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Validation Test Report: Coupled Ocean/Atmosphere Mesoscale Prediction System – Tropical Cyclone Ensemble (COAMPS-TC Ensemble) v2023

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14. ABSTRACT
Here, we describe the v2023 COAMPS-TC ensemble, which has transitioned to Fleet Numerical Meteorology and Oceanography Center and has replaced the v2021 COAMPS-TC ensemble in operations as of 5 July 2023. The v2023 COAMPS-TC ensemble is a relatively minor upgrade encompassing one important change to the model code that improves forecast performance, as well as an expanded graphics suite used to display ensemble forecasts. The change to the model consists of increasing the storm-following inner nest blend zone width (for both the 12-km grid spacing nest 2 and the 4-km grid spacing nest 3) to 18 points. Here, we show, using the ensemble control member tested over 399 retrospective forecast cases, that this inner nest blend zone expansion improves wind radii prediction and forecasts of rapid intensification (RI) without meaningful degradation to track or intensity forecasts. The larger grid 3 blend zone serves both to inhibit convection on the outskirts of the storm and to import relatively dry air from grid 2, causing tropical cyclones to be smaller and seemingly more amenable to RI. The updated graphical forecast product suite includes a new plot for minimum sea-level pressure (MSLP) and two new types of plots for the radius of 34-kt winds (R34), radius of 50-kt winds (R50), and radius of 64-kt winds (R64).

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Here we describe the v2023 COAMPS-TC ensemble, which has transitioned to Fleet Numerical Meteorology and Oceanography Center and replaced the v2021 COAMPS-TC ensemble in operations as of July 5, 2023. The v2023 COAMPS-TC ensemble is a relatively minor upgrade encompassing one important change to the model code that improves forecast performance, as well as an expanded graphics suite used to display ensemble forecasts. The change to the model consists of increasing the storm-following inner nest blend zone width (for both the 12-km grid spacing nest 2 and 4-km grid spacing nest 3) to 18 points. We show, using the ensemble control member tested over 399 retrospective forecast cases, that this inner nest blend zone expansion improves wind radii prediction and forecasts of rapid intensification (RI) without meaningful degradation to track or intensity forecasts. The larger grid 3 blend zone serves both to inhibit convection on the outskirts of the storm and to import relatively dry air from grid 2, causing tropical cyclones to be smaller and seemingly more amenable to RI. The updated graphical forecast product suite includes a new plot for minimum sea-level pressure (MSLP) and two new types of plots for the radius of 34-kt winds (R34), the radius of 50-kt winds (R50), and the radius of 64-kt winds (R64).

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VALIDATION TEST REPORT: COUPLED OCEAN/ATMOSPHERE MESOSCALE PREDICTION SYSTEM — TROPICAL CYCLONE ENSEMBLE (COAMPS-TC ENSEMBLE) v2023

1. INTRODUCTION

The Coupled Ocean-Atmosphere Mesoscale Prediction System for Tropical Cyclones (COAMPS-TC®) is a regional dynamical tropical cyclone (TC) model that has been operational at Fleet Numerical Meteorology and Oceanography Center (FNMOC) for over a decade (Doyle et al. 2012, 2014). The CTCX version of deterministic COAMPS-TC, which uses initial and lateral boundary conditions from the National Oceanic and Atmospheric Administration (NOAA) Global Forecast System (GFS), has world-class skill in both track and intensity prediction (Doyle et al. 2021, 2022). Deterministic CTCX is the "base model" for the COAMPS-TC regional dynamical TC ensemble model, which went into operational production in 2020 as the first of its kind in the world (Komaromi et al. 2021). The COAMPS-TC ensemble uses 10 perturbed members, along with the unperturbed control, to form the basis for a probabilistic prediction of TC track, intensity, and structure. The COAMPS-TC ensemble has quickly become a key component of the TC guidance suite utilized at the Joint Typhoon Warning Center (JTWC), particularly for prediction of rapid intensification (Cowan 2022).

The COAMPS-TC ensemble was last updated in 2021 (v2021), which was a major upgrade to the initial version of the ensemble with many new features, as described in full by Komaromi et al. (2022). The v2023 update is relatively minor, consisting of one change to the model code and an expansion of the graphics suite used to display COAMPS-TC ensemble forecasts to include plots for radius of 34-kt winds (R34), radius of 50-kt winds (R50), radius of 64-kt winds (R64), and minimum sea-level pressure (MSLP). The model change and its performance implications are detailed in Section 2. The new graphical forecast products are described in Section 3. A brief summary and conclusions are provided in Section 4.

2. INNER NEST BLEND ZONE CHANGE AND ITS PERFORMANCE IMPLICATIONS

2.1 Description of Change

In the CTCX deterministic "base model" for the v2023 ensemble, the blend zone for the storm-following inner nests (12-km grid spacing nest 2 and 4-km grid spacing nest 3) is increased from 2 grid points to 18 grid points. The blend zone exists along the inner edges of each nest, smoothly blending the states of the child nest and its parent nest. As such, the expanded nest 2 blend zone in v2023 increases the influence of the fixed outer nest on nest 2 (relative to v2021), and the expanded nest 3 blend zone in v2023 increases the influence of nest 2 on nest 3 (relative to v2021). We found the expansion of the nest 3 blend zone in v2023 is of most importance in terms of impacts on TC forecast performance.

Our review of a number of case studies indicates the expansion of the nest 3 blend zone in v2023 1) inhibits deep convection in nest 3 along the outskirts of the storm in the vicinity of the nest boundary, which

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can reduce R34 for large storms, and 2) imports relatively dry air from nest 2 farther into nest 3, which can suppress storm size well away from the nest boundary. These impacts can both be seen in a case study of Hurricane Dorian (2019) with forecast initial time of 0600 UTC 02 September 2019. The left panel of Fig. 1 shows the CTCX deterministic intensity forecast for v2021 and v2023 along with the best track re-analysis from the National Hurricane Center (NHC). As we will show, it is not generally the case, but for this particular forecast, the v2023 intensity prediction is a better match to the best track than the v2021 intensity prediction. The right panel of Fig. 1 shows the corresponding R34 forecast and best track, with averaging for R34 performed over the four quadrants at each lead time. The v2023 average R34 forecast has lower values than the v2021 forecast and is more accurate relative to the best track, which are both characteristic of v2023 performance w.r.t. v2021 (as we will show). The two track forecasts are very similar, and for brevity, are not included.

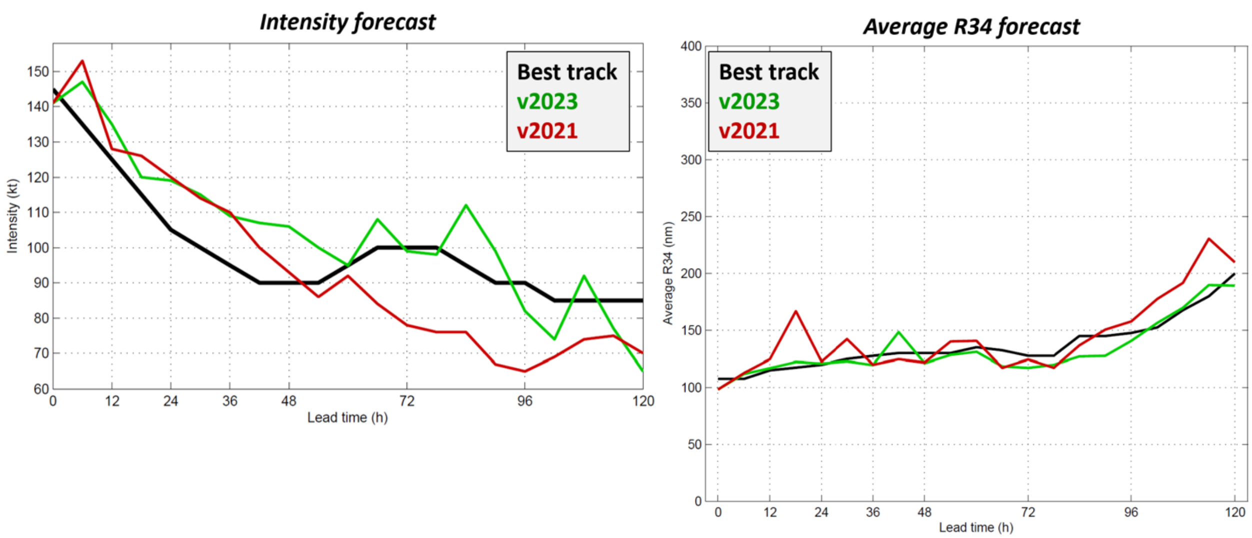


Fig. 1—Hurricane Dorian CTCX forecast using the v2023 (green) and the v2021 (red) deterministic models for the 0600 UTC 02 September 2019 initial time. The left panel shows the intensity forecasts as compared with the best track (reanalysis) intensity time series. The right panel is similar but for quadrant-average radius of 34-kt winds (R34).

Figure 2 shows the simulated composite radar reflectivity (and 10-m winds) for nest 3 of the v2021 and v2023 deterministic CTCX forecasts of Dorian initialized at 0600 UTC 02 September 2019, valid at the 18-h and 102-h lead times. At 18 h, there is a relative lack of deep convective activity in v2023 w.r.t. v2021 on the south side of the storm and near the western boundary of nest 3. The same is true at 102 h along the east, south, and west sides of the storm. Though the expanded nest 3 blend zone extends 18 grid points from the edge of the domain (the entire grid is 226 × 226 points), much of the inhibited convection in v2023 occurs outside the blend zone itself.

