Ensemble forecasts at the Joint Typhoon Warning Center:

Current applications and recommendations

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Key Takeaways

- Ensemble model forecasts are key input to JTWC's two-week tropical cyclone (TC) formation outlook prediction process

- Ensemble forecasts heavily influence TC track prediction
  - Forecasters access ensemble-based TC track forecasts from multiple sources; some data available for display within the Automated Tropical Cyclone Forecast (ATCF) system

  - Ensemble mean TC vortex trackers contribute to the consensus for deterministic forecasting and derived probabilistic guidance

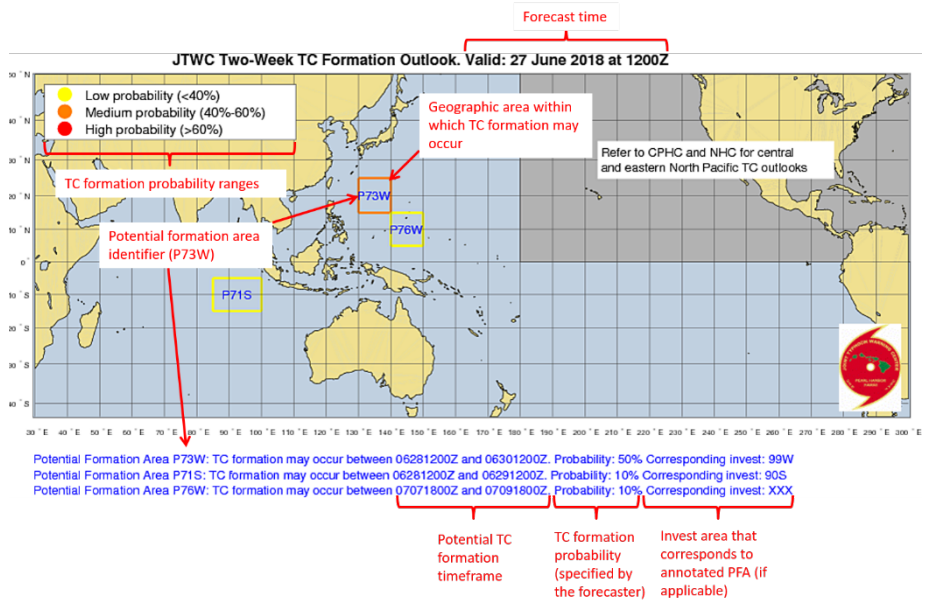
- Ensemble product recommendations:
  - Continue to emphasize TC track prediction

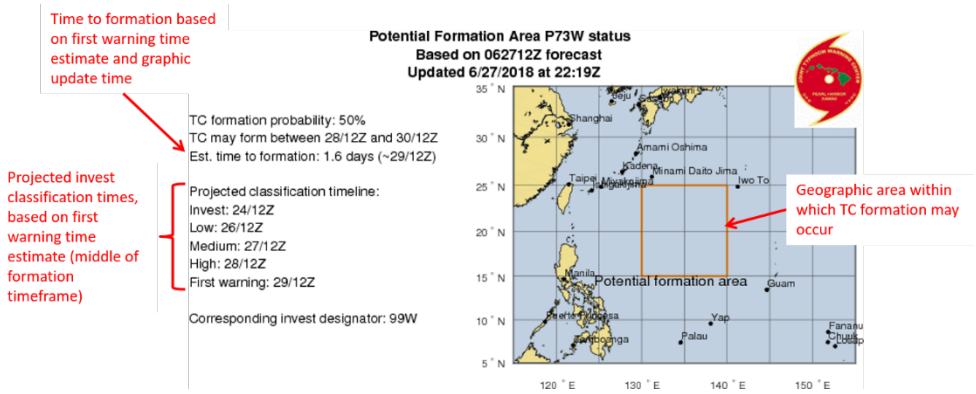
  - Develop ensemble-based guidance for predicting TC formation, particularly at extended lead times

