# Extended-Range Tropical Cyclogenesis:
# The CPC Global Tropics Hazards Outlook (GTH)

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SECART Webinar Series
May 17, 2022

# Outline

- ✓ Product overview and objectives
- ✓ Scientific basis and outlook preparation
- ✓ Verification
- ✓ Proposed plan to transition to a probabilistic format targeting the Week 2-3 time period

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# Overview

- ✓ The CPC releases the Global Tropics Hazards Outlook (GTH) once per week on Tuesday (updated on Friday during NH hurricane season) for the Week 1-2 time period. The outlook depicts hazardous enhanced/suppressed weekly tropical rainfall and mean temperature areas as well as **favored tropical cyclogenesis regions**.

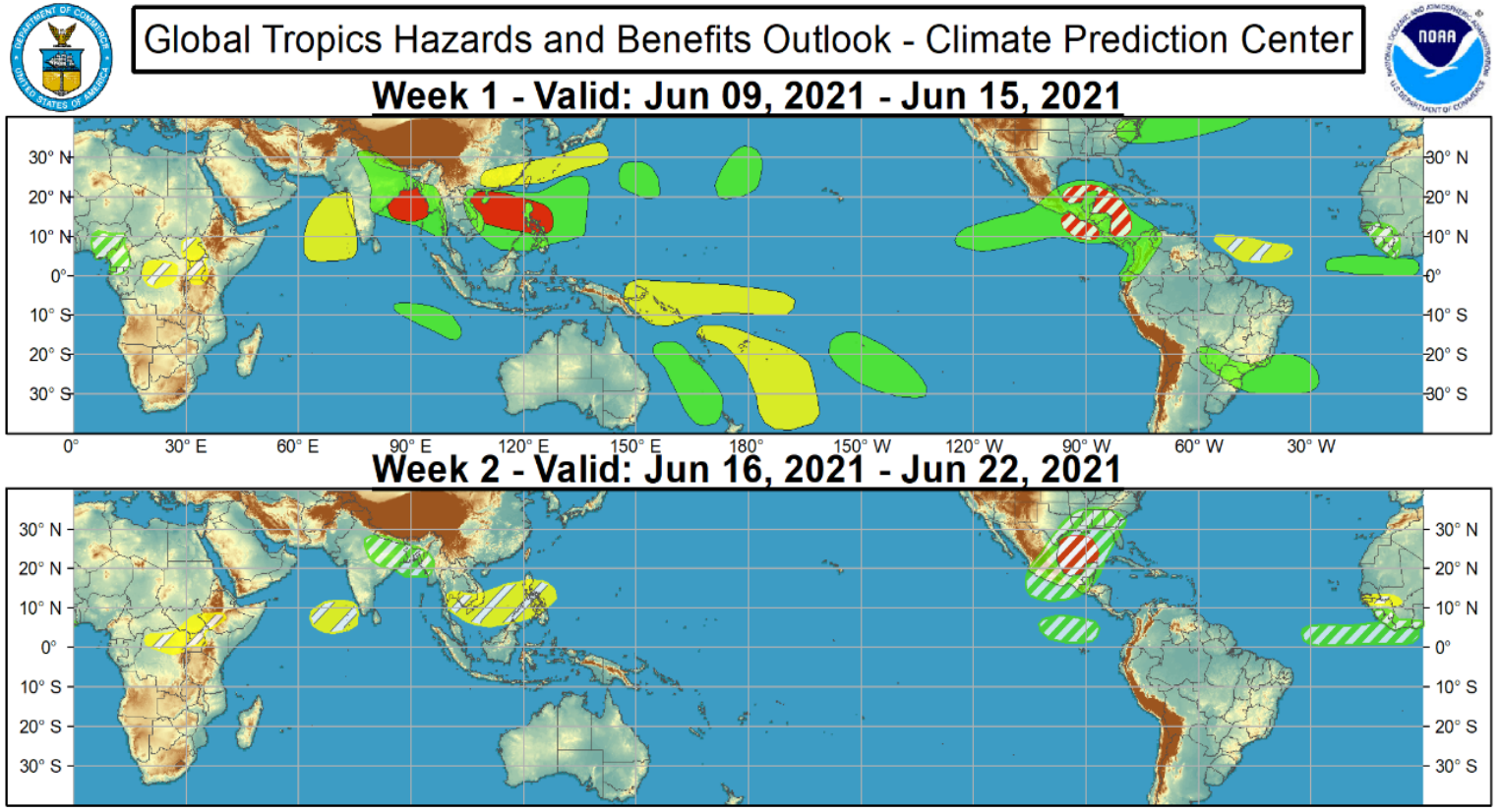
- ✓ The current product is categorical with confidence denoted in a limited, subjective manner.

- ✓ Commerce and economic stability is global in nature and many sectors of the U.S. economy have international links, requirements and interests. The product supports NOAA, the NWS and other federal agencies by:

  - Assessing and evaluating the forecast distribution of anomalous tropical rainfall to aid in communicating advance notice of potential pattern changes to the U.S.,
  - Providing a subseasonal tropical cyclone outlook for U.S. impacted areas,
  - U.S national security interests as input to DoD, Red Cross, etc. global operations

# Overview

https://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php



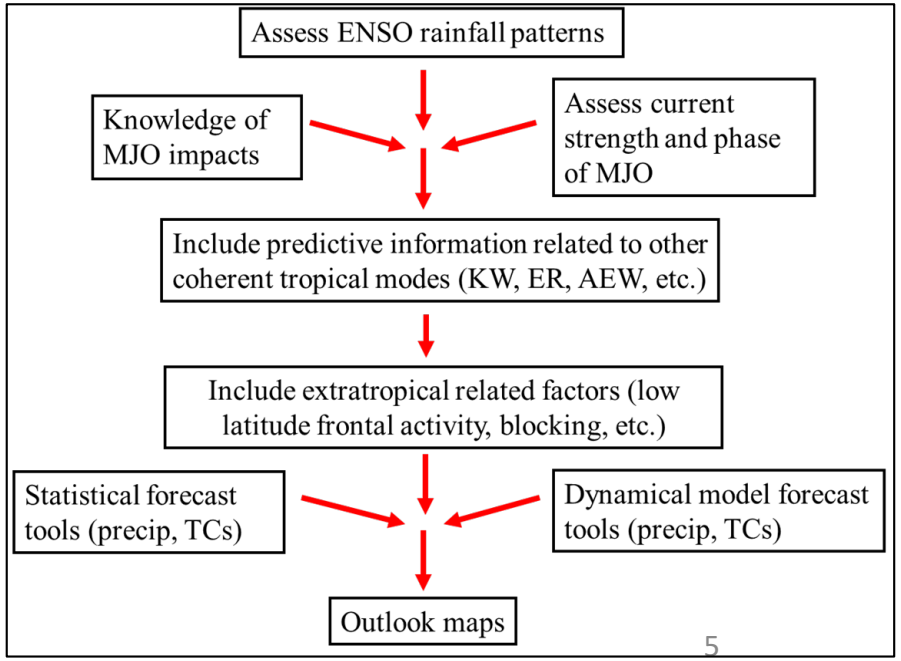

| | Week 1 | Week 2 |
|---|---|---|
| Tropical Cyclone Formation | KMZ / KML / SHP | KMZ / KML / SHP |
| Upper Tercile Precipitation | KMZ / KML / SHP | KMZ / KML / SHP |
| Lower Tercile Precipitation | KMZ / KML / SHP | KMZ / KML / SHP |
| Above Average Temperatures | KMZ / KML / SHP | KMZ / KML / SHP |
| Below Average Temperatures | KMZ / KML / SHP | KMZ / KML / SHP |

**Global Tropics Hazards and Benefits Outlook Discussion**

**Last Updated: 06.26.18** **Valid: 06.27.18 - 07.10.18**

There is a weak MJO signal apparent in both the RMM-based and CPC velocity potential-based indices, with the enhanced (suppressed) phase over Africa and the far western Indian Ocean (western and central Pacific). The presence of an intraseasonal signal is more apparent in the wind field than the convective anomalies, and other modes continue to interfere with the overall picture. The suppressed phase of an equatorial Rossby wave over the west Pacific appears to be constructively interfering with the suppressed phase of the MJO, but Kelvin wave activity over the East Pacific is restricting the eastern extent of the signal. There is considerable uncertainty among the dynamical model RMM-index forecasts, with the ECMWF generally supporting weak MJO activity that strengthens by the end of Week-2 over the Maritime Continent, and the GEFS depicting no eastward propagation and instead bringing the index outside of the circle back in Phase-1. It is possible that model forecasted tropical cyclone activity over the East Pacific is interfering with the RMM-index forecasts, acting to pull the index back towards the Western Hemisphere, especially given the lack of a robust intraseasonal convective signal. Therefore, the MJO may be active during the next two weeks, but there is too much uncertainty to project potential impacts of this signal on the global tropical convective pattern.

