

Navy COAMPS-TC Update

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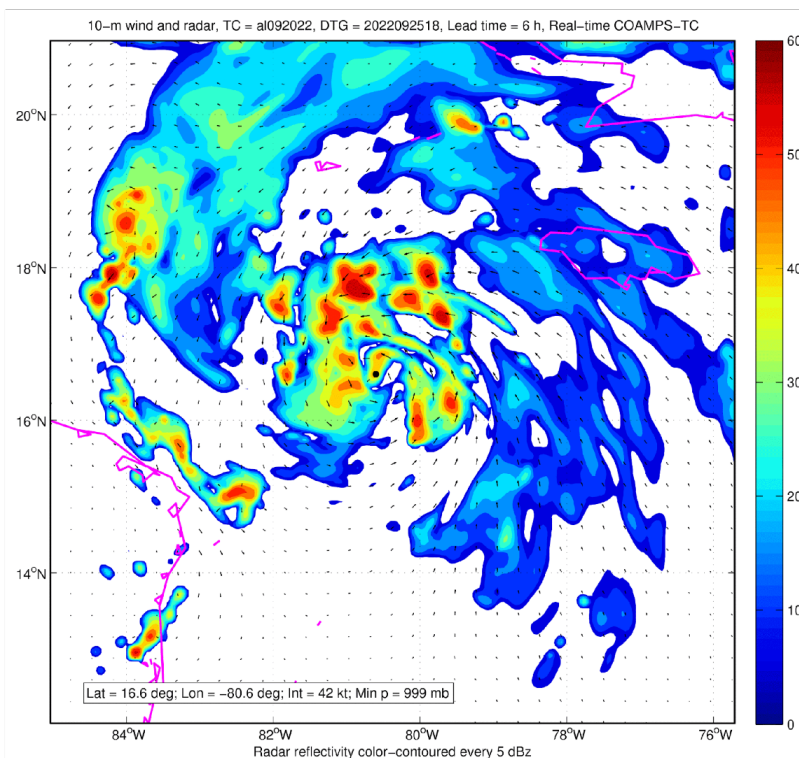
³Fleet Numerical Meteorology and Oceanography Center

Sponsors: Office of Naval Research, Naval Research Laboratory

COAMPS-TC

System overview

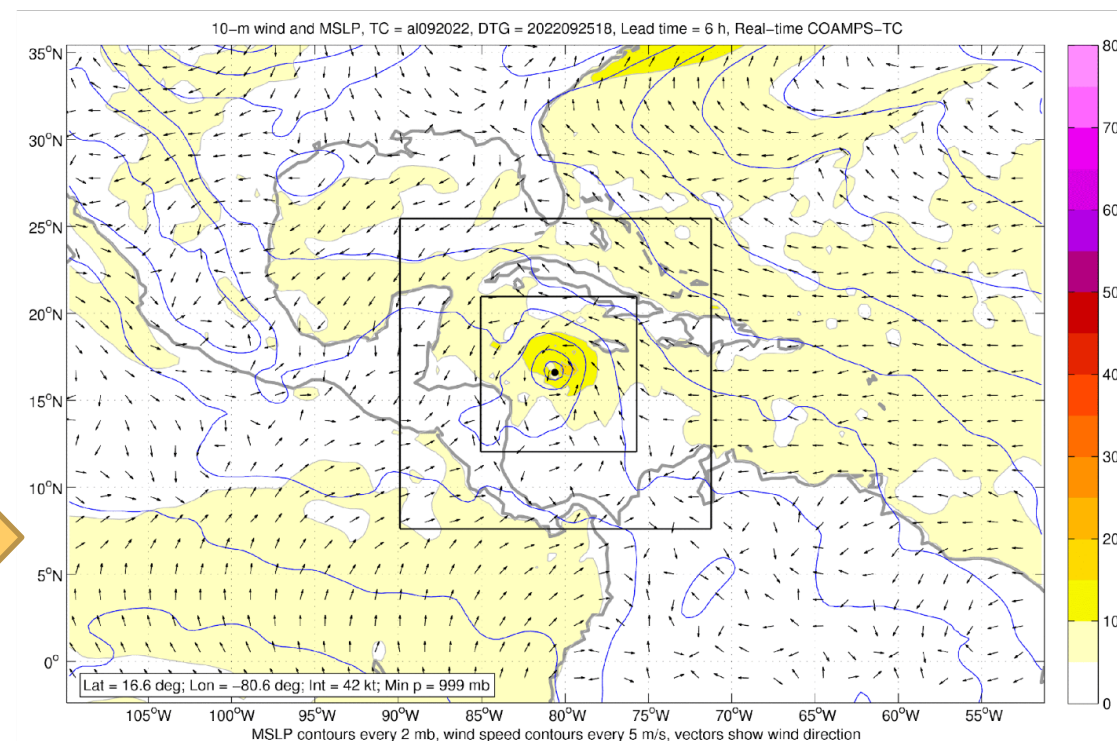
- COAMPS-TC is a specialized version of the Navy's mesoscale numerical weather prediction (NWP) model, COAMPS, designed to predict tropical cyclone (TC) track, intensity and structure (wind radii)
- Features:
 - TC-following nested grid meshes (4 km on inner mesh, 40L)
 - Specialized TC physics (Drag coefficient; boundary layer); TC Vortex initialization
 - Coupled with NRL Coastal Ocean Model, NCOM
- Operational at Navy FNMOC: i) deterministic NAVGEM BCs (**COTC**) and NOAA GFS BCs (**CTCX**)
ii) COAMPS-TC ensemble (11 member, 4 km resolution) based on NOAA GFS



Hurricane Ian (09L) CTCX forecast 18 UTC 25 Sept 2022

Inner nest simulated
radar reflectivity

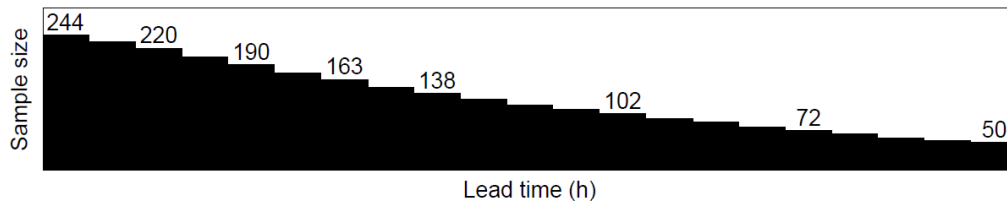
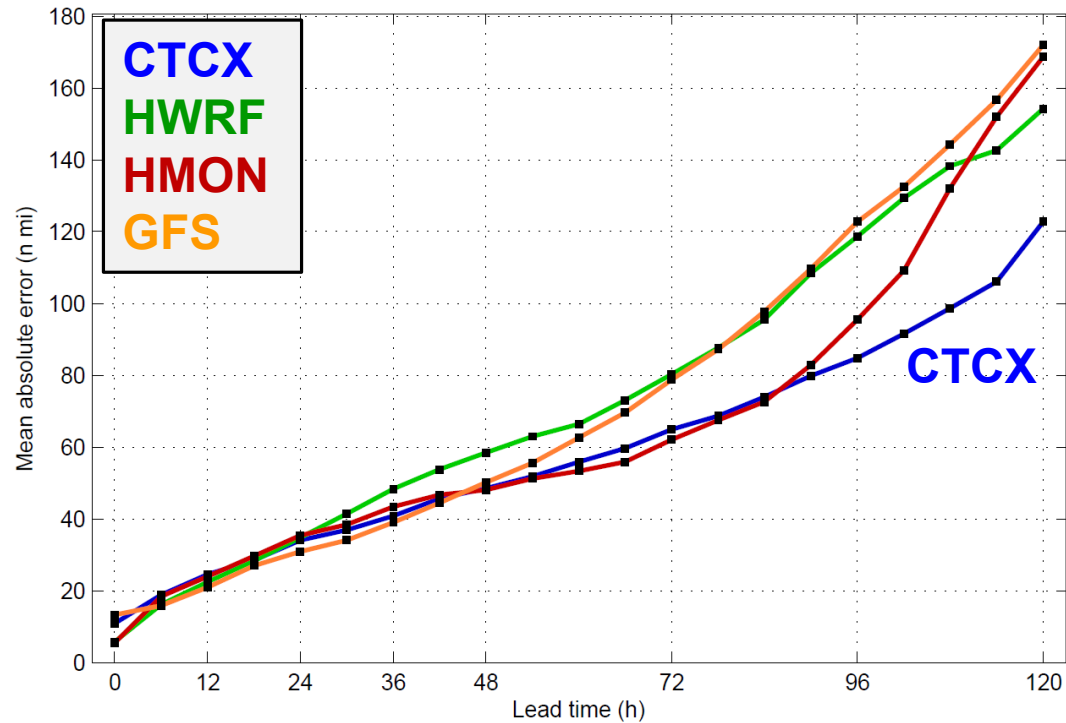
Multi-nest view of
10-m winds & MSLP



