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Recent Updates to SHIPS-MI

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1. INTRODUCTION

The Statistical Hurricane Intensity Prediction Scheme (SHIPS) is a statistical-dynamical linear regression model, using climatology, persistence, and environmental conditions to forecast tropical cyclone intensity change. Jones et al. (2006) follow the same approach but add passive microwave brightness temperatures to the list of input predictors. The brightness temperatures, primarily at 19 GHz, respond to precipitation and are used as indicators of latent heating in the tropical cyclone inner core. Because this additional data comes from microwave imagers (SSM/I, TMI, and AMSR-E), the new regression is called SHIPS-MI.

Several improvements have recently been made to SHIPS-MI. The most significant of these is the expansion of the training sample back to 1988 (previously 1995) and the addition of tropical cyclones from the 2004 season to the Atlantic and Eastern North Pacific models. The expanded training sample improves comparability with SHIPS, as well as allowing the creation of forecasts out to 120 h. The new SHIPS-MI has smaller errors than those reported by Jones et al. (2006). This new version will be run in an experimental mode at both the University of Alabama in Huntsville (UAH) and NOAA National Hurricane Center (NHC) in 2006.

This paper summarizes the predictors in Section 2. Forecast errors for the 2005 season are shown in Section 3. Section 4 summarizes error statistics from the dependent training sample.

2. INPUT PREDICTORS

The input predictors are listed in Table 1. Most are taken from SHIPS training files for model development and from SHIPS diagnostic files for real time forecast generation. As such, all except the microwave-derived predictors are described in a sequence of papers detailing SHIPS (DeMaria and Kaplan 1994, 1999, DeMaria et al. 2005).

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Table 1. Input predictors in the Atlantic version of SHIPS-MI. The Eastern North Pacific version uses a similar list of predictors, although latitude itself is also an important predictor in that model.

MSW0	Initial Maximum Sustained Winds
PER	Persistence (previous 12-h intensity change)
VPER	MSW0 x PER
EDAY	Function of Julian Day
USPD	Zonal Component of Storm Motion
POT	MPI-MSW0 (Potential for further intensification)
POT2	POT squared
SHRD	200-850 hPa wind shear
SHRDLAT	SHRD x Latitude
MSWSHRD	MSW0 x SHRD
EPOS	θ_e excess of a lifted parcel
T200	200 hPa temperature
Z850	850 hPa vorticity
PSLV	Pressure at the Steering Level
MEANH19	0-100 km mean 19 GHz Horizontal TB
MAXH19	0-100 km maximum 19 GHz Horizontal TB

3. INITIAL RESULTS FOR THE 2005 ATLANTIC SEASON

The new version of SHIPS-MI has been used to regenerate forecasts for the 2005 cases in which we initially collected forecast information. Some initial results are presented below. *These results are based on verification using NHC's operational intensity estimates, since the 2005 best tracks are not yet complete.*

SHIPS-MI forecasts are only generated when the satellite data is available during an appropriate time window. The forecasts here use only satellite data that was collected between T-4 and T-1 hours (e.g., 0200 – 0500 UTC for a 0600 UTC forecast). Using this criterion, we were able to generate SHIPS-MI forecasts for about 25% of all synoptic times. This fraction should have been higher (30-40%), but some forecasts were missing due to network, power, or scripting issues at UAH. In operations, some forecasts may be available slightly later than T-1 hours, but the analysis here assumes a worst-case-scenario.

For the homogeneous sample of forecasts where SHIPS-MI can be compared against SHIPS, SHIFOR (Statistical Hurricane Intensity Forecast), and OFCL (official forecasts from NHC), we get the RMS errors in Table 1 and bias in Table 2. These exclude any forecasts in which landfall occurred before the forecast verified.

Table 2. RMS Errors for 2005 forecasts, excluding landfalls.

	12-h	**24-h**	**36-h**	**48-h**	**72-h**	**96-h**	**120-h**
# fcsts	*115*	*103*	*94*	*85*	*71*	*58*	*45*
SHIPS-MI	8.5	12.4	16.0	19.3	21.9	22.5	27.7
SHIPS	8.7	12.6	16.4	18.7	21.3	21.7	26.3
OFCL	7.4	11.1	14.6	17.7	20.9	22.9	28.4
SHIFOR	9.2	14.0	18.8	21.0	24.8	25.4	25.5

Table 3. Bias for 2005 forecasts, excluding landfalls.

