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Project Title: Ensemble-based pre-genesis watches and warnings for Atlantic and North Pacific tropical cyclones

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Reporting Timeline: Year-1 first semi-annual report of a 2-year project

1. ACCOMPLISHMENTS

The objective of this proposal is to provide guidance products for the National Hurricane Center (NHC), Central Pacific Hurricane Center, and the Joint Typhoon Warning Center (JTWC) for the production of pre-genesis watches and warnings of Atlantic and eastern North Pacific, Central North Pacific, and western North Pacific, respectively. These guidance products will be based on the NOAA Global Ensemble Forecast System (GEFS) and the European Center for Medium-range Weather Forecasts (ECMWF) ensemble forecasts and will provide the genesis time and location along the Weighted-Mean Vector Motion (WMVM) ensemble storm tracks, and also the Weighted Analog Intensity Atlantic (WAIA) or corresponding Pacific (WAIP) intensity and intensity spread forecasts to seven days.

The proposed ensemble-based guidance, which includes the deterministic model forecasts plus either 20 (for GEFS) or 50 (for ECMWF) perturbed ensemble members, has the advantage of providing uncertainty information so that a probability metric or uncertainty in genesis timing, track, and intensity are also specified. Such uncertainty information is critically important for genesis (and intensity) forecasting because the tropical cyclone genesis depends not only on the environmental forcing that is relatively well forecast – rather, the precise timing and location of tropical cyclone genesis depends on mesoscale convective systems and convective-scale systems that are not well observed or well forecast. Ensemble prediction systems that include perturbed initial conditions and physical processes such as convection are intended to represent both the environmental and convective scale uncertainty that are not represented in the corresponding deterministic model forecast that represents a single model solution. The GEFS and ECMWF

ensemble have the potential to predict formation of tropical cyclones from African Easterly Waves (AEWs) or other equatorial waves as well as the monsoon depressions, hybrids, etc. that are listed in program priority JHT-4 in the Announcement.

For reasons that will be explained in section 5, the original Work Plan in the proposal had to substantially be revised. The new Work Plan for Year 1 is in Table 1. New Table 2 will be described in connection with section 5. Item 1.1 on ending storms (e.g., landfall, extratropical transition) is important because the National Hurricane Center (NHC) criteria for pre-genesis watches are that genesis is possible within 48 h and for warnings that genesis is expected within 36 h – for storms that are likely to make landfall. Tsai and Elsberry (2017a) had created a Weighted Analog Intensity technique for Atlantic tropical cyclones (TCs) that had accounted for ending storm situations by constraining the analog selection to also include just ending storms. This analog selection constraint almost eliminated an over-forecast bias.

Table 1. Revised Work Plan for Year 1 required by changes in the project described in section 5, and re-defining time periods in the original Table 1 to now begin on 1 July 2017. Completion of some Eastern/Central Pacific items during Year 1 is questionable as we do not have baseline intensity and intensity spread model in that basin as we have for WPAC and Atlantic.

<u>Work Plan for Year 1</u>	July - December	January - June
(1.1) Completion of ending storm versions, and development of the pre-genesis/formation (defined as 35 kt) functional form describing optimum intensity (i) Western North Pacific (WPAC) (ii) Atlantic (iii) Eastern/Central Pacific (iv) Report results at 2018 IHC	X X	X X
(1.2) Couple the pre-genesis version of the weighted-analog intensity technique to the intensification version with the bifurcation option, with best-track datasets (i) WPAC – WAIP (ii) Atlantic – WAIA (iii) Eastern/Central Pacific		X X X(?)
(1.3) Couple the ending storm version to the coupled pre-genesis and bifurcation version to address landfall, extratropical transition with best-track data (i) WPAC – WAIP (ii) Atlantic – WAIA (iii) Eastern/Central Pacific		X X X(?)
(1.4) Receive historical files of Marchok genesis/formation for last 6 months of 2015 (time period of TCI-15) and evaluate Time to Forecast (T2F) weighted mean and spread (i) WPAC (ii) Atlantic (iii) Eastern/Central Pacific		X X X

Thus, the first accomplishment was to develop and test an ending storm version of the Weighted Analog Intensity-Pacific (WAIP). An expedited contribution with a remarkably short review and publication resulted in publication schedule in December (Tsai and Elsberry 2017b).