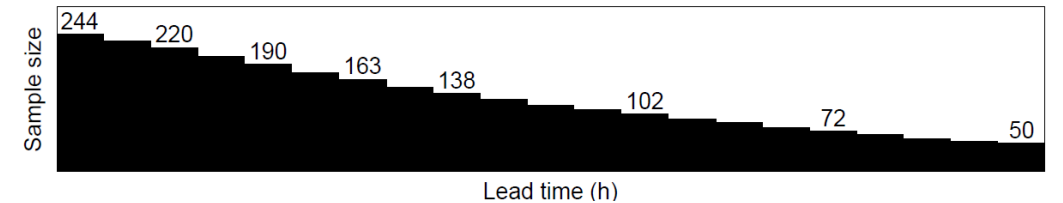
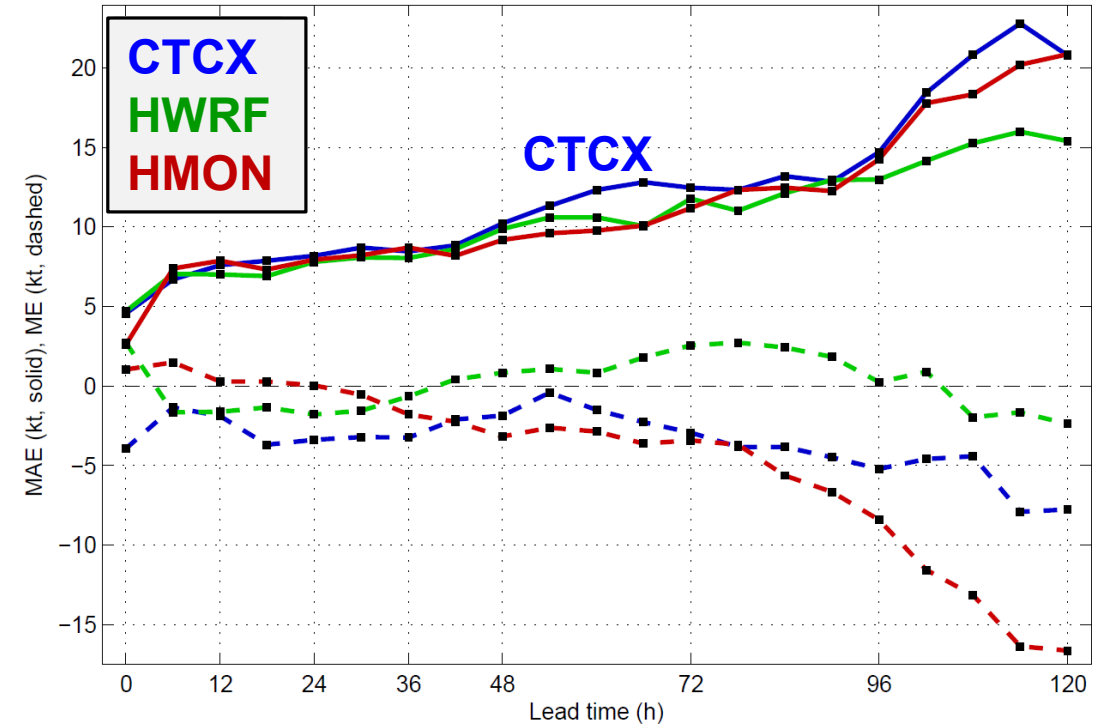
COAMPS-TC Performance

Atlantic Basin 2022

Track Mean Absolute Error



Intensity MAE (solid) and ME (dashed)



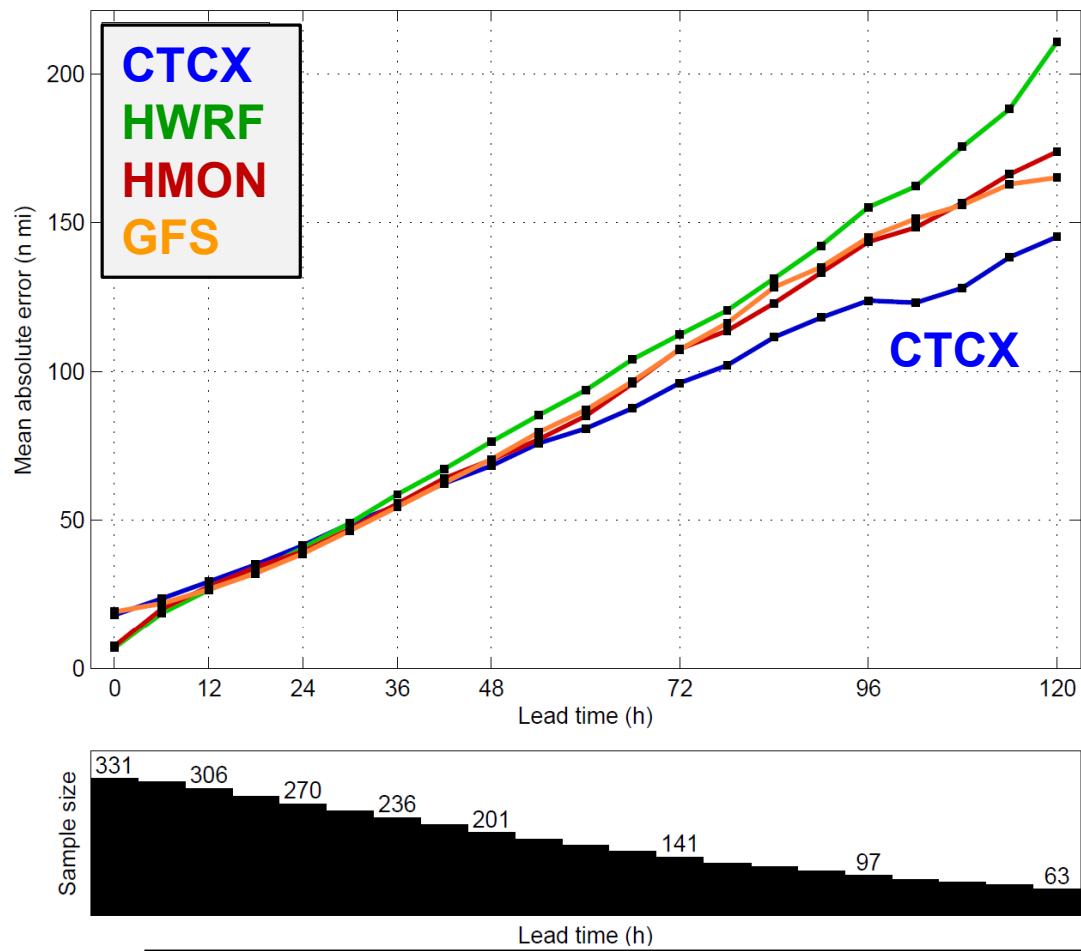
- CTCX performed exceptionally well for track, especially for Ian, Earl, and Fiona
- CTCX intensity MAE is similar to HWRF & HMON through 48 h, then somewhat higher

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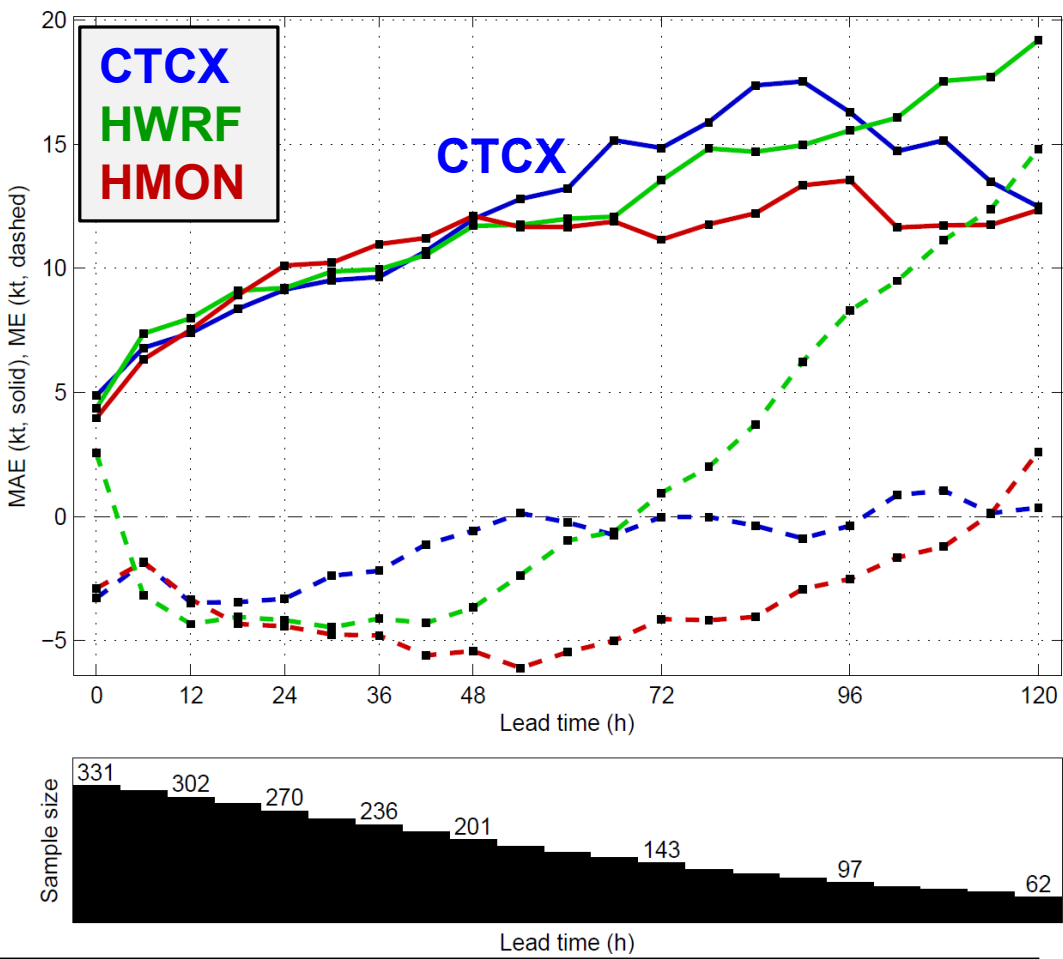
COAMPS-TC Performance