Figure 3 is similar to Fig. 2 but shows 10-m wind speed and direction. The m/s equivalents of the 34-kt, 50-kt, and 64-kt isotachs are contoured in blue. At 18 h in the v2021 run, there is convection off the Gulf Coast of the Florida peninsula north of Tampa Bay, associated with a nearly indiscernibly tiny area of 34-kt winds. This area of 34-kt winds does not exist in the v2023 forecast such that the R34 in the northwest quadrant is much smaller in v2023 w.r.t. v2021 (see the impact on the average R34 at 18 h in the right panel of Fig. 1). This is a rather extreme example of how the expanded nest 3 blend zone in v2023 can directly lead to a smaller R34 forecast. Late in the same forecast, at 102-h lead time, it is clear from Fig. 2 and Fig. 3 that the v2023 storm is smaller on the vortex scale w.r.t. v2021 (in particular on the east and south sides), not that it lacks an outlying patch of 34-kt winds. Here, the expanded nest 3 blend zone is having an indirect impact on storm size, we believe by increasing the influence of dry air around the storm by importing it into grid 3 from grid 2. Note that the shallow cumulus parameterization in COAMPS-TC is different in nest 2 w.r.t. nest 3 in a manner that favors a drier lower and middle troposphere in nest 2. The expanded nest 3 blend zone in v2023 essentially brings these drier conditions closer to the storm's center.

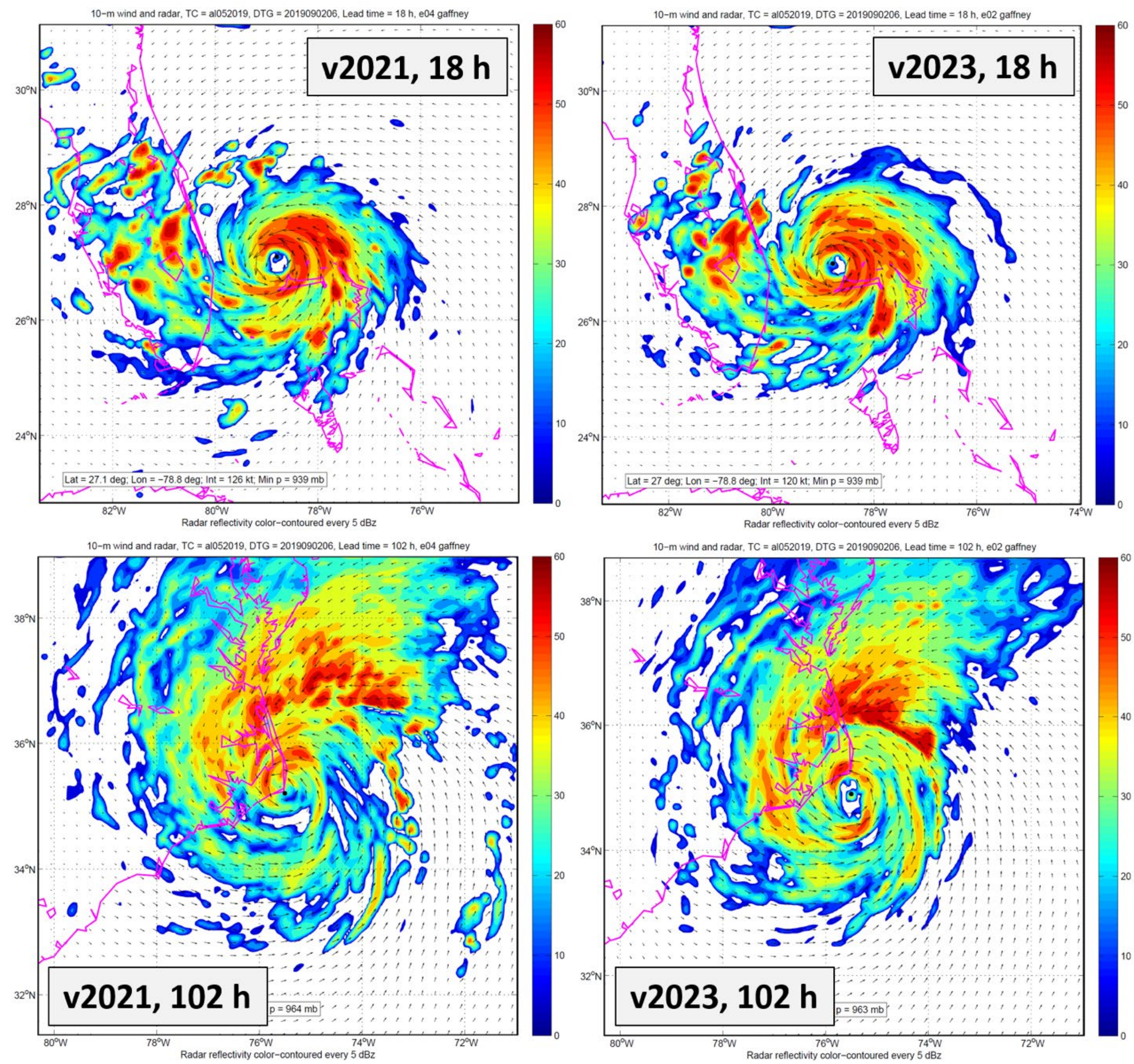


Fig. 2—Simulated composite radar reflectivity (dBz) for the v2021 (left column) and v2023 (right column) runs of deterministic CTCX at the 18-h (top row) and 102-h (bottom row) lead times for the 0600 UTC 02 September 2019 Dorian forecast. The vectors on the plots show 10-m winds. The domain shown in each panel is that encompassed by nest 3 of the model.

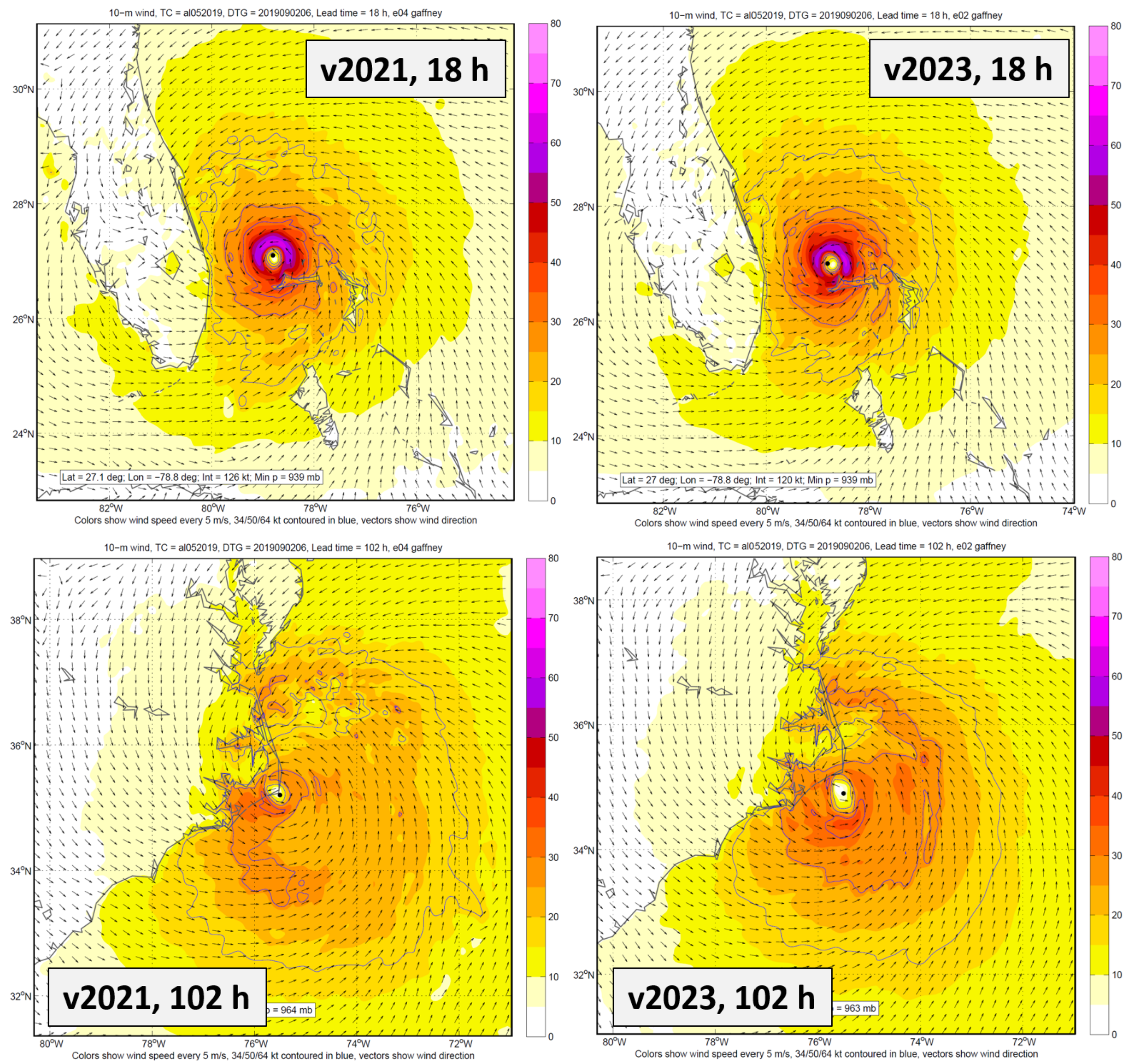


Fig. 3—10-m wind speed (color shading) and direction (vectors) for the v2021 (left column) and v2023 (right column) runs of deterministic CTCX at the 18-h (top row) and 102-h (bottom row) lead times for the 0600 UTC 02 September 2019 Dorian forecast. The wind speed units are m/s, the contours corresponding to 34 kt, 50 kt, and 64 kt are drawn in blue (17.49 m/s, 25.72 m/s, 32.92 m/s). The domain shown in each panel is that encompassed by grid 3 of the model.

