Experiments with Tropical Cyclone Wave and Intensity Forecasts

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Award Number: N0001407WX21197
http://www.nrlmry.navy.mil/atcf_web/wavewatch

LONG-TERM GOALS

The goal of this project is to improve guidance for the prediction of waves and intensity associated with tropical cyclones.

OBJECTIVES

The objectives of this project are to develop, test and evaluate new strategies to predict (a) tropical cyclone generated waves and (b) tropical cyclone intensity as measured by one-minute mean maximum sustained wind speed.

APPROACH

(1) Develop a strategy to forecast waves that are consistent with tropical cyclone warnings/advisories from the Joint Typhoon Warning Center and the National Hurricane Center. Evaluate results against available buoys or other observations. The wave forecast algorithm must be designed to operate within the constraints of the Fleet Numerical Meteorology and Oceanography Center infrastructure and must be efficient in that the products can be made available to users within six hours of the warning/advisory dissemination. (2) Attempt to improve intensity forecasts from the Statistical Typhoon Intensity Prediction System (STIPS) and other forecast models. Implement and experiment with new formulations of STIPS. Publish results.

WORK COMPLETED

1. Wave forecast algorithm

In collaboration with Paul Wittmann (Fleet Numerical Metorology and Oceanography Center) and Hendrik Tolman (National Centers for Environmental Prediction), we completed the prototype version of WAVEWATCH III (Tolman et al. 2005), which uses tropical cyclone warnings/advisories as input. The emphasis was in developing an algorithm to generate a realistic vortex and merge it with a background NWP model with its vortex removed. The algorithm has been run in real-time for the entire 2008 season and is being evaluated by NMFC, NHC/TAFB, CTF 70, NMOC Yokosuka, FNMOC and various NWS offices. Shape files are being generated (by FNMOC) and disseminated by NRL for use in JMV.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2008	**Annual**	**00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Experiments With Tropical Cyclone Wave And Intensity Forecasts	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Research Laboratory,Monterey,CA,93943-5502**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT
The goal of this project is to improve guidance for the prediction of waves and intensity associated with tropical cyclones.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**7**	

2. Intensity forecast algorithm.

In FY08, we updated intensity consensus combinations for the Atlantic, eastern and western North Pacific basins. The Atlantic and eastern North Pacific have two new members (HWRF and GFDN), and the western North Pacific intensity consensus includes members that make use of Ocean Heat Content fields from NOAA AOML. Two intensity algorithms and a consensus were evaluated in the Southern Hemisphere, documented and submitted for publication.

RESULTS

1. Wave forecast algorithm

Funding of this project grew out of a Yokosuka sortie during 2006, which in hindsight was determined to be unnecessary since the 12 ft seas never arrived on the coast near Tokyo. Figure 1 shows a 72-h NOGAPS-driven WAVEWATCH III forecast from September 19 2006 at 12 UTC available with the JTWC forecast from Sep 19 at 18 UTC. This is the chart that was used in the Yokosuka sortie decision. The 12 ft seas encroached on Tokyo Bay by the 84-h forecast and ships were sortied in order to give them time to steam far enough southwest to avoid the approaching high seas associated with YAGI.

Analysis of the NOGAPS vortex tracker shows that the 72-h NOGAPS track was slightly closer to the verifying position than the JTWC forecast (84 nm vs 110 nm), but the intensity and wind radii forecasts were poor. The NOGAPS intensity forecasts are strongly negatively biased (70, 72, 71, 88 and 64 kt at 12, 24, 36, 48 and 72 h, respectively). The NOGAPS 34 kt-wind radii are also far too large for this forecast. This is evident in Fig. 2 where the northeast quadrant of the NOGAPS 34-kt wind radii for 96 h is over Tokyo Bay while the verifying analysis shows the 34-kt wind radius coming about 175 nm from the coast. For the whole storm, the NOGAPS 34-kt wind radii forecasts were positively biased. For example, the 34-kt NOGAPS northwest quadrant was biased 87, 84, 97, 78 and 79 nm while the JTWC forecast bias was consistently within 10 nm of the verifying track wind radii.