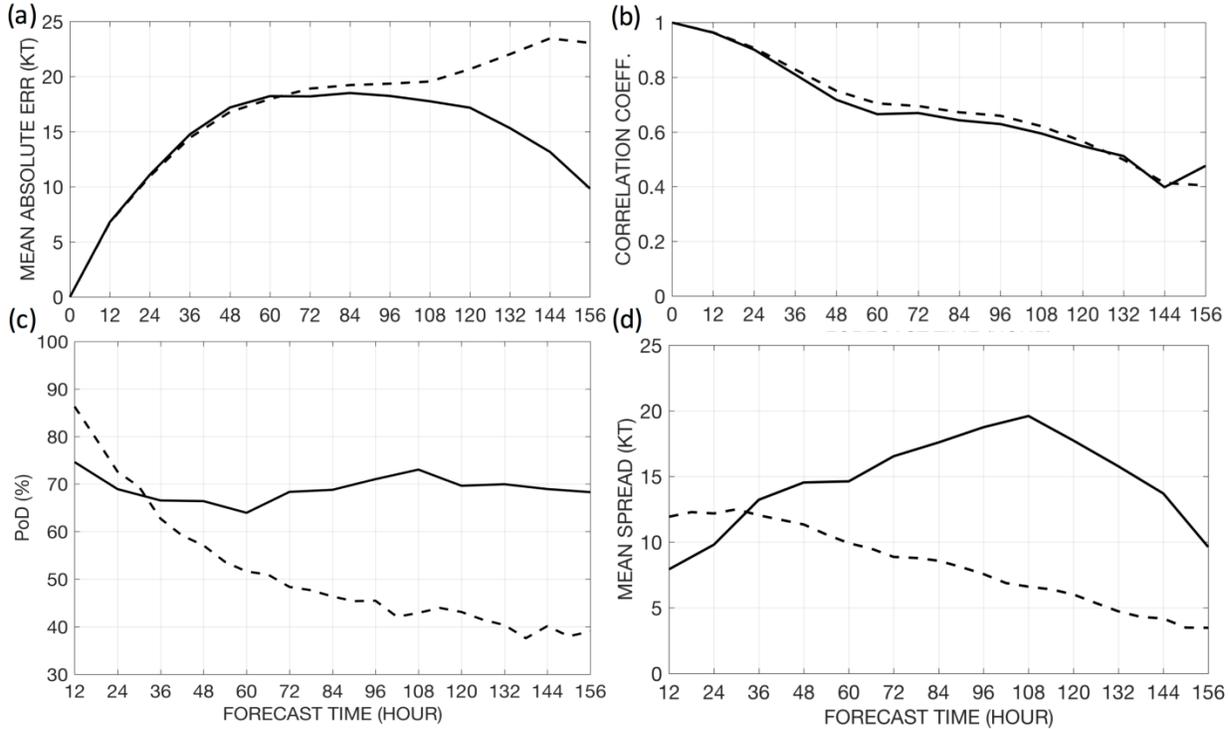


Fig. 1(a) Mean Absolute Errors (MAE, kt) for independent set of ending storm subsample when a separate bias correction has been applied (solid line) or the All Sample bias corrections are applied (dashed line). (b) As in panel (a), except for correlation coefficients of the WAIP intensity predictions with the verifying intensities. (c) As in panel (a), except for Probability of Detection before (dashed line) or after (solid line applying a calibration of the raw intensity spreads to the independent set). (d) Mean intensity spreads (kt) before (dashed line) or after (solid line) applying a calibration of the raw intensity spreads to the independent set.

Impacts in terms of the independent set MAEs with the separate bias correction for the ending storms are shown in Fig. 1a (solid line). Although these MAEs increase rapidly to 15 kt at 36 h, the MAEs are then about 18 kt from 60 h to 96 h before rapidly decreasing to only 10 kt at 156 h. Thus, the ending storm constraint of only selecting analogs with intensities < 50 kt is particularly effective if the TC is known to end in the 4- to 7-day forecast interval. By contrast, this independent set of ending storms has much larger MAEs if the All Sample bias correction is utilized, because rather than leveling off after 84 h the MAEs continue to increase to ~23 kt at 144 and 156 h (Fig. 1a, dashed line).

Another metric for assessing the impact of the separate bias correction for the ending storm cases is the correlation coefficient of the WAIP intensity predictions with the verifying intensities. For the independent set ending storm WAIP predictions with the separate bias correction, the correlation coefficients rapidly decrease to 0.66 by 60 h, and then decrease more slowly to 0.6 around 120 h before decreasing to 0.45 at 156 h (Fig. 1b). One contribution to these smaller correlations beyond 120 h (even though the MAEs in Fig. 1a are smaller) is that the

independent sample sizes are smaller at these longer forecast intervals and even a small bias of 5 kt could lead to smaller correlation coefficients.

A necessary feature of the original 7-day WAIP (Tsai and Elsberry 2015) was a calibration of the “raw intensity spread” among the 10 analog intensities each 12 h to ensure an intensity spread that would include 68% of the verifying intensities. Separate calibrations of the intensity spreads of the ending storm and non-ending storm training sets were carried out and applied to the intensity spreads of the independent sets. An example of the application of the calibration for the ending storm independent set is given in Fig. 1c (solid line). Note that the PoDs prior to the calibration are over-dispersive (raw intensity spreads of the 10 analog intensities are too large) during the first 30 h (Fig. 1c, dashed line), and then are very under-dispersive out to 156 h with a PoD of 40% rather than the desired value of 68%. The success of the calibration for this ending storm independent set is evident from the PoDs that are within 5% of the 68% value over most of the 7-day forecast interval (Fig. 1c, solid line).