2.2 Testing Strategy

The expanded inner nest blend zone change was tested using the procedure typically utilized in testing the COAMPS-TC deterministic model, but this time applied to the CTCX ensemble control member. The v2021 ensemble control member (with 2-point inner nest blend zones) and v2023 ensemble control member (with 18-point inner nest blend zones) were run for a set of 399 cases from 87 different TCs during the 2019–2021 time frame. In total, 177 cases were run for 38 western North Pacific storms, 135 cases were run for 25 Atlantic storms, 82 cases were run for 19 eastern North Pacific storms, and 1 case each was run for the Arabian Sea, the Bay of Bengal, the central North Pacific, the southern Indian basin, and the western South Pacific basins. Further details regarding this retrospective forecast sample are contained in Table 1.

Note that for any given storm, forecast initial times are separated by 24 h so that sequential forecasts are quasi-independent. Both sets of forecasts used 0.25-degree real-time GFS data for initial and lateral boundary conditions. Forecasts results were validated against the final or working best track (depending on what was available in December 2022) from JTWC or NHC.

Table 1—List of Storms, Along with Number of Forecasts Per Storm, Utilized in Retrospective Testing of the Ensemble Control Member

WestPac

Storm	Cases
wp092019	4
wp102019	6
wp112019	9
wp142019	5
wp152019	4
wp192019	4
wp202019	5
wp212019	3
wp222019	5
wp242019	5
wp262019	3
wp272019	3
wp292019	7
wp012020	3
wp032020	2
wp092020	3
wp102020	4
wp112020	5
wp142020	3
wp152020	2
wp162020	6
wp192020	5
wp212020	3
wp222020	8
wp232020	2
wp252020	3
wp022021	6
wp042021	5
wp062021	5
wp092021	8
wp132021	5
wp142021	4
wp162021	4
wp182021	3
wp192021	9
wp202021	7
wp232021	5
wp252021	4
Total	**177**

Atlantic

Storm	Cases
al052019	11
al082019	5
al092019	4
al102019	6
al122019	3
al132019	7
al082020	3
al092020	4
al132020	7
al172020	7
al182020	6
al192020	4
al202020	7
al262020	3
al272020	4
al292020	10
al052021	6
al062021	4
al072021	5
al082021	6
al092021	3
al102021	3
al122021	8
al172021	3
al182021	6
Total	**135**

EastPac

Storm	Cases
ep022019	1
ep062019	4
ep072019	7
ep112019	4
ep132019	10
ep052020	4
ep082020	7
ep092020	2
ep122020	3
ep142020	3
ep172020	3
ep182020	6
ep192020	3
ep052021	3
ep062021	5
ep082021	5
ep122021	8
ep152021	2
ep162021	2
Total	**82**

Other

Storm	Cases
cp012019	1
io012019	1
io042019	1
sh222020	1
sh252020	1
Total	**5**

2.3 Performance Results

Here, performance results for the v2023 CTCX ensemble control and the v2021 CTCX ensemble control (which we will henceforth refer to as “v2023” and “v2021” for the remainder of this subsection) are described for the full retrospective sample. Results were also calculated specifically for the western North Pacific portion of the sample, for the Atlantic portion of the sample, and for the eastern North Pacific portion of the sample, but for brevity, they are not included here.

As alluded to earlier, the performance of v2023 in terms of R34 prediction is consistently superior to that of v2021. The mean absolute error (MAE) and mean error (ME) statistics for R34 are shown in Fig. 4. MAE is improved at all positive lead times except 120 h in v2023 w.r.t. v2021. The largest percentwise MAE improvement (21%) occurs at 12 h, with the percentwise MAE improvement tailing off to near zero by the end of the forecast. Mean error is greatly improved at all positive lead times, with the positive bias in v2021 improved by about 10 nmi in v2023.

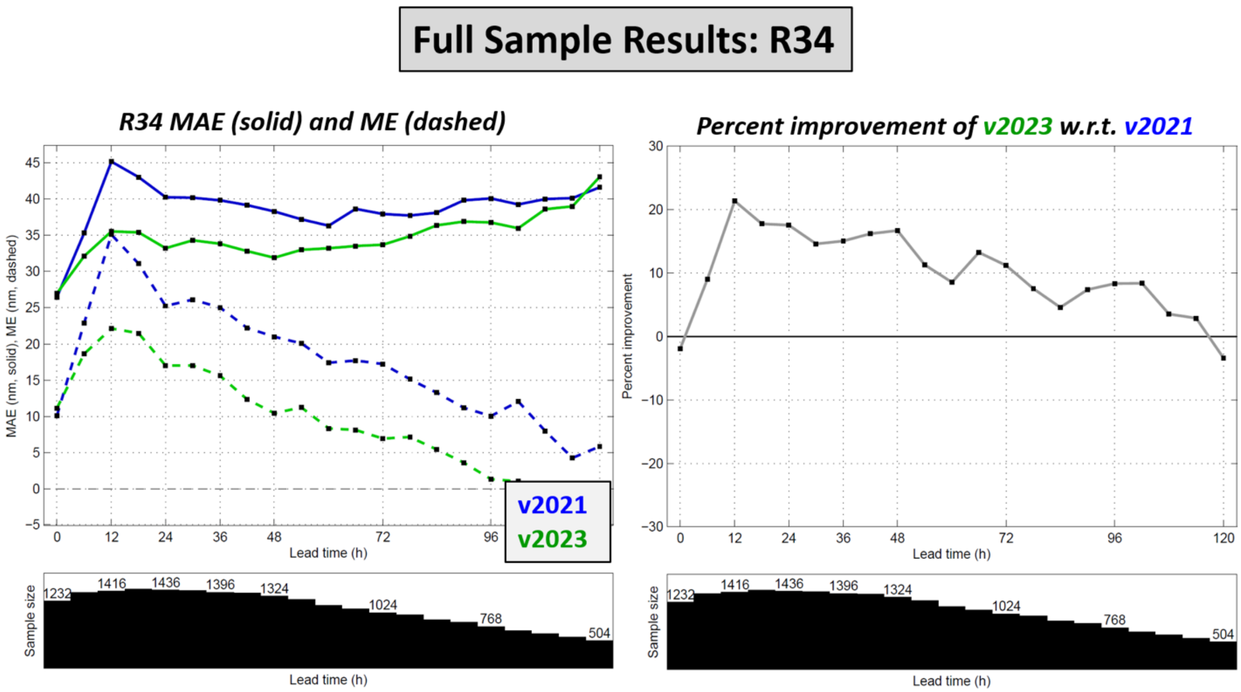


Fig. 4—The upper left panel shows radius of 34-kt winds (R34) mean absolute error (MAE; nmi, solid) and R34 mean error (ME; nmi, dashed) as a function of forecast lead time for v2021 and v2023. The upper right panel shows the percent improvement of v2023 R34 MAE w.r.t. v2021 R34 MAE. The lower panels, which are identical, show sample size as a function of lead time. The sample size indicates the total number of individual quadrant-wise R34 values that are homogeneously verified against the best track (with up to 4 for a given forecast case/lead time).

Similarly to Fig. 4, Fig. 5 shows results for R50 forecast performance. Summary R50 statistics are improved in v2023 w.r.t. v2021, but by a smaller amount than for R34. The percentwise improvements for MAE range mostly between 0% and 10%, and mean error is improved (reduction of positive bias by a few kt) in v2023 w.r.t. v2021 at all but the latest lead times. Figure 6 shows performance results for R64. Here, there is little difference in performance between the two runs, though v2023 tends to have slightly less of a positive bias than v2021 and a slightly smaller MAE, results which are qualitatively in the same vein as those for R34 and R50. Radius of maximum wind summary statistics show no consistent difference between the two runs (not shown). It is clear that the beneficial impact of the inner nest blend zone expansion on wind radii prediction decreases with decreasing distance to the center of the storm.

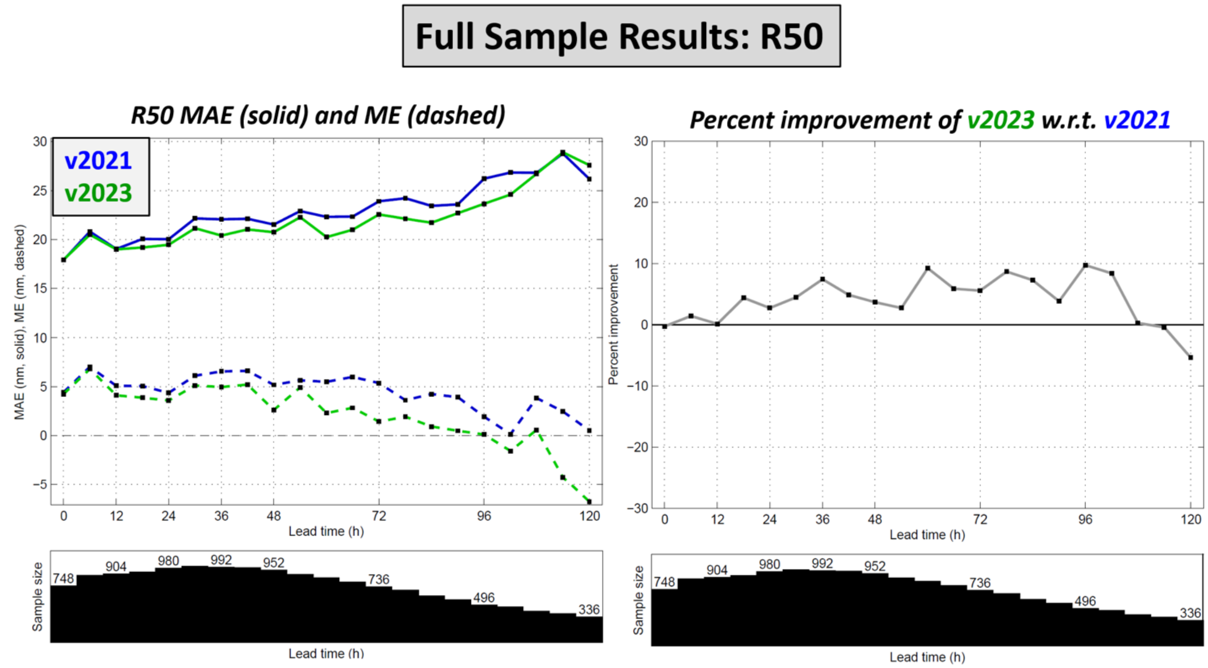


Fig. 5—As in Fig. 4, but for radius of 50-kt winds (R50)