Tropical Storm Daniel formed over the East Pacific on June 24, and remained well out to sea before becoming post-tropical. No additional tropical cyclone development occured across the global basins during the past week. During Week-1, the East Pacific is anticipated to become extremely active, partly due to the aforementioned recent Kelvin wave activity. The National Hurricane Center (NHC) is currently monitoring a broad area of disturbed weather approximately 600 miles south of Acapulco, Mexico, and



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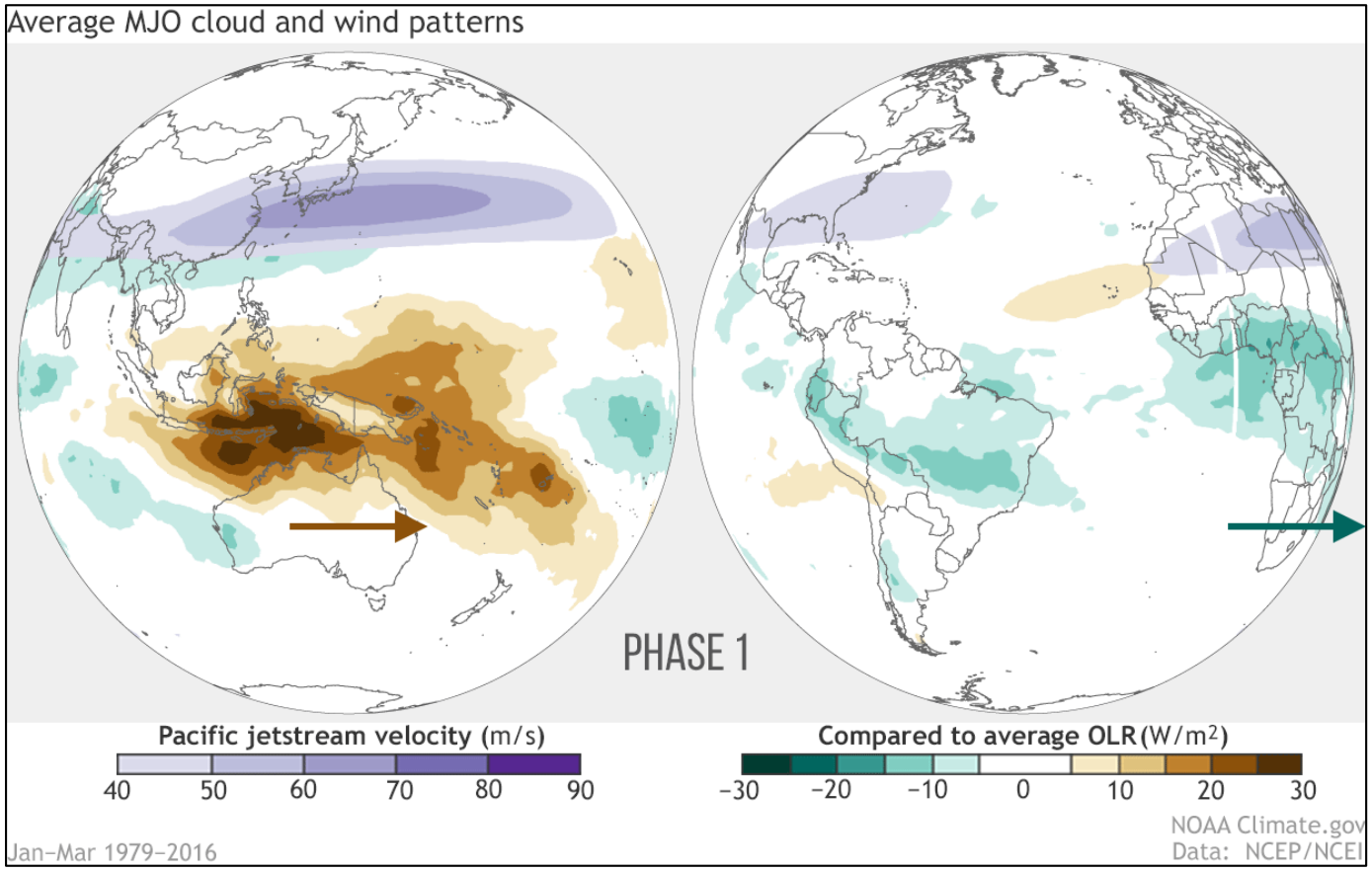
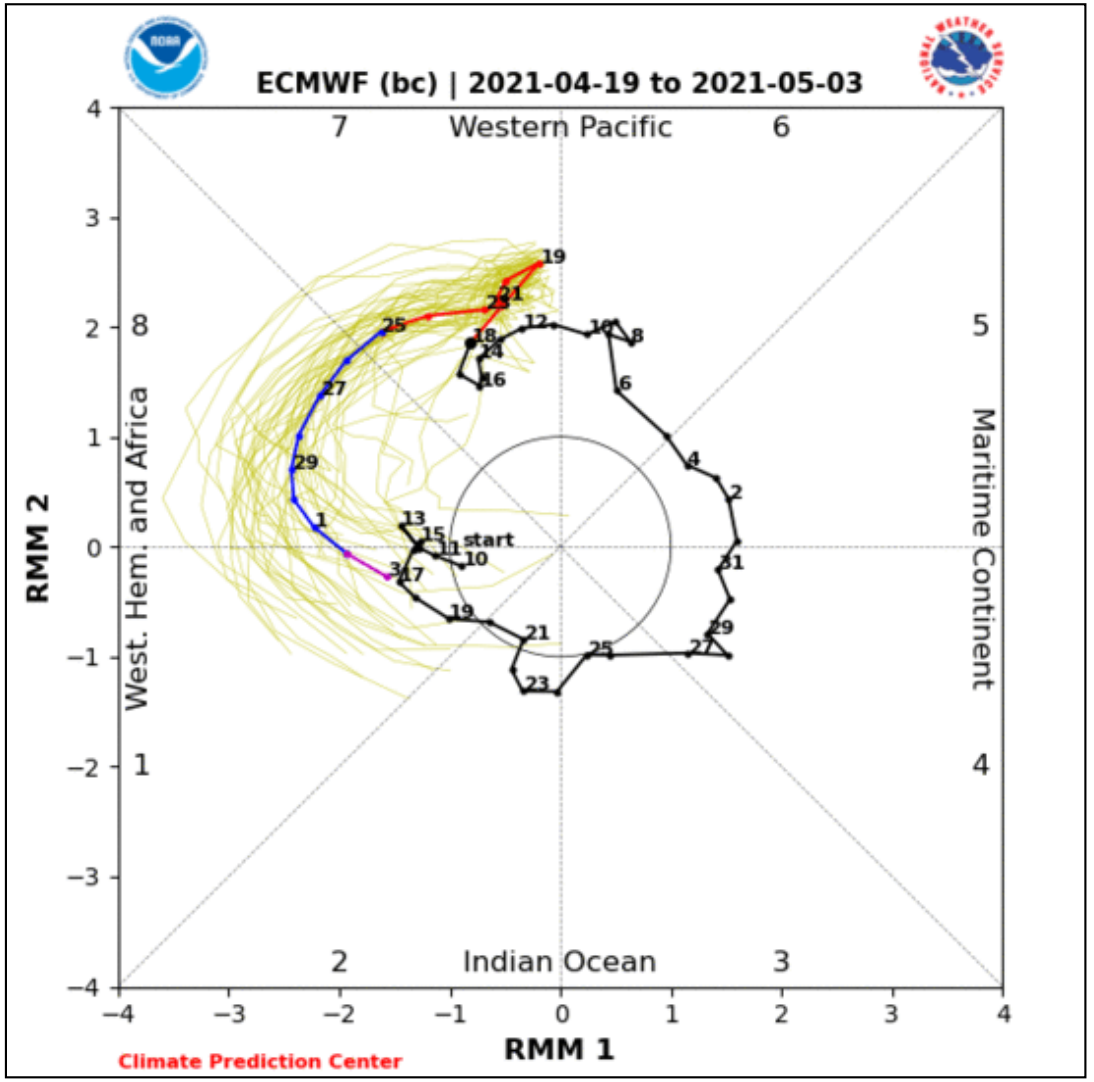
# Outlook Scientific Basis - MJO