  - Evaluate suitability of ensemble forecasts for predicting TC structure (wind radii)

JTWC Two-Week Outlooks: Overview

- JTWC began issuing two-week tropical cyclone (TC) formation outlooks to DoD customers 01 July 2018
- Products specify locations and times at which TCs may form within the JTWC area-of-responsibility (AOR) during two-week forecast period
- Two-week outlooks consist of an AOR-scale graphic and detail graphics for each identified potential formation area (examples below)





Two-Week Outlooks: Ensemble Model Forecasts

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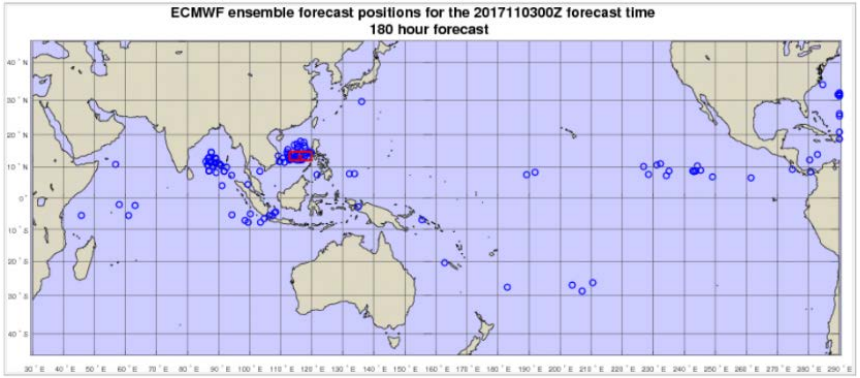
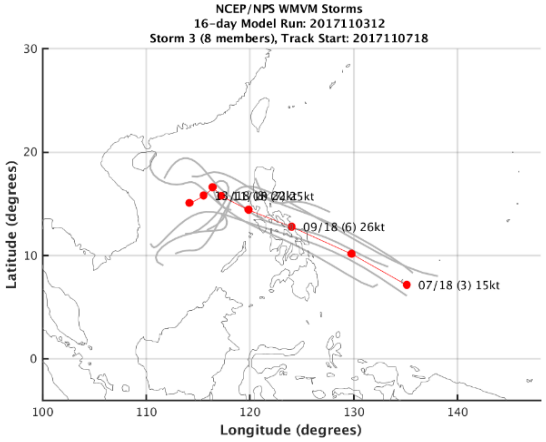
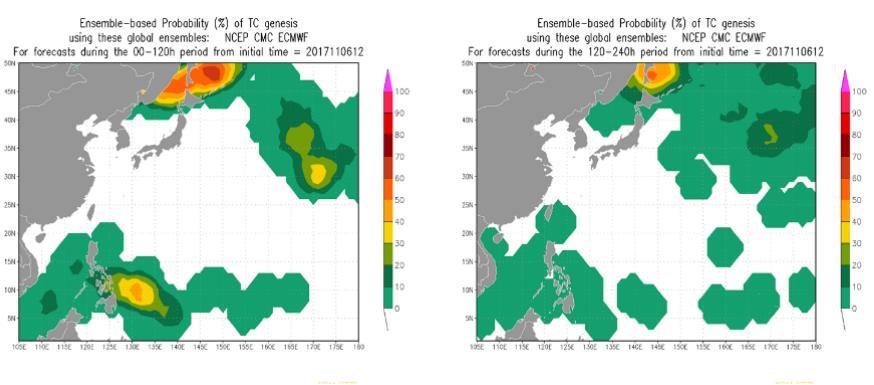
- Data: ECMWF ensemble TC forecast positions (0-240 hrs)
- Source: ECMWF (WMO essentials)
- Plots of forecasts positions generated “in-house”