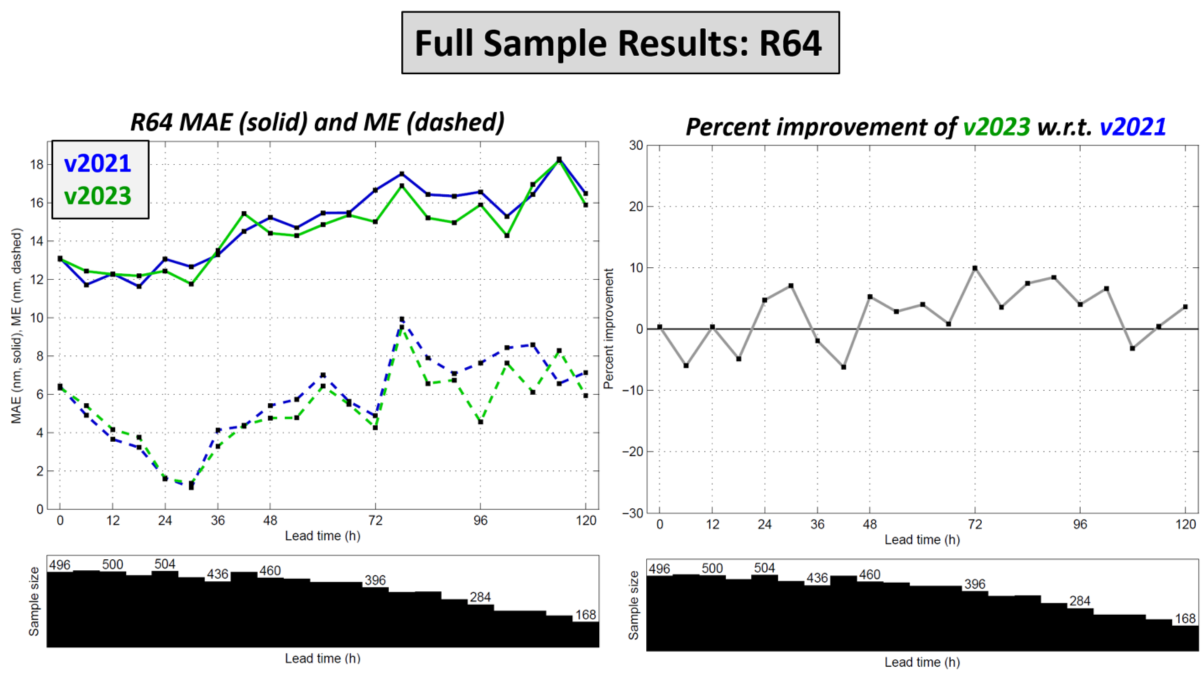


Fig. 6—As in Fig. 4, but for radius of 64-kt winds (R64)

Figure 7 shows performance results for track prediction. For individual cases, the track predictions can be meaningfully different, but in the overall statistics, the accuracy of the two sets of track forecasts is very similar. Nonetheless, there is a very slight degradation to track MAE in v2023 w.r.t. v2021, less than 1 percent at most lead times. Similar to track, individual intensity forecasts are different in v2023 w.r.t. v2021, but the overall accuracy of the two sets of forecasts is very much similar, as shown in Fig. 8. The average intensity forecast is slightly weaker in v2023 w.r.t. v2021, as can be seen from the mean error lines in Fig. 8, by 0.5 kt in a weighted average calculated over all positive lead times.

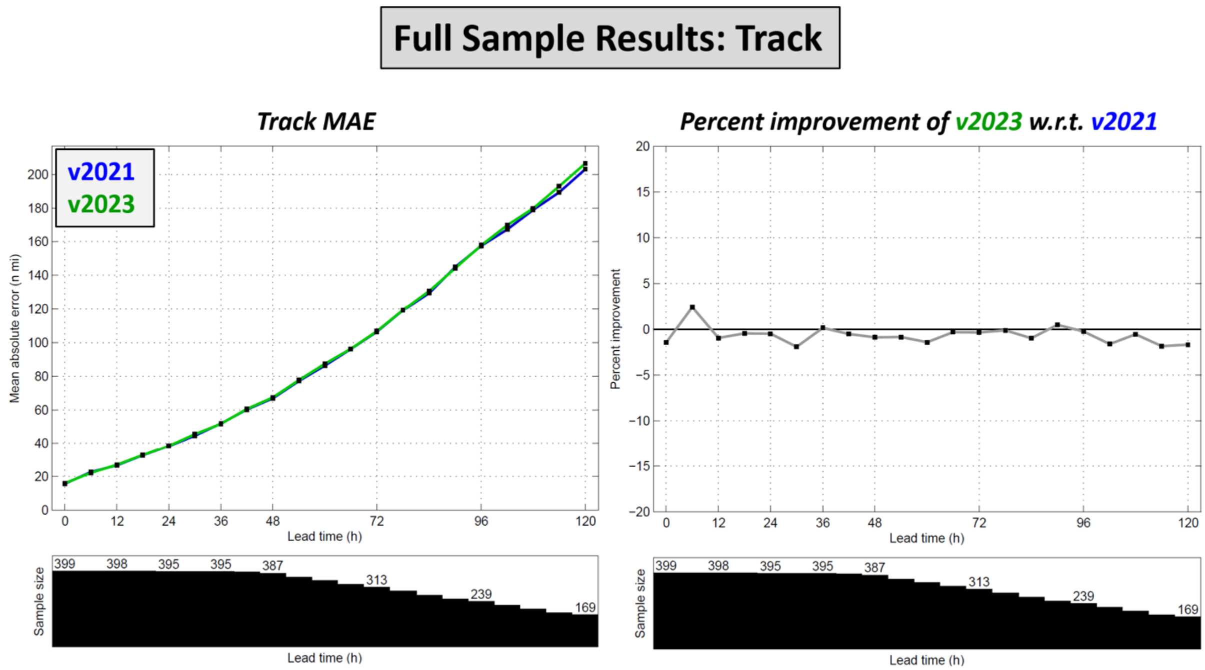


Fig. 7—The upper left panel shows track mean absolute error (MAE; nmi) as a function of forecast lead time for v2021 and v2023. The upper right panel shows the percent improvement of v2023 track MAE w.r.t. v2021 track MAE. The lower panels, which are identical, show sample size as a function of lead time.

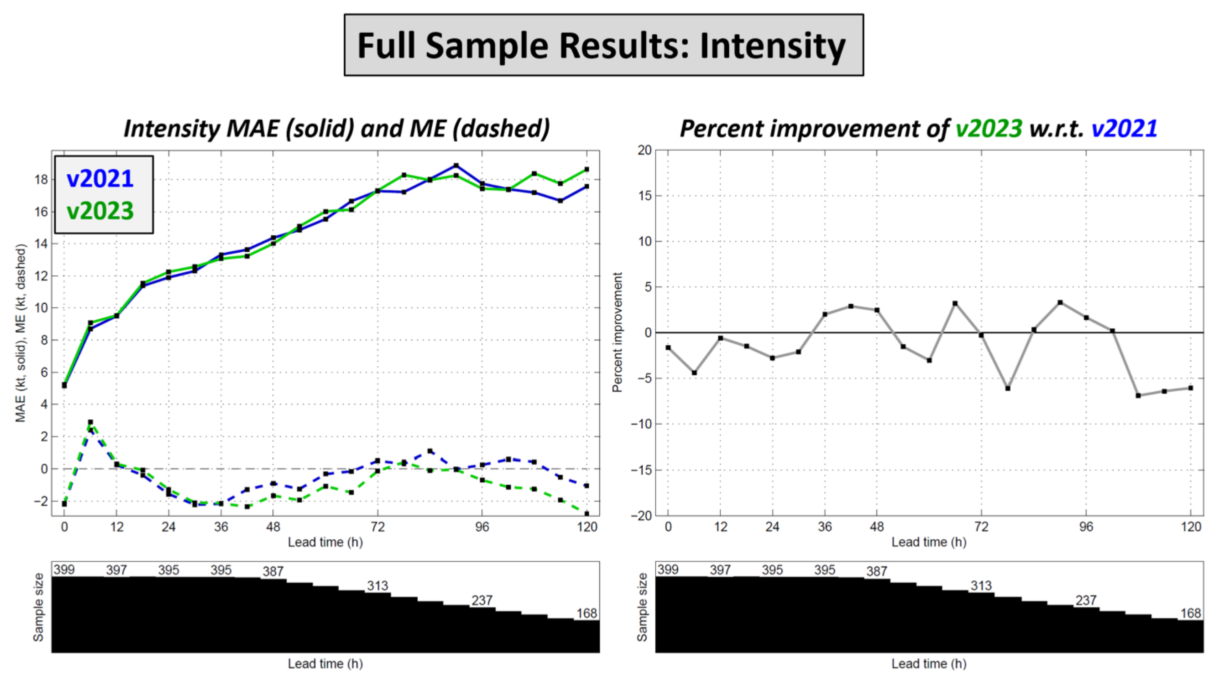
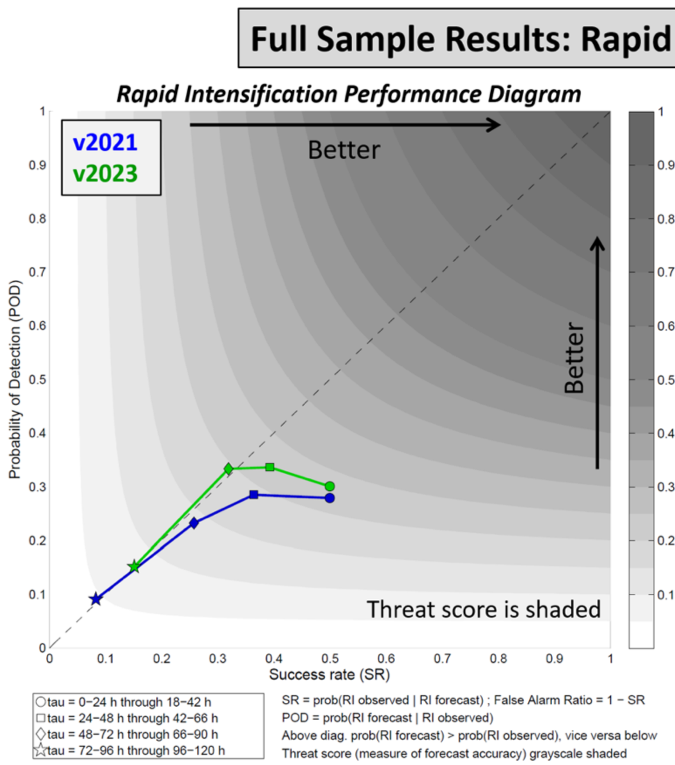


Fig. 8—The upper left panel shows intensity mean absolute error (MAE; kt, solid) and intensity mean error (ME; kt, dashed) as a function of forecast lead time for v2021 and v2023. The upper right panel shows the percent improvement of v2023 intensity MAE w.r.t. v2021 intensity MAE. The lower panels, which are identical, show sample size as a function of lead time.