	12-h	**24-h**	**36-h**	**48-h**	**72-h**	**96-h**	**120-h**
SHIPS-MI	-0.1	0.1	1.0	0.2	-0.2	0.8	3.5
SHIPS	-0.9	-1.1	-0.6	-2.1	-3.7	-3.2	-3.4
OFCL	0.2	-0.5	0.0	-2.7	-4.9	-5.1	-4.9
SHIFOR	-0.8	-1.6	-2.1	-5.0	-6.6	-6.3	-6.7

Generally, SHIPS-MI forecasts are within a few knots of the SHIPS forecasts. For short range forecasts (< 48 h), SHIPS-MI is usually nudging the SHIPS forecast in the correct direction, although the opposite is sometimes the case. For the 24 h forecasts, SHIPS-MI is more accurate than SHIPS 60% of the time. These differences for 2005 are smaller than expected; errors in the training sample are generally around 5% smaller for SHIPS-MI than for SHIPS.

For most storms, only a few forecasts are available for analysis and it is difficult to make meaningful statements about forecast quality in those storms. Those with at least ten 36-hour forecasts are listed in Table 3. In some cases, the scripts at UAH did not keep up with the record-setting pace of storm development in 2005 (i.e., a storm name was not added to the script until after forecasts had been missed). In other cases, the sun-synchronous DMSP satellites visit parts of the Western Caribbean and Gulf of Mexico at a bad time of day for the data to be included in the normal forecast cycle. Dealing with this latter issue will be a point to address in the future.

Table 3. 36-h RMS errors for those storms that had at least ten SHIPS-MI forecasts.

Storm	# fcsts	SHIPS-MI	SHIPS	OFCL	SHIFOR
Emily	13	24.9	27.3	18.5	33.5
Irene	15	12.3	8.6	8.8	8.2
Maria	12	8.7	9.9	12.3	10.5
Epsilon	13	15.2	17.6	17.1	15.1

4. ERROR ANALYSIS FROM DEPENDENT TRAINING SAMPLE

Beginning with 1995, infrared (IR) and oceanic heat content (OHC) data is available for use in SHIPS. That data is *not* used in SHIPS-MI, because an insufficient number of forecasts have the full combination of microwave, infrared, and oceanic heat content data. SHIPS is developed from a 1982-2004 training sample, with the IR and OHC correction in the 1995-2004 sample. SHIPS-MI is now developed from a 1988-2004 training sample (1991-2004 for the Eastern North Pacific). A homogeneous sample of 1995-2004 forecasts is used to compare SHIPS-MI and SHIPS forecast errors. Note that this is a dependent subset of the training samples for both SHIPS and SHIPS-MI.

Mean absolute errors are normalized against those from SHIPS in Fig. 1 for the Atlantic and Fig. 2 for the Eastern North Pacific. That is, the zero line represents forecasts generated using the 2005 operational coefficients for the SHIPS model. Atlantic SHIPS-MI mean absolute errors are up to 6% smaller than those from SHIPS at 18-30 hours (Fig. 1). The apparent improvements beyond 60 hours should be disregarded, as the small sample size for long-term forecasts makes these insignificant. The additional lines in Fig. 1 show the detrimental effect of removing IR and OHC inputs from SHIPS ("SHIPS-E") or removing microwave data from SHIPS-MI ("base"). In both cases, the forecasts are up to about 2% worse than SHIPS if no satellite data is included.

For the Eastern North Pacific (Fig. 2), SHIPS-MI mean absolute errors are 5% smaller than SHIPS at 24 hours. Another line is added in this figure ("SHIPS-85") showing a model in which only the 85 GHz channel is used to produce microwave-based forecasts. Normally these errors are slightly worse than those from SHIPS-MI, but they happen to be smaller than SHIPS-MI errors for the 1995-2004 sample.

Fig. 3 shows the relative contribution to the Atlantic SHIPS-MI forecasts from predictors grouped together as microwave; potential for intensification based on sea surface temperature (SST); vertical wind shear; other environmental variables; and climatology and persistence. While SST is generally the most important type of input, the microwave predictors are more important than vertical wind shear in the first 36 hours. There is very little contribution from the microwave predictors at 72 hours and beyond – it would be alarming if this were not the case.