Eastern North Pacific Basin 2022

Track Mean Absolute Error



Intensity MAE (solid) and ME (dashed)



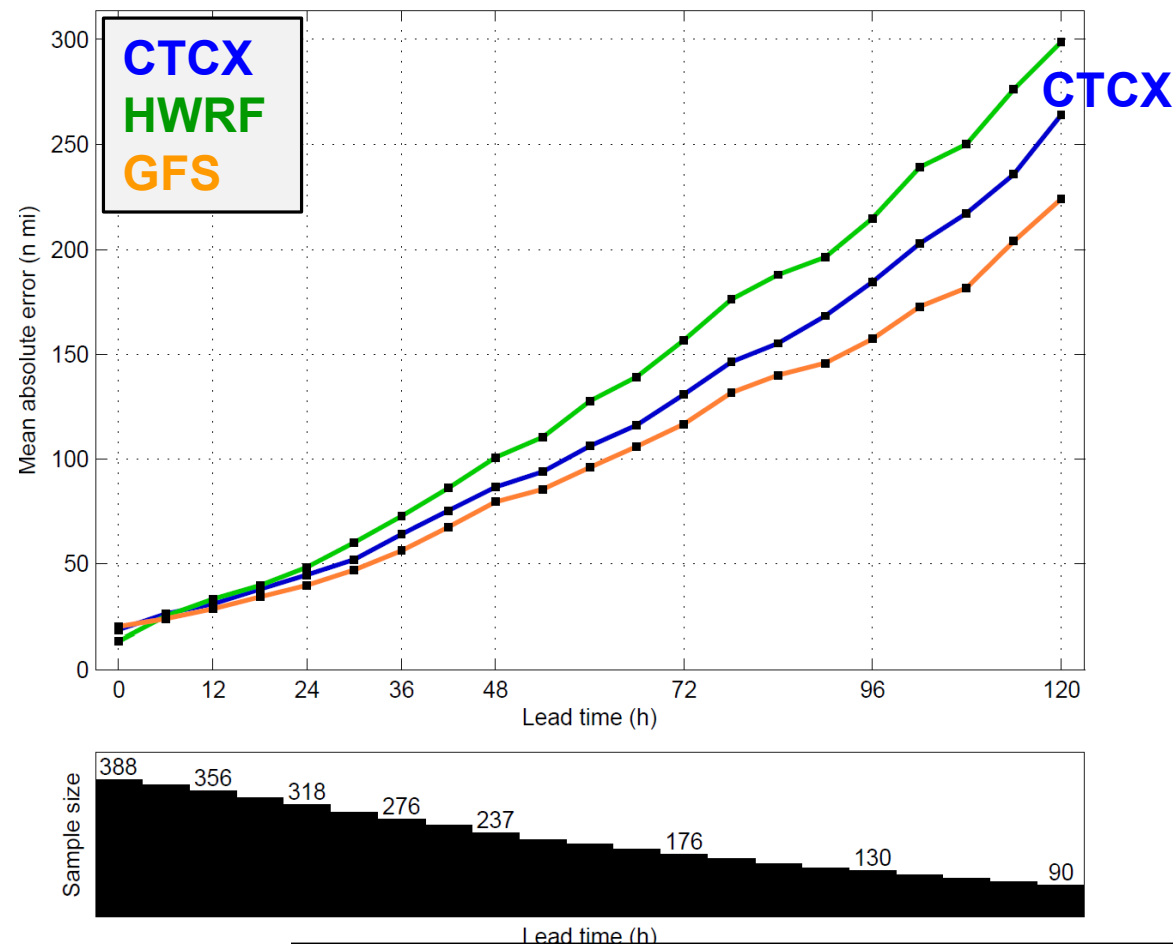
- Like in the Atlantic, CTCX track forecasts performed very well in the EP
- CTCX intensity MAE is similar to HWRF & HMON through 48 h, errors higher later on

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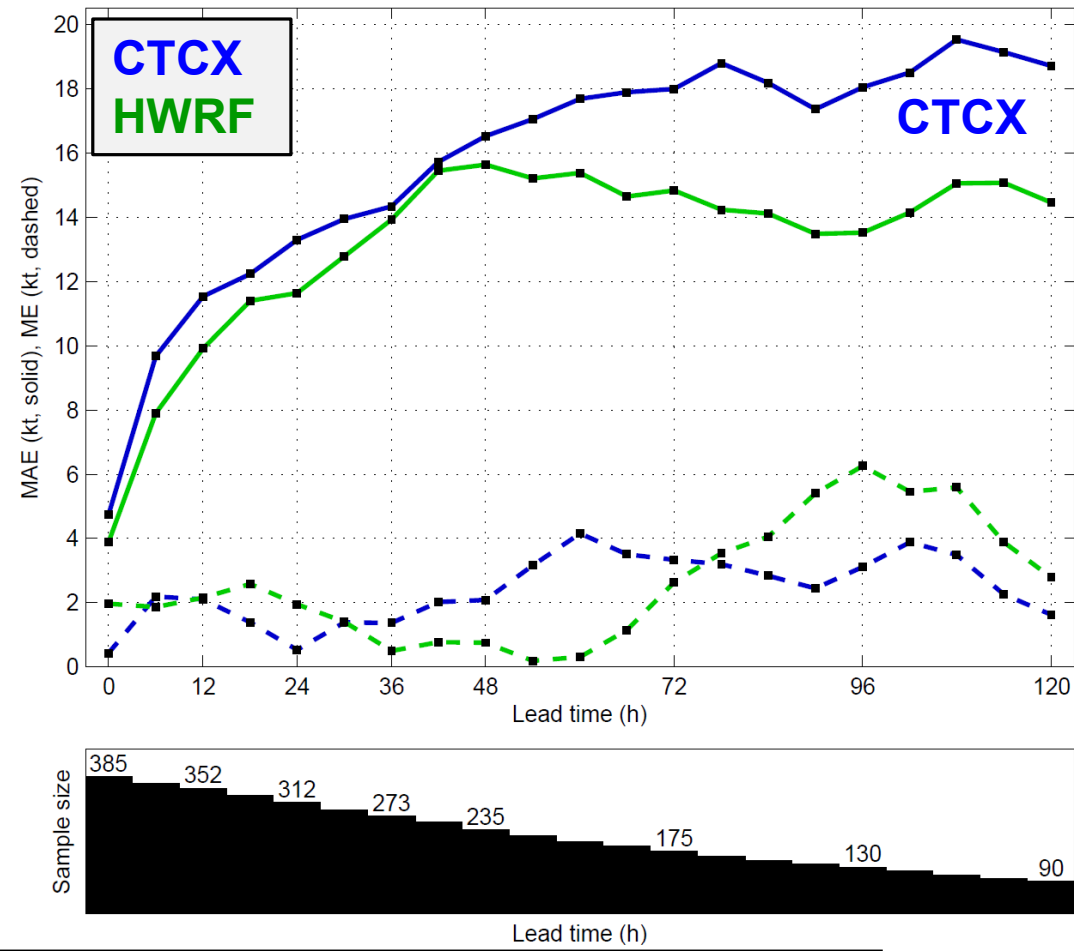
COAMPS-TC Performance

Western North Pacific Basin 2022

Track Mean Absolute Error



Intensity MAE (solid) and ME (dashed)