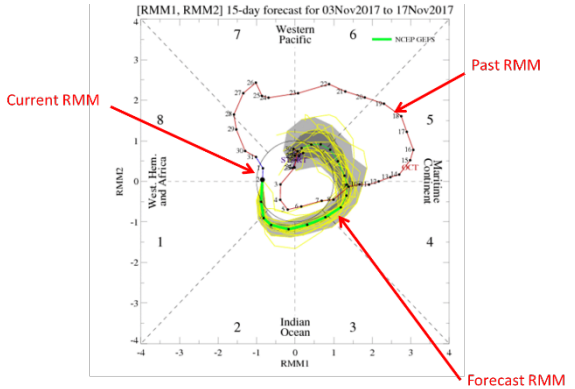
- Data: GEFS ensemble TC forecast positions (0 to 384 hrs)
- Source: NCEP
- Plots of forecast tracks generated “in-house” with scripts developed at Naval Postgraduate School (member tracks with weighted motion vector mean consensus)



- Data: Ensemble-based TC genesis probability plots (0-120 hrs and 120-240 hrs)
- Source: NCEP



- Data: Real-Time Multivariate MJO Index forecast values derived from GEFS
- Source: CPC



Ensemble Model Forecasts: Two-week TC Outlook Application

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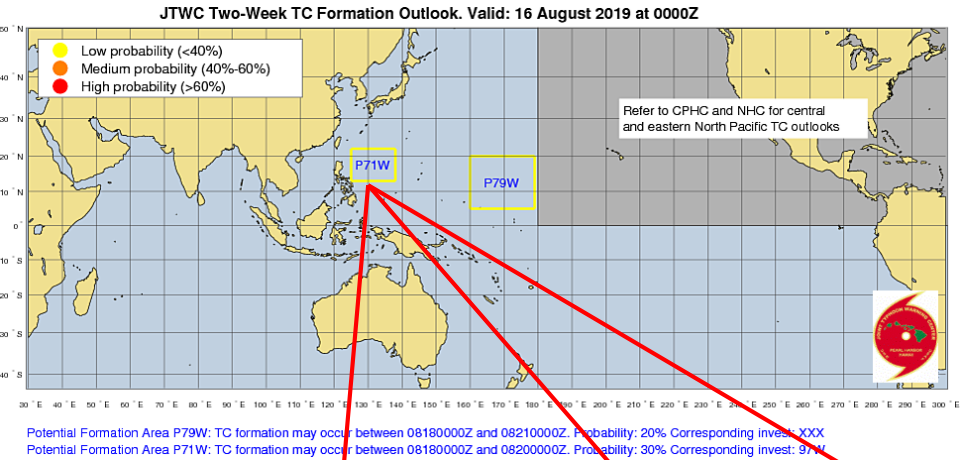
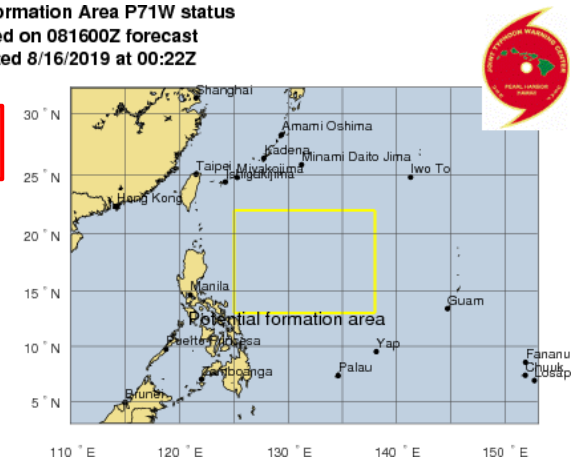
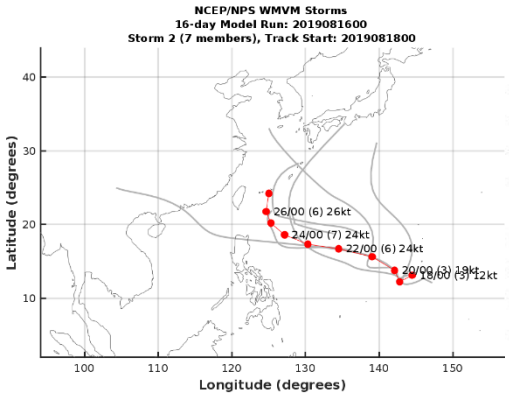