The impact of the calibration on the intensity spreads for the ending storm independent set is displayed in Fig. 1d (solid line). Because progressively smaller numbers of storms are extending to 156 h before ending, the mean intensity spreads become smaller with increasing forecast interval (and thus are under-dispersive). After the calibration of the intensity spreads, the mean intensity spreads are made smaller from 12 h to 24 h, but need to be much larger to 108 h to ensure 68% of the verifying WAIP intensity forecasts would be within the intensity spreads (Fig. 1d, solid line). **However, the calibrated intensity spread at 156 h is only ± 10 kt** because all of these storms must by definition end prior to 168 h, and thus are more homogeneous in intensities so an **intensity spread of only 10 kt still encompasses 68% of the WAIP ending storm intensities.**

For JTWC that has the Global Ensemble Forecast System (GEFS) ensemble storm tracks for WPAC, timing of an ending storm due to landfall can be easily determined. **We are also exploring providing the timing of the extratropical transition type of “ending storm.” Another category of our ending storms is that formation will not occur within the next 7 days, i.e., genesis was not predicted.** The WAIP is very accurate for these non-formation cases. This development of an ending storm version of the WAIP was presented at the 2018 PACOM Joint TC Forecasting Assembly in February 2018, and seemed to be well received by representatives of the Joint Typhoon Warning Center (JTWC) and the Central Pacific Hurricane Center (CPHC).

A second accomplishment has been to address the pre-formation stage for the WAIP. It was decided to first accomplish this task in WPAC because of large database of TC circulations with initial intensities of 15 kt, 20 kt, 25 kt, and 30 kt in the JTWC best-track files. However, the sample sizes drop off rapidly because it is relatively rare for a TC-like circulation to require more than 72 h to form. In this case, we define formation as ≥ 35 kt and test three functional forms (linear, exponential, and square) to represent the intensity evolution from the initial time to Time to Formation (T2F). As shown in Fig. 2, starting from an initial intensity of 15 kt, a few cases are already at 35 kt in 12-18 h, a large cluster intensify to 35 kt in < 42 h, and only a few cases take longer than 72 h to formation. For an initial intensity of 20 kt, more cases reach 35 kt by 72 h, and only a few do not reach 35 kt until beyond 96 h. For a Tropical Depression intensity of 25 kt

in the WPAC, the majority reach 35 kt over a range of 24 h to 72 h, and none take longer than 120 h to reach 35 kt. **If the T2F is known**, assuming a square function intensity evolution from the initial time (again, from 15 kt, 20 kt, 25 kt, and 30 kt values) to formation time will have a small sample mean bias (MB) and small (< 4 kt) mean absolute errors (MAEs) [Fig. 3].

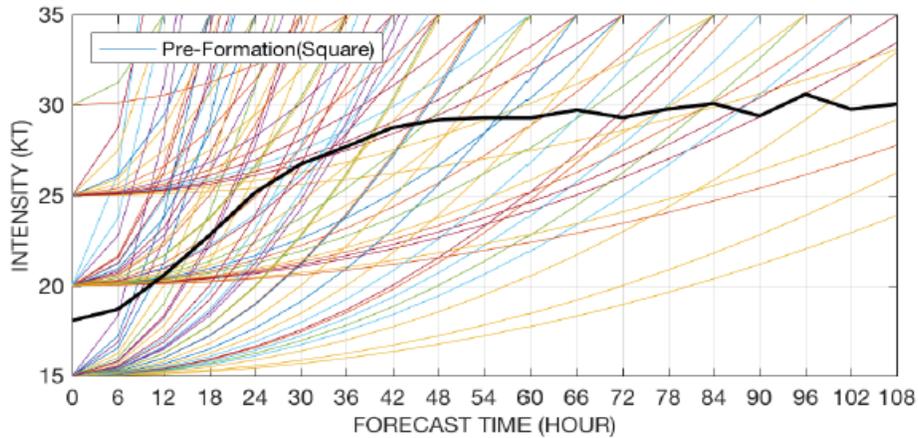


Fig. 2 Intensity evolutions with time assuming a square function from the initial intensities of 15 kt, 20 kt, 25 kt, and 30 kt until the time of formation (defined as 35 kt, top line).