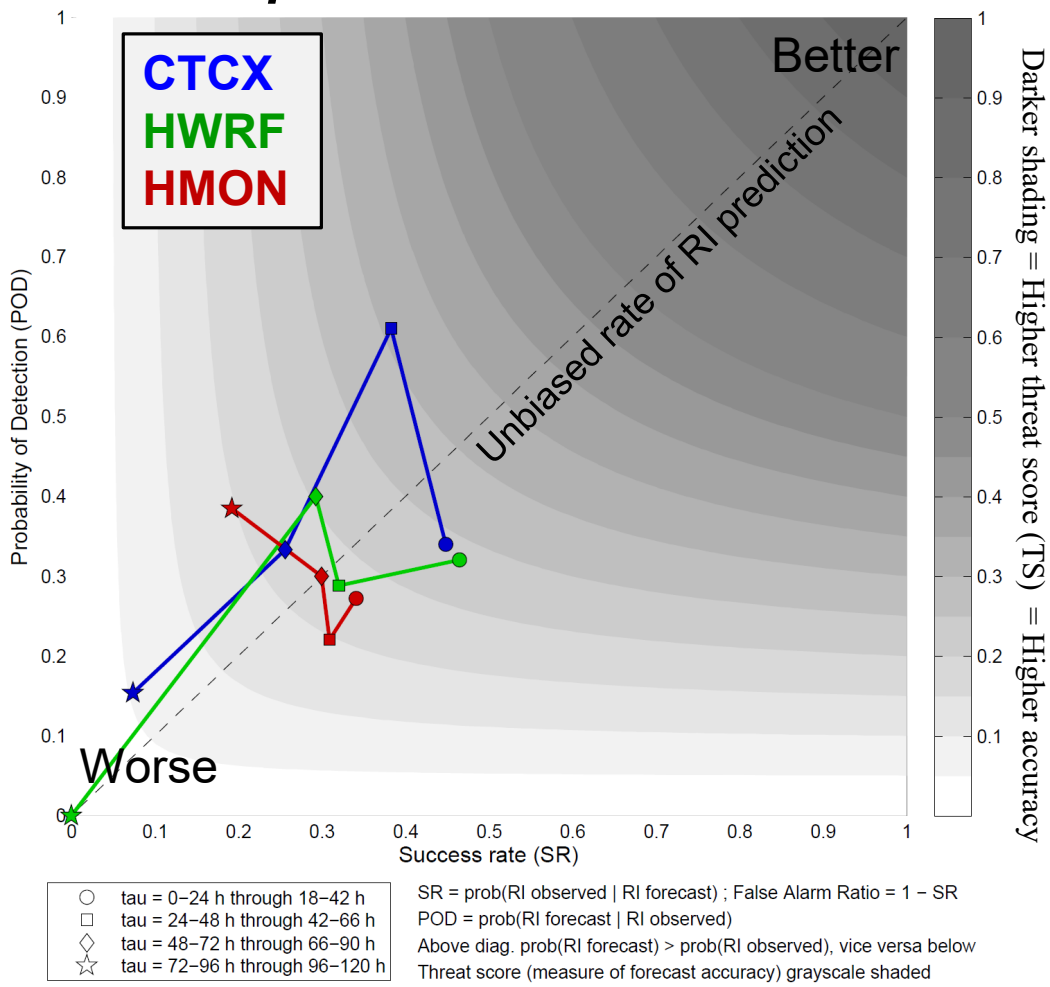
- Since 2021 CTCX has much improved accuracy for WP recurving storms
- CTCX intensity MAE behind HWRF, which did very well in the 2022 WP

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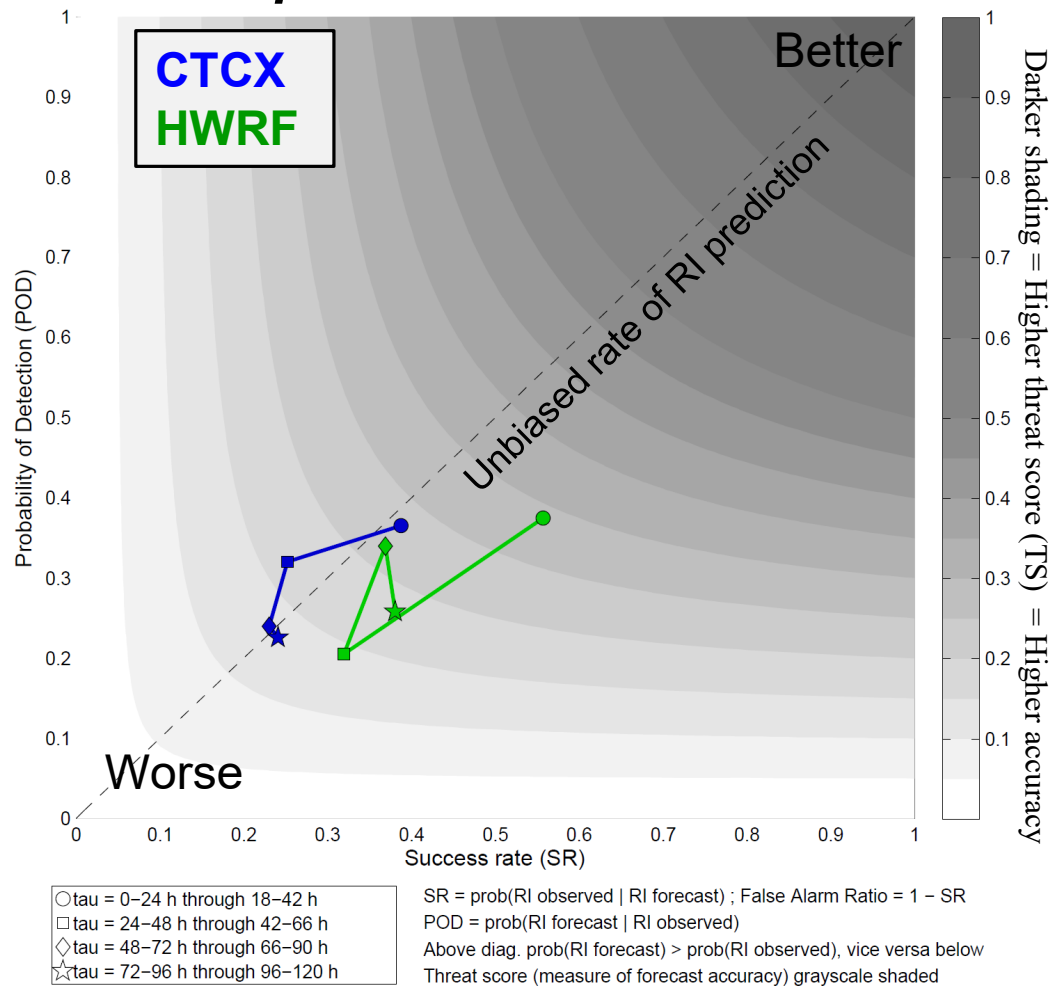
COAMPS-TC RI Performance

Atlantic / Eastern Pacific & Western Pacific

RI performance: 2022 AL/EP



RI performance: 2022 WP

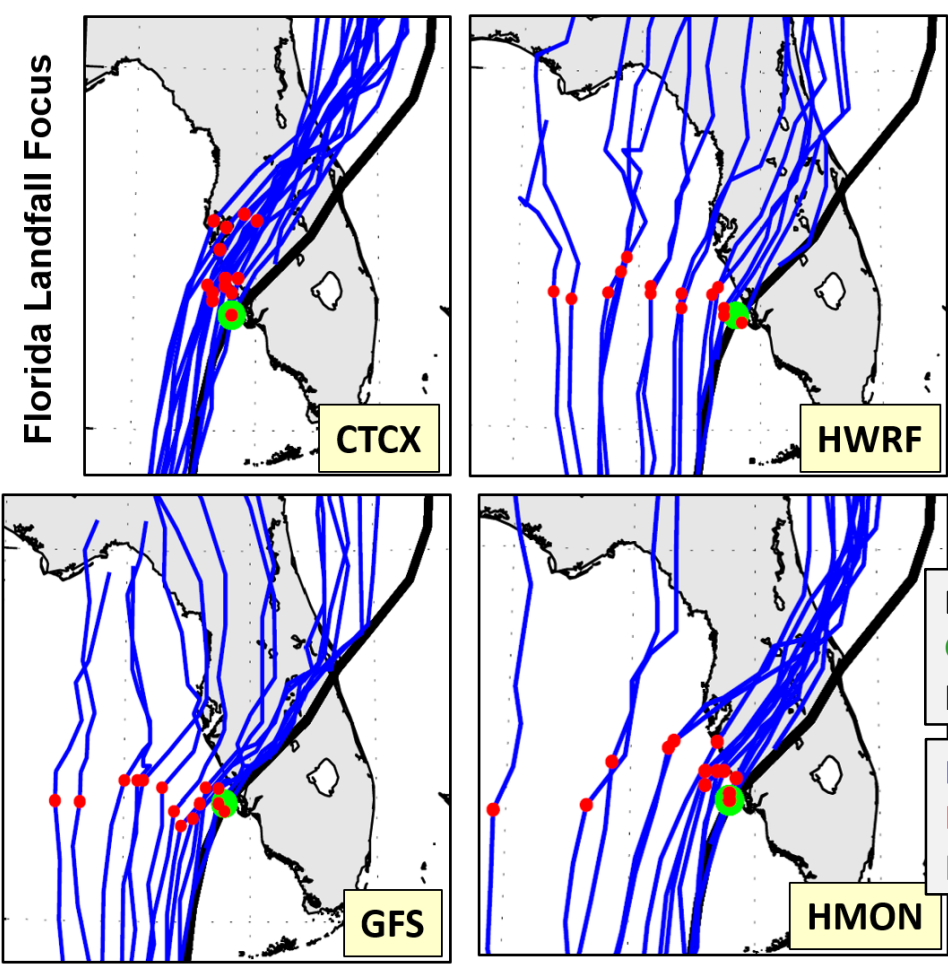


Since 2020 CTCX has improved RI prediction. Predicted RI slightly too often in 2022(!)