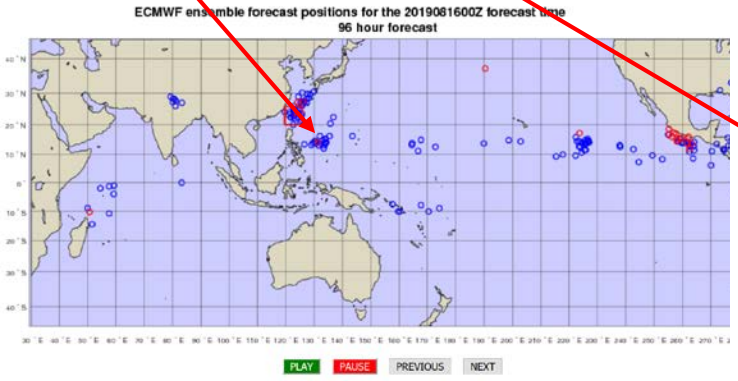
TC formation probability: 30%
TC may form between 18/00Z and 20/00Z
Est. time to formation: 3.0 days (~19/00Z)

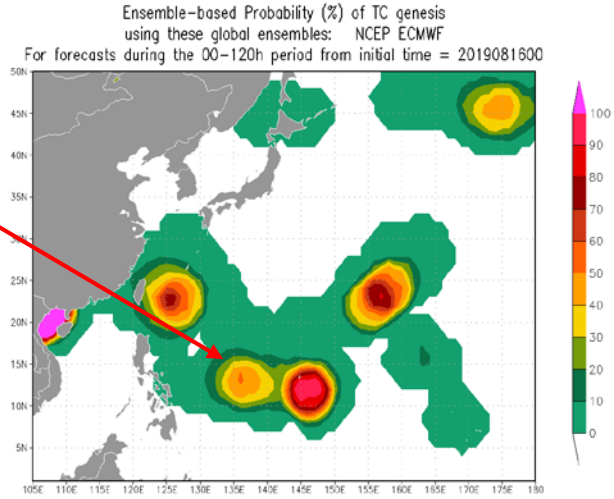
Projected classification timeline:
Invest: 14/00Z
Low: 16/00Z
Medium: 17/00Z
High: 18/00Z
First warning: 19/00Z

Corresponding invest designator: 97W









Example Potential Formation Area (P71W) and the associated ensemble model forecast datasets that informed the forecaster's decision-making process regarding the geographic area for potential formation, timeframe for formation and formation probability.