Finally, Fig. 9 shows performance results for event-based prediction of rapid intensification (RI), which is defined as an increase in intensity of at least 30 kt in a 24-h time interval. For the 399 case sample, RI is verified for each 24-h forecast interval (0–24 h, 6–30 h, … 96–120 h) in which a forecast intensity and a best track intensity (for a storm characterized as a TC) exist at the endpoints of the interval. There is a total of 5,062 verified 24-h intensity change intervals in the sample, though these are not independent, in part due to the overlapping nature of the 24-h intervals. Of the 5,062 verified intensity change 24-h intervals, 6.0% contain RI for v2021, 6.6% contain RI for v2023, and 8.3% contain RI for the observations. The aforementioned observed rate of RI occurrence is rather low,[1] but note that 53 of the 87 storms in the sample have at least one interval of observed RI, as the sample tends to select for longer-lived TCs that are more likely to experience RI sometime in their life cycle.



Threat Score

	0 - 24 h	24 - 48 h	48 - 72 h	72 - 96 h
v2021	0.22	0.19	0.14	0.05
v2023	0.23	0.22	0.19	0.08

RI relative frequency

	0 - 24 h	24 - 48 h	48 - 72 h	72 - 96 h
Observed	11.7%	9.7%	6.2%	3.4%
v2021	6.5%	7.6%	5.6%	3.7%
v2023	7.1%	8.3%	6.5%	3.4%

Fig. 9—Rapid intensification (RI) performance diagram for v2021 and v2023. The x-axis indicates success rate (SR), the y-axis indicates probability of detection (POD), and the threat score (an accuracy metric) is shaded. The dashed diagonal is the line of zero bias. Results for four lead time bins are represented on the diagram according to the legend at the lower left. Tables indicating the threat score and the RI relative frequency for the four lead time bins are also included.

Interestingly, Fig. 9 shows RI forecast accuracy (as measured by threat score) is improved in v2023 w.r.t. v2021 at all lead times, especially the middle lead times. In addition, RI relative frequency is generally increased in v2023 w.r.t. v2021 (particularly at the early to middle lead times) and is closer to the observed RI relative frequency at all lead times. These improvements to RI accompany the aforementioned neutral results for overall intensity accuracy and a slight decrease in the average predicted intensity for v2023 w.r.t. v2021. We hypothesize that the improvements to RI prediction are because v2023 predicts smaller TCs on

[1] The 30 kt / 24-h threshold for "rapid" intensification, defined in early RI research, was set such that RI occurred in ~5% of 24-h intervals for observed Atlantic TCs.

average, with a more peaked radial profile of the tangential wind and less convective activity far from the center of the storm. However, further study is needed to better understand these results.

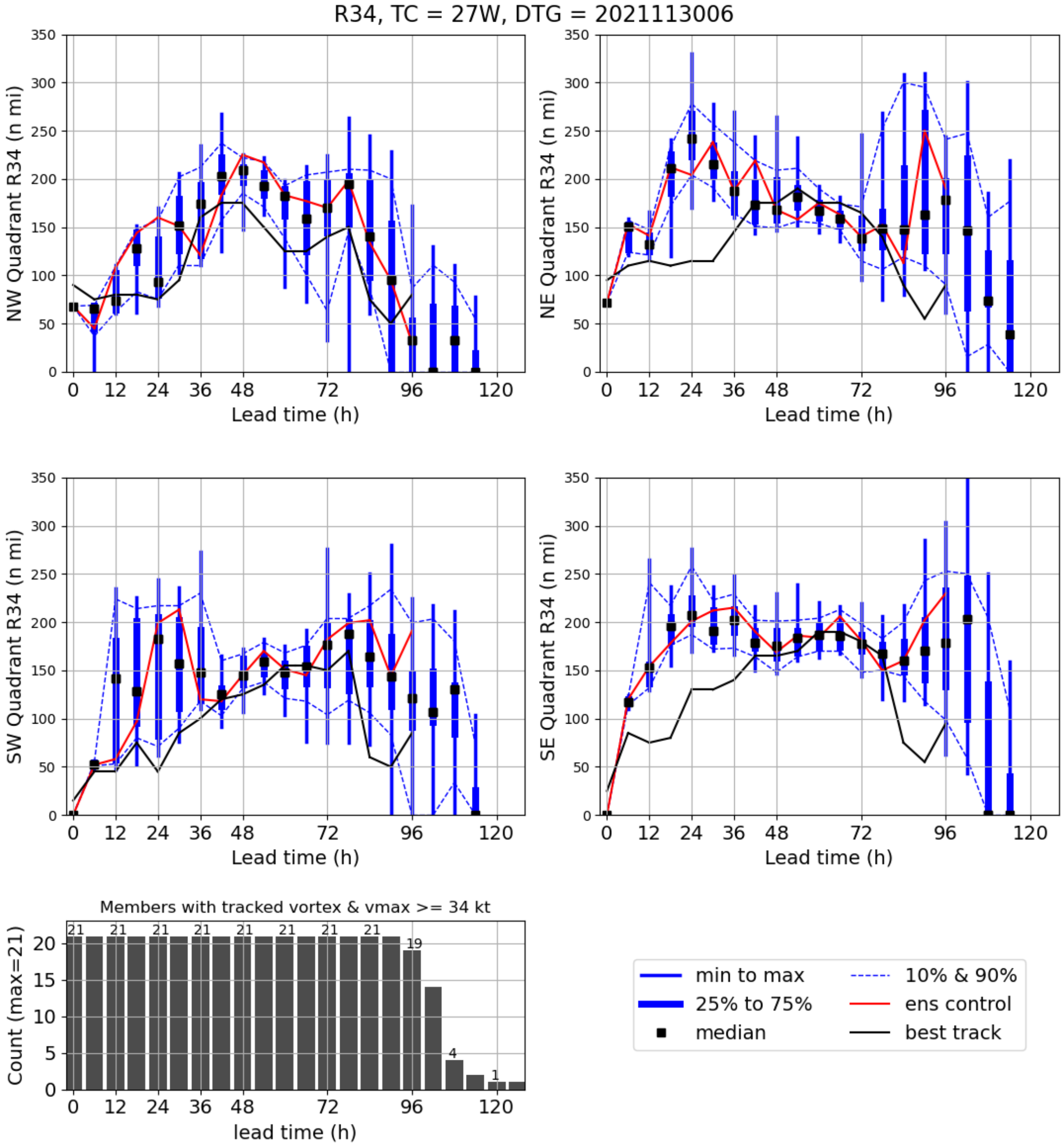
3. GRAPHICAL FORECAST PRODUCT SUITE UPDATE

Only the blend zone change for the inner nests detailed in the previous section impacts v2023 CTCX ensemble performance results, but a major component of the v2023 COAMPS-TC ensemble transition is the updated graphical suite for displaying ensemble forecasts, in particular wind radii forecasts. Here, we show examples of the new graphical forecast products included in the v2023 update. The graphical forecast products that were part of the v2021 update are unchanged in v2023, save for a few minor adjustments for labeling consistency amongst plots.

Figure 10 shows an example of the R34 “candlestick”-style plot, applied to the 21-member CTCX NRL real-time demo ensemble for the 0600 UTC 30 November 2021 forecast of Typhoon Nyatoh (27W). The candlestick plotting convention is exactly the same as in the existing intensity candlestick plot. Note that for R34, for an ensemble member to be included in the plotted distribution, not only must the vortex be tracked by the Geophysical Fluid Dynamics Laboratory (GFDL) tracker, but also the forecast intensity has to be at least 34 kt. So, strictly speaking, the plot represents the time-evolution of the conditional distribution of R34, given the forecast intensity is greater than or equal to 34 kt. Similar candlestick-style plots have been developed for R50 and R64, which are displayed in Fig. 11 and Fig. 12, respectively, for the same Typhoon Nyatoh case.

The candlestick plots are very well suited for showing the time evolution of the ensemble forecast distribution of R34/R50/R64 for each quadrant of the storm. However, at any given lead time, it is challenging to relate the four quadrant-wise ensemble forecast distributions to each other to create a snapshot in time of the R34/R50/R64 ensemble forecast. Thus, we created a second style of plot, the R34/R50/R64 “circle”-style plot, to explicitly show the relationship amongst the four quadrants at a given lead time. The circle plots are created for a sequence of lead times (by default every 6 h from 0 to 126 h) and can be viewed as a loop. As an example, the circle plot in Fig. 13 pertains to the 48-h lead time forecast of R34 for the aforementioned Typhoon Nyatoh case. Figure 14 and Fig. 15 show plots similar to Fig. 13, but for R50 and R64, respectively.