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COAMPS-TC: Hurricane Ian
2022 Atlantic Storm 09L

CTCX consistently indicated FL west coast landfall starting 3 days in advance

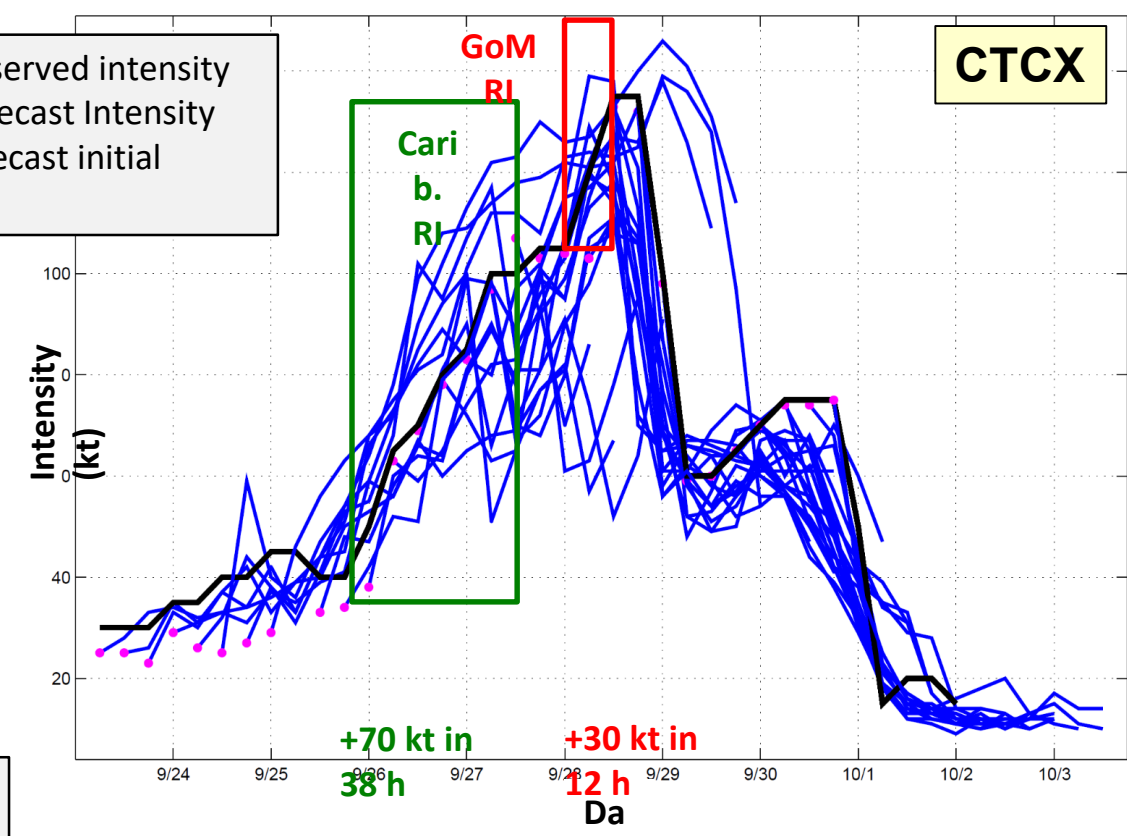


Florida landfall plots:
Forecasts from
2022092512 -
2022092818

Black line: Observed track
Green dot: Observed TC position at time of landfall

Blue lines: Forecast tracks
Red dots: Forecast TC positions at time of landfall

Black line: Observed intensity
Blue lines: Forecast Intensity
Pink dots: Forecast initial intensity

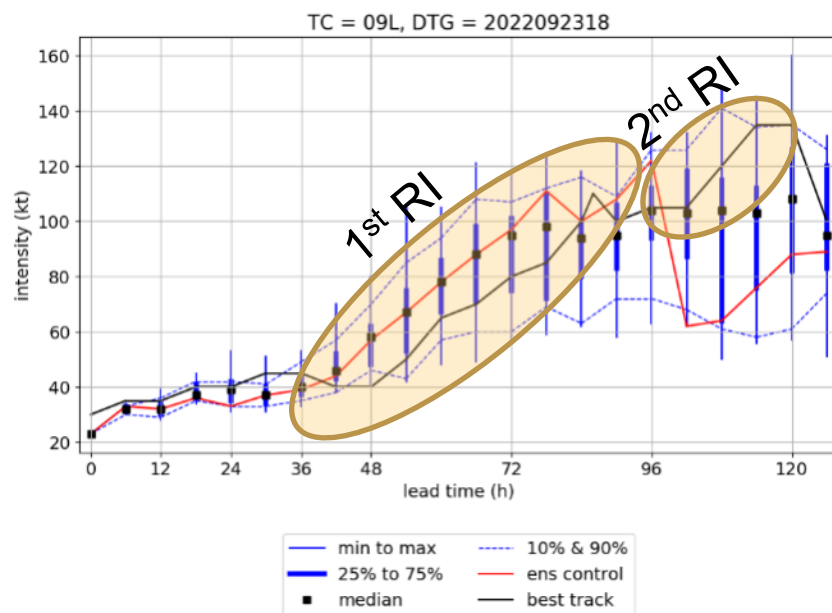


All but one CTCX forecast predicted RI in the Caribbean, and many forecasts had a second RI period in the GoM

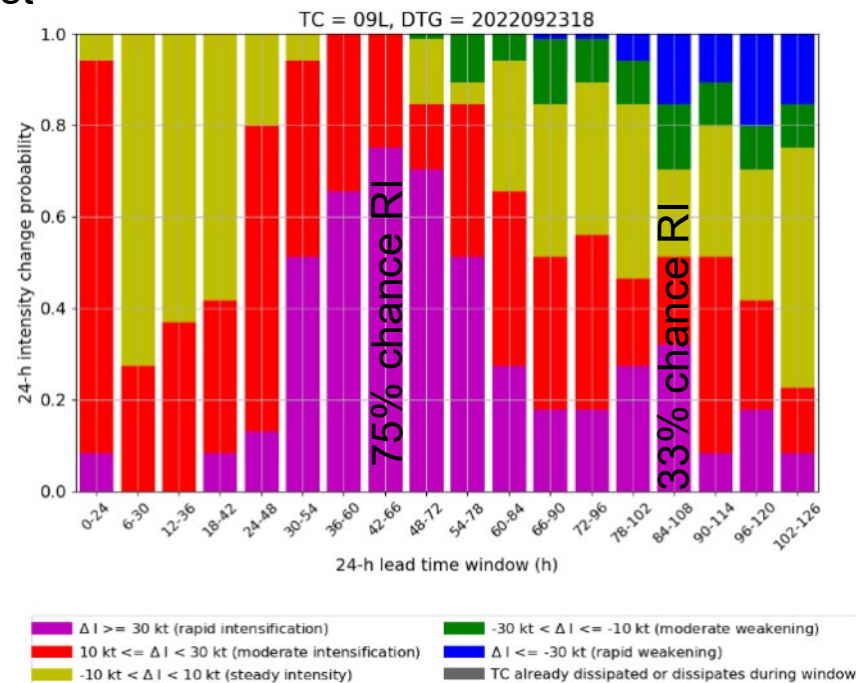
COAMPS-TC Ensemble

Predictability Case Study: Hurricane Ian (2022)

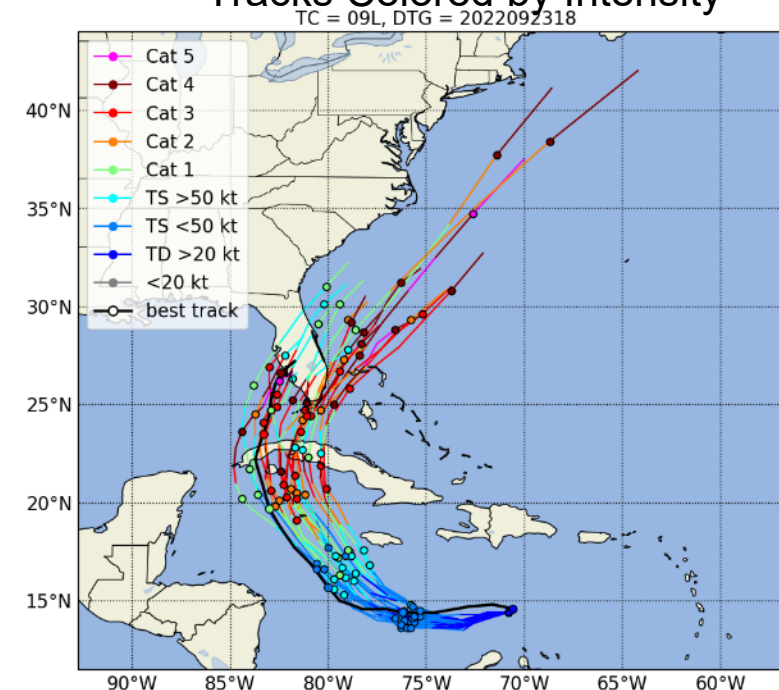
Probabilistic Intensity Candlestick Forecast



