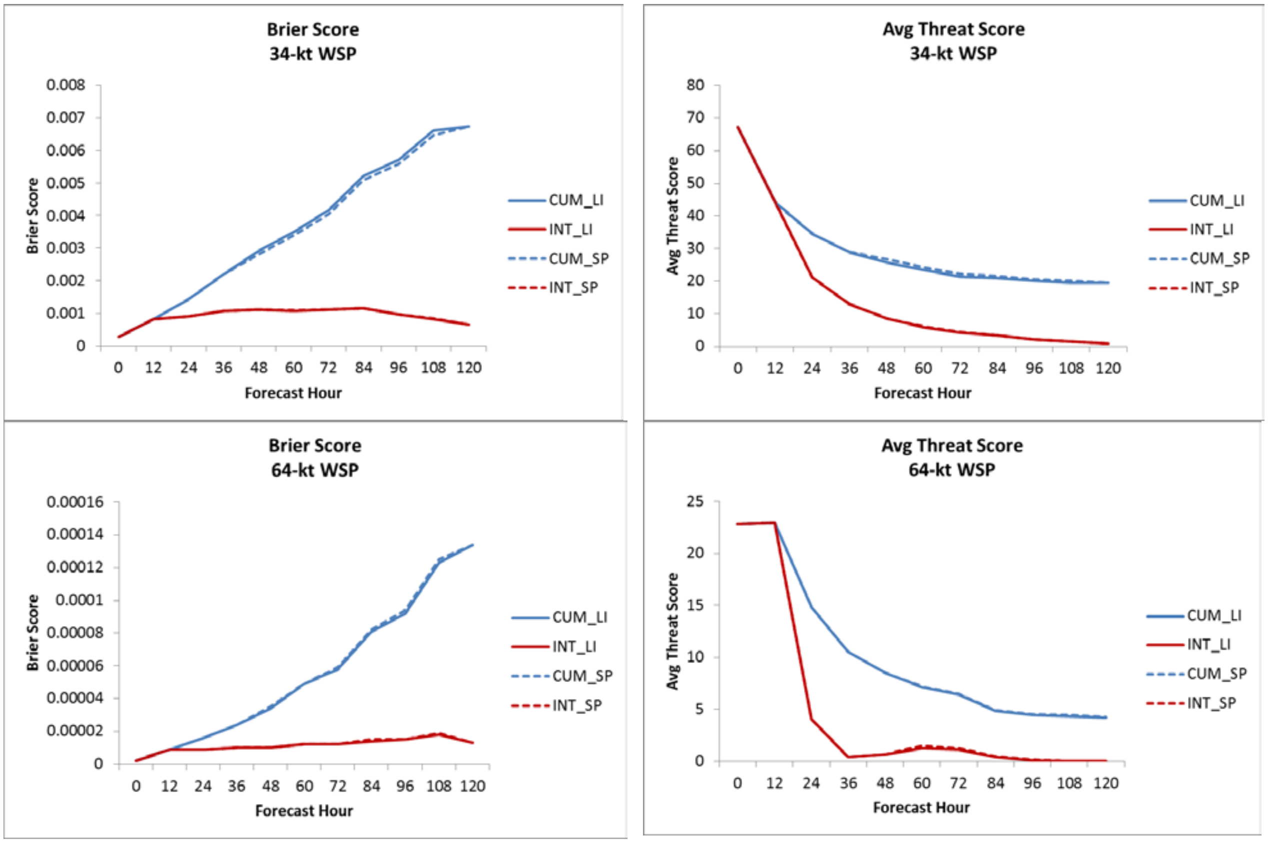

Figure 1. Brier scores for the 34-kt (left, top) and 64-kt (left, bottom) wind speed probabilities and threat scores average over all probabilities thresholds for the 34-kt (right, top) and 64-kt (right, bottom) wind speed probabilities for 2008-2012 Atlantic tropical cyclones. Verification metrics for cumulative (integrated) wind speed probabilities are shown in blue (red). Solid lines represent values using the linear interpolation scheme and dashed lines represent values using a spline fit scheme.