**MJO plays a major role in the extended-range GTH outlook**

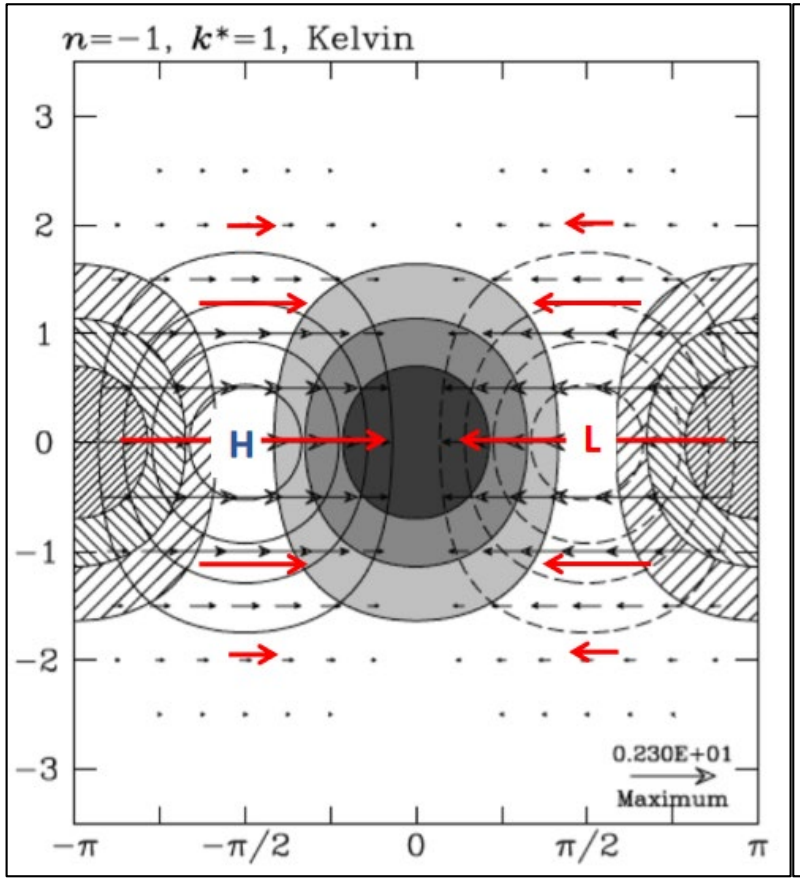


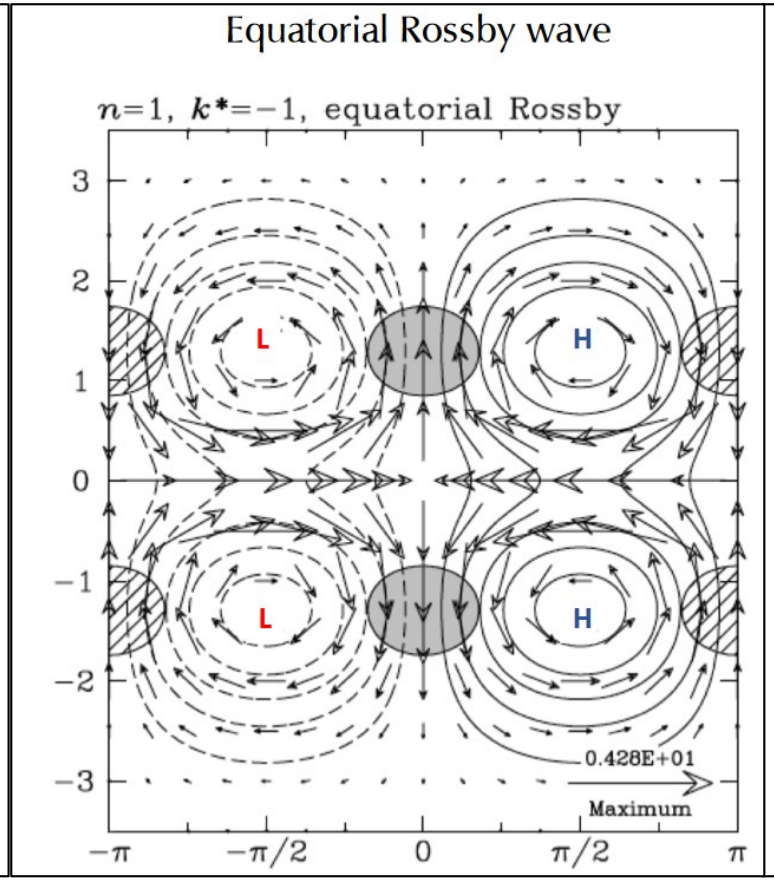



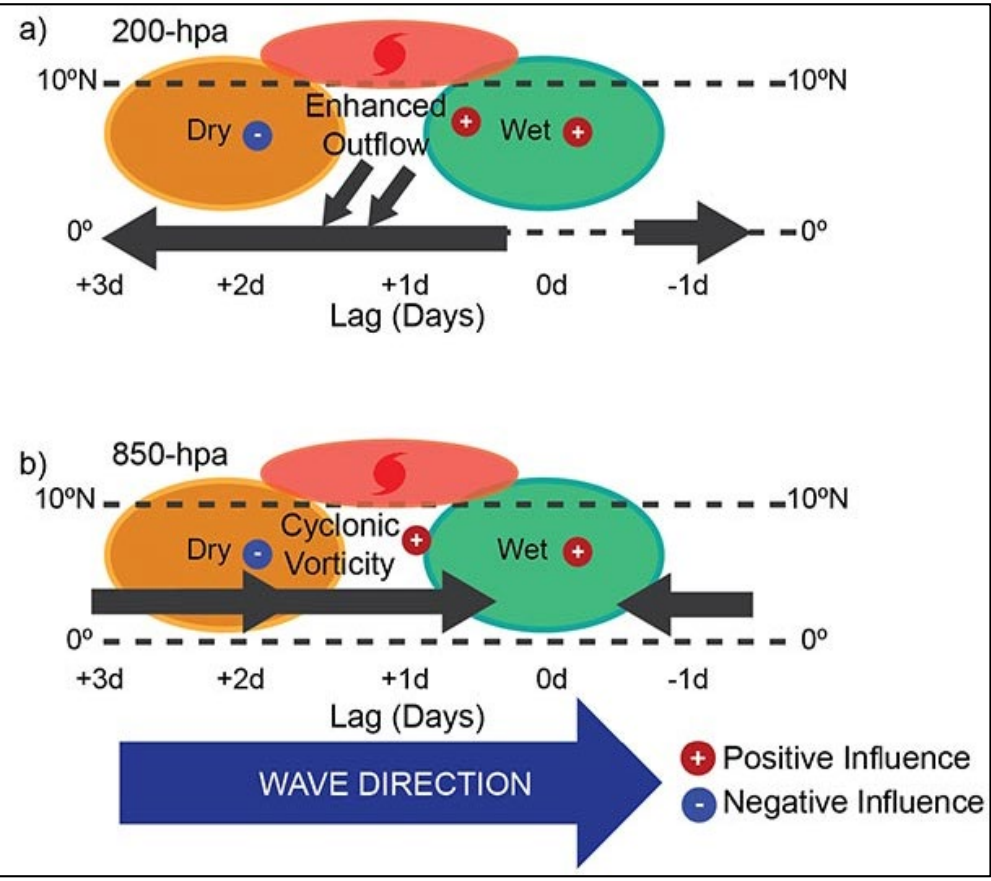

**Madden and Julian (1971,1972); Rui and Wang (1990); Wheeler and Hendon (2004); Zhang (2005); Gottschalck et al. (2010); Gottschalck et al. (2013)**

# Outlook Scientific Basis – Other Waves

**Atmospheric Kelvin Waves (KWs) and Equatorial Rossby Waves (ERW) play substantial roles in the extended-range GTH outlook**



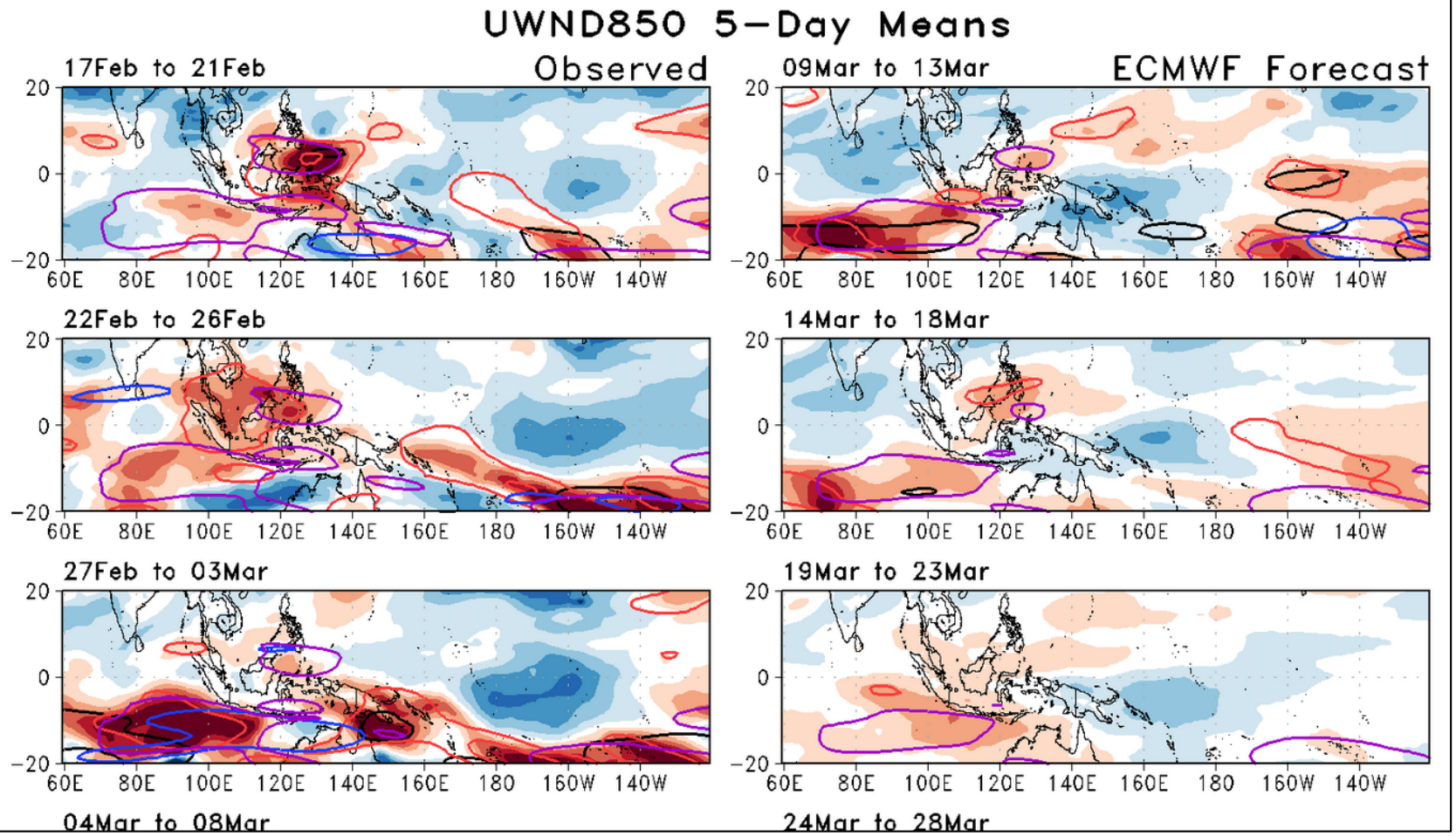

Wheeler and Kiladis (1999); Wheeler and Weickmann (2001); Maloney and Hartmann (2000); Schreck and Molinari (2011); Schreck et al. (2012); Schreck (2015); Janiga et al. (2018), etc.