The 84-h prediction for the JTWC forecast inserted into the NOGAPS background is shown in Fig. 3. The NOGAPS forecast fields were not available for this run, so the initial analysis was used as a proxy for the forecast fields. Of particular interest is the small area of greater than 12-ft seas. While the NOGAPS-driven WAVEWATCH shows the area of greater than 12-ft seas impacting the Japanese coast, the new algorithm shows that the 12-ft seas contour is still about 300 nm from the coast. This implies that the sortie decision could be delayed. Runs at September 20 12 UTC and September 21 12 UTC also indicate that the 12-ft seas contour only grazes the area just outside Tokyo Bay, leaving the coastline southwest of Tokyo Bay with less than 12-ft seas. The YAGI hindcast (Fig. 3b) shows that the 12-ft seas remained just off the coast during the event so that the sortie was probably not warranted.

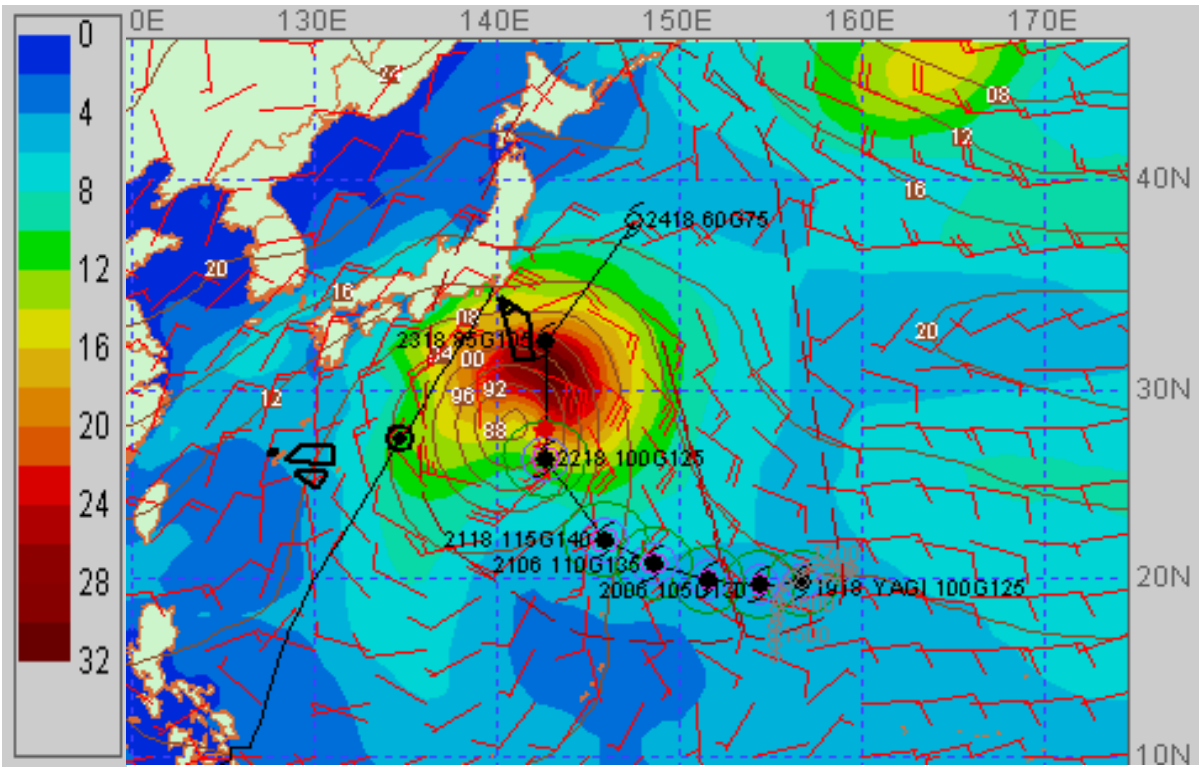

Figure 1. NOGAPS WAVEWATCH III 84-h forecast of Yagi (WP162006) from Sep 19 12 UTC valid Sep 23 00 UTC with NOGAPS surface winds (wind barbs), surface pressure (contours) and JTWC forecast track and 34 kt wind (green) radii from Sep 19 18 UTC overlaid. NOGAPS WAVEWATCH III shows 12 ft seas impacting much of the Japanese coast. Key for significant wave (ft) heights shown on left.