Ensemble Model Forecasts: Preformation Track / Intensity

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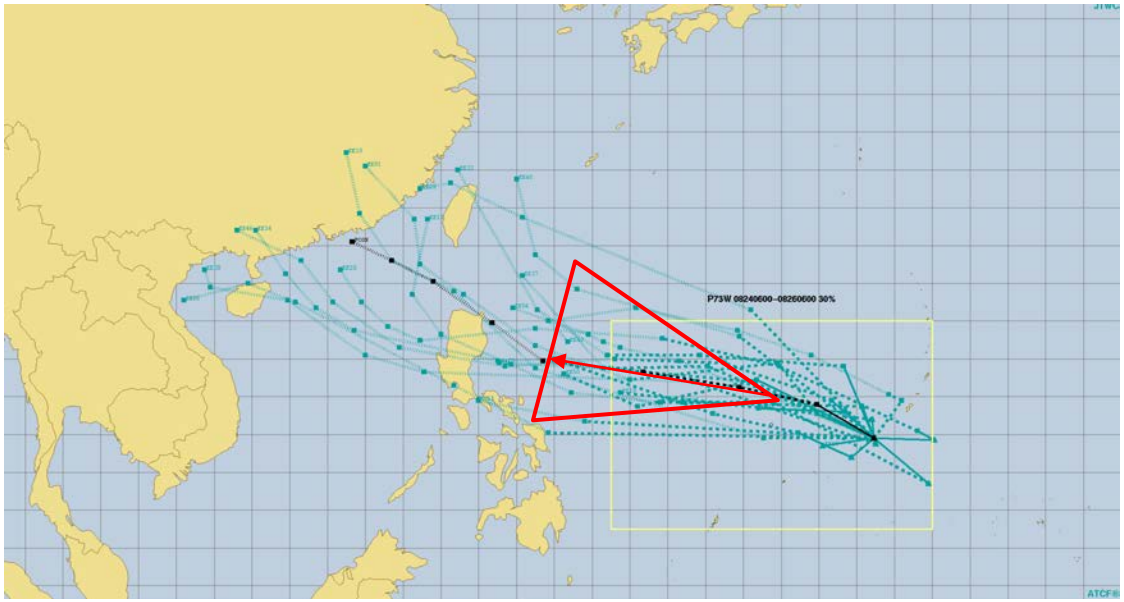
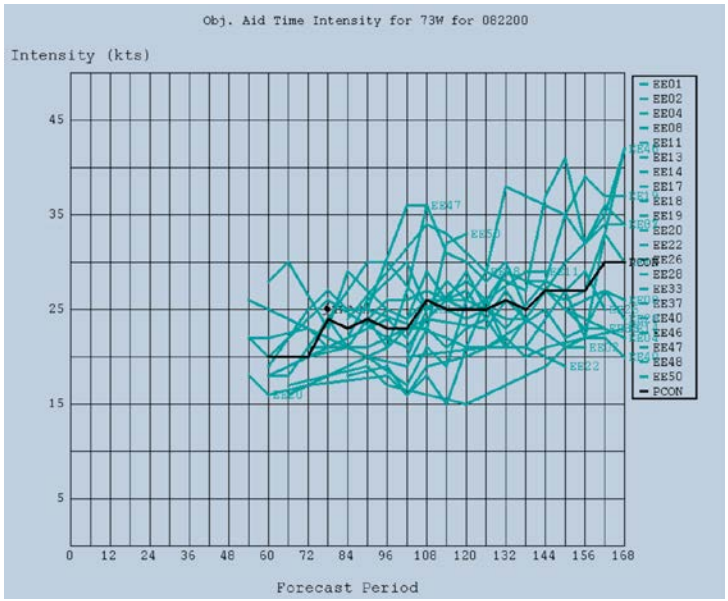
- NCEP and ECMWF provide pre-formation TC track and intensity forecasts derived from various global model ensembles
  - Forecasts matched to JTWC Potential Formation Areas and presented to forecasters via ATCF and automated data plots
  - Basis for prospective preformation track and / or intensity forecasts - e.g., potential track for the first 48 hours following anticipated formation time





TC track (left) and intensity (right) ensemble (ECMWF) forecasts for Potential Formation Area P73W from August 22, 2019 at 1200Z. The potential formation area, development timeframe and subjective formation potential are highlighted by the yellow box and accompanying label. The red arrow and cone highlight a conceptual “initial potential track” area based on the ensemble forecast spread.