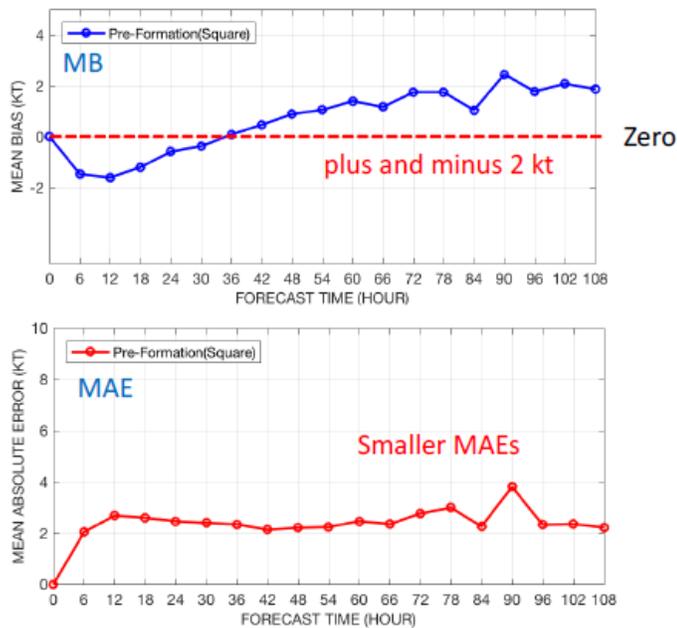


Fig. 3 Sample mean biases and MAEs assuming a square function for the pre-formation intensity evolution as in Fig. 2.

In this study with the JTWC best-track files, the formation time (and thus the T2F) is known. In operations, the JTWC forecaster would have to provide the T2F, or specify that the TC-like circulation will not form within 7 days, which are the non-developing cases in the ending storm version of WAIP. For the 24 h to 48 h forecast interval, perhaps the regional numerical models such as COAMPS-TC and HWRF may provide guidance as to the T2F. In this JHT project, we will apply Tim Marchok’s ensemble-based track genesis prediction of formation, which is based on a number of genesis-related variables evaluated along ensemble storm tracks of all 21 members of the Global Ensemble Forecast System (GEFS; already available at JTWC). To account for uncertainty in that formation time, we will test an “early formation” versus “late formation” relative to the Marchok formation time.

Our proposed operational test at JTWC of the combined pre-formation, intensification, and ending storm WAIP is shown in Fig. 4. In this schematic, the circulation system is assumed to have an initial intensity of 20 kt. Given the T2F (i.e., 35 kt) provided from the Marchok formation prediction, the time to landfall (T2L) will be from the official JTWC track forecast or the GEFS ensemble storm track forecast. The time to an ending storm due to Extratropical Transition (ET) is expected to be from Marchok’s ET prediction along the ensemble storm track forecast from GEFS. Finally, the cases of non-development (N-DEV) within the 7-day forecast will also be from the Marchok genesis variables indicating this circulation system will **not** achieve > 35 kt intensity.

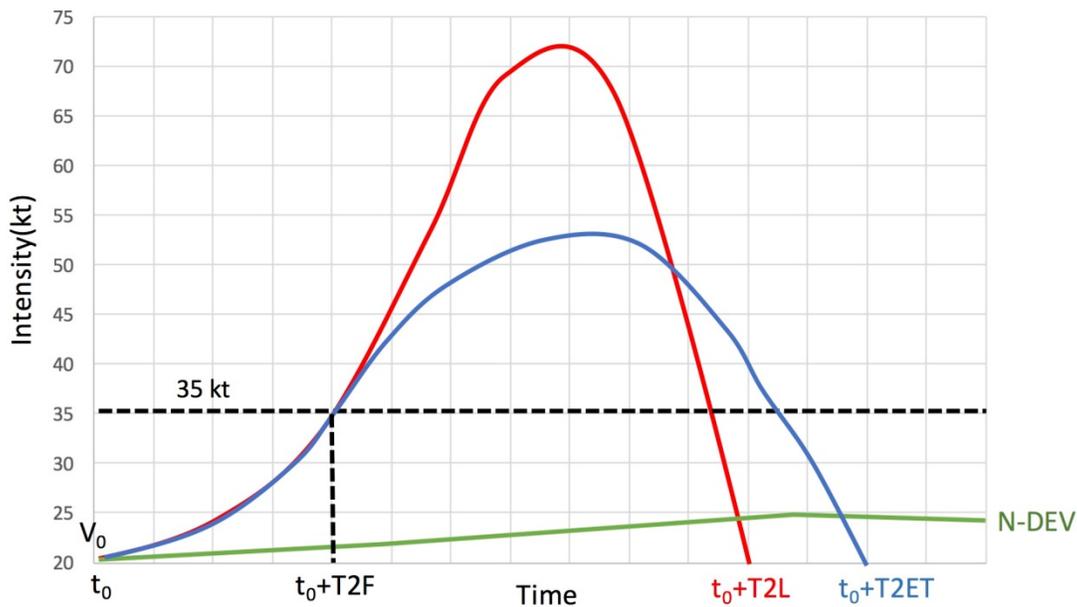


Fig. 4 Proposed operational test of the combined WAIP version that includes the pre-formation, intensification, and ending storm stages. The descriptions of time to formation (T2F), time to landfall (T2L), time to extratropical transition (T2ET), and the non-development (N-DEV) are in the text.