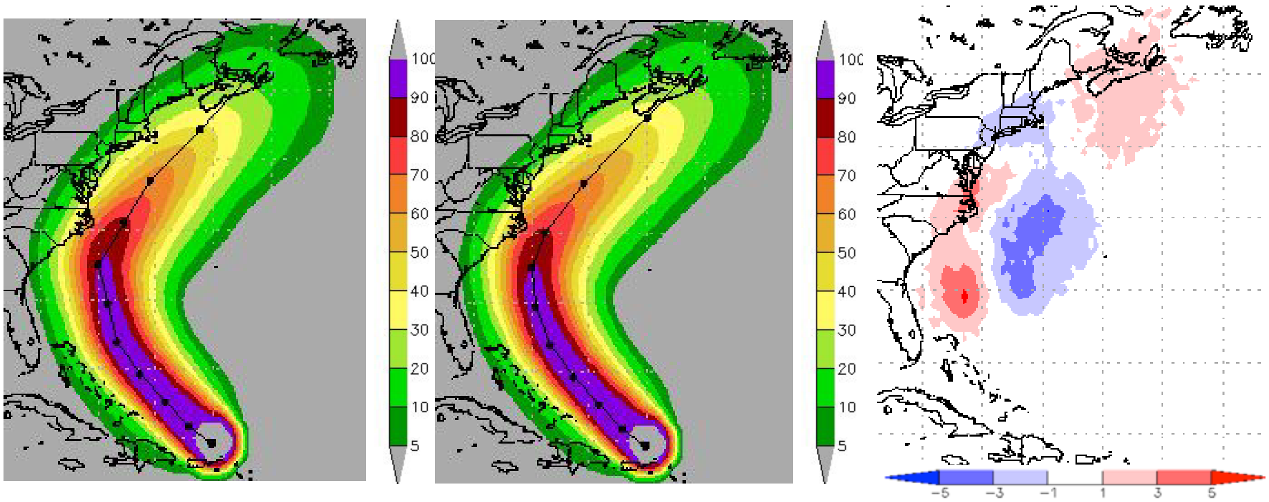

Figure 2. 34-kt wind speed probabilities using linear interpolation (left), spline fit (center), and difference plot (spline - linear, right) for Hurricane Earl on 31 Aug 2010 0000 UTC.

b. Development of an integrated GPCE parameter

It has been shown that past NHC track forecast errors can be separated into terciles based on their corresponding GPCE value, and that track forecast errors in the low (high) terciles tend to correspond to less (more) spread in forecast errors (DeMaria et al. 2013). This finding motivated the use of a GPCE parameter in the MC model. At present, this GPCE parameter determines the track error statistics used by the MC model to estimate wind speed probabilities, but the GPCE categories (low, medium, high) are not output directly.

It was proposed that a time integrated GPCE parameter be developed from the GPCE information used by the MC model. This information could be relayed to users through the NHC discussion product, and could potentially be used to modify the cone of uncertainty. A preliminary time integrated GPCE parameter has been developed using the following methodology; 1) GPCE values at each forecast time from 12h to 120h is normalized by their standard deviation and 2) 12h to 120h normalized GPCE values are averaged. This methodology provides a single GPCE parameter for each 120h track forecast that characterizes the overall uncertainty of that forecast. The same methodology was applied to NHC track forecast errors from 2008-2012. The time integrated forecast errors corresponding to the three time integrated GPCE terciles are shown in Figure 3. Similar to the findings for GPCE values at each forecast time, the low (high) integrated GPCE tercile tends to correspond to less (more) spread in integrated forecast errors. A recent meeting with NHC point of contact Dan Brown, Mark DeMaria, and James Franklin brought forth some useful ideas with respect to how this upgrade can be made to best fit the needs of the NHC forecasters, including creating separate integrated GPCE parameters for the early (1-2 days) and later (3-5 days) parts of the track forecast and looking at bins other than terciles to increase the separation in forecast errors between the low and high GPCE bin. Testing continues to determine the optimal weighting scheme for providing the most separation in integrated forecast errors.

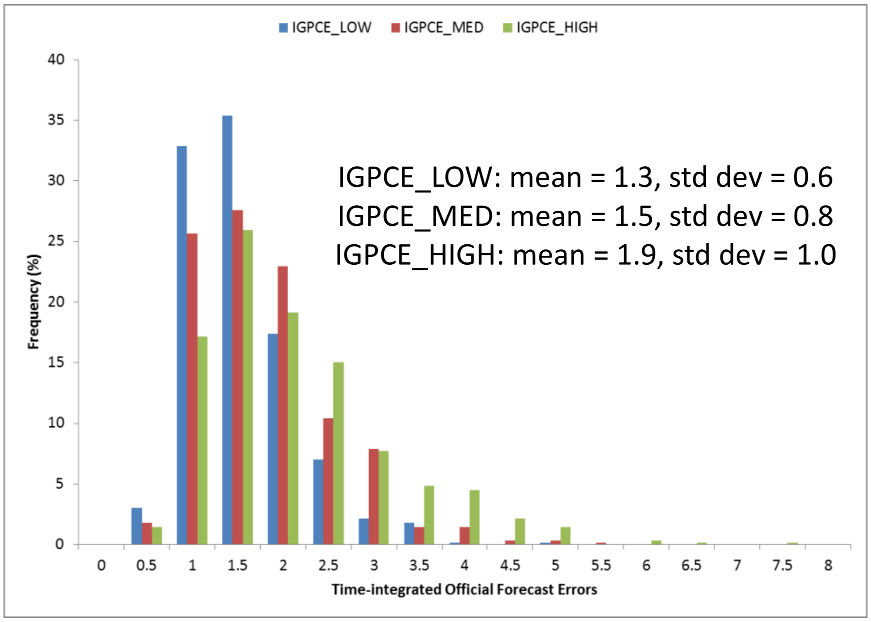

Figure 3. Integrated forecast error distributions corresponding to the low, medium, and high integrated GPCE parameter terciles for all 2008-2012 NHC Atlantic tropical cyclone forecasts.