# Outlook Scientific Basis – Other Waves

Atmospheric Kelvin Waves (KWs) and Equatorial Rossby Waves (ERW) play substantial roles in the extended-range GTH outlook

**Maps:**

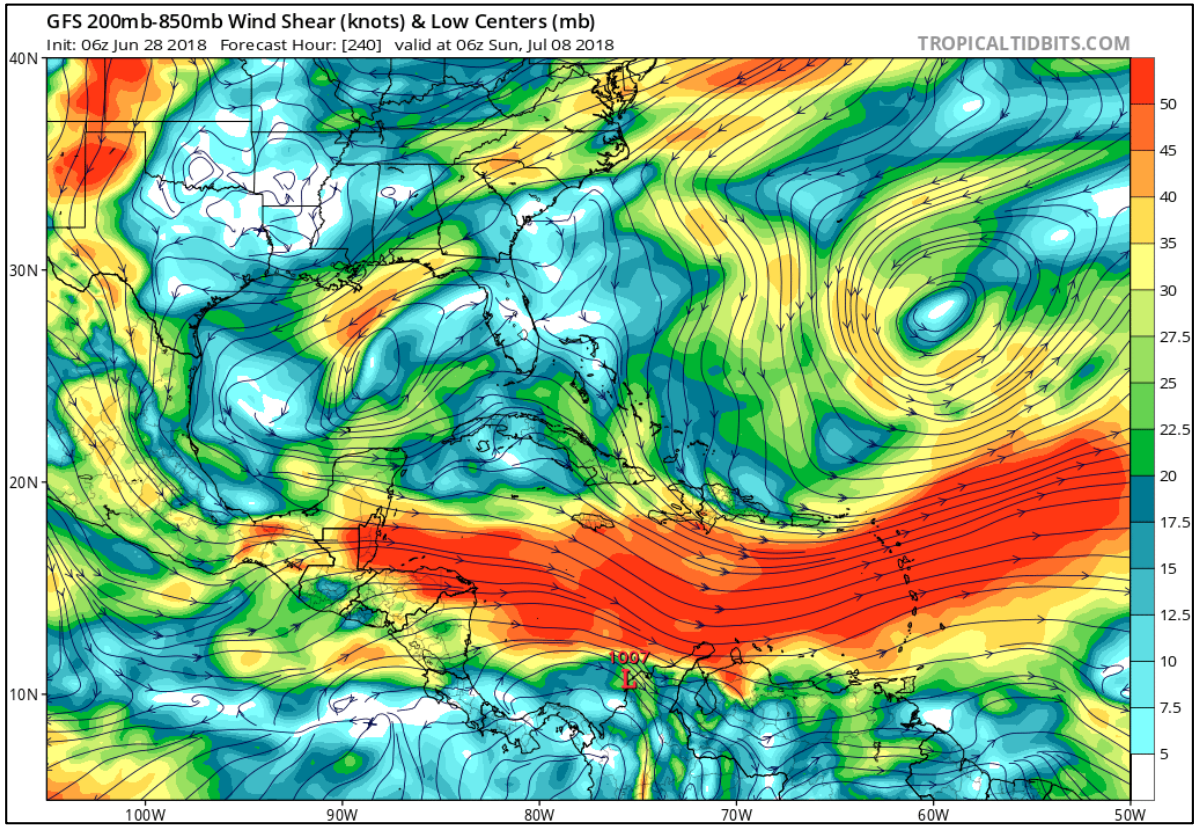
Zonal Wind | 850-hPa | ECMWF Forecasts* | Pacific Ocean | 5 days

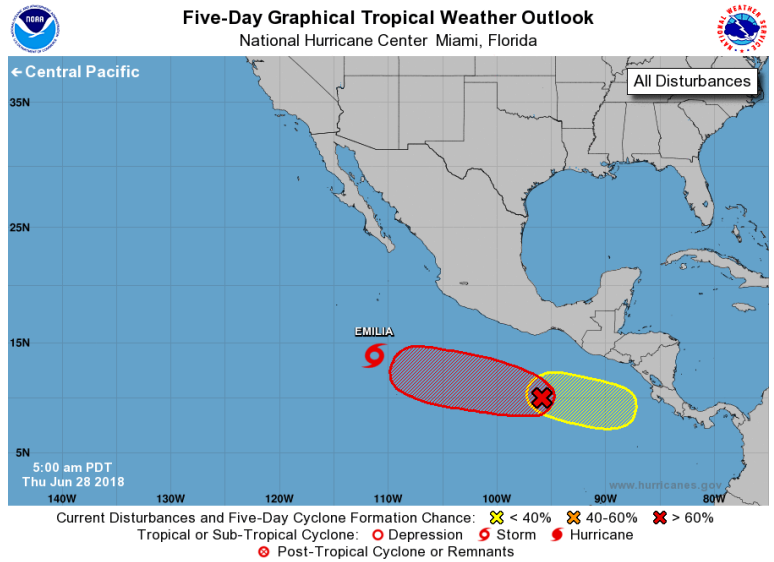


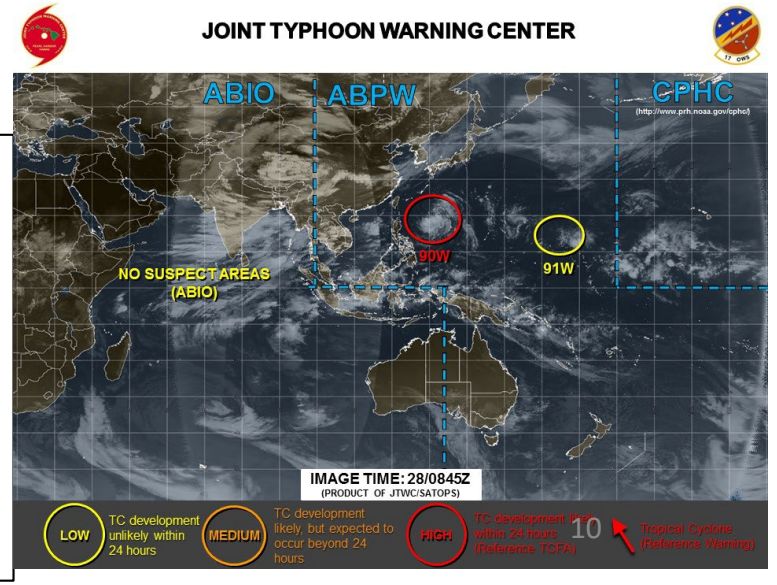

**Map of 850-hPa zonal wind with contributions from tropical modes using observations, ECMWF forecast**

**Wheeler and Kiladis (1999); Wheeler and Weickmann (2001); Maloney and Hartmann (2000); Schreck and Molinari (2011); Schreck et al. (2012); Schreck (2015); Janiga et al. (2018), etc.**

# Outlook Scientific Basis – Model Guidance



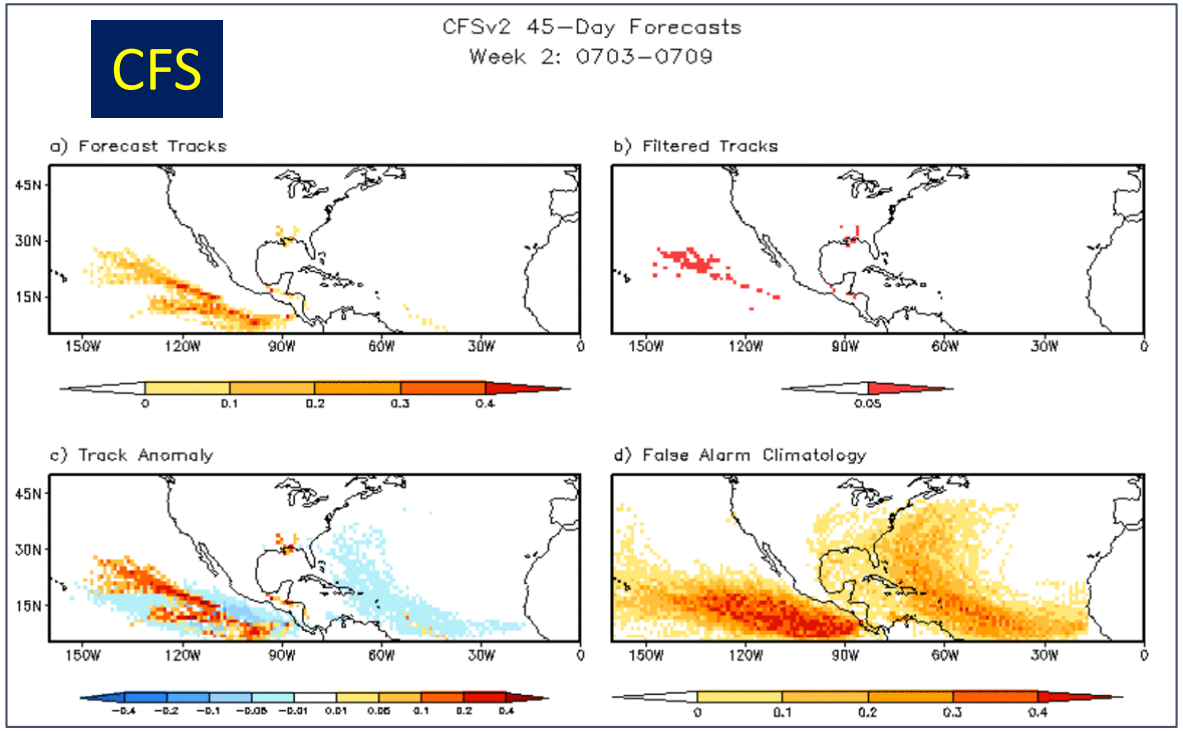




- Dynamical model guidance from NCEP [Global Ensemble Forecast System (GEFS), Climate Forecast System (CFS)], ECMWF and ECCC [Global Ensemble Prediction System (GEPS)] also informs the outlook