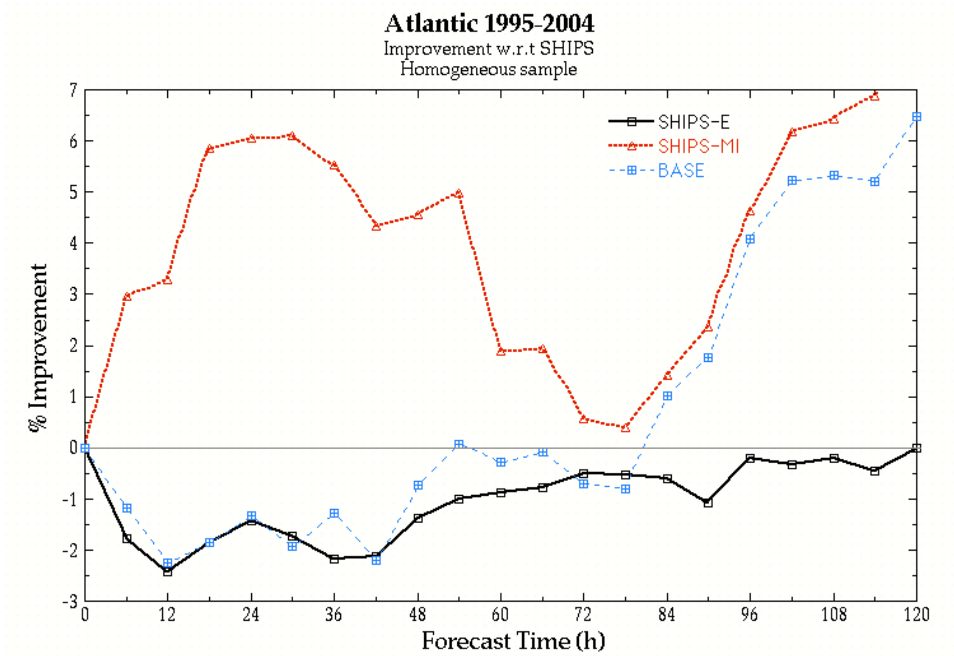

Figure 1. Percentage improvement of Atlantic SHIPS-MI mean absolute errors, compared to SHIPS using the 2005 version of the model. A homogeneous 1995-2004 sample is used for verification, allowing inclusion of the IR and OHC corrections in SHIPS. This is a subset of the dependent training sample for both SHIPS-MI and SHIPS. "SHIPS-E" is SHIPS without the IR and OHC corrections. "Base" uses the same predictors as SHIPS-MI, except microwave predictors are excluded.

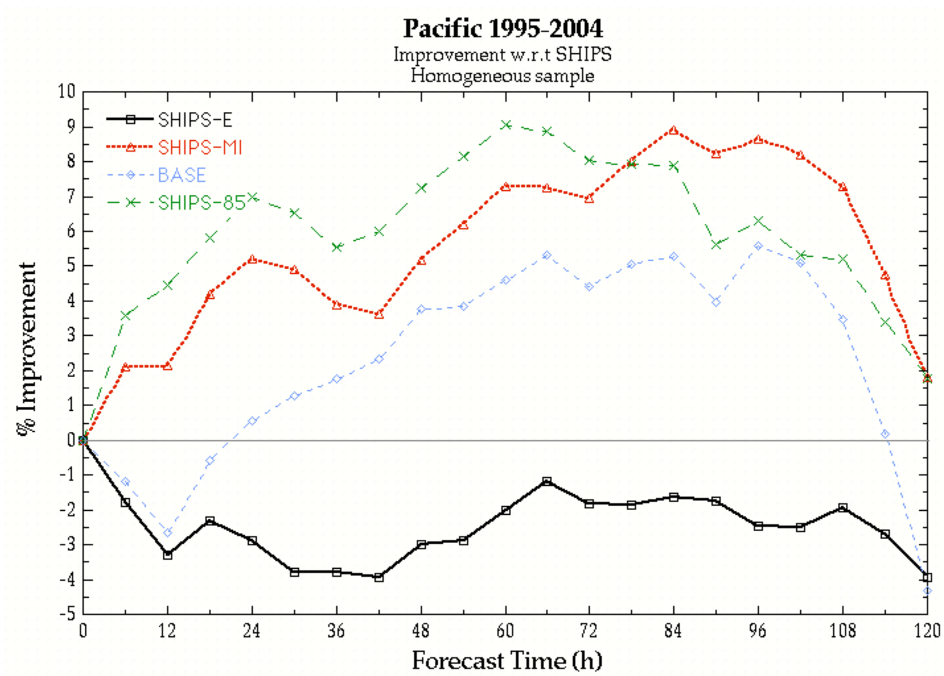

Figure 2. As in Figure 1, but for the Eastern North Pacific. "SHIPS-85" uses only the 85 GHz channel for microwave terms, whereas SHIPS-MI also uses 19 GHz.

