# Applications of ensembles for tropical cyclone forecasting at JTWC

Matthew Kucas
Technical Services Team, Joint Typhoon Warning Center
9th NOAA Ensemble Users Workshop - August 2023

# Overview

- Application of ensemble forecast data interwoven into tropical cyclone forecasting at JTWC, particularly the following processes:
  - Predicting genesis (two-week outlooks)
  - Establishing forecast philosophies
  - Forecasting track
  - Forecasting intensity
  - Expressing uncertainty
- There are several challenges, gaps and opportunities related to the use of ensembles for tropical forecasting at JTWC

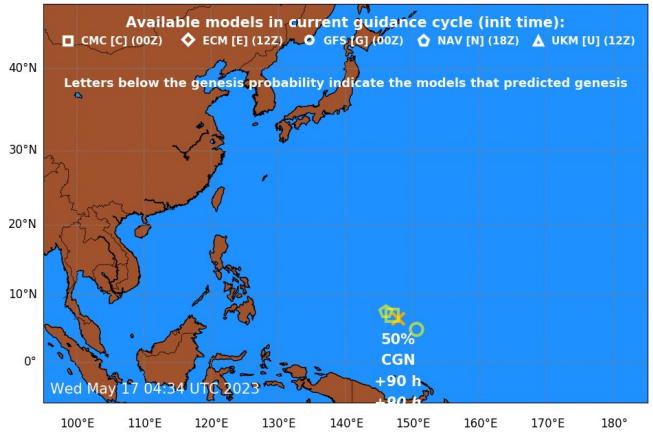
# Predicting Genesis

- TC formation predicted in Two-week TC Formation Outlooks (for DoD customers) and ABPW/ABIO Significant Tropical Weather Advisories (24-hour timeframe)

- Forecasters rely on ensemble model output to determine key properties of Potential Formation Areas in two-week outlook:
    - Location and size
    - Development timeframe
    - Formation probability

- Data from NCEP and ECMWF particularly crucial – raw data and derived products

Experimental 0-168 h TC genesis probability
2023-05-17 00Z consensus guidance



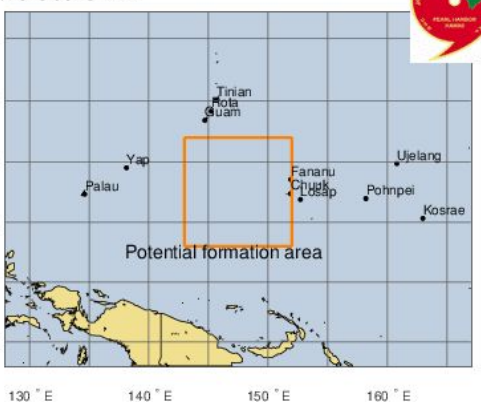

https://moe.met.fsu.edu/modelgen

**Potential Formation Area P73W status**
**Based on 051700Z forecast**
**Updated 5/16/2023 at 23:41Z**

TC formation probability: 50%
TC may form between 19/12Z and 22/12Z
Est. time to formation: 4.0 days (~21/00Z)

Projected classification timeline:
Invest: 16/00Z
Low: 18/00Z
Medium: 19/00Z
High: 20/00Z
First warning: 21/00Z