A similar approach of using a square function to represent the intensity evolution between the initial time and the formation time for the Atlantic based on the HURDAT is shown in Fig. 5. Note that only one HURDAT entry during 2000 – 2015 had an initial intensity of 15 kt. For an initial intensity of 20 kt the T2F ranges from 18 h to 90 h, and for 25 kt initial intensity the range is 12 h to 84 h except for three cases that had a T2F of 148 h. In contrast to

the WPAC intensity evolutions having only two cases with an initial intensity of 30 kt and going quickly to 35 kt (Fig. 2), in the Atlantic a substantial fraction of the cases have a 30 kt initial intensity that do not immediately achieve 35 kt. Indeed, five 30 kt initial intensity cases had taken longer than 90 h to achieve 35 kt. **IF the T2F is known**, a simple square function representation of the intensity evolution from the initial intensity to the formation time can result in the smallest MBs (Fig. 6, top) and smallest MAEs (Fig. 6, bottom) compared to the linear or exponential functions. Since both the MBs and MAEs increase rather linearly in time, a bias correction is likely to further reduce these MAEs.

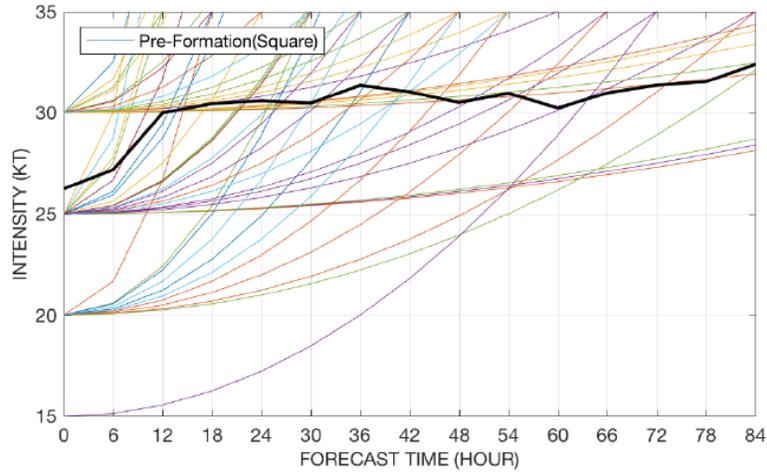


Fig. 5 As in Fig. 2, except for the Atlantic based on the HURDAT.

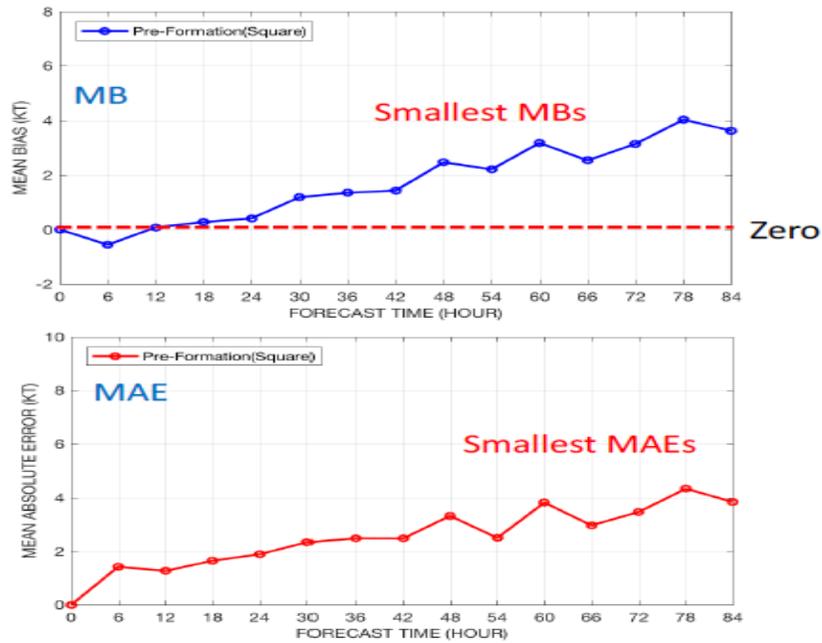


Fig. 6 As in Fig. 3, except for the Atlantic based on the HURDAT.

2. PRODUCTS

A presentation entitled: “Improvement of seven-day weighted analog intensity prediction technique: Addressing pre-formation and ending storm stages” was made at the 2018 PACOM Assembly. This was an opportunity for discussions with JTWC personnel and planning for an operational test for the WPAC later this year. Discussions were also held with CPHC personnel.

A presentation will be made at the 2018 IHC entitled: “Ensemble-based pre-genesis watches and warnings for Atlantic and North Pacific tropical cyclones.” This will be an opportunity for discussions with NHC personnel.

3. PARTICIPANTS

Dr. Hsiao-Chung Tsai of Tamkang University, New Taipei City, Taiwan and Tim Marchok, Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey.

4. IMPACTS

Approximately 25% of the budget has been spent in a foreign country (Taiwan).