c. MC model error statistics adjusted to be consistent with official error statistics

It was proposed that the MC model error statistics be adjusted to match those of NHC. This task was completed by 1) removing extratropical cases from the MC model error statistics and 2) applying a bias correction to account for bias introduced by the serial correlation of errors. Figure 4 shows the distributions of the current and bias-corrected along and cross track error distributions for 2009-2013. In general, this correction does not significantly change the wind speed probability values, yet it will allow for consistency between NHC uncertainty products.

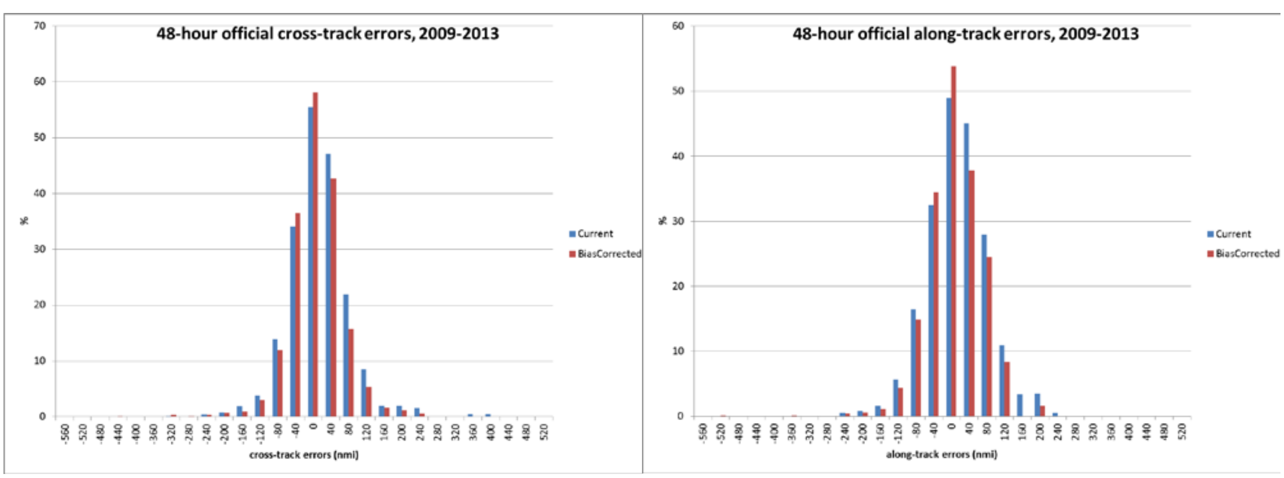

Figure 4. Current (blue) and bias-corrected (red) 2009-2013 official 48-h cross (left) and along (right) track errors.

d. Bias correction of radii-CLIPER

Work continues on the development of a procedure to bias correct the MC model radii-CLIPER model using NHC forecast 34, 50, and 64-kt wind radii forecasts in order to reduce wind speed probability biases in tropical cyclones that are significantly smaller or larger than climatology. NHC radii forecast data has been collected and preliminary work has begun to determine the best methodology for using radii forecasts to bias correct radii CLIPER. However, the optimal methodology for completing this bias correction has yet to be determined and work will continue on this upgrade into the beginning of year 2.

e. Experimental version of the MC model was developed and is currently running in parallel at CIRA

After consulting with NHC TSB staff, it was decided that the experimental MC model developed in Y1 be run in quasi-real-time at CIRA during the 2014 Atlantic and N.E. Pacific hurricane seasons. Currently 2 experimental versions of the MC model, v1.1 and v1.2, are running at CIRA that incorporate upgrades *a* and *c*, respectively. Additionally, an experimental version of the MC model that uses the operational algorithm is being run for comparison. Model output wind speed probability plots and difference plots are posted on the RAMMB website (http://rammb.cira.colostate.edu/realtime_data/nhc/mc_model/) in near-real-time.

3. Year 2 Milestones (through mid-year):

Sep 2014 -	Begin parallel runs during 2014 season and monitor results during the season
Nov 2014 -	Complete development of MC model code to calculate estimates of the arrival/departure of 34-, 50-, and 64-kt winds
Jan 2015 -	Evaluate parallel runs from 2014 season and make any necessary adjustments to the experimental model
Feb 2015 -	Create developmental dataset of 7-day forecasts (NHC for 2012, GFS tracks and new trajectory-CLIPER intensity prior to 2012)