Corresponding invest designator: XXX



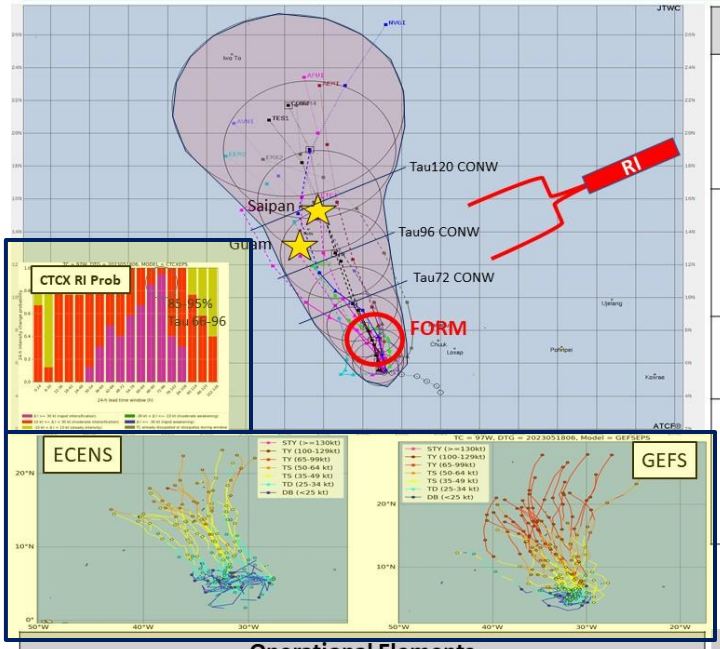
# Establishing Forecast Philosophies



- Internal aid for forecast team
- Generated during invest (development) stage – updated when key factors change
- Sets track, intensity, wind radii structure forecast philosophy
- Incorporates deterministic and probabilistic guidance to capture forecast track / intensity uncertainty
- Bounds track and intensity (including peak intensity)
- Identifies rapid intensification (RI) regions (if applicable) leveraging ensemble probabilities and suite of reliable deterministic intensity guidance

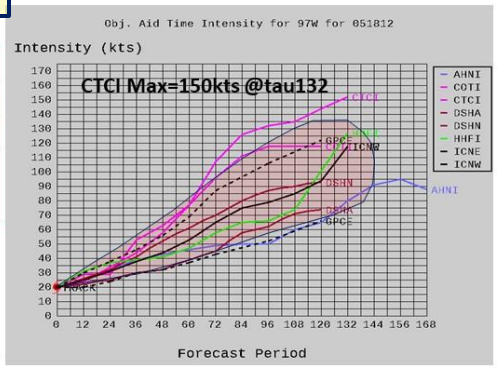
## Forecast Philosophy for 97W (2023)

18 MAY 2023 / 1200Z




| Meteorological Elements | | |
|---|---|---|
| Track | Type: | Poleward No Recurve |
| | Notes: STR complex to N, meso anticyclone moves by to N thru tau60, keeps system QS south of 7N→strong NER dvlps along 10N by tau72 and steers system northward (NNW-NNE). | |
| Intensity | **Peak 90-120 kts→ 22/18Z to 24/00Z** | |
| | Notes: Likely will peak as its passing Guam or after but a faster RI to a higher peak ala CTCX cannot be ruled out. | |
| Wind Field | Size: | Average (3-6°/180-360 nm Radius) |
| | Notes: | |
| Transition | Type: None during FPG timeframe | |
| | Notes: System eventually dissipates SE of Japan but more than 10days out. Update FPG at day 5 with update. | |

| Operational Elements | |
|---|---|
| Impacted Assets | Asset / Asset Group 1: Guam |
| | Asset / Asset Group 2: Saipan |
| | Asset / Asset Group 3: |
| Additional Update Criteria | |
| Notes | - ~48hrs before system moves north of 7N and 72hrs before 10N in bulk of guidance. High uncertainty in ensemble guidance though means concentrated IVO Guam. |
| | - CTCX Ens and Deterministic indicate strong prob of RI prior to Guam CPA. SHIPS shows mod SE VWS through tau72 offset by very strong outflow into poleward channel. |