Probabilistic RI Forecast



Tracks Colored by Intensity



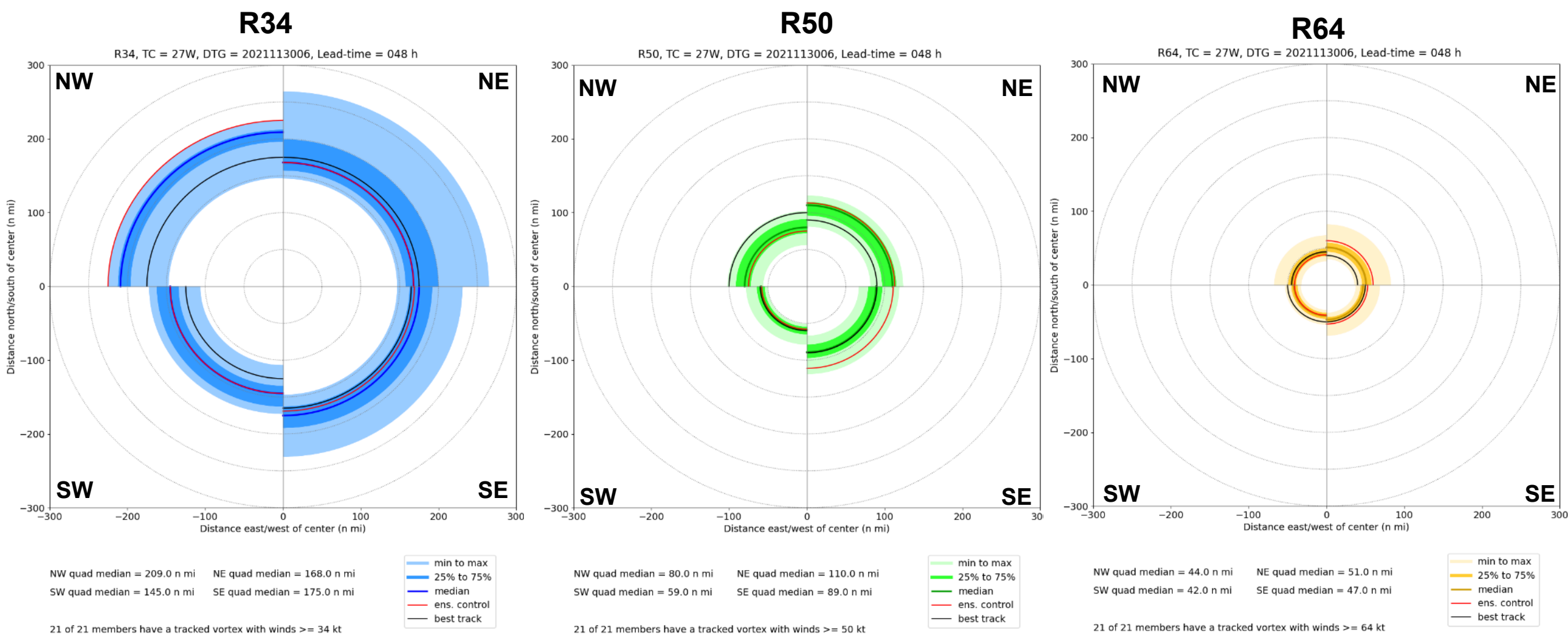
- Hurricane Ian underwent rapid intensification (RI), from 40 kt at 1800 UTC 25 Sep 2022 to 110 kt at 0800 UTC 27 Sep 2022 (Cuba landfall), or +70 kt in 38 h.
 - 75% probability of RI (based on COAMPS-TC Ensemble)
- A second RI period occurred prior to Florida landfall: +35 kt in 24 h, from 100 kt at 1200 UTC 27 Sep 2022 to 135 kt at 1200 UTC 28 Sep 2022.
 - 33% probability of RI, >50% probability of intensification

- FL landfall occurred somewhat north of most members in early lead time forecasts, but ~1/3rd of members are as far north as verifying landfall location

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COAMPS-TC Ensemble

New Probabilistic Wind Radii Circles



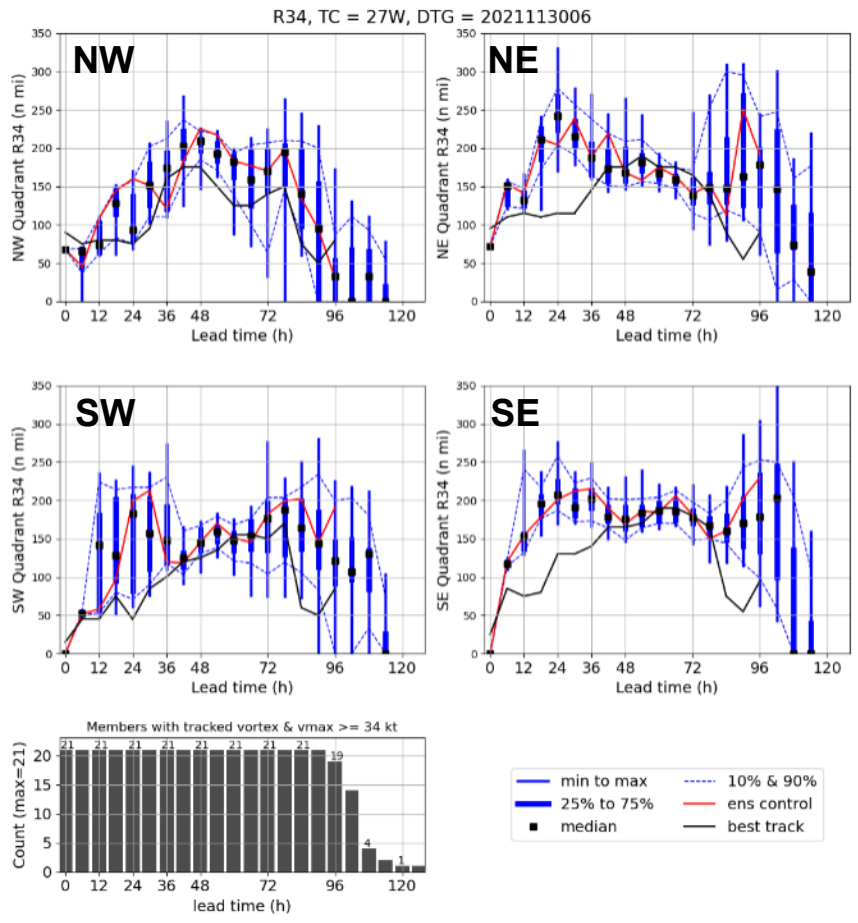
New probabilistic wind radii circles depict ensemble mean and percentiles of wind radii in each quadrant at a particular forecast lead time

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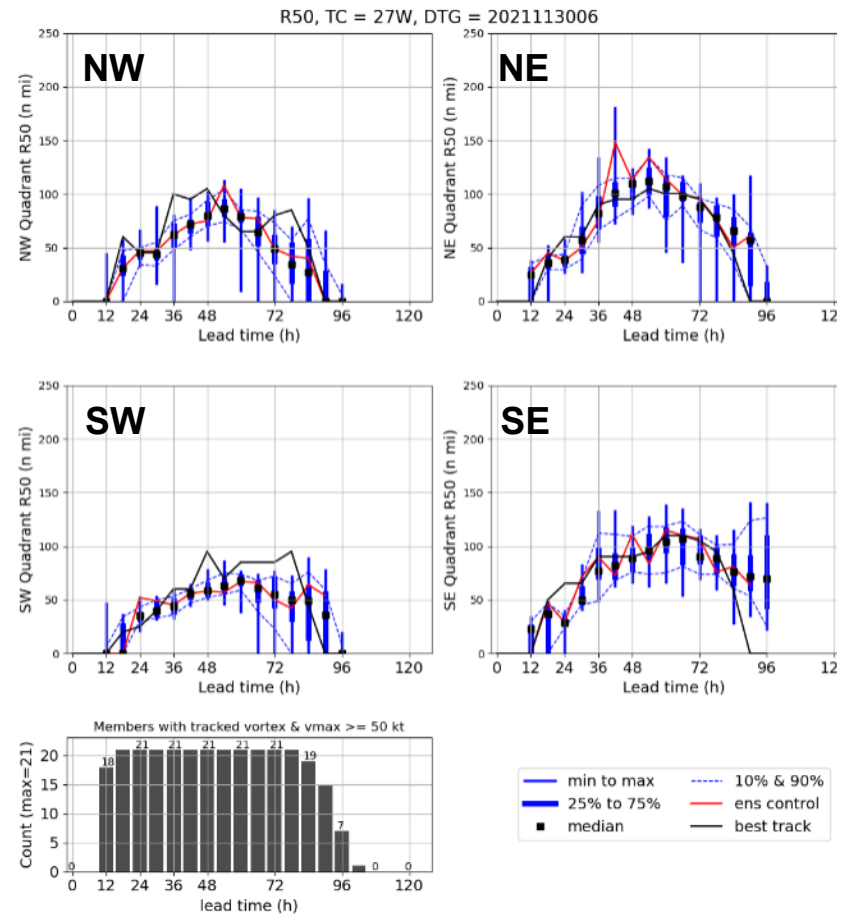
COAMPS-TC Ensemble