TC Track Forecasting: Ensemble Model Guidance

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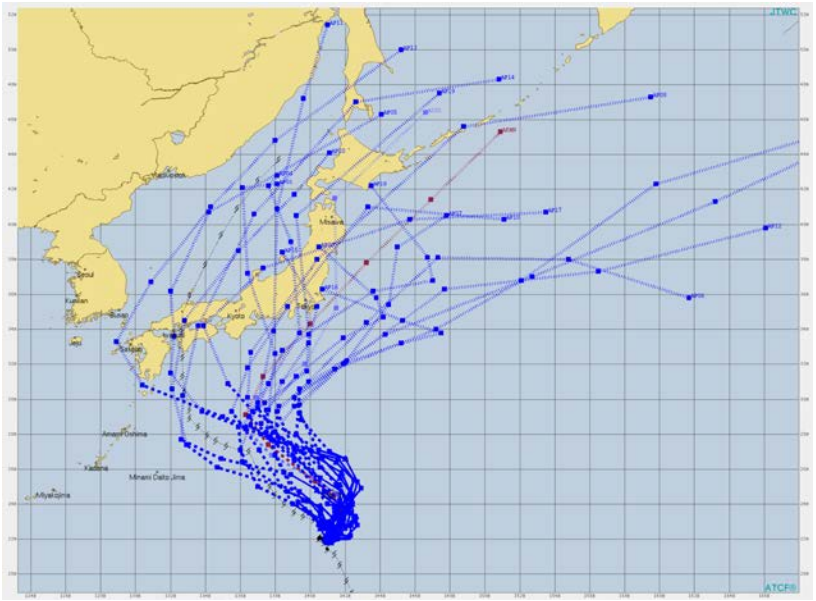
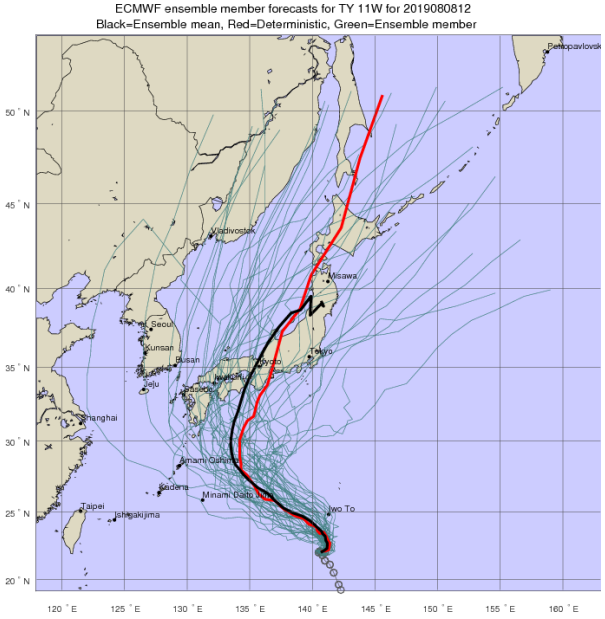
- TC track forecasts from GEFS and NAVGEM ensembles available to forecasters via ATCF
- Automated plots of ECMWF ensemble members presented to forecasters through intranet website; mean track generated in-house and distributed to ATCF
- Applications:
  - GEFS and ECMWF ensemble mean in model track consensus; UKMET ensemble mean to be added
  - Forecasters view ensemble members to *evaluate* possible forecast outcomes and *qualify* those potential outcomes in prognostic reasoning messages (forecast discussions)





Typhoon 11W 2019 (Krosa), August 8, 2019 at 1200Z: TC track forecasts derived from GEFS ensemble members with verifying working best track as displayed in ATCF (left); plot of TC track forecasts derived from ECMWF ensemble members and deterministic model (right).