5. CHANGES/PROBLEMS

The Work Plan for Years 1 and 2 in the proposal were based on a bad assumption that the start date was January, which seemed reasonable as the Q3 and Q4 of each year would be during the hurricane season. Thus, the proposal assumed the first six months of Year 1 would be available to prepare the code for testing during the second six months (i.e., during the hurricane season). Then in Year 2, the first six months would be for evaluation of the performance during that first hurricane season and making necessary revisions in preparation for the final demonstration in the second hurricane season. A July starting date (with actual funding availability in mid-September 2017) essentially made the original Work Plans off by nine months, and this was the first reason for abandoning those original Work Plans.

The more important reason that required a revision of the Work Plans was the limited availability of Tim Marchok of GFDL. At the time the proposal was being prepared, Marchok was working with Morris Bender, which included applications of Marchok’s vortex tracker that was to be modified for this project. In addition, Marchok had provided our Naval Postgraduate School research team the GEFS and ECMWF ensemble vortex tracker files for preparing Weighted Mean Vector Motion (WMVM) ensemble storm track forecasts during the Tropical Cyclone Intensity (TCI-15) field experiment. It had been anticipated that the WMVM code would be transferred to GFDL so that the GEFS and ECMWF ensemble storm track forecasts would be calculated there, and that Marchok would provide the genesis/formation timing along those WMVM ensemble storm tracks.

All of these plans changed when Morris Bender retired, and Marchok was transferred to S. J. Lin’s research team. Marchok’s availability for external TC work became very limited,

although he did commit to continue his near real-time vortex tracker files. However, Task (1.1) in the original proposal Work Plan was: “Add WMVM track forecast subroutine to Marchok vortex tracker program with additional genesis timing.” This was to be followed by Task (1.2) Production, monitoring, and evaluation of quasi-real time test of season genesis events. Task (1.1) could not be carried out as planned, and had to be delayed until Marchok is able to provide the timing genesis files (now anticipated in May 2018, see new Task (1.4) in Table 1 above). Evaluation of these archived Marchok T2F files thus had to be shifted to Task (2.2) in the Year 2 Work Plan (Table 2). The first season for testing the genesis timing predictions (old Task (1.2) has been shifted to be part of Task (2.4), and this 2018 season will be the only season for testing as the project expires 30 June 2019.

Table 2. Revised Work Plan for Year 2 as in Table 1

<u>Work Plan for Year 2</u>	July - December	January - June
(2.1) Publish the results of combined pre-genesis, intensification stage, and ending storm version using best-track inputs in all three basins	X	
(2.2) Evaluation of Marchok T2F forecasts in archive (i) WPAC retro test (ii) Atlantic retro test (iii) Present results at 2019 IHC	X X	X
(2.3) Develop an alternate ensemble storm track forecast type if the prior NPS ensemble storm track forecast technique is not available from Marchok	X	
(2.4) Production, monitoring, and evaluation of quasi-real time intensity and intensity spread predictions with Marchok T2F and uncertainty range (i) WPAC – WAIP (ii) Atlantic – WAIP (iii) Eastern/Central Pacific	X X	X
(2.5) Publish results of quasi-real-time intensity and intensity spread forecasts, and present results at 2019 IHC		X

Another necessary revision in the Year 2 Work Plan (Table 2) was a new Task 2.3, which is an alternate ensemble storm track forecast to replace our WMVM track forecasts. While JTWC calculates onsite the GEFS WMVM ensemble storm track forecasts, it does not have the ECMWF WMVM ensemble storm track forecasts. Unfortunately, NHC does not have a MATLAB license that is necessary to calculate the Naval Postgraduate School WMVM ensemble storm track forecasts. What is needed is a simple-to-calculate ensemble track forecast, which might be the ensemble mean track as long as Marchok provides the formation timing (or non-formation) along each track. Another alternate might be a Best-10 matches of ensemble member tracks to the projected track of the pre-TC circulation.

6. SPECIAL REPORTING REQUIREMENTS

The project Readiness Level has advanced from RL5 at the start of the project to RL6 for the WPAC component.

The Test Plan and the Research-to-Operations Transition Plan are separately attached to this progress report.

7. BUDGETARY INFORMATION

The project is on budget and no changes are planned.

8. PROJECT OUTCOMES

No project outcomes this early in the project.

REFERENCES

- Tsai, H.-C., and R. L. Elsberry, 2015: Seven-day intensity and intensity spread predictions for western North Pacific tropical cyclones. *Asia-Pacific Journal Atmospheric Sciences*, **51**, 331-342.
- Tsai, H.-C., and R. L. Elsberry, 2017a: Seven-day intensity and intensity spread predictions for Atlantic tropical cyclones. *Weather and Forecasting*, **32**, 141-147.
- Tsai, H.-C., and R. L. Elsberry, 2017: Ending storm version of the 7-day weighted analog intensity prediction technique for western North Pacific tropical cyclones. *Weather and Forecasting*, **32**, 2229-2235.

