14A.3

HIGH RESOLUTION SST IN THE SHIPS MODEL: IMPROVING OPERATIONAL GUIDANCE OF TROPICAL CYCLONE INTENSITY FORECASTS

Robbie Berg* and Chris Sisko
NOAA/Tropical Prediction Center/National Hurricane Center, Miami, Florida

Mark DeMaria
National Environmental Satellite, Data, and Information Service, Ft. Collins, Colorado

1. INTRODUCTION

Since its inception, the operational Statistical Hurricane Intensity Prediction Scheme (SHIPS) model has used several different types of sea surface temperature (SST) data to produce tropical cyclone intensity guidance. The SST originally used by the SHIPS model was obtained from a climatological analysis (Levitus 1982) but has since transitioned to a weekly-updated Reynold's analysis (Reynolds and Smith 1994) which is currently used in the operational SHIPS model at the National Hurricane Center (DeMaria and Kaplan 1999).

Tropical cyclones fluctuate in intensity based on several environmental factors, but the underlying ocean is perhaps the most important in supplying the necessary energy to sustain these systems (DeMaria and Kaplan 1994). Therefore, a more accurate representation of the SST would potentially produce more realistic forecasts. For example, a tropical cyclone crossing a strong SST gradient (e.g. along the Gulf Stream) requires an accurate depiction of SSTs to ensure the model incorporates the observed lateral variability of the temperature. This study utilizes the statistical-dynamical SHIPS model and the NCEP Global SST to yield improvements to tropical cyclone intensity forecasts given higher resolution SST data.

2. DATA AND METHODS

The National Centers for Environmental Prediction (NCEP) Global SST is a daily, $\frac{1}{2}° \times \frac{1}{2}°$ global analysis developed by the Marine Modeling Branch of NCEP. The analysis is produced as a weighted interpolation of the most recent 24 hours of buoy and ship data, satellite-retrieved SST, and SST from satellite-observed sea ice coverage from the NOAA polar orbiters. The primary advantage of this SST dataset is its production of realistically tight gradients along western boundary ocean currents such as the Gulf Stream and Kuroshio Current (Thiébaux et al. 2001).

SHIPS utilizes a $1° \times 1°$ SST grid and requires that the NCEP SST be re-sampled into a grid of that resolution using 2-D bi-linear interpolation. The model is then re-run for every tropical cyclone in the Atlantic and East Pacific basin during the 2002 hurricane season. Results are derived by two separate methods—using the National Hurricane Center's official forecast track as well as the end-of-season best track (which would be a "perfect" track forecast). Improvements to model performance are then assessed by comparing the average intensity errors from the operational SHIPS runs with the errors from the experimental NCEP SST runs. Since each forecast run in the operational SHIPS is directly partnered with a forecast run in the experimental SHIPS, a paired two-sample *t* test is used to test for statistically significant differences between the mean intensity errors. Mean intensity error reductions cited in the results section below pass the *t* test at the 95% significance level or higher.

3. RESULTS

The inclusion of high resolution SST into the SHIPS model reduces intensity errors for the 2002 season as a whole, with greater improvement coming at longer forecast periods and for storms which tracked across or along a strong SST gradient. In addition, systematic intensity errors (the intensity bias) are also greatly reduced with a uniform distribution of errors across all forecast periods.

a. 2002 Atlantic season

Mean intensity errors and biases for the 2002 Atlantic hurricane season show considerable reduction when SHIPS is re-run with the NCEP Global SST. Figure 1 shows a comparison of these results. Using the NHC best track, the SHIPS runs with the NCEP SST reduced the mean intensity error by as much as 9.4% at a forecast time of five days (120 hours). Mean bias is reduced by a couple of knots (2.5 kts at 120 hours). These results are shown in Table 1.

Results also suggest that the majority of the errors for the season are heavily influenced by a few storms. In addition, the inclusion of higher resolution SST does not initially appear to contribute to equally significant reductions to mean intensity errors for these same storms. For example, Hurricanes Isidore and Lili showed a maximum 4.3% (120-hr) and 2.6% (48-hr) improvement, respectively, using the NHC official forecast track. These small improvements compared to the season may be a factor of the low spatial SST variability over the Caribbean Sea and Gulf of Mexico.

* *Corresponding author address:* Robbie Berg, NOAA / Tropical Prediction Center, Miami, FL 33165; email: Robert.Berg@noaa.gov.

b. 2002 East Pacific season

Results from the 2002 East Pacific season are similar to those from the Atlantic season. Figure 2 shows the comparison of the results using the official and best tracks. The greatest improvement occurred at 72 hours with a 5.9% reduction in intensity error. Most other forecast periods also showed significant yet smaller improvements, but the 120 hour forecast period showed a 1.4% *increase* in mean intensity error (which may be the result of a small sample size). Bias values for the Pacific are usually small, and the NCEP SST provides nominal improvements. In fact, biases become negative for several forecast periods when the high resolution SST data is used.

