A STATISTICAL INTENSITY MODEL CONSENSUS FOR THE JOINT TYPHOON WARNING CENTER

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1. INTRODUCTION

The Statistical Intensity Prediction System or STIPS (Knaff, et al. 2005) has been developed to forecast tropical cyclone intensity (wind speed) for both the western North Pacific and Southern Hemisphere. The operational STIPS is installed as part of the Automated Tropical Cyclone Forecasting System (ATCF; Sampson and Schrader 2000) at the Joint Typhoon Warning Center (JTWC) in Pearl Harbor, Hawaii. STIPS is executed using the official JTWC track and gridded data from the Navy Operational Global Atmospheric Prediction System (NOGAPS; Hogan and Rosmond 1991).

An evaluation of operational forecasts indicates that STIPS is skillful out to approximately 60h when compared to the statistical model baseline (Knaff, et al. 2003). Using the development data (Knaff, et al. 2005) as a perfect prog, it is estimated that current operational STIPS performance is within about 15% of its potential skill.

Part of this 15% degradation in the operational model is probably due to problems incurred when the official JTWC forecast track is correct, but deviates from that of NOGAPS. This can provide artificial shear for STIPS not present in the real atmosphere along the JTWC track. STIPS computations along the NOGAPS track would provide more realistic shear forecasts in cases where the actual track follows the NOGAPS forecast track. However, the NOGAPS tracks are generally not as accurate as those from the JTWC.

Another potential factor is large JTWC forecast track errors or even small errors near land. For example, when the JTWC track passes near land and the verifying position does not, the STIPS forecast will execute the landfall module (DeMaria, et al. 2005) that shouldn't be executed. A suite of STIPS forecasts based on routinely available operational NWP model forecast tracks like those used in the track consensus at JTWC (Sampson, et al., 2006) might help mitigate large landfall timing errors and provide alternate scenarios during landfall, especially when the tracks are dispersed. Also, a consensus of the STIPS forecasts run using forecast tracks of the NWP models and their shear (when available) might outperform the individual forecasts. The purpose of this work is to investigate this strategy and compare its performance against that of the operational STIPS.

2. METHOD

At approximately synoptic time + 1.5 hours, the operational NWP model forecasts and best tracks available at JTWC are downloaded to a workstation at NRL Monterey. Since the NWP model forecasts are received late, they are interpolated to the current time (Goerss, et al. 2004). These interpolated NWP model tracks are then used to initialize STIPS. For five of the NWP forecast models, enough gridded data are available to do STIPS shear computations. These include NOGAPS (Goerss and Jeffries 1994), the Global Forecast System (Lord 1993), the Japanese Global Spectral Model (Kuma 1996), the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®; Hodur 1997[1]) and the United Kingdom Meteorology Office model (Cullen 1993; Heming et al. 1995). For the the Japanese Typhoon Model(Kuma 1996) forecast tracks, the Japanese Global Spectral Model fields are used are used for shear computations. This is done because it is assumed that the two models will generally have somewhat similar tracks for a given forecast. For the remaining four models, the NOGAPS wind fields are used for the shear computations. These include the U.S. Navy version of Geophysical Fluid Dynamics Laboratory Model (Kurihara et al. 1998; Rennick 1998), the Air Force Weather Agency Model (Grell et al. 1995), the Australian Tropical Cyclone Local Area Prediction System (Davidson and Weber 2000), and the Weber barotropic model (Weber 2001). All fields are stored via the Tactical Environmental Data Server (TEDS). The TEDS is a relational database bundled with decoders for the observations and grid point data.

Once the member models have completed their forecasts, a consensus is computed. The consensus results as well as a textual output of the individual member forecasts is then sent via email to the JTWC Typhoon Duty Officer for consideration. The results are also kept for evaluation at NRL.

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3. RESULTS

Track and intensity performance skill for each of the ten members included in the STIPS consensus is shown in Figure 1. For track, the skill baseline is CLIPER (Neumann 1992) while for intensity the skill baseline is ST5D (Knaff et al. 2003). Results indicate that all ten members are skillful at the 48-h forecast period for both track and intensity. The track skill as a percentage is generally much larger than the intensity skill. This is expected since all the intensity forecasts are based on the STIPS algorithm, which is only marginally skillful even in a perfect prognosis mode (Knaff et al. 2005).