Ensemble-based Pre-Genesis Watches and Warnings
for Atlantic and North Pacific Tropical Cyclones

PI: Russell L. Elsberry

I. The plan is to evaluate track, intensity, and intensity spread forecasts for pre-tropical cyclone circulations in the North Atlantic (ATL), eastern (EPAC) and central (CPAC) North Pacific, and in the western North Pacific (WPAC) that are based on six-hourly NCEP Global Ensemble Forecast System (GEFS) and 12-hourly ECMWF ensemble predictions. These two ensemble forecast systems are to be utilized because ensemble storm tracks derived from the GEFS and the ECMWF ensemble typically predict the tracks of the pre-tropical cyclone circulations (pre-TCs) 3-4 days before the National Hurricane Center (NHC – for ATL and EPAC), Central Pacific Hurricane Center (CPHC – for CPAC), and Joint Typhoon Warning Center (JTWC – for WPAC) declare that a Tropical Depression (and for certain before a Tropical Storm) now exists. For the NHC pre-genesis watches and warnings, a particular focus will be on pre-TCs that may make landfall within 48 h or 36 h, respectively. However, the tracks, intensities, and intensity spreads will be provided to NHC for any pre-TC in the ATL, EPAC, and CPAC regions that is expected to achieve TS (35 kt) intensity in order for the NHC forecasters to be monitoring those pre-TCs that might later meet the pre-genesis watch and warning criteria (including a potential landfall). Similarly, the JTWC forecaster will be provided guidance on pre-TCs anywhere in their WPAC area of responsibility. This track, intensity, and intensity spread guidance will be for 7 days from the initial time regardless of the time to formation (T2F, which is defined as achieving 35 kt intensity).

II.A. WPAC.

Tim Marchok of Geophysical Fluid Dynamics Lab (GFDL) will provide his vortex tracker files for the 6-h GEFS and 12-h ECMWF ensemble to the JTWC, who already have a MATLAB code for generating the Naval Postgraduate School ensemble storm track forecasts in WPAC. Similarly, Hsiao-Chung Tsai will receive these Marchok tracker files to “shadow” the JTWC processing, and to develop and test the combined Weighted Analog Intensity Pacific (WAIP) technique forecasts of intensity and intensity spread for pre-TCs in WPAC. When the additional code to extract the T2F (and any landfall and/or extratropical transition for the ending storm constraint on analog selection in WAIP) has been tested, that code will be integrated into the WMVM ensemble storm track forecast code at JTWC. Because the WAIP is also written in MATLAB for which JTWC has a license, JTWC will be able to do their own evaluation of the combined WAIP for the pre-formation, intensification, and ending storm stages. Since the combined WAIP has a bifurcation option in which separate analogs are selected for a larger (smaller) peak intensity labeled as Cluster 1 (Cluster 2), a separate evaluation may be necessary for the situation in which a bifurcation was detected. Matt Kucas indicates it is unlikely that JTWC will issue in 2018 official 7-day track forecasts for the TDs (or perhaps even extend the present 5-day track forecasts for Invests to 7 days). Thus, the T2F (i.e., reach an intensity of 35 kt) for the entire pre-formation period will be calculated for the GEFS and ECMWF ensemble

storm track forecasts in order to provide 7-day intensity and intensity spread guidance. While the landfall timing will be determined from the JTWC track, the timing of an extratropical transition needed for the WAIP ending storm may have to be selected from nearby GEFS or ECMWF ensemble storms to ensure 7-day values are provided. These procedures are necessary to calculate with the WAIP intensity forecasts and intensity spreads that are consistent with the JTWC track. Matt Kucas also to provide these 7-day WAIP forecast to the DoD and NWS customers of the JTWC 2-week formation outlooks that are becoming operational in June 2018, so there is potential for an “eyes on” subjective evaluation as well.

II.B. ATL and EPAC/CPAC.

The plans for these two basins are similar to the WPAC plan, except the NHC (who eventually will prepare the CPAC forecasts as well as the EPAC forecasts) does not have onsite the WMVM ensemble storm track forecasts that are the input to the WAIA (“A” indicating ATL versus “P” for WPAC) intensity and intensity spread guidance. Note that NHC has plans to again explore preparation of 7-day track forecasts, but according to Dr. Mark DeMaria (private communication, April 2018) these forecasts will only be for tropical storms, and specifically will not be available for the pre-genesis period that is the focus of this project. Thus, the GEFS and ECMWF ensemble storm track forecasts for all stages from pre-TC to 35 kt must first be prepared based on the files from Tim Marchok. An ending storm version of WAIA was developed by Tsai and Elsberry (2017a, WAF), and we will use a variation of the pre-formation version of WAIP in the ATL (and later in EPAC/CPAC). For the EPAC/CPAC, comparable WMVM ensemble storm track forecasts and a weighted analog intensity and intensity spread guidance products will need to be developed. Arrangements will be made to have NHC do an independent validation of the forecasts as discussed above in II.A.WPAC.

III.A. WPAC.