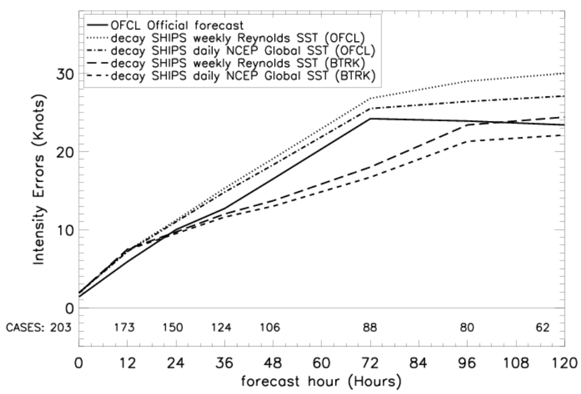

Figure 1. Mean intensity errors for the 2002 Atlantic hurricane season comparing the decay SHIPS runs with Reynolds SST and NCEP daily SST. OFCL plots utilize the official forecast track and BTRK plots utilize a perfect forecast track derived from the system's best track.

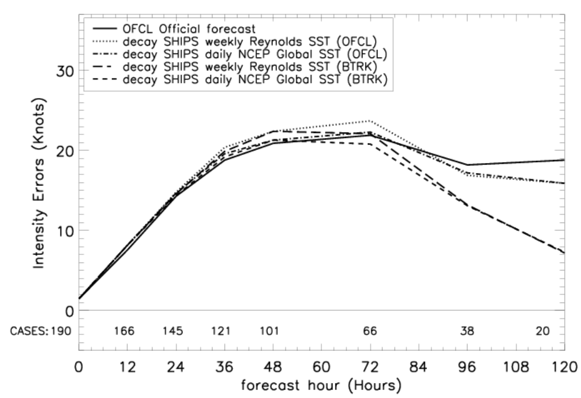

Figure 2. Mean intensity errors for the 2002 East Pacific hurricane season comparing the decay SHIPS runs with Reynolds SST and NCEP daily SST. OFCL plots utilize the official forecast track and BTRK plots utilize a perfect forecast track derived from the system's best track.

4. CONCLUSION

Although mean intensity errors as a whole are reduced with the inclusion of high resolution NCEP Global SST, these results are strongly dependent on a storm's location relative to a strong SST gradient. For example, during the 2002 hurricane season, Hurricanes Isidore and Lili had relatively small intensity error reductions even though the season average was significant. Part of this may be the result of erroneous track forecasts, such as in the case of Isidore when the storm unexpectedly meandered along the northern coast of the Yucatan Peninsula. In addition, neither Isidore nor Lili tracked across a strong SST gradient. Conversely, preliminary results for Hurricane Danny (2003), a storm which tracked along the Gulf Stream in the North Atlantic, suggest significant intensity error reduction when a strong along- or cross-track SST gradient is present. One of the primary advantages of the NCEP SST is the reproduction of realistically tight SST gradients and therefore may prove most useful to storms which cross or parallel these strong gradients.

	Mean Error		Bias	
Fcst Hr	**ATL 02**	**PAC 02**	**ATL 02**	**PAC 02**
12	1.3%	0.0%	0.3 kts	0.5 kts
24	2.1%	1.4%	0.9 kts	0.9 kts
36	3.3%	3.5%	1.2 kts	1.2 kts
48	5.1%	4.9%	1.7 kts	1.1 kts
72	7.2%	5.9%	2.0 kts	0.4 kts
96	9.0%	0.8%	2.2 kts	-0.2 kts
120	9.4%	-1.4%	2.4 kts	0.2 kts

Table 1. Reduction in error and bias between the operational SHIPS runs from the 2002 hurricane seasons and the SHIPS runs with the NCEP daily global SST using the best track. Shaded boxes indicate forecast periods in which the bias became negative.

5. REFERENCES

DeMaria, M. and J. Kaplan, 1994: Sea surface temperature and the maximum intensity of Atlantic tropical cyclones. *J. Climate*, **7**, 1324-1333.

DeMaria, M. and J. Kaplan, 1999: An updated statistical hurricane intensity prediction scheme (SHIPS) for the Atlantic and Eastern North Pacific basins. *Wea. Forecasting*, **14**, 326-337.

Levitus, S., 1982: *Climatological Atlas of the World Ocean*. NOAA Prof. Paper 13, U.S. Government Printing Office, 173 pp.

Reynolds, R. W. and T. M. Smith, 1994: Improved global sea surface temperature analyses using optimum interpolation. *J. Climate*, **7**, 929-948.

Thiébaux, J., B. Katz, W. Wang, and L. D. Burroughs, 2001: The Real-time, Global Sea Surface Temperature Analysis: RTG_SST. *Technical Procedures Bulletin,* 477. Dept. of Commerce, NOAA, National Weather Service, Office of Meteorology, Silver Spring, MD.