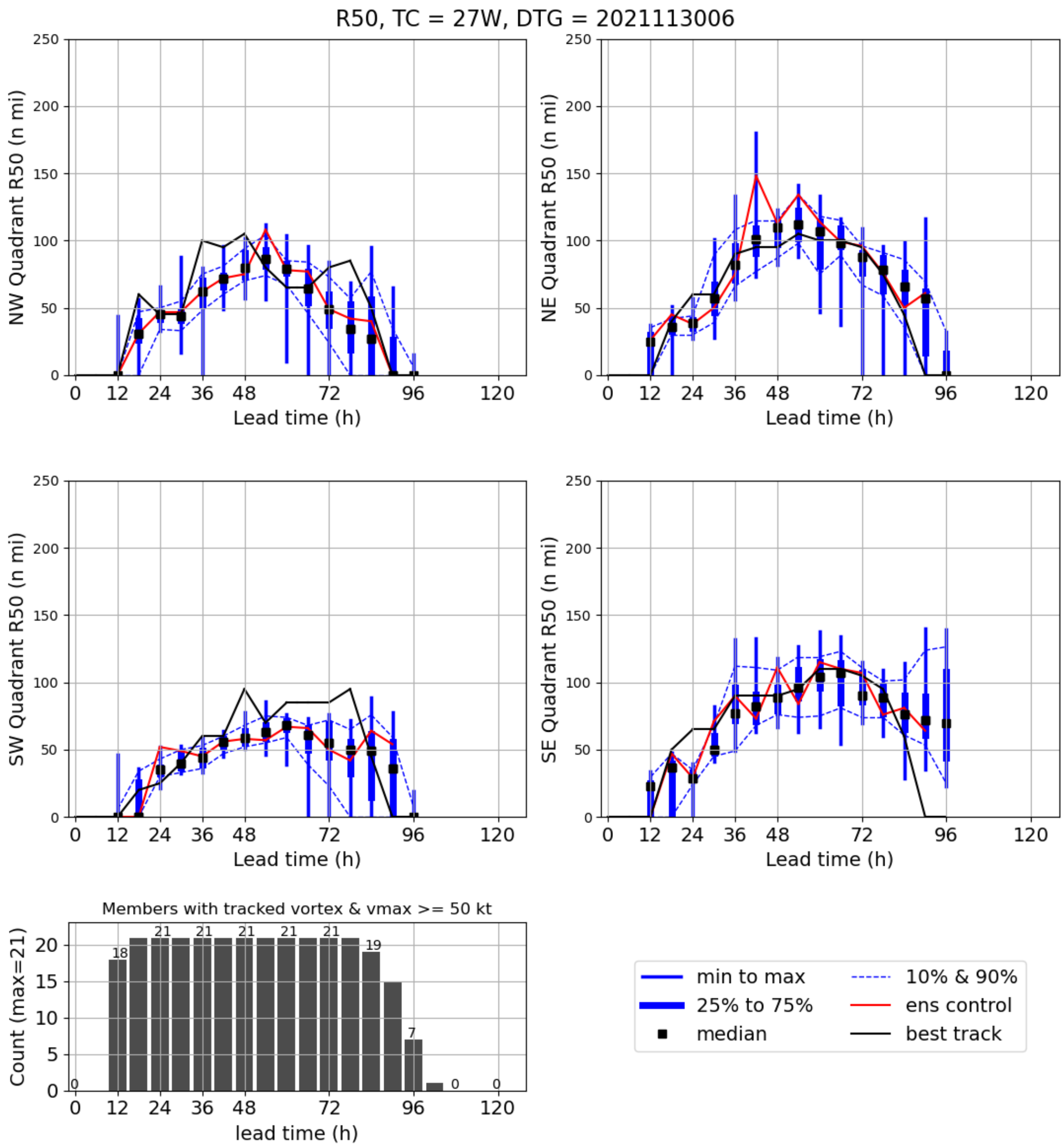
Finally, Fig. 16 shows an example of a candlestick-style MSLP plot, which is also included in the upgraded graphical forecast product suite for v2023. The nature of the candlestick style used for MSLP is consistent with the existing intensity candlestick plot and the new R34, R50, and R64 candlestick plots.



Lead time (h)	NE quad. median (n mi)	SE quad. median (n mi)
12.0	132.0	153.0
24.0	242.0	207.0
36.0	188.0	202.0
48.0	168.0	175.0
72.0	138.0	178.0
96.0	178.0	179.0
120.0	0.0	0.0

Lead time (h)	SW quad. median (n mi)	NW quad. median (n mi)
12.0	142.0	74.0
24.0	183.0	93.0
36.0	148.0	174.0
48.0	145.0	209.0
72.0	176.0	170.0
96.0	121.0	33.0
120.0	0.0	0.0

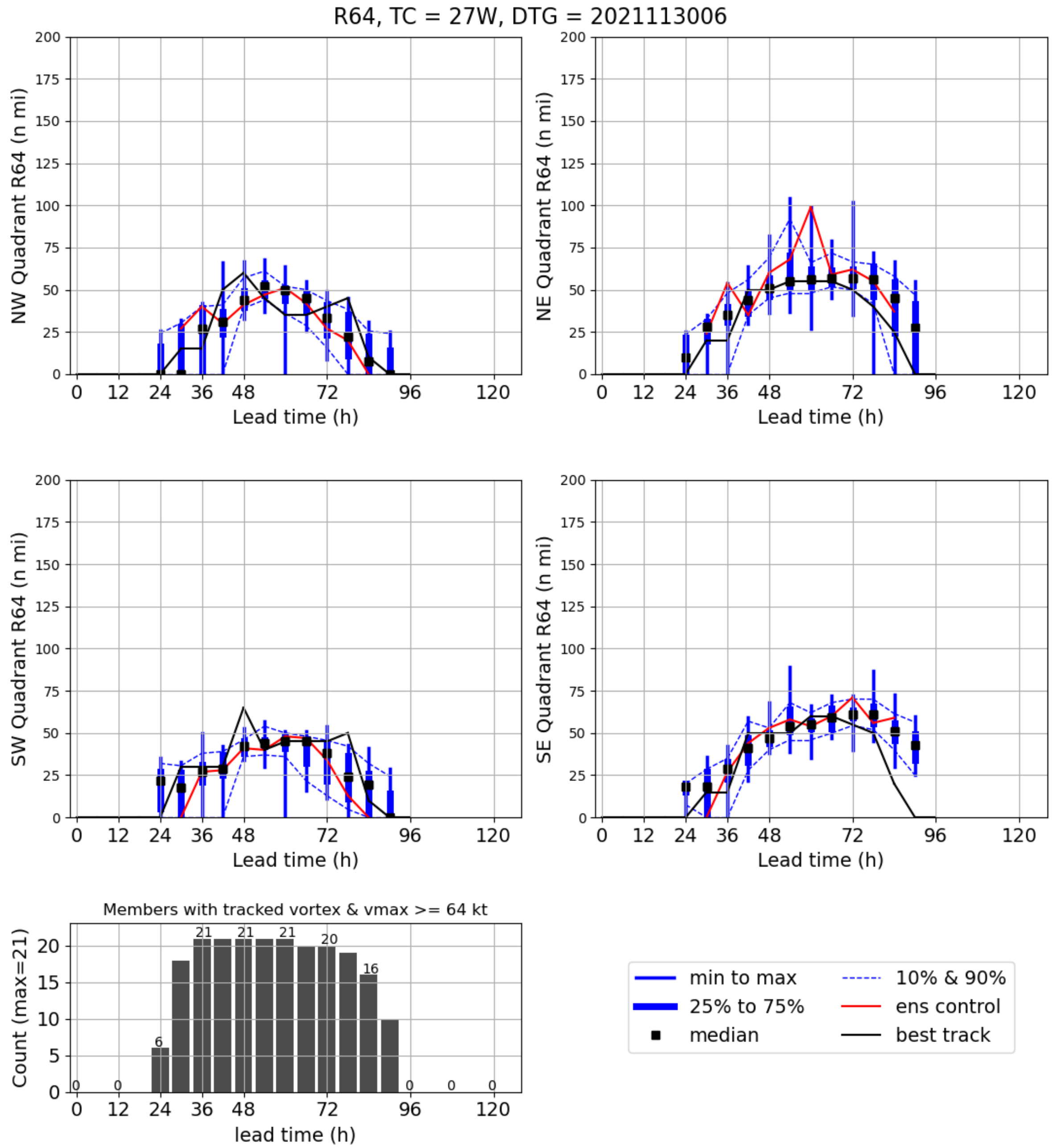
Fig. 10—Radius of 34-kt winds (R34) "candlestick"-style display, for the 21-member CTCX NRL real-time demo ensemble prediction of Typhoon Nyatoh (27W) from the 0600 UTC 30 November 2021 initial time. The upper four panels show candlestick plots for R34 in each of the four quadrants, with features of the plots exactly following those utilized in the existing intensity candlestick plot: At each lead time, the thin, blue line extends from the maximum to minimum of the ensemble forecast distribution, the thick, blue line extends over the interquartile range of the ensemble forecast distribution, and the black square indicates the median of the ensemble forecast distribution. The dashed lines connect the 10th and 90th percentiles of the ensemble forecast distribution over the various lead times and the red line shows the ensemble control member forecast (and the best track is shown in black). The bar graph shows the number of members for which the vortex is tracked and the intensity is greater than or equal to 34 kt, preconditions for the existence of a forecast R34. Finally, the tables at bottom show numerical values for the ensemble median at key forecast times relevant to JTWC.