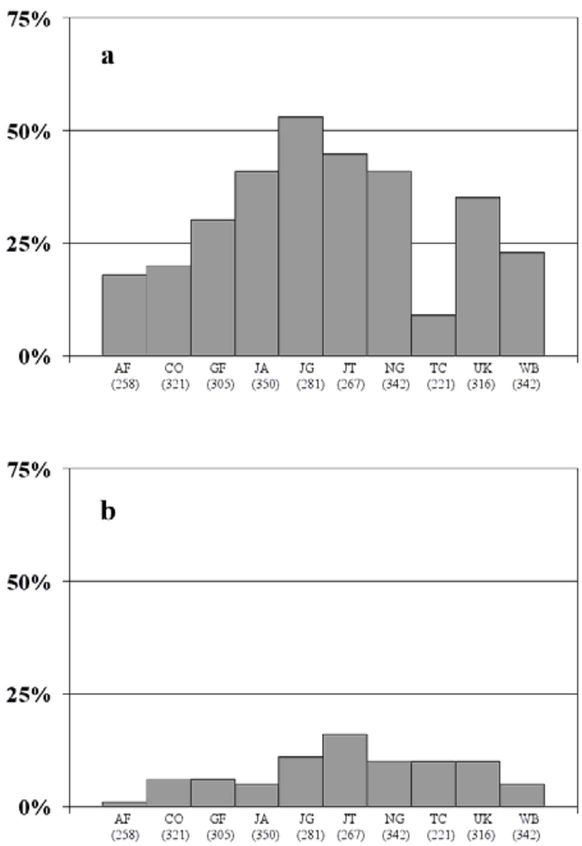

Figure 1. 48-h forecast (a) track and (b) intensity improvement (%)of individual STIPS consensus members over statistical skill baselines (CLIPER and ST5D, respectively). Results are for the 2005 western North Pacific season. Two character model identifiers are as follows: AF=Air Force, CO= COAMPS, GF=GFDN, JA=GFS, JG=Japanese Global, JT=Japanese Typhoon, NG=NOGAPS, TC=Australian TCLAPS, UK=United Kingdom, WB=WBAR. Numbers of cases are listed in parentheses.

Track and intensity performance skill for each of the ten members included in the STIPS consensus relative to the consensus is shown in Figure 2. Immediately noticeable is that the track and intensity performance of the members are generally worse than the consensus. Also apparent is that the gain in skill from forming an intensity consensus from these members is generally not as large as the gain in skill from forming a track consensus of the same ten members. This result was anticipated, as the skill and independence of the consensus member intensity forecasts are less than the skill and independence of the track forecasts (Sampson et al. 2006).

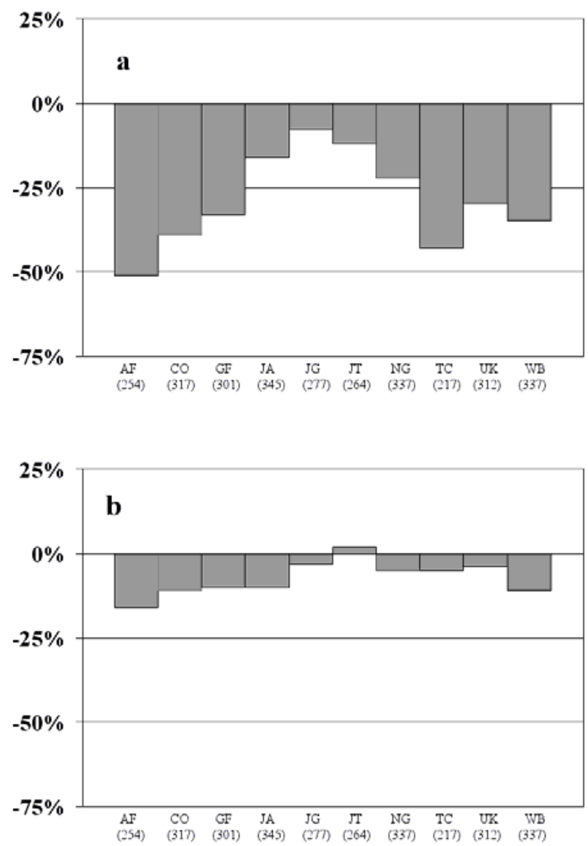

Figure 2. 48-h forecast (a) track and (b) intensity improvement (%) of individual STIPS consensus members relative to the ten-model consensus. Results are for the 2005 western North Pacific season. Two character model identifiers are listed in Figure 1. Numbers of cases are listed in parentheses.