TC Forecasting: Ensembles, Consensus and Probabilistic Guidance

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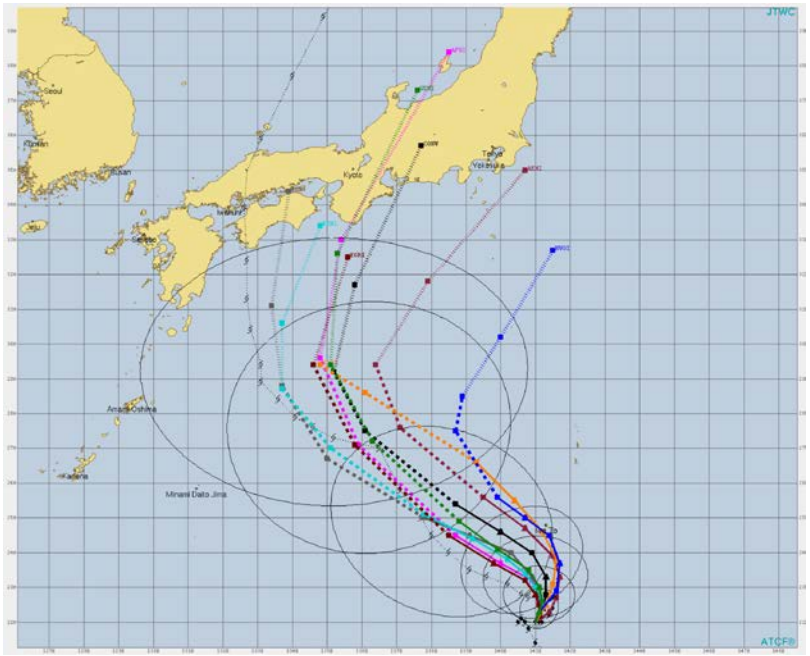
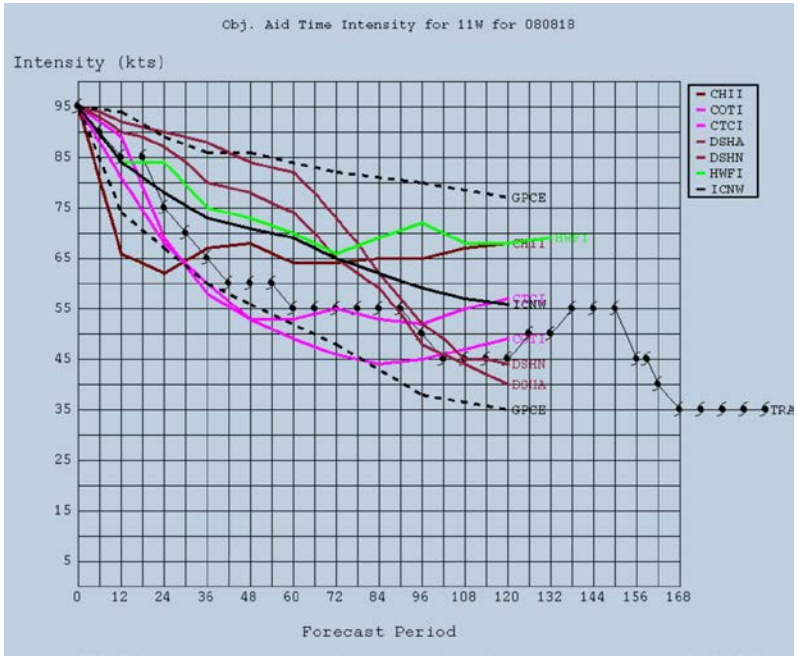
- Multi-model consensuses are primary guidance for deterministic TC track, intensity and wind radii prediction:
  - **CONW:** Track consensus (global dynamic and ensemble (mean) models)
  - **ICNW:** Intensity consensus (mesoscale dynamic and statistical-dynamical models)
  - **RVCN:** Wind radii consensus (global, mesoscale dynamic and statistical-dynamical models)

- ATCF system calculates Goerss Probability Consensus Estimate (GPCE) guidance for CONW and ICNW
  - ~70% probability TC will pass through track GPCE area and intensity will fall within intensity GPCE range