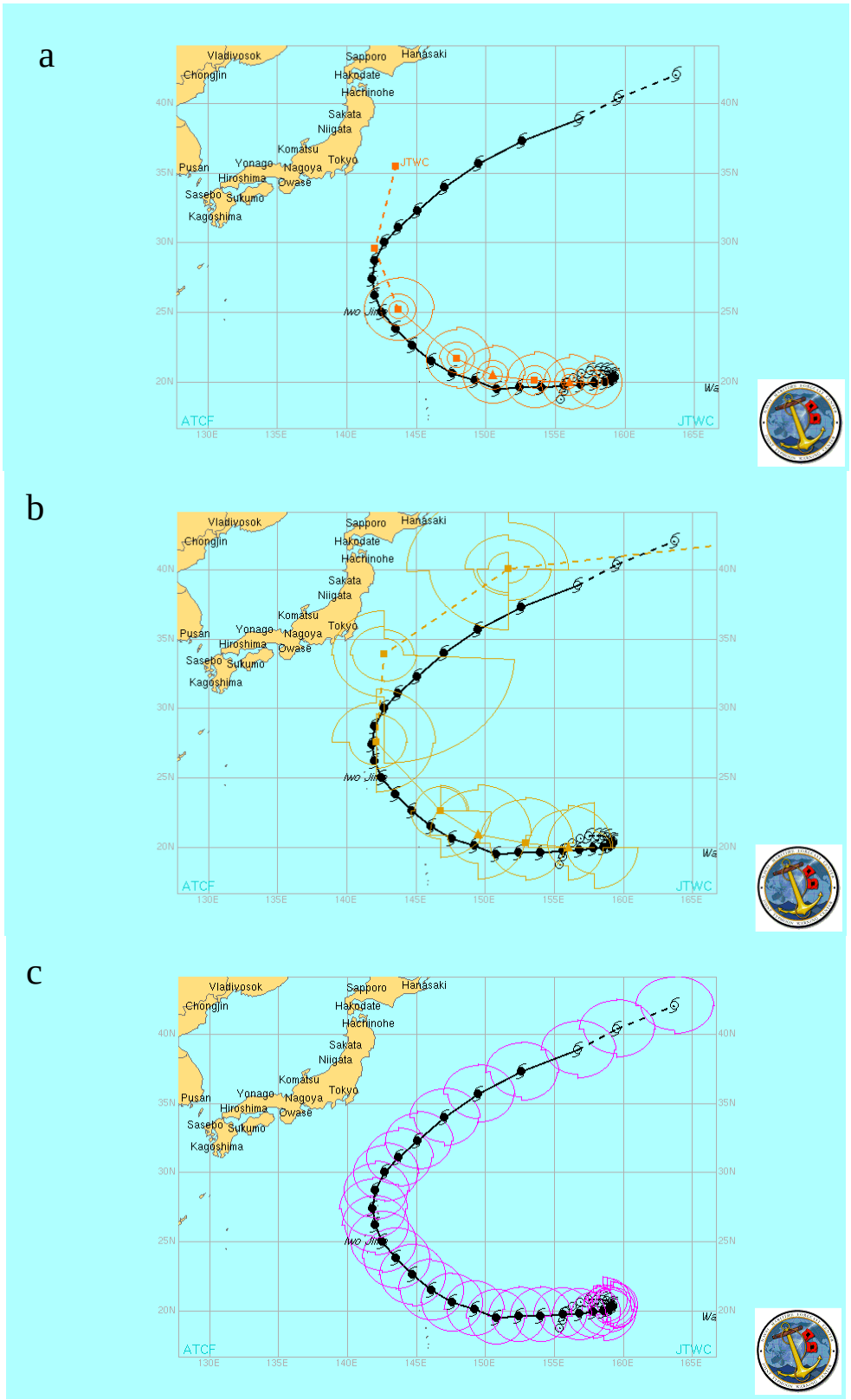

Figure 2. YAGI (WP162006) track and 34-, 50- and 64-kt wind radii for a) the JTWC forecast b) the NOGAPS forecast, c) the verifying tropical cyclone analysis. Forecasts are from September 19 12 UTC.