The combined WAIP intensity and intensity spread technique has been developed and tested with JTWC best-track files for tracks, initial intensities, time to formation (T2F), and landfall timing (presentation 16C.6 on April 20, 2018 at the American Meteorology Society Hurricane and Tropical Meteorology conference). A version suitable for operational testing (e.g., combining both the independent and dependent samples of analog storms, re-doing the bias correction, and re-calibrating the raw intensity spreads) is planned to be delivered to the JTWC the second week in June. Coordination with the Training Officer and briefings to the forecasters are being organized. Plans for the displays and for the verifications will be finalized. To take advantage of this visit to Hawaii, coordination with forecasters at the CPHC will also be explored.

III.B. ATL

As indicated in II.B., the original 7-day WAIA intensity and intensity spread technique for Atlantic TCs included an ending storm constraint, but did not include a bifurcation version for the intensification stage. The formation stage will be represented by a squared function for the intensity evolution between the initial intensity and 35 kt at the T2F provided by Tim Marchok. As for the WAIP described above, the final combined WAIA version for operational testing in the Atlantic will utilize the full sample of potential analogs with re-calculation of the bias corrections and re-calibration of the raw intensity spreads. Hsiao-Chung Tsai will provide the MATLAB code for the WMVM ensemble storm track forecasts as input to the WAIA forecasts

during the 2018 season. The main NHC support will be installing the WMVM code and the combined WAIA described in section II.B. Coordination with Hurricane Specialists Avila and Berg and other NHC staff is needed in refining the displays and the plans for validation. The objective is to provide the 7-day WAIA intensity and intensity spread guidance at least 2-3 days prior to a situation in which a pre-genesis watch or warning will be issued for a potential landfall. The target date to begin providing ATL WAIA forecasts is 1 August 2018.

III.C. EPAC and CPAC.

Given the prior progress in developing the combined WAIP and WAIA guidance products, and that no similar weighted-analog intensity technique has been developed for the EPAC and CPAC basins, this task will have to be delayed until the tasks related to the WPAC and ATL testing are in progress. The CPAC region has many fewer potential analogs for use with this approach. As with previous TC guidance products for the CPAC, the EPAC and CPAC databases are combined, and a single product is developed and tested by NHC, or in this case by our JHT project. Since the tools have already been developed as for the combined WAIP for the WPAC and the combined WAIA for the ATL, the development and testing of a combined WAIE(C) forecasts will be straight-forward. Thus, the tentative target date for the provision of WAIE(C) forecasts to NHC for EPAC and to CPHC for CPAC is 1 October 2018. Again, these WAIE(C) forecasts will be prepared by NHC staff based on GEFS and ECMWF ensemble track forecast files and T2F files provided by Tim Marchok. Verifications for WAIE(C) will be with the same procedures as for WAIA.

IV.

The combined WAIP will be tested at the Joint Typhoon Warning Center, which provides guidance to the NOAA NWS office in Guam. The combined WAIA forecasts for the Atlantic and combined WAIE(C) forecasts for EPAC and CPAC will be evaluated by NHC and CPHC.

V. P.I. Russell L. Elsberry will over-see the test in each basin and participate in the evaluation of the guidance products. Lead Scientist Hsiao-Chung Tsai will develop the forecast guidance products and displays. In the case of the WAIP, Matt Kucas is the coordinator for JTWC, he will implement the combined WAIP and will be our primary collaborator in the evaluation. Lixion Avila and Robbie Berg will be the coordinators for the WAIA in ATL and WAIE(C) in the EPAC. Bob Ballard is the coordinator for the WAIA(C) in the CPAC. In addition to participating in the validation of the systems, an important role of each coordinator is to provide feedback for improving the systems during and after the 2018 season.

VI.

For the WAIP, we plan to slightly modify the WMVM code for generating ensemble storm tracks at JTWC to directly produce the weighted-mean T2F required for WAIP. Tim Marchok will provide the GEFS and ECMWF ensemble track forecasts and the genesis parameter code. Hsiao-Chung Tsai will utilize local computers to “shallow” the WAIP, WAIA, and WAIE(C) forecasts and do the validations in cooperation with the JTWC, NHC, and CPHC.

VII.

The primary test goal is to demonstrate that accurate tracks, intensities, and intensity spread guidance can be provided for the pre-formation stage of TCs throughout the Atlantic and North

Pacific. The performance measure at NHC for track and intensity forecasts is a climatology and persistence approach. Neither NHC nor JTWC currently provide intensity uncertainty guidance. Thus, our success criterion will be to verify that 68% of the verifying intensities will lie within the provided intensity spreads.

VIII.

Thus far, the preliminary results have been described at the PACOM Joint TC Forecasting Assembly in Hawaii during 20-23 February 2018, the recent IHC meeting during 13-15 March 2018 in Miami, Florida, and the AMS Hurricane and Tropical Meeting conference on 20 April 2018. Final results from the 2018 season will be reported at the 2019 PACOM Assembly and the 2019 IHC. Summaries of the pre-formation WAIP intensity forecasts and intensity spread guidance for the 2018 typhoon season, and pre-genesis WAIA and WAIA(C) intensity forecasts and intensity spread guidance for the 2018 hurricane season, will be included in the test results final report.