9C.6 CHALLENGES OF FORECASTING TROPICAL CYCLONE INTENSITY CHANGE AT THE JOINT TYPHOON WARNING CENTER

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1. INTRODUCTION

Consistently preparing accurate forecasts of tropical cyclone intensity change remains an elusive goal for Joint Typhoon Warning Center (JTWC) forecasters, even as increasingly sophisticated dynamical forecast models yield remarkably improved tropical cyclone track forecast guidance (Goerss and Sampson, 2004). Unfortunately, many of the dynamical models that have demonstrated increasing track forecast skill have shown little corresponding improvement in predicting tropical cyclone intensity change throughout the five-day forecast period employed by the JTWC. Statistical-dynamical methods that incorporate model output predictors, such as the Statistical Typhoon Intensity Prediction Scheme (STIPS) used at JTWC, have proven more skillful at forecasting tropical cyclone intensity change than the dynamical models. In fact, STIPS schemes provide the most skillful automated intensity forecast guidance available to the JTWC forecaster. However, both STIPS schemes and subjective intensity forecast processes are sensitive to tropical cyclone intensity analysis errors and a heavy reliance upon large-scale environmental factors as predictors of tropical cyclone intensity change (Knaff et al., 2005; Sampson et al., 2008). It is hypothesized that improving tropical cyclone intensity analysis methods and incorporating elements of storm structure into the automated and subjective intensity forecast processes employed at JTWC will translate into more accurate tropical cyclone intensity forecasts.

2. INTENSITY ANALYSIS

Tropical cyclone intensity trend is a critical statistical predictor of intensity change in STIPS prediction schemes, so sound tropical cyclone intensity analyses are vital to short and medium-range intensity forecasts (Knaff et al., 2005).

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However, analyzing tropical cyclone intensity in JTWC forecast basins is complicated by a paucity of “ground truth,” in-situ observations as well as operational time constraints. Although targeted aircraft observations and synoptic observations from reporting stations are occasionally available during the analysis process, the JTWC forecaster must typically interpret data from remote-sensing sources, including subjective Dvorak analyses, automated satellite intensity estimates, microwave satellite imagery, scatterometer data, and radar, to formulate tropical cyclone initial intensity estimates.

Useful microwave satellite imagery is sometimes unavailable until after a tropical cyclone forecast has been prepared and transmitted. Additionally, the recent failure of the QuikSCAT sensor has limited operational availability of scatterometer data. And, of course, most cyclones form, track and dissipate over open ocean areas where radar data is rarely available. Thus, forecasters must often set tropical cyclone initial intensities using only the available subjective Dvorak and automated intensity estimates, including the CIRA and CIMSS AMSU-based intensity estimates and the CIMSS Advanced Dvorak Technique (ADT) and satellite consensus (SATCON) (Demuth et al., 2004; Brueske and Velden, 2003; Olander and Velden, 2007; Herndon and Velden, 2008). These automated intensity estimates are typically available at or very near synoptic forecast times. Forecasters currently consider each subjective and automated intensity estimate as a unique input. However, the potential benefits of formulating an intensity consensus that incorporates both subjective and automated intensity estimates warrants consideration, particularly given the promising performance of consensus methods applied to automated intensity fix techniques (Hendon and Velden, 2008).

JTWC forecasters examine storm structure revealed by microwave imagery, when available, as a qualitative check on the probable accuracy of subjective Dvorak and automated intensity estimates. A more objective technique to estimate intensity from microwave satellite imagery is currently under development and evaluation at JTWC, and such estimates may be incorporated into future intensity analysis processes and any potential subjective / objective intensity consensus.

3. INTENSITY FORECAST

The JTWC forecaster has about one to one and one-half hours to synthesize forecast track, intensity, and wind distribution guidance before issuing a tropical cyclone forecast. Therefore, automated forecast guidance must be easily interpreted and applied to receive full consideration during the forecast process. JTWC forecasters carefully scrutinize potential environmental influences on intensity change, including upper-level outflow, vertical wind shear, mid-level moisture, and ocean heat content relative to predicted track, as they prepare the intensity forecast. These factors are among those incorporated into the STIPS prediction schemes.

3.1 *Sources of intensity forecast errors*

As previously discussed, optimizing tropical cyclone intensity trend analysis can improve STIPS forecast performance. However, even when the intensity trend is well analyzed, STIPS may under forecast rapid intensity changes due, in part, to the schemes' emphasis on large-scale environmental parameters as predictors (Knaff et al., 2005). Incorporating elements of storm core dynamics into the STIPS "ST11" scheme through inclusion of GFDN dynamical model intensity output does modestly increase STIPS intensity forecast skill, but general biases remain (Sampson et al., 2008).