Lead time (h)	NE quad. median (n mi)	SE quad. median (n mi)
12.0	24.5	22.5
24.0	39.0	29.0
36.0	82.0	77.0
48.0	110.0	89.0
72.0	88.0	90.0
96.0	0.0	70.0
120.0	0.0	0.0

Lead time (h)	SW quad. median (n mi)	NW quad. median (n mi)
12.0	0.0	0.0
24.0	35.0	45.0
36.0	44.0	62.0
48.0	59.0	80.0
72.0	55.0	49.0
96.0	0.0	0.0
120.0	0.0	0.0

Fig. 11—As in Fig. 10, but for radius of 50-kt winds (R50)



Lead time (h)	NE quad. median (n mi)	SE quad. median (n mi)
12.0	0.0	0.0
24.0	10.0	18.0
36.0	35.0	29.0
48.0	51.0	47.0
72.0	57.0	61.0
96.0	0.0	0.0
120.0	0.0	0.0

Lead time (h)	SW quad. median (n mi)	NW quad. median (n mi)
12.0	0.0	0.0
24.0	21.5	0.0
36.0	27.0	27.0
48.0	42.0	44.0
72.0	38.0	33.5
96.0	0.0	0.0
120.0	0.0	0.0

Fig. 12—As in Fig. 10, but for radius of 64-kt winds (R64)

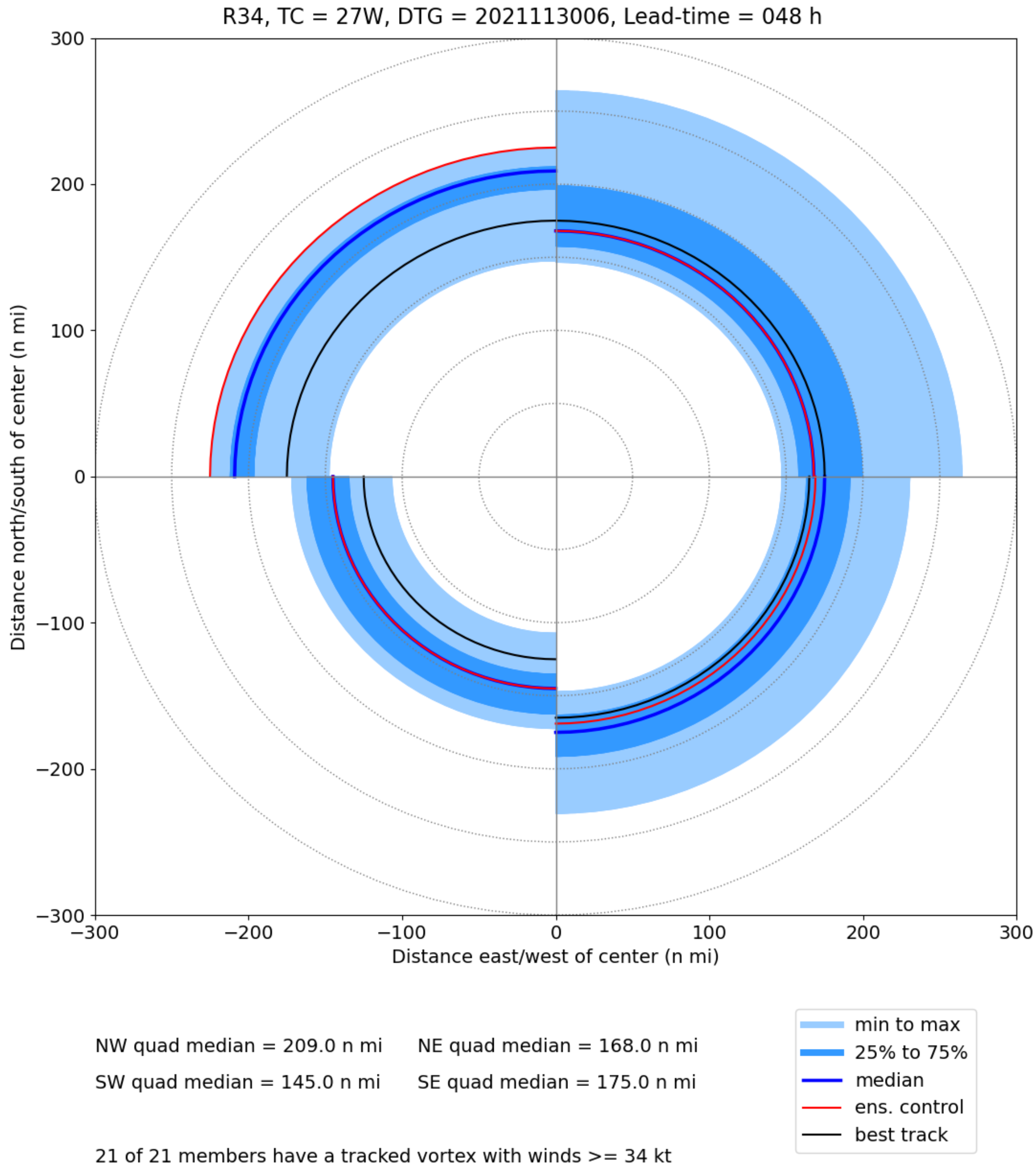


Fig. 13—Radius of 34-kt winds (R34) "circle" style display, valid at the 48-h lead time, for the 21-member CTCX NRL real-time demo ensemble prediction of Typhoon Nyatoh (27W) from the 0600 UTC 30 November 2021 initial time. The plot uses lines and shading to represent the ensemble forecast distribution in each quadrant of the storm (northeast quadrant in upper right, southeast quadrant in lower right, southwest quadrant in lower left, northwest quadrant in upper left). The light-blue shading extends from the minimum to the maximum of the ensemble forecast distribution; the medium-blue shading extends over the interquartile range, and the dark-blue line marks the median of the ensemble forecast distribution. The red lines show the ensemble control (and the black line is the verifying best track). Below the plot, the medians are noted for each quadrant and the number of members with a tracked vortex and intensity greater than or equal to 34 kt intensity is specified.

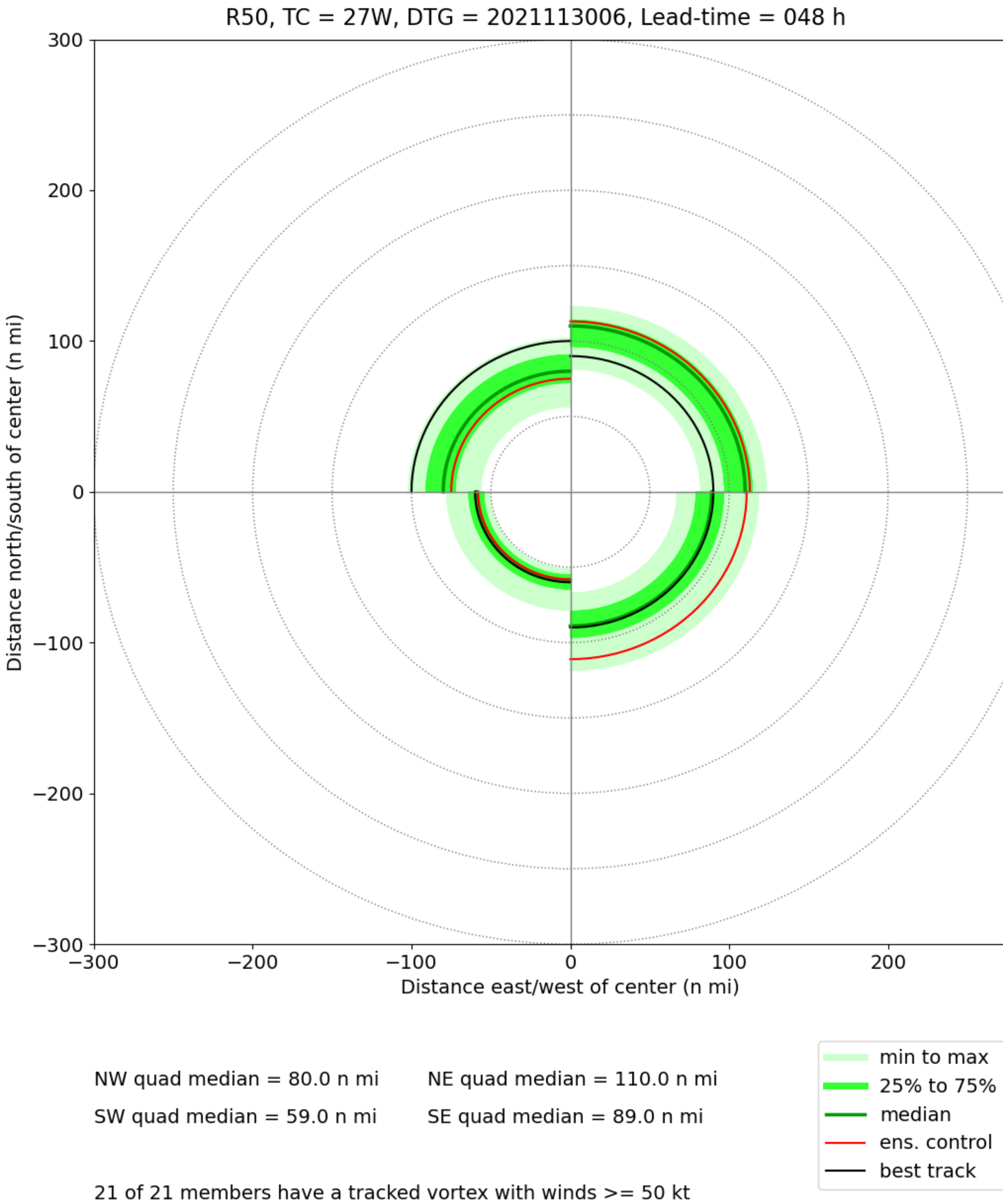


Fig. 14—As in Fig. 13, but for radius of 50-kt winds (R50) and using green shading rather than blue shading