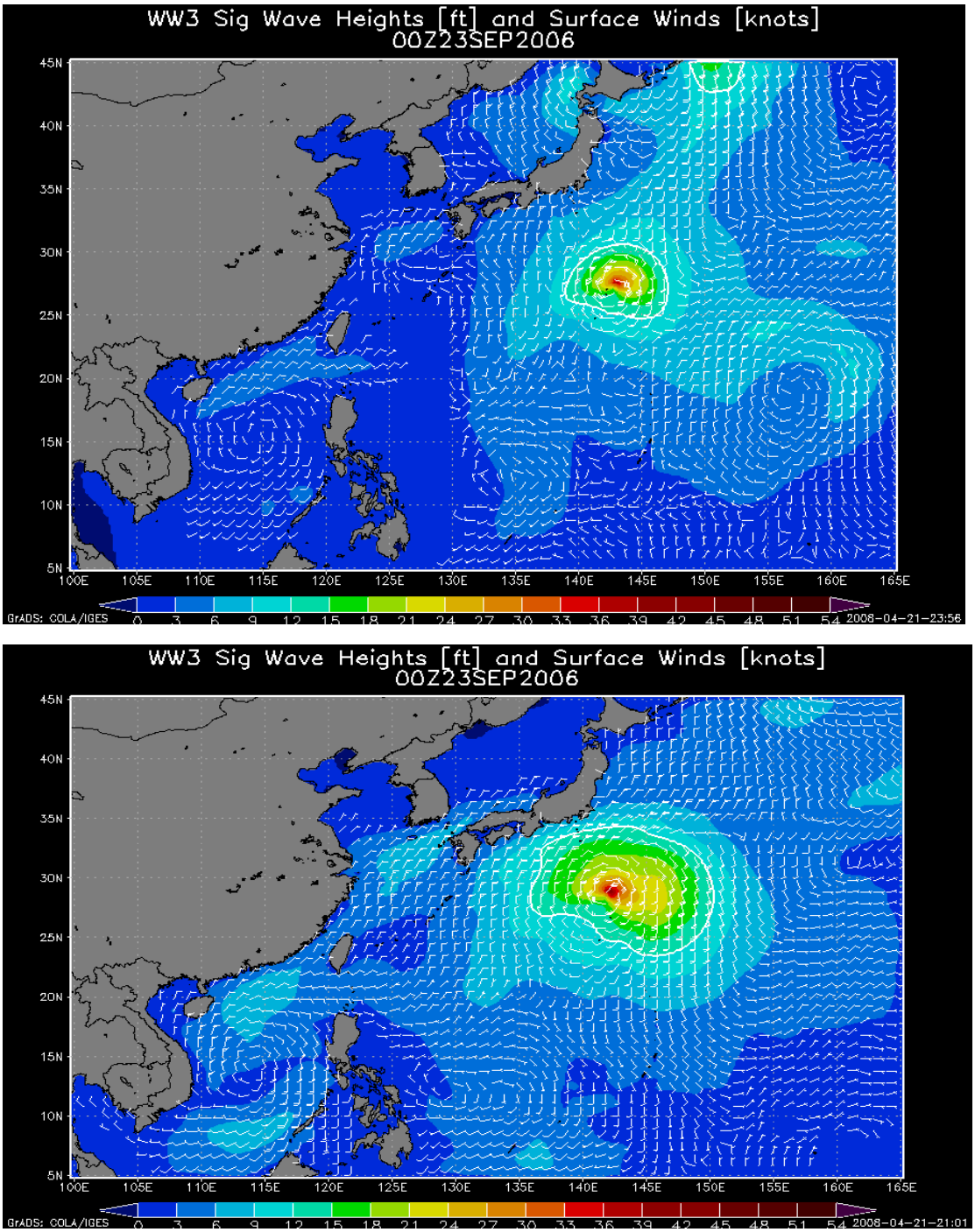

Figure 3. a) JTWC WAVEWATCH III 84-h forecast of YAGI (WP162006) from September 19 12 UTC valid September 23 00 UTC with NOGAPS background surface winds (from September 19 12 UTC analysis only) and the JTWC forecast inserted in the background (wind barbs). The JTWC WAVEWATCH III shows 12 ft seas remaining offshore of Tokyo Bay. Key for significant wave (ft) heights shown on left and the 12 ft seas are contoured. b) Hindcast of YAGI using NOGAPS analysis and JTWC vortex insertion for September 23 00 UTC.

2. Intensity forecast algorithm.

Last year we found that forming a consensus (average) of the most skillful model forecasts produces forecasts with mean forecast errors that are generally lower than the individual model errors. The associated paper for this work was published in Weather and Forecasting. The intensity consensus aids are now operational at the Joint Typhoon Warning Center and National Hurricane Center.

This year we improved the western North Pacific basin consensus by including ocean heat content as a predictor in some of the consensus members. Results from tests on independent data indicate a 1-3% improvement in mean forecast error performance, which is significant at 72 h and nearly so at 36, 48, 96 and 120 h. This is now undergoing operational evaluation at JTWC.

In related work that isn't directly specified within this proposal, we improved the consensus track forecast for the western North Pacific by adding capability to use ECMWF tracks that are 18-h and 24-h old. In tests with dependent data, this resulted in improvements of 1% at 12 h and up to 5% at 120 h. Results at all times are significant. This has been pushed into operations.