So far we have shown that we can create marginally skillful, marginally independent intensity consensus members and that the resultant consensus intensity performs near the top of the pack. This in itself is of benefit because it provides the forecaster a range of forecast results, especially when a tropical cyclone is near land or the consensus tracks are widely distributed. On the other hand, we have not demonstrated improved deterministic forecast skill.

An evaluation of track and intensity skill for the current operational method of running STIPS is compared with that of the consensus in Figure 3. The dataset for this comparison is quite limited, as the version of STIPS used for the consensus experiments was not consistently run as the version run in operations is run until the 17th tropical cyclone of the 2005 season. Even with the limited dataset, results are intriguing. The STIPS track forecast errors (i.e. the JTWC official track forecast errors) and consensus track errors are within 10% of each other out to 72 hours. The STIPS consensus intensity forecast skill is slightly higher (within a few percent) of the traditional STIPS out to 36 hours, then 9% higher at 48 hours. T-test results indicate that the probability of model differences at the 48-h forecast period are significant at the 90% level, with removal of 30 hours serial correlation (von Storch and Zwiers 1999). One possible explanation for improved consensus performance at the longer forecast periods is that the STIPS shear computations are more realistic for the consensus members than for the STIPS run with the official JTWC track, especially when the JTWC track deviates from the NOGAPS vortex. Other likely contributors are independence of the STIPS consensus members and differences in track forecasts.

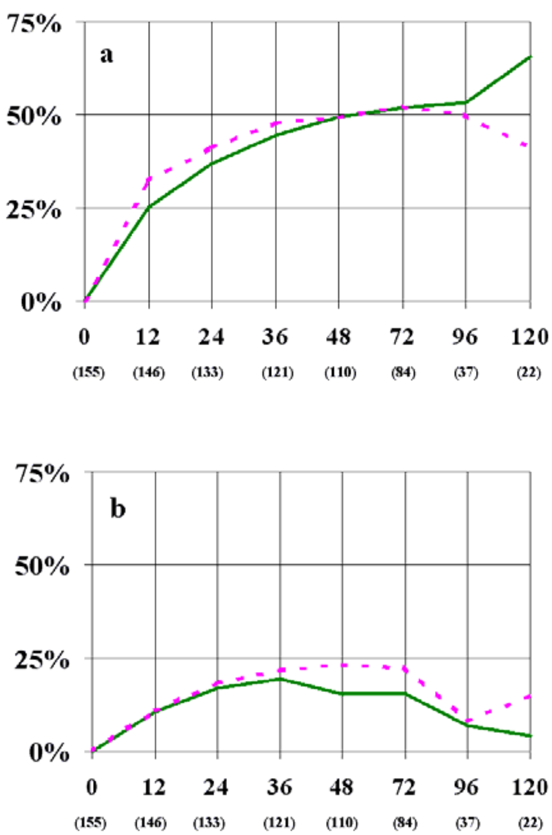

Figure 3. Forecast (a) track and (b) intensity improvement (%) over the statistical skill baselines (CLIPER and ST5D, respectively) of the STIPS run as it has been in operations (STIPS) and run as ten-model consensus (ST10). Results are limited to 17-25W and a handful of forecasts from 04W, 05W, 07W, 10W and 11W.

4. FUTURE PLANS

The results from preliminary tests with a STIPS consensus show promise, but are far from conclusive. Another year of operational tests should provide enough data for statistical analysis. Tests for the larger data set might provide insight into independence and optimal number of STIPS consensus members. NWP field data for the four models currently using NOGAPS fields would be beneficial, as would the other fields required by STIPS. Long-term plans include development or acquisition of other independent, skillful intensity forecasts for use in an intensity consensus. Finally, improvements to the STIPS model itself are always worth investigating.

5. ACKNOWLEDGEMENTS

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