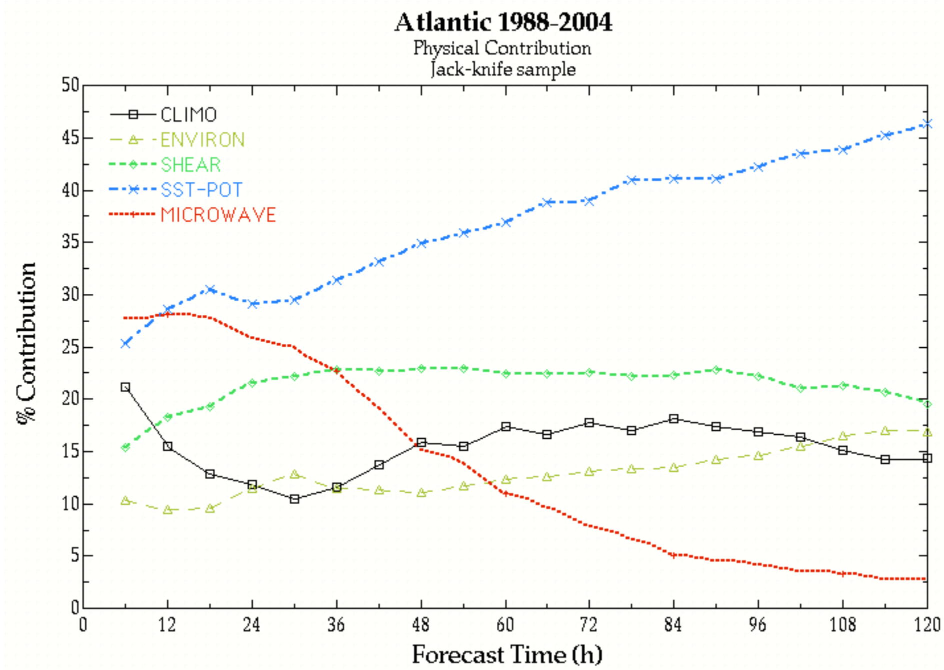

Figure 3. Mean relative contribution to Atlantic SHIPS-MI forecasts from predictors grouped together as microwave; potential for intensification based on sea surface temperature (SST); vertical wind shear; other environmental variables; and climatology and persistence. This accounts for related predictors that sometimes have offsetting effects. At any given forecast period, the lines sum together to 100%.

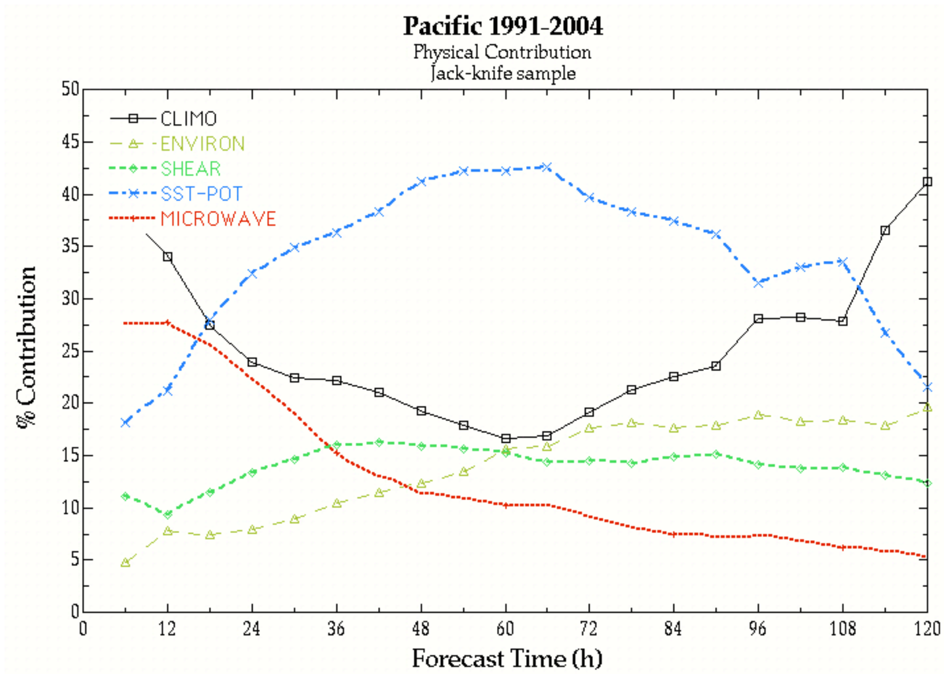

Figure 4. As in Figure 3, but for the Eastern North Pacific.

Similarly, Fig. 4 shows the contributions to the Eastern North Pacific SHIPS-MI. Climatology and persistence has the greatest impact in the first 12 hours, followed by the microwave predictors. SST-based predictors dominate after 12 hours. The relative importance of microwave predictors decreases more rapidly with increasing forecast time in the Eastern North Pacific than in the Atlantic.

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