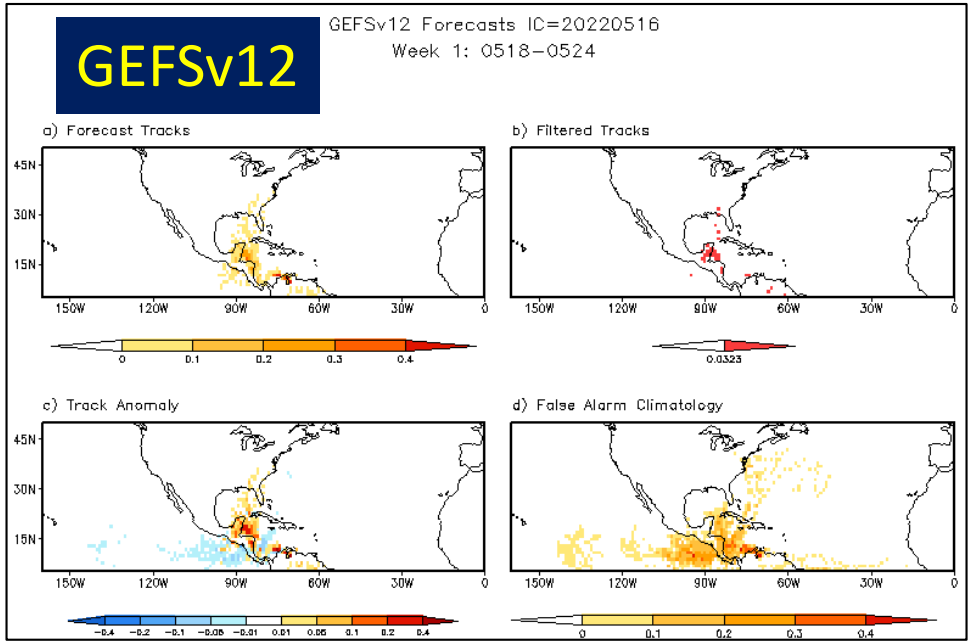
- Current assessments and coordination with tropical cyclone operational centers

# Outlook Scientific Basis – TC Tracking

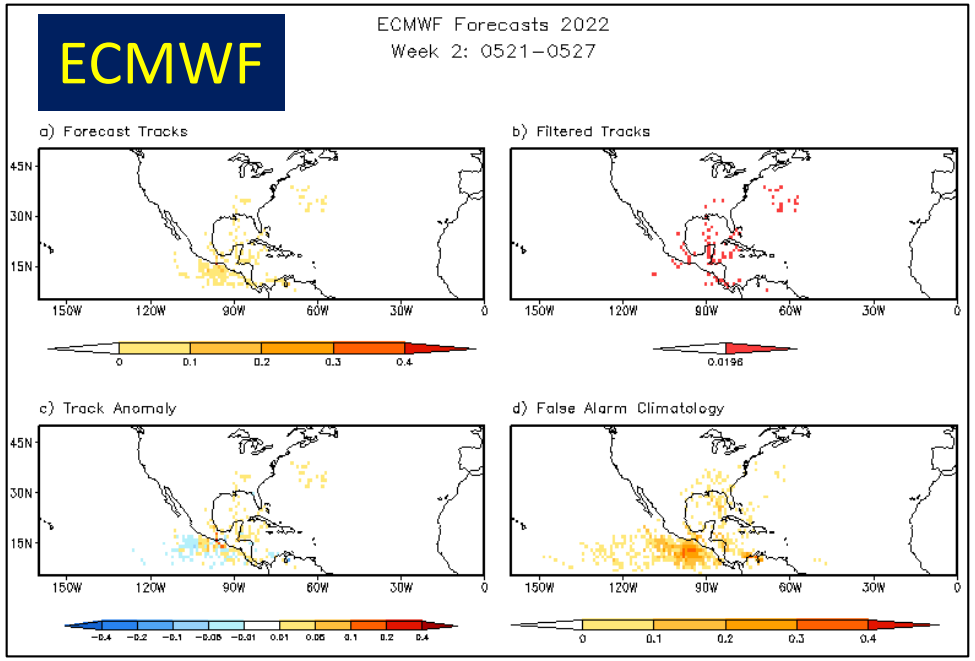
CFS




GEFSv12




ECMWF




Explicit tropical cyclone identification and tracking for the CFS, GEFSv12 and ECMWF prediction systems

**Camargo and Zebiak (2002)**

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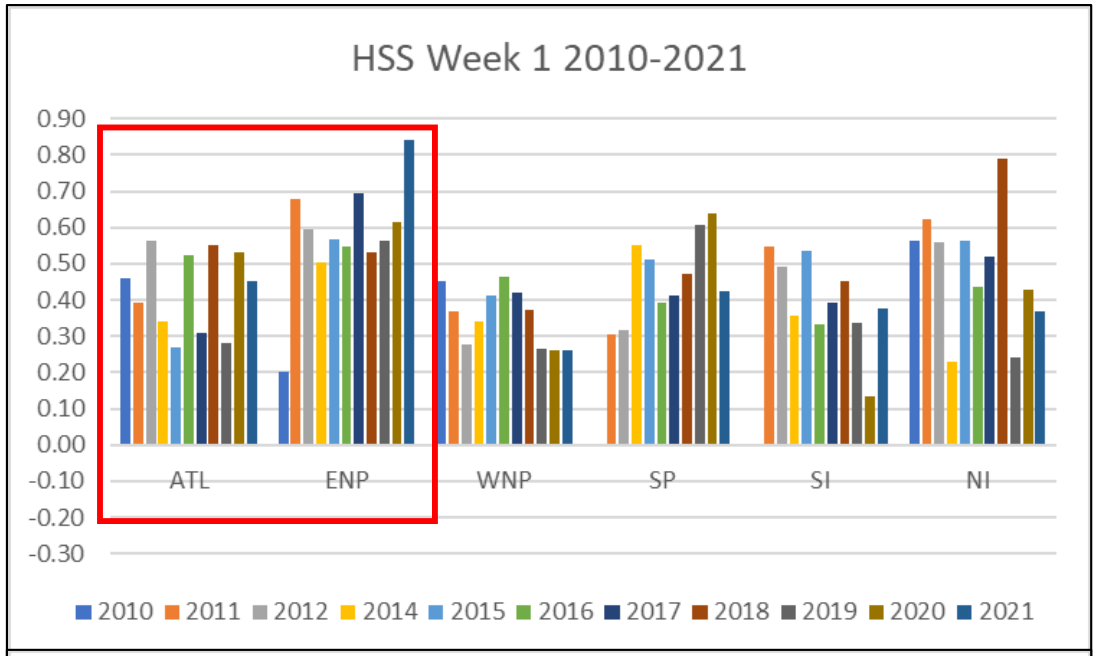
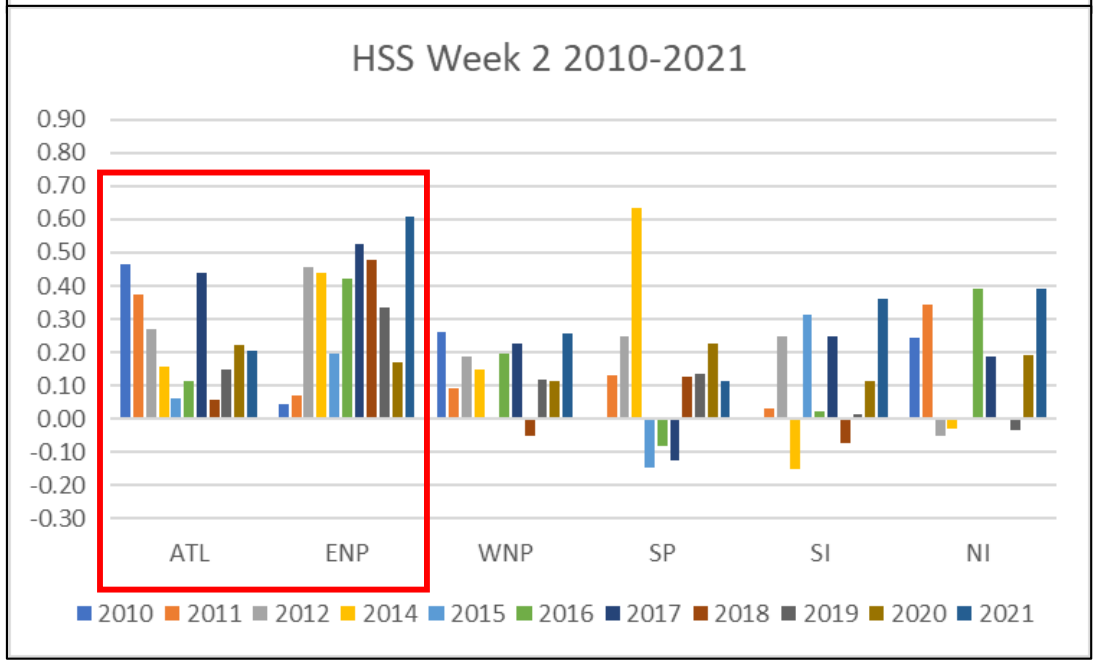
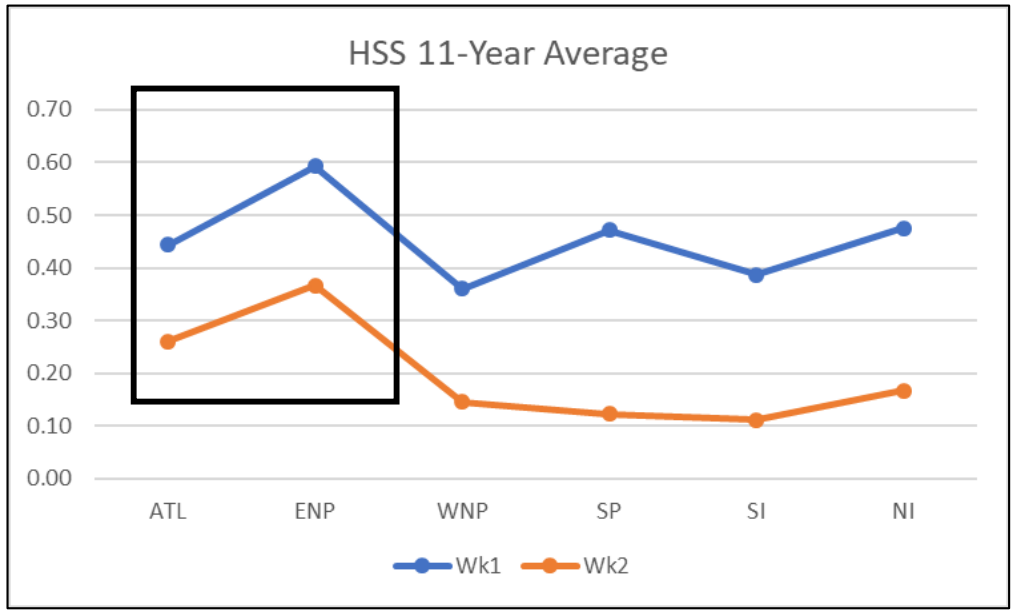
# GTH Outlook Verification