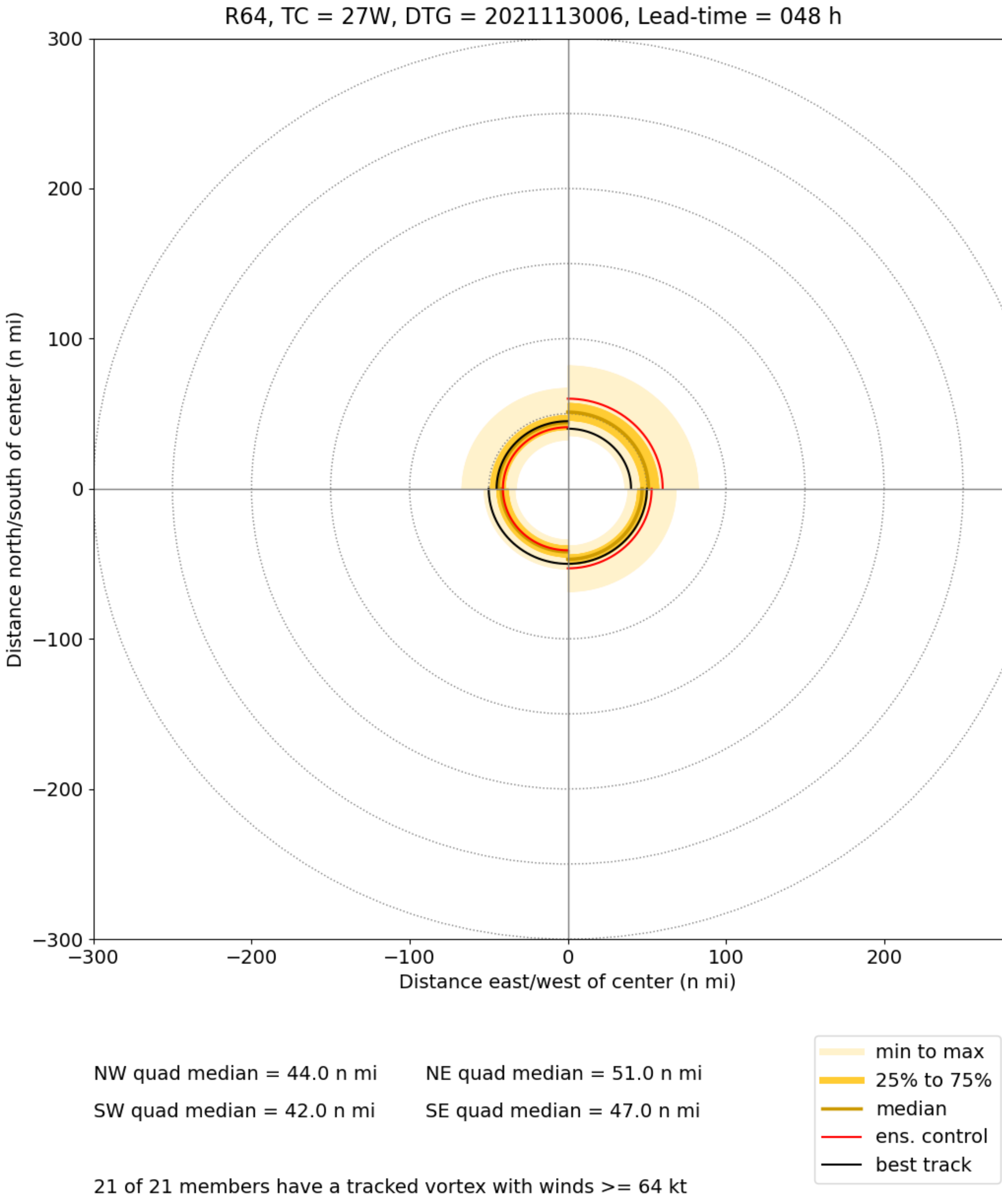


Fig. 15—As in Fig. 13, but for radius of 64-kt winds (R64) and using orange shading rather than blue shading

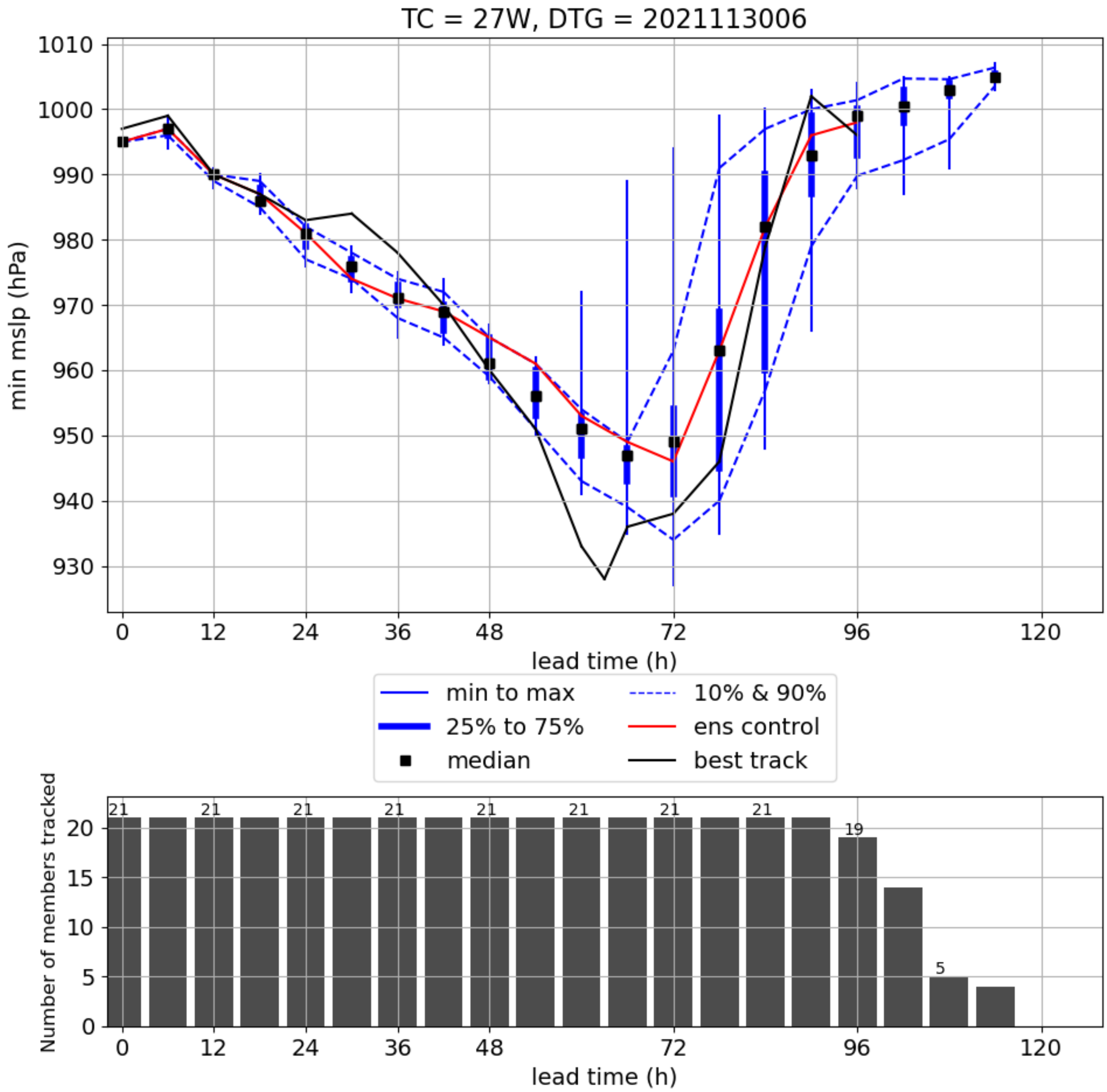


Fig. 16—Minimum sea-level pressure (MSLP) candlestick-style display for the 21-member CTCX NRL real-time demo ensemble prediction of Typhoon Nyatoh from the 0600 UTC 30 November 2021 initial time. The features of the candlestick plot are as described in Fig. 10. The bar graph at bottom shows the number of members for which a vortex is tracked.

4. SUMMARY AND CONCLUSIONS

The v2023 COAMPS-TC ensemble transition includes one update to the model code, expanding the storm-following inner-nest blend zones, as well as an augmented graphical forecast product suite with new ensemble forecast plots for R34, R50, R64 and MSLP. The forecast performance improvements for v2023 w.r.t. v2021, as tested for the ensemble control member over a 399-case retrospective sample, can be summarized as follows: 1) a very large improvement to R34 accuracy and bias, 2) a small-but-meaningful improvement to R50 accuracy and bias, and 3) a substantial improvement to RI forecast accuracy and bias. Meanwhile, little change was noted in the accuracy and bias statistics for track and intensity, including a very small degradation to track MAE for v2023 w.r.t. v2021.

In addition to the forecast performance improvements, the v2023 COAMPS-TC ensemble includes new candlestick-style plots and circle-style plots for R34, R50, and R64, as well as a new candlestick-style plot for minimum MSLP. The candlestick-style plot is already in use for intensity in the v2021 COAMPS-TC ensemble. The new displays were reviewed by JTWC with favorable feedback, and it is our hope that they can be easily integrated into the JTWC forecast process.

Based on the results presented here, the unanimous recommendation of the Validation Test Panel was to implement the v2023 COAMPS-TC ensemble into operations at FNMOC. After implementation and testing at FNMOC, the v2023 COAMPS-TC ensemble went into operational production on July 5, 2023. On the same date, FNMOC also put a new version of deterministic COAMPS-TC, v2023, into operations. This new version of deterministic COAMPS-TC differs from its predecessor in operations (v2021) only in the width of the inner nest blend zones: v2023 uses the 18-grid-point blend zone, while v2021 uses a 2-grid-point blend zone. Thus, v2023 deterministic COAMPS-TC and the v2023 COAMPS-TC ensemble are consistent in the use of 18-grid-point inner nest blend zones. A separate validation test report was not written for v2023 deterministic COAMPS-TC, as the change to the deterministic model was justified by the ensemble control member results reported here in Section 2.

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