New Probabilistic Wind Radii Candlestick Plots

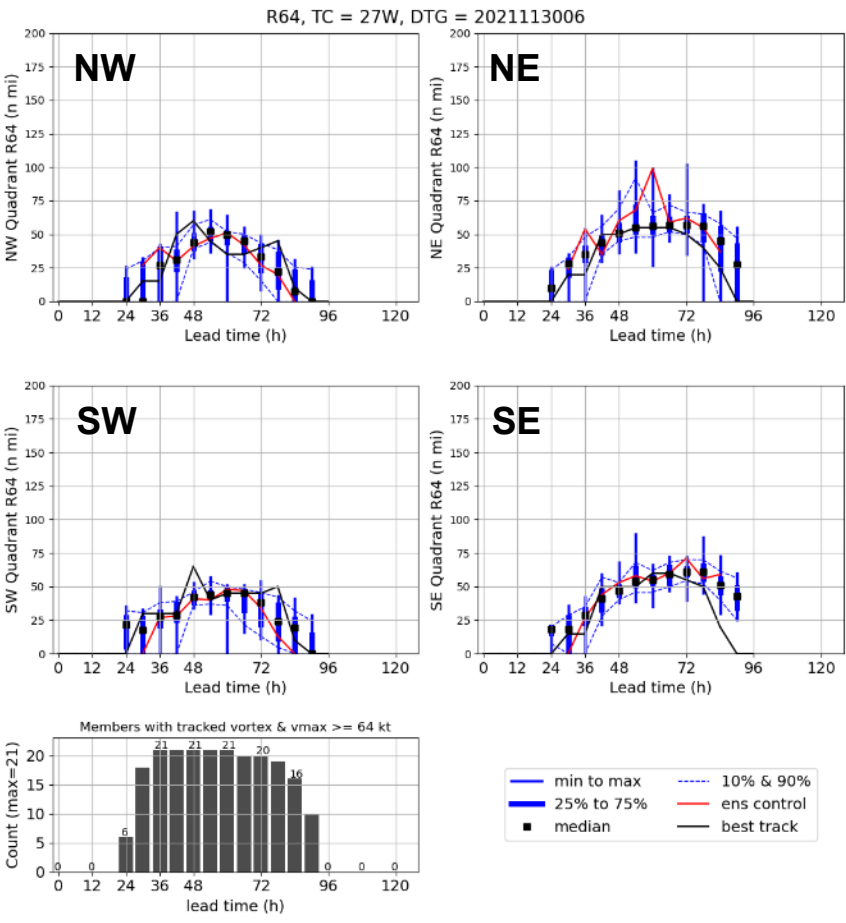
R34



R50



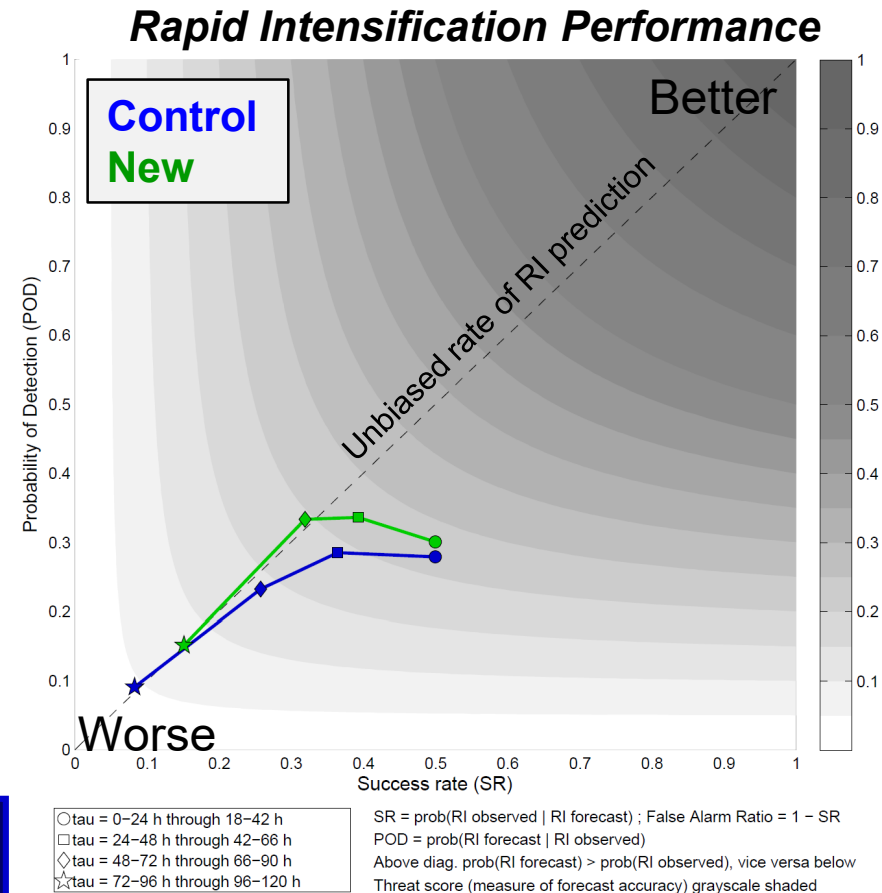
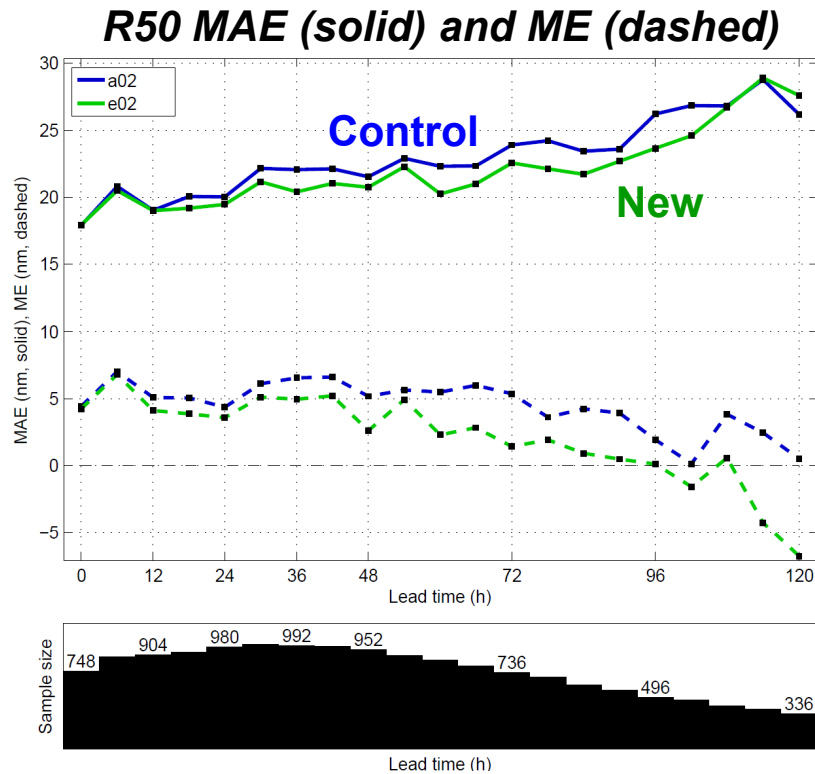
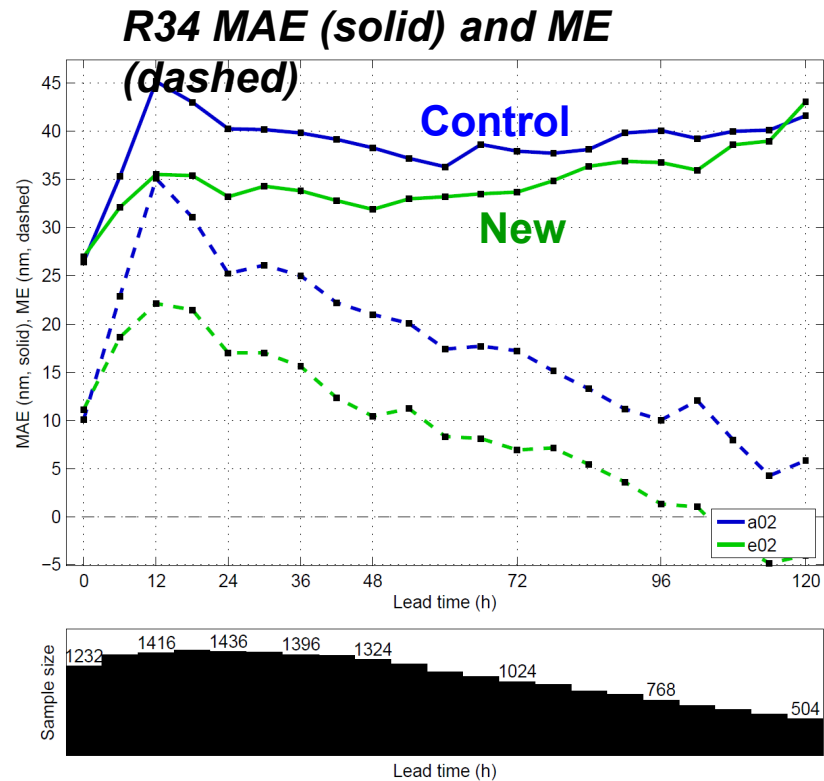
R64