Heidke Skill Score (HSS): Hit based skill metric based on a 2x2 hit/miss contingency table for observations and forecasts.

Forecast skill > 0
No skill <= 0

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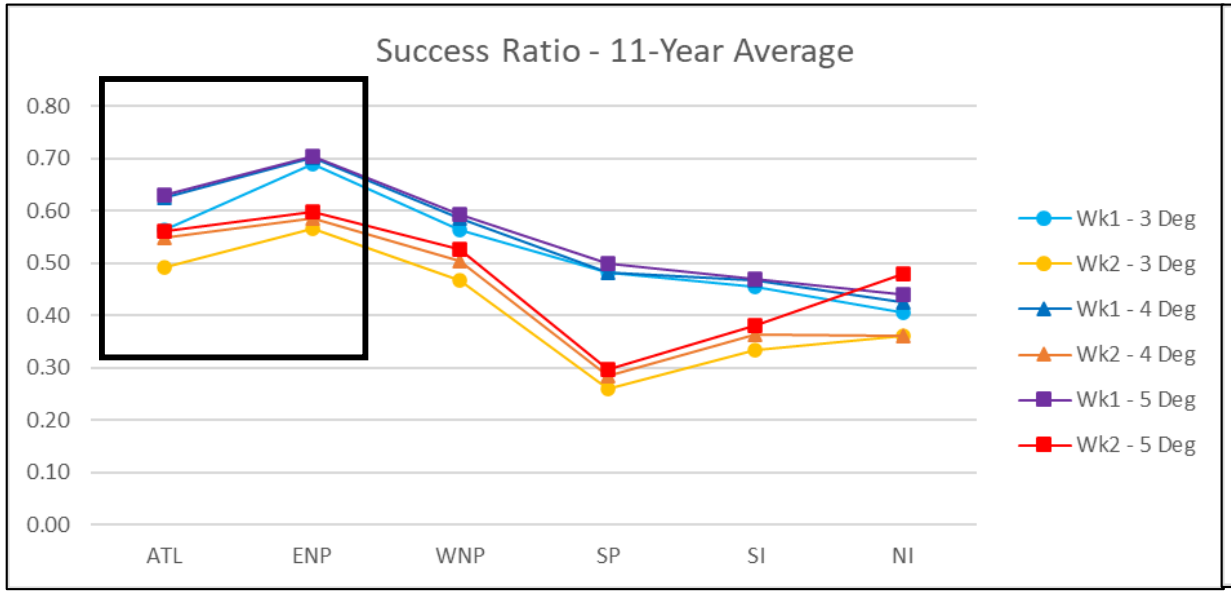


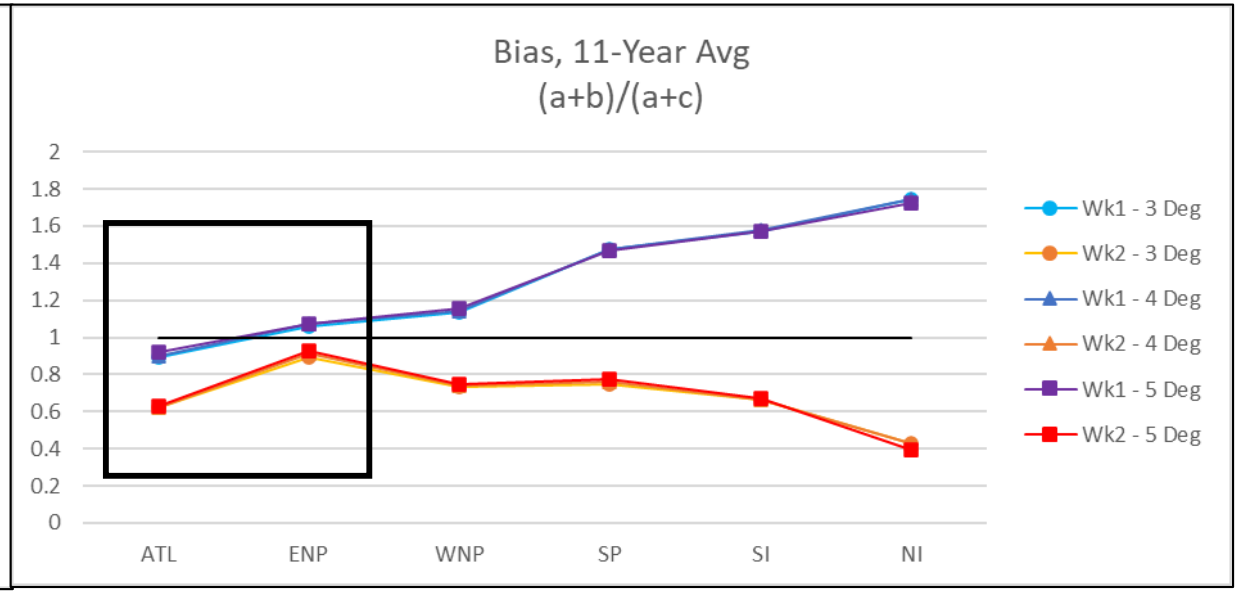


Success Ratio (left), Bias (right)

Week-1 (blue colors), Week-2 (orange colors)