Subjective forecast errors often follow noted deficiencies in the STIPS guidance as forecasters struggle to formulate an appropriate quantitative adjustment through subjective interpretation of the same large-scale environmental features already incorporated into STIPS schemes. This challenge results in a tendency to under-forecast the intensification rate for rapidly intensifying cyclones as well as the dissipation rate for rapidly weakening cyclones. Forecasts for the strongest cyclones tend to underestimate peak intensity as well, especially those forecasts issued early in a cyclone's life cycle (Blackerby, 2005). Early intensity forecasts for super typhoon 15W (Choi-Wan) from 2009, shown in figure 1, exemplify these slow intensification and delayed peak intensity trends. Potential incorporation of additional environmental predictors into STIPS, such as total precipitable water and satellite-observed infrared radiance data, and the planned pursuit of new predictive methods, such as logistic growth equations, could partially mitigate these errors (John Knaff, personal correspondence).

3.2 *Incorporation of storm structure data*

The JTWC forecaster applies various data sources and methods to scrutinize potential large-scale influences on cyclone intensity. However, he or she typically lacks the information and tools needed to fully incorporate cyclone core structure as a predictor of intensity change. Still, forecasters do identify a few major structural changes such as eyewall replacement cycles and annular transitions, primarily through analysis of microwave satellite data, and subjectively adjust intensity forecasts to account for documented trends associated with these changes.

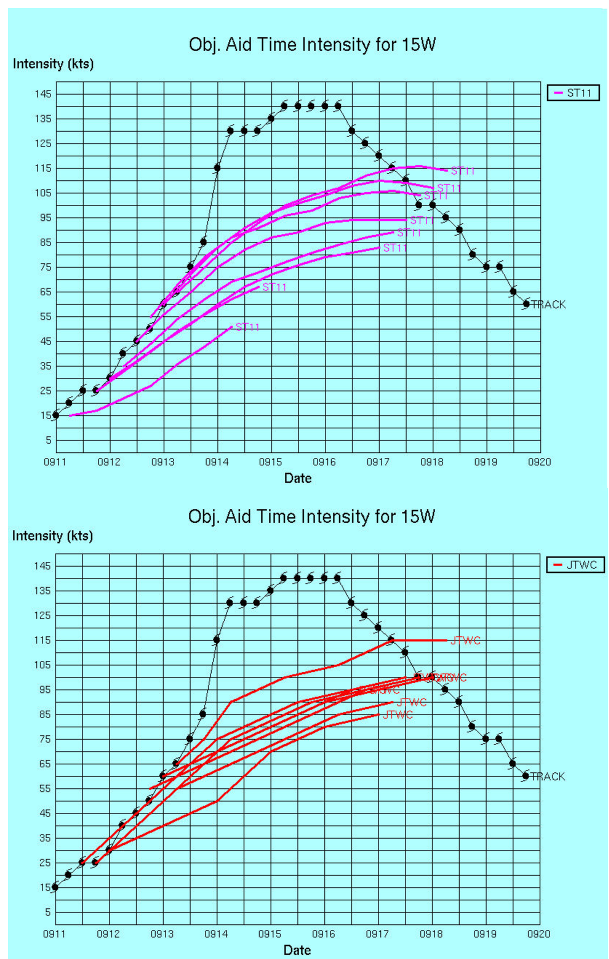

Figure 1: Super Typhoon 15W (Choi-Wan) from 2009 intensified from a 75 knot typhoon to a 130 knot super typhoon between 0000Z and 1800Z on September 14, 2009. STIPS guidance and JTWC forecasts (ST11 and JTWC above) suggested a far slower intensification trend than observed.

Promisingly, recent work suggests that considering additional elements of storm structure, such as the core convection characteristics of developing cyclones observed by microwave satellite sensors and lightning strike data from long-range detection networks, may improve both automated and subjective tropical cyclone intensity prediction processes (Jones et al., 2006; Kieper, 2008; Edson and Ventham, 2008; Demetriades and Holle, 2008; Solorzano et al., 2008). Such improvements could help JTWC forecasters anticipate both rapid intensification and rapid weakening events, fluctuations that current forecast methods fail to accurately predict. Additionally, lessons learned through development and operational use of the Statistical Hurricane Intensity Prediction System Rapid Intensification (SHIPS-RI) index for Atlantic and Eastern Pacific Ocean tropical cyclones could be applied to the subjective forecast process at JTWC and potential future development of a similar index for the JTWC forecast area (Kaplan et al., 2010).

4. DISCUSSION

Difficulty analyzing tropical cyclone intensity and a reliance on large-scale environmental influences as primary determinants of intensity change contribute significantly to the JTWC tropical cyclone intensity forecast challenge. Ongoing development of mesoscale numerical prediction models, including anticipated improvements to tropical cyclone structure simulation by the operational GFDN, may ultimately enable forecasters to better anticipate intensity changes and increase statistical-dynamical intensity forecast skill (Ginis, et al., 2010). However, until significant progress in explicit numerical prediction of tropical cyclone intensity change is realized, developing existing and future intensity analysis methods and introducing new techniques to incorporate additional environmental and storm structure data into both automated and subjective forecasting processes will remain the best avenues for improving JTWC tropical cyclone intensity forecast performance.

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