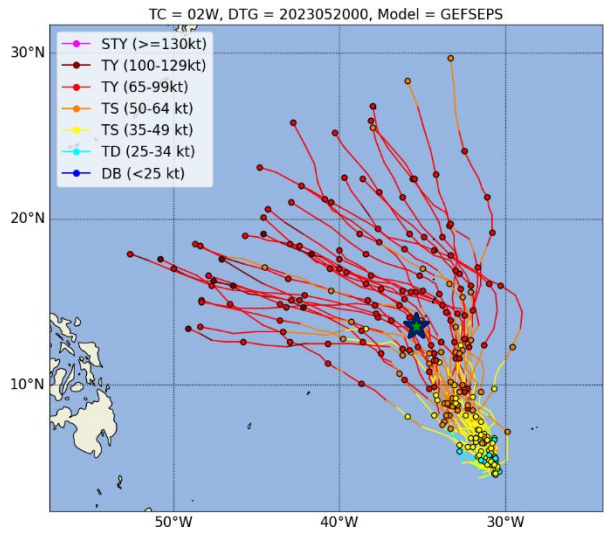


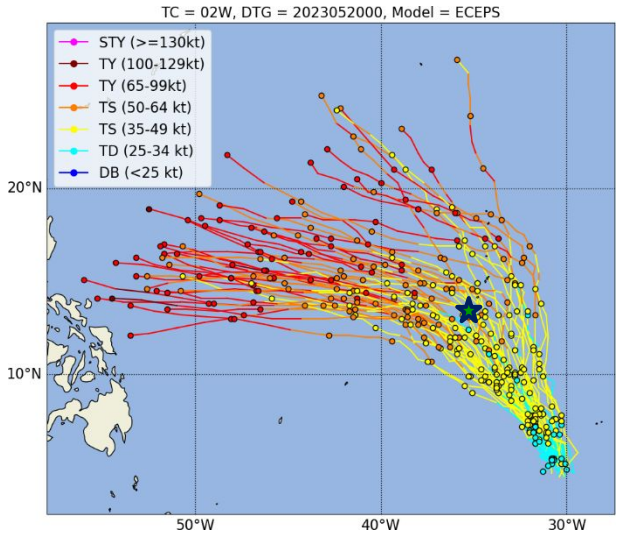
# Forecasting Track

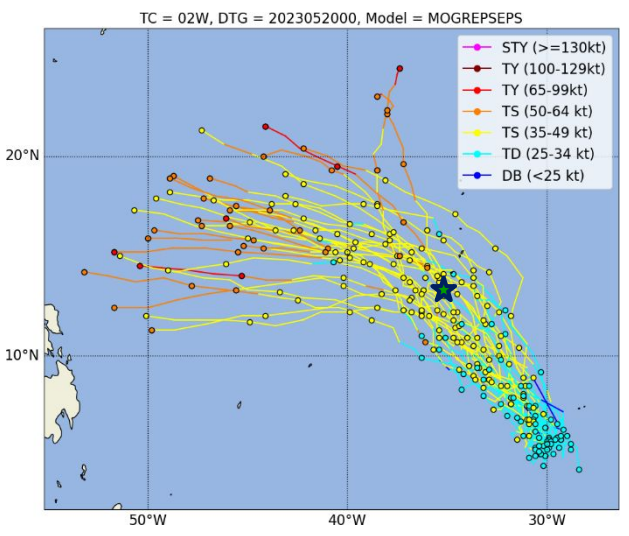
- Use of ensemble data for track forecasting primarily via processing and application of TC vortex trackers (rather than fields)

- Primary uses of ensemble TC track forecast data:
  - Support forecast philosophy and modifications (identify the right time to make changes)
  - Add skill to multi-model consensus via ensemble means (GEFS, EC-EPS, MOGREPS)
  - Provide context for “corresponding” deterministic tracker (e.g., GFS relative to GEFS)

- Suite of products available to forecasters: EC-EPS, GEFS, ACCESS-GE, MOGREPS, GALWEM-GE; adapted code developed by NRL COAMPS-TC team