Two intensity forecast aids for the Southern Hemisphere have been developed, evaluated and submitted for publication. The first is a statistical intensity forecast based only on best track information, similar to the Atlantic SHIFOR and western Pacific STIFOR. This model serves as a skill baseline for other more complex models. The second forecast aid is the Southern Hemisphere version of the Atlantic SHIPS and western Pacific STIPS. In independent tests, this model demonstrates skill out to 48 h.

Finally, consensus methods have been applied to intensity forecast for the Southern Hemisphere. In evaluation with independent data, an ensemble of STIPS forecasts generally outperforms the individual members at 48 h. Addition of the GFDN member to the STIPS ensemble results in small but significant reductions in the mean forecast error at 24 and 48 h, but not at 72 h. Addition of more aids to the consensus yields mixed results.

IMPACT/APPLICATIONS

The Wavewatch III work is intended to be a forecast aid for ship routing and shore sites with assets affected by high seas. The output is consistent with the operational tropical cyclone forecast, which can be much different than that of an individual NWP model. The concept has received interest and encouragement from Naval personnel at NMFC Pearl Harbor, NMFC Norfolk, COMSUBGRUSEVEN Japan, TPC Miami and NOAA/NWS WFO Honolulu.

The intensity consensus aids produce deterministic forecasts that are intended for use at the Joint Typhoon Warning Center and the National Hurricane Center. Intended uses are for operational guidance and as baselines to evaluate the skill (in terms of mean forecast error) of other more complex ensemble techniques. The aids developed in this work are either operational or undergoing operational evaluation.

TRANSITIONS

The Wavewatch III work transitions directly to Fleet Numerical Meteorology and Oceanography Center. The intensity consensus transitions directly to the Joint Typhoon Warning Center and the National Hurricane Center.

RELATED PROJECTS

None.

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