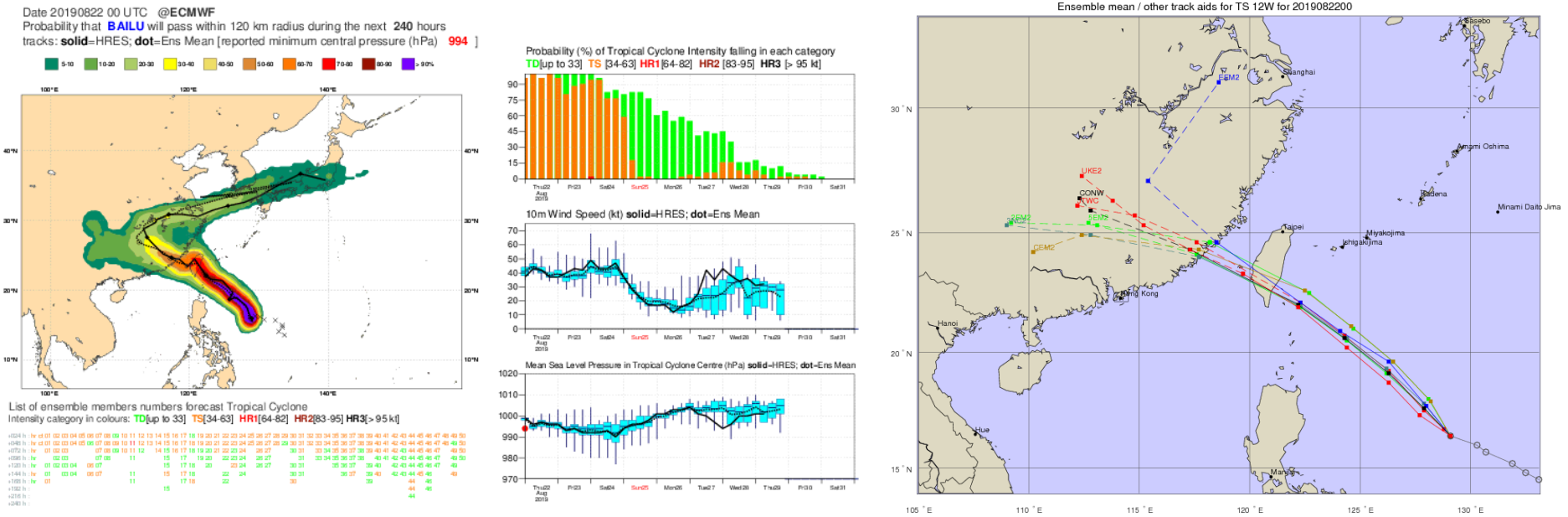


TC track forecast guidance with verifying working best track and GPCE probability ellipses (left) and intensity forecast guidance with verifying working best track and GPCE intensity range (right) for Typhoon 11W 2019 (Krosa), August 8, 2019 at 1800Z. The track consensus includes the GEFS and ECMWF ensemble mean track forecasts (AEMI and EEMI), and will soon incorporate the UKMET ensemble mean (UEMI).

TC Forecasting: Other Ensembles

- Forecasters canvas “non-consensus” ensemble output to support deterministic TC track and intensity forecasts and associated forecast discussions:
  - Mesoscale Ensemble Prediction System (MEPS) – 557th Weather Wing
  - Japan Ensemble Prediction System (JENS) – Japan Meteorological Agency
  - Navy Global Environmental Model (NAVGEM) ensemble – Fleet Numerical Meteorology and Oceanography Center

- Ensemble forecasts generally more useful for track forecasting than intensity forecasting



TC track and intensity forecast data plots provided by ECMWF (left) and track forecasts provided by NCEP and other sources (right) for TC 12W 2019 (Bailu), 22 August 2019 at 0000Z.

Ensembles: Recommendations For TC Forecasting

- Continue developing tools to support TC track prediction, with two primary objectives:
  1) Increase deterministic forecast accuracy

  2) Improve the representation of alternate forecast scenarios by increasing the accuracy of areas of uncertainty / strike probabilities and enabling higher-quality forecast discussions

- Pursue ensemble forecast applications for extended-range TC formation prediction
  - Inherently probabilistic forecast problem

  - Customers appreciate probabilistic guidance for extended-range TC formation:
    - Low near-term threat - less specificity required in the forecasts

    - High potential benefit - risk reduction easier, more efficient at longer lead times

- Develop ensemble forecast guidance for TC structure (especially 34-, 50- and 64-kt wind radii)

Thank you