New probabilistic wind radii candlestick plots show the ensemble mean, control, 25th, 75th, 10th, and 90th percentiles, and max/min R34, R50, and R64 (radius of 34-, 50-, and 64-kt wind) every 6 h

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COAMPS-TC Improvements
Improved inner nest blend zone



New blend zone formulation supports drier environment around storm, resulting in smaller storms that RI more frequently

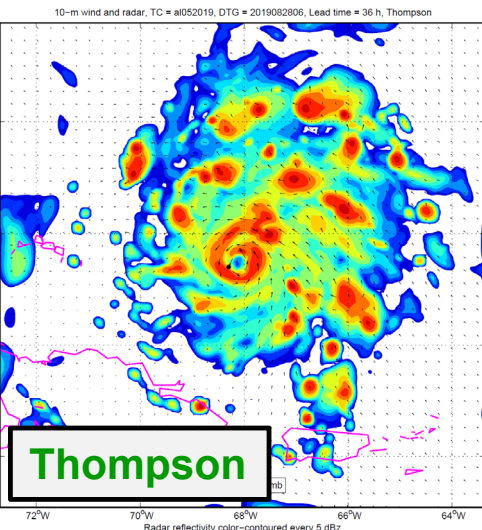
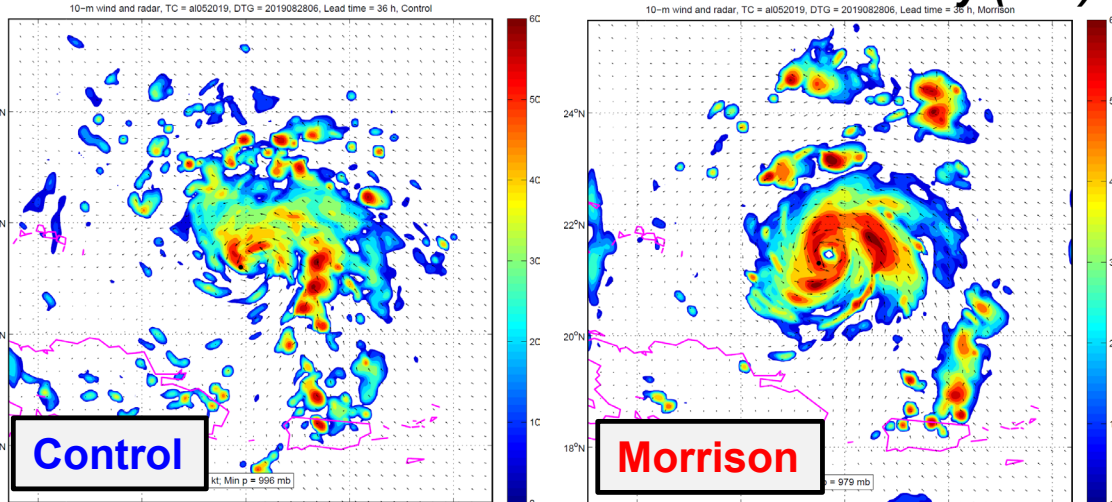
Included in recent v2023 ensemble update and will be part of upcoming v2023 deterministic update

COAMPS-TC Improvements

Future Upgrades

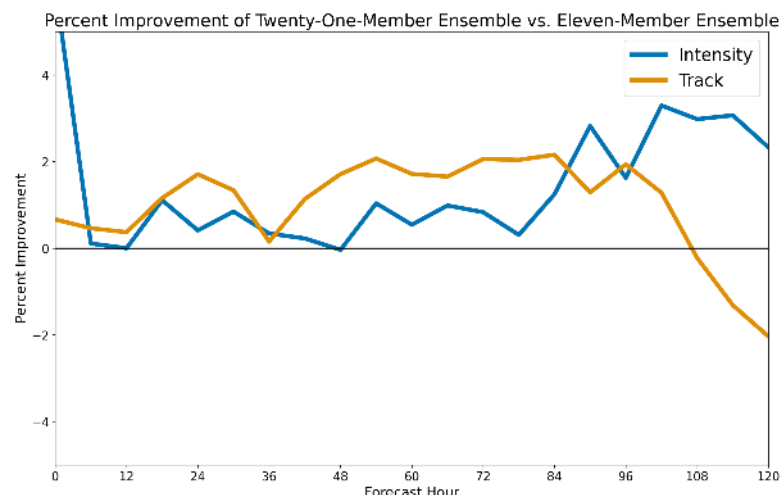
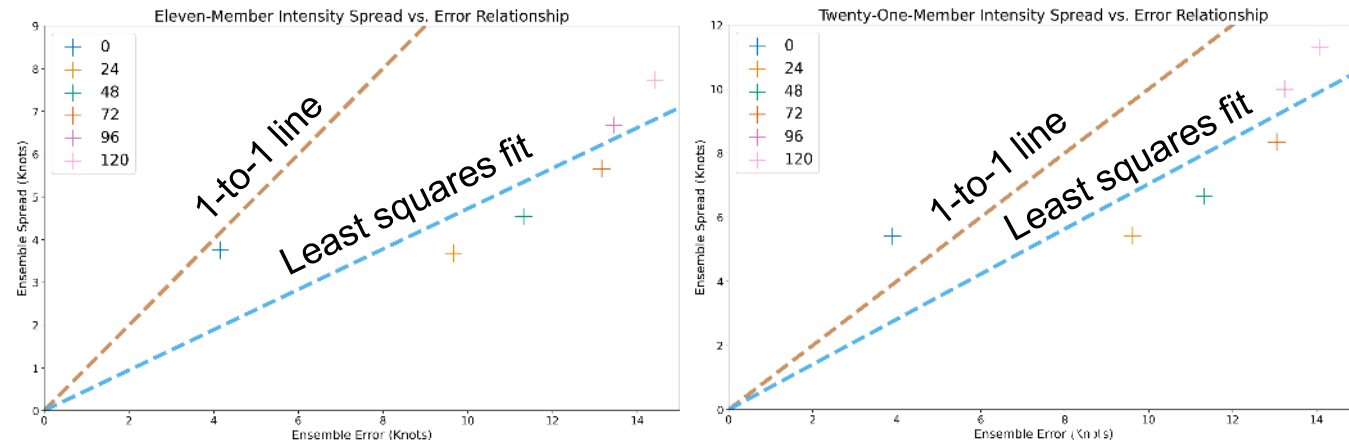
Microphysics Parameterization

Hurricane Dorian Simulated Radar Reflectivity (36h)



- Substantial differences among NRL (Control), Thompson, Morrison microphysics
- Other new params. being tested include PBL, deep/shallow cumulus

11 vs 21 Ensemble Members

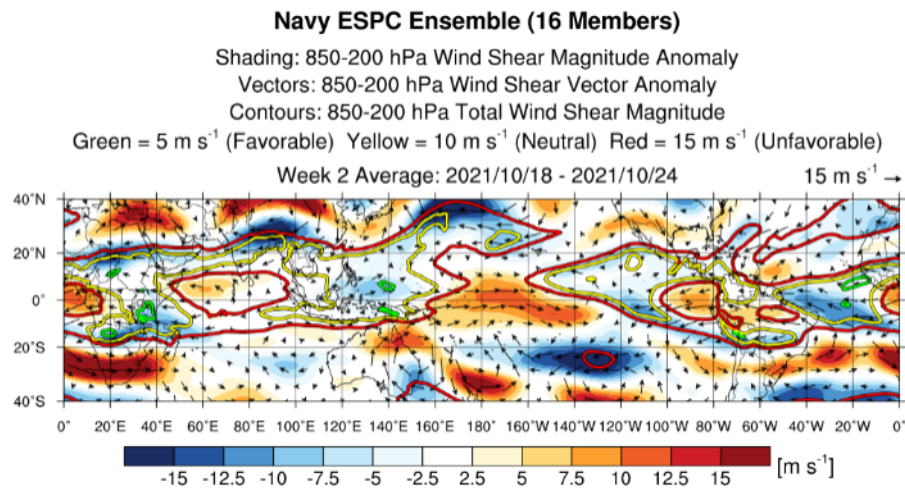


- 21 members improves spread-skill relationship than 11 members for intensity
- 21 members improves the ensemble mean track and intensity at virtually all forecast lead times

Summary

- COAMPS-TC much improved for RI, Intensity, Track over last several years
 - Track (up to 17% better MAE), RI and intensity (up to 10% better MAE), R34 (up to 27% better ME)
 - v2023 ensemble: New nesting and expanded forecast graphics suite
 - • v2023+ deterministic: New nesting, higher resolution, new physics (cumulus, microphysics, PBL)
- Continue to use TC observations to inform model development (ONR TCRI, APHEX...)
- Navy ESPC (coupled subseasonal) & next-gen NEPTUNE global model

Navy ESPC: Coupled (NAVGE-HYCOM-CICE)
subseasonal 45 day forecasts with 16 members in operations



NEPTUNE: Spectral element dynamical core using CCPP
physics with $dx \sim 9\text{km}$ transitioned to FNMOC in FY24