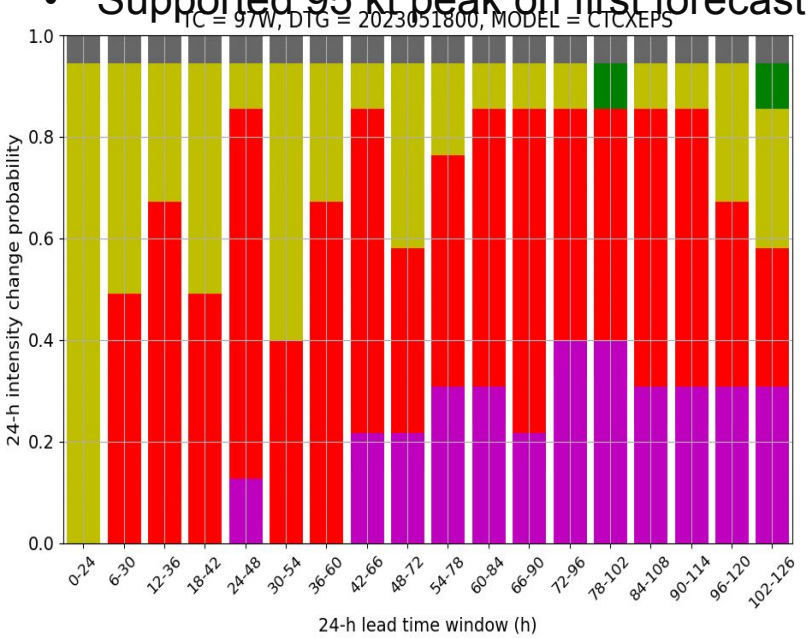



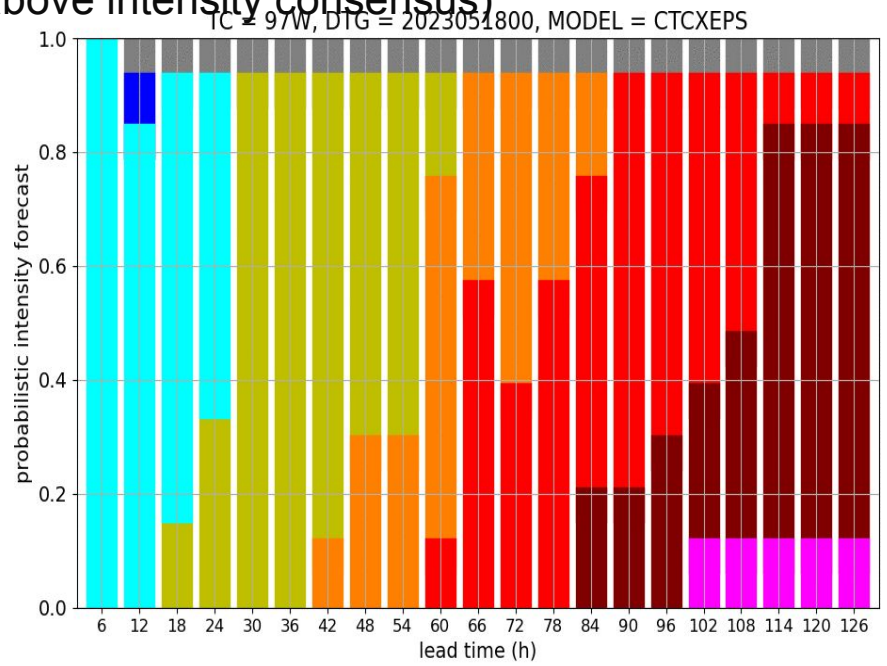



# Forecasting Intensity

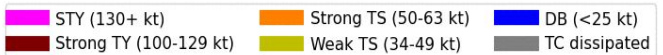


- COAMPS-TC 11-member ensemble operational (FNMOC) in 2020
  - Up to two systems (runs) per cycle; slots allocated for NHC / CPHC systems if JTWC does not request
  - Very useful for framing predicting intensity *trends* – particularly development and timing of possible rapid intensification (RI) – and intensity *levels*
- 02W 2023 (Mawar): Consistent RI and strong Typhoon / Super Typhoon signals prior to passage near Guam on 24 May
  - Supported 95 kt peak on first forecast (above intensity consensus)







# Expressing Uncertainty

- **Written forecast discussions** (Prognostic Reasoning Messages include characterization of confidence (low, medium, high)
  - Typically based on consensus models – ensembles provide additional support

```
MODEL DISCUSSION: THE DETERMINISTIC AND ENSEMBLE MODELS ARE ALL IN
TIGHT AGREEMENT THAT TC MAWAR WILL CONTINUE TO TRACK
NORTH-NORTHWESTWARD THROUGH TAU 24, THEN MAKE THE TURN
NORTHWESTWARD BY TAU 36. IN THE SHORT TERM, THE JTWC FORECAST TRACK
```

```
FORECAST CONFIDENCE:
   TRACK 0 - 72 HR: HIGH
   TRACK 72-120 HR: MEDIUM
   INTENSITY 0 - 72 HR: MEDIUM
   INTENSITY 72-120 HR: MEDIUM//
```

- **Direct customer support**
  - Ensembles highlighted during phone calls / chats with individual customers

- Primarily refer to ensemble track forecast guidance
  - Less and lower accuracy guidance for intensity and structure

# Challenges and Opportunities

- Challenges:
  - Under-dispersive & un-calibrated solutions
  - Differences in probabilities, e.g., 20% chance of “event” in one ensemble solution vs 80% in another
  - Inconsistency with official guidance

- Gaps:
  - Lack of skillful high-resolution ensembles to predict TC intensity and structure change (to complement COAMPS-TC ensemble)

- Opportunities:
  - Characterizing forecast uncertainty using ensemble forecasts
    - International TC warning centers beginning to use ensembles to construct area of track forecast uncertainty
    - Ensemble forecast data could be used to frame range of potential intensities in forecast products - need skillful, high-resolution ensembles

# Mahalo!