Forecast skill > 0, No skill <= 0

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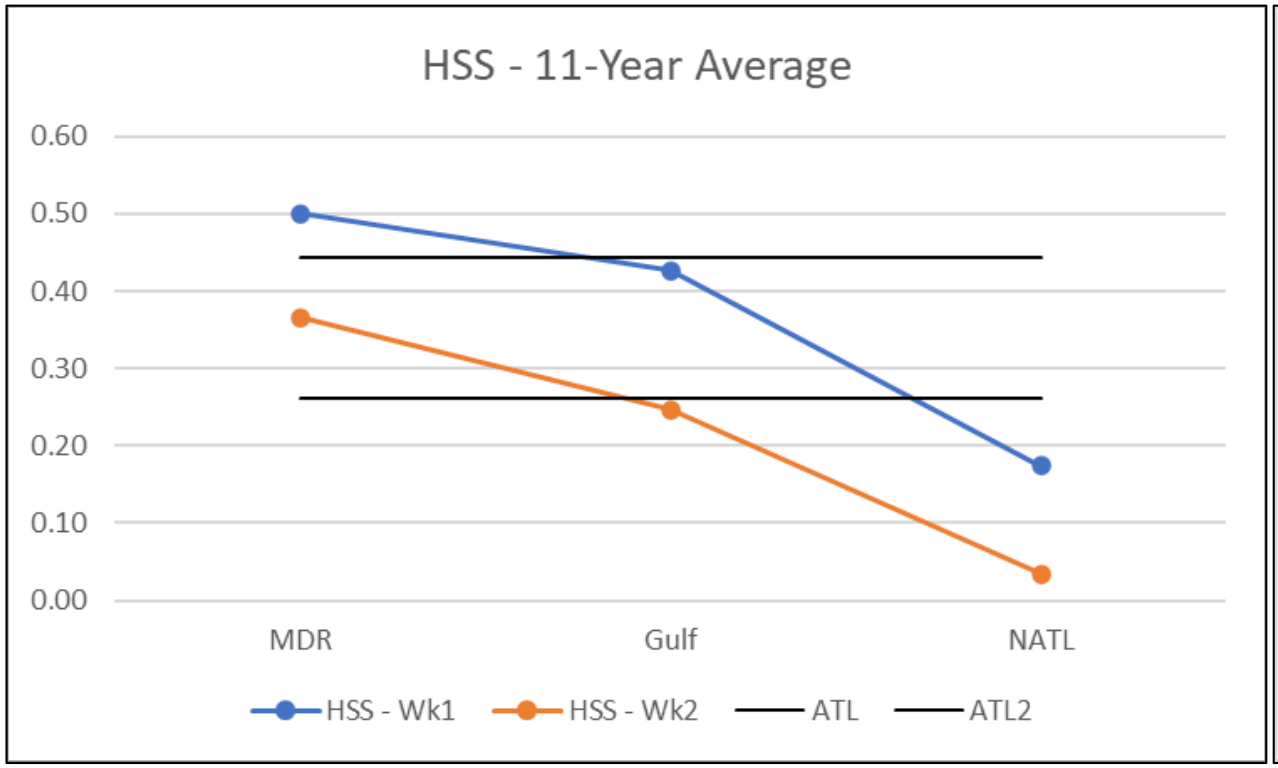
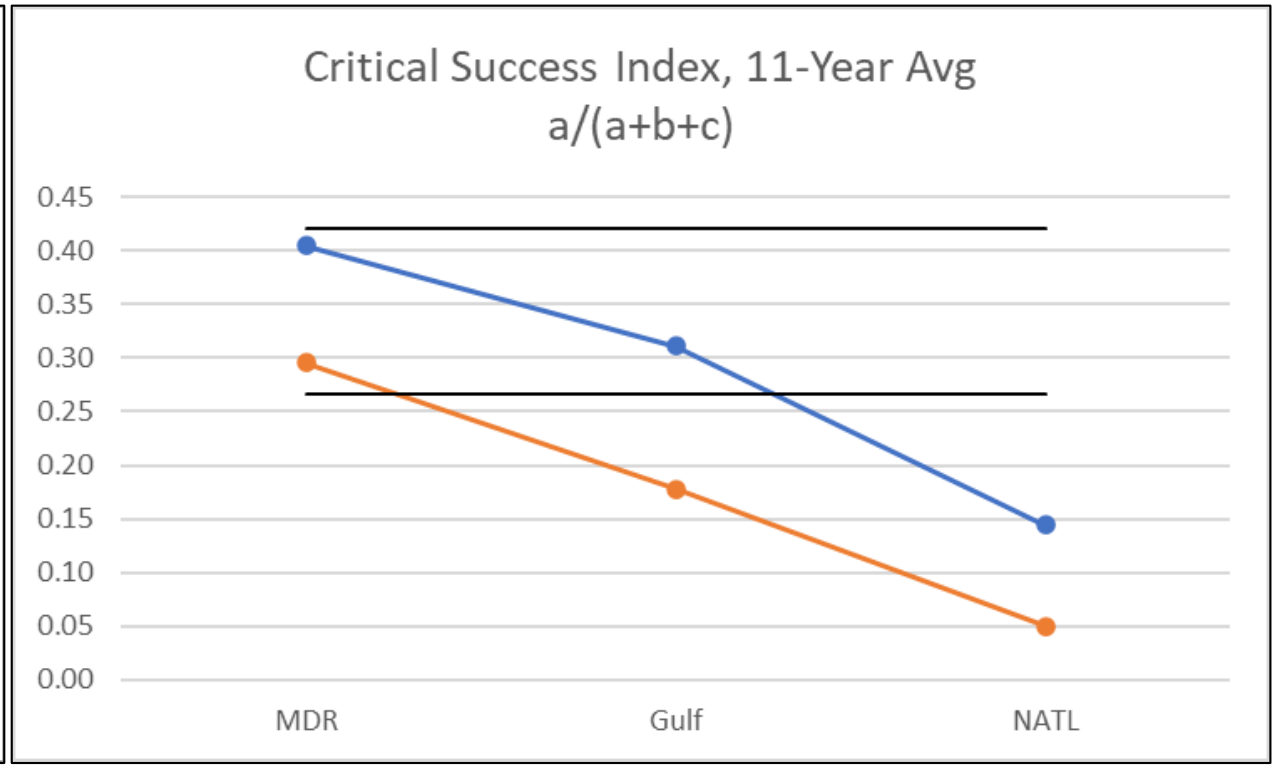



Heidke Skill Score (left), Critical Success Index (right)

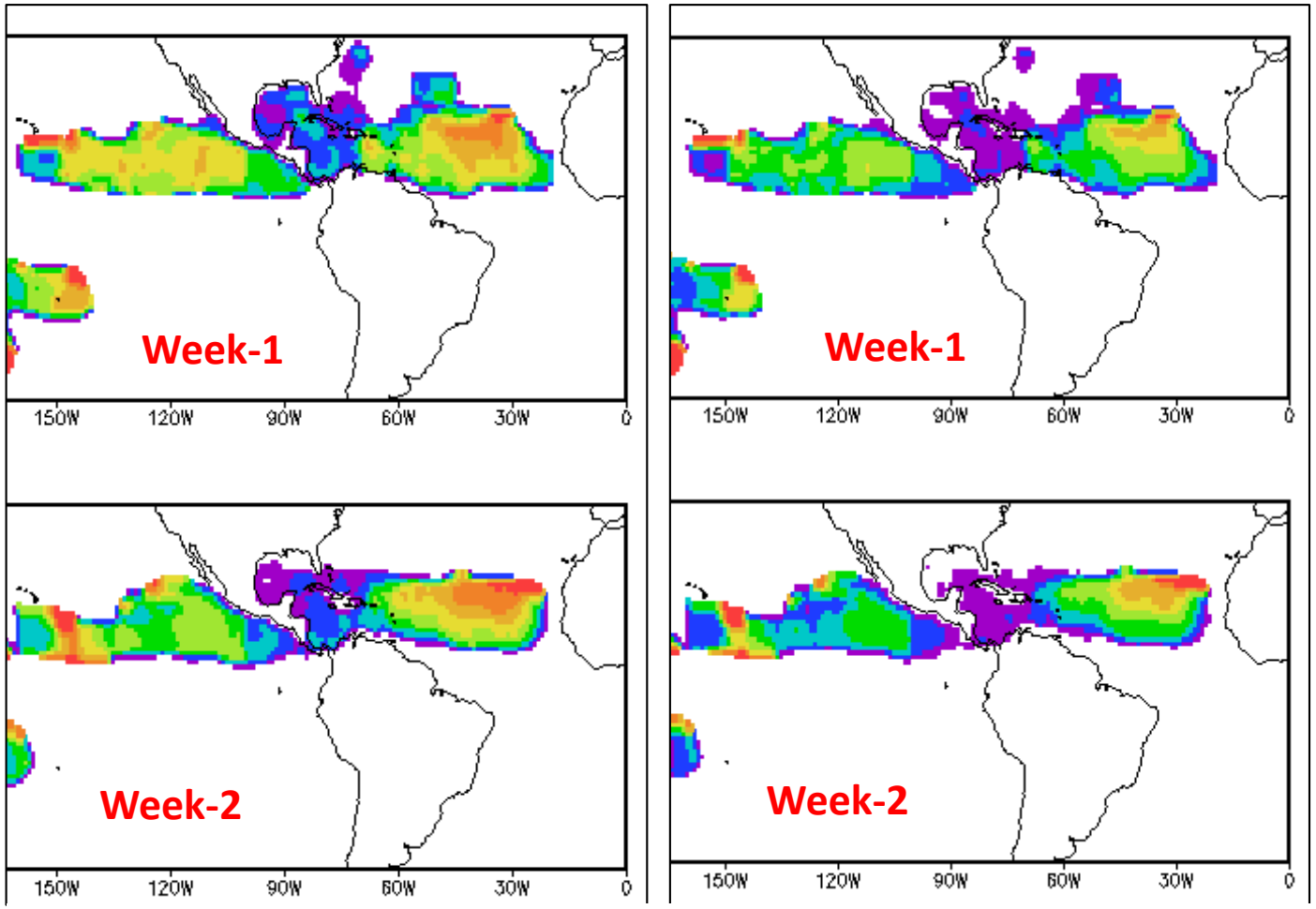
Week-1 (blue), Week-2 (orange)

Forecast skill > 0, No skill <= 0

# GTH Outlook Verification

Heidke Skill Score

Critical Success Index




Heidke Skill Score (left)
Critical Success Index (right)

Week-1 (top)
Week-2 (bottom)

Forecast skill > 0
No skill <= 0

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# Week 2-3 Probabilistic GTH Outlook

**New product includes two major changes:**

(1) Convert the GTH outlook to an objective, probabilistic based outlook,
(2) Shift the GTH outlook target forecast to the Week 2-3 period to align it more appropriately with the CPC mission

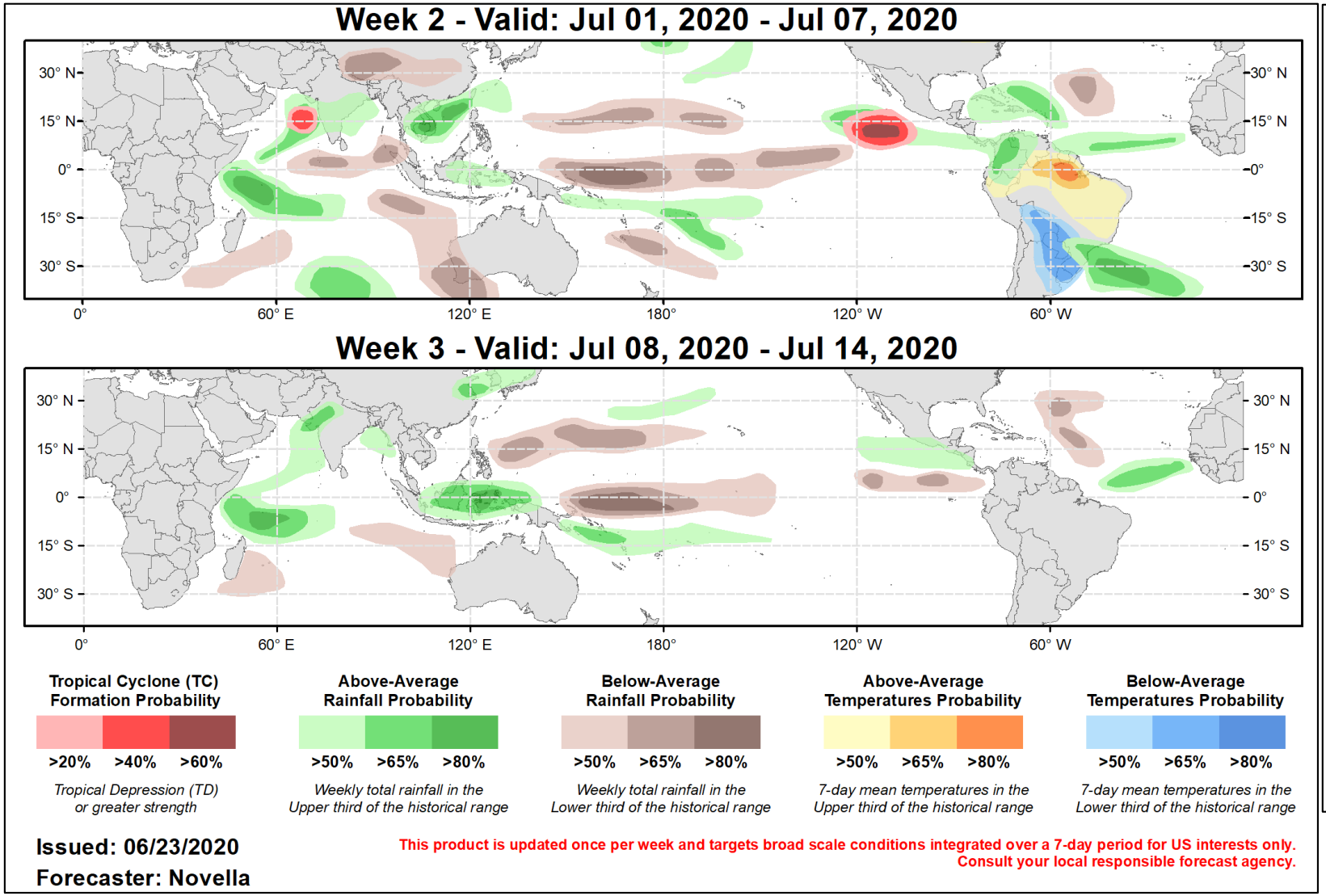
To support these changes, objectively derived probabilistic dynamical model and statistical / hybrid forecast tool information has been developed to inform the new GTH product

The conversion of the product increases the climate IDSS opportunities for pivotal impacts from tropical linked phenomena (TCs, monsoon breaks/surges, atmospheric river events, *etc*.)

The advance addresses key target areas outlined in the "Weather Research and Forecasting Innovation Act of 2017" ➔

(1) extending outlooks of extreme events further into the subseasonal time scale and,
(2) applied research targeting tropical cyclone activity

# Week 2-3 Probabilistic GTH Outlook



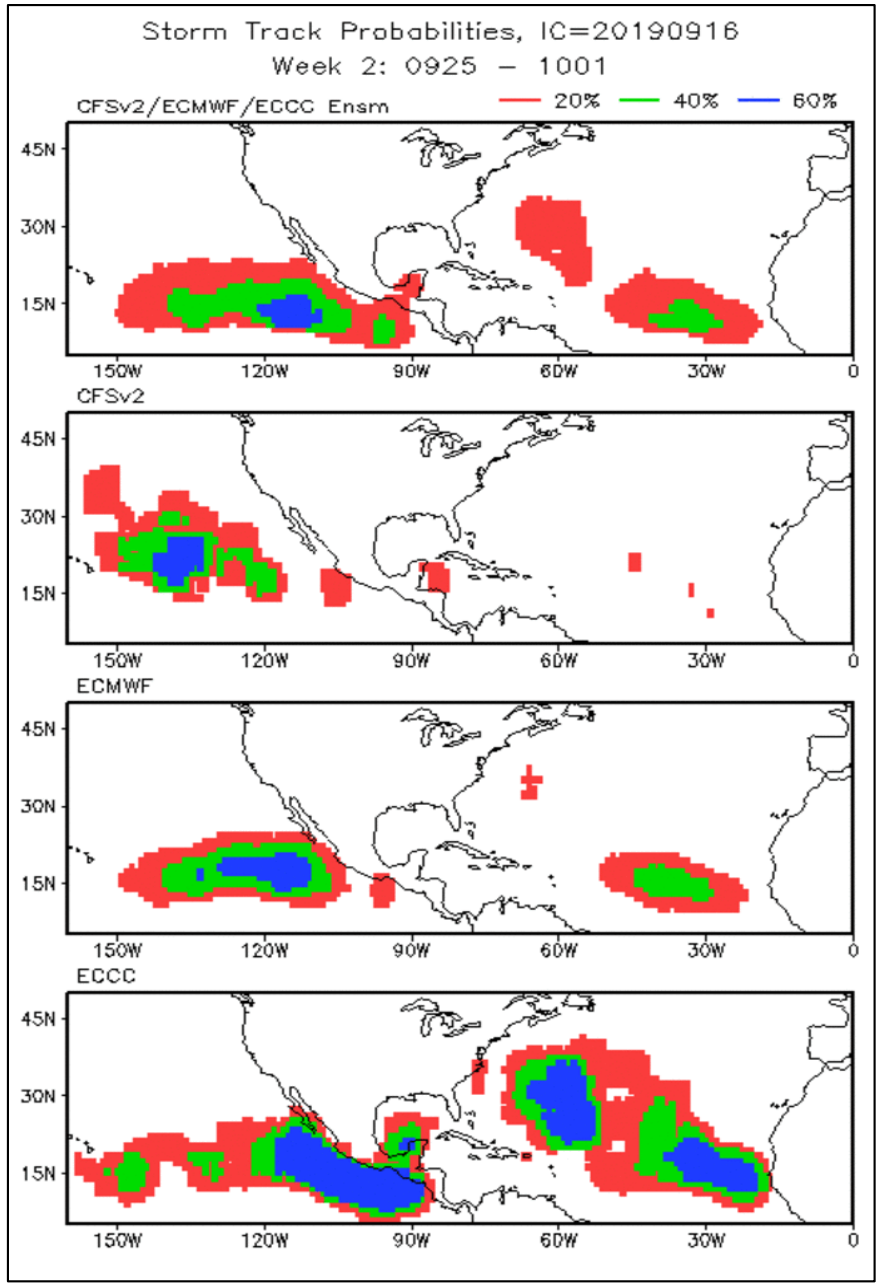

Model guidance based inputs are anchored to reforecast datasets and bias-corrected and calibrated

Applied to precipitation, temperature and TC tracking and related fields

Products from the CFS, ECMWF, ECCC, GEFSv12 and objectively, skill based combined ensemble systems available.

3-tiered probability ranges correspond to low, moderate and high confidence / risk for 5 forecast areas.

# Week 2-3 Probabilistic GTH Outlook




Experimental development of probabilistic tropical cyclone genesis and forecast track guidance tools to support subseasonal-TC relationship outlooks.

Based on the CFS, ECMWF, ECCC and GEFSv12 dynamical model ensemble prediction systems.

Example genesis / track probability maps (*i.e*. low, moderate, high risk) from combined, CFS, ECMWF and ECCC model data for a Week-2 outlook from September 16, 2019.

Represents percentage of ensemble members remaining within a surrounding 7°x7° grid box after filtering (*i.e*., bias correction, calibration).

# Week 2-3 Probabilistic GTH Outlook

## Tropical Cyclone Skill – Track Week 2

$$Hit\ Rate = \frac{a}{a+c}$$

$$False\ Alarm\ Rate = \frac{b}{b+d}$$

- Hit Rate and False Alarm (FA) Rate for each model hindcast.
- Based on a 2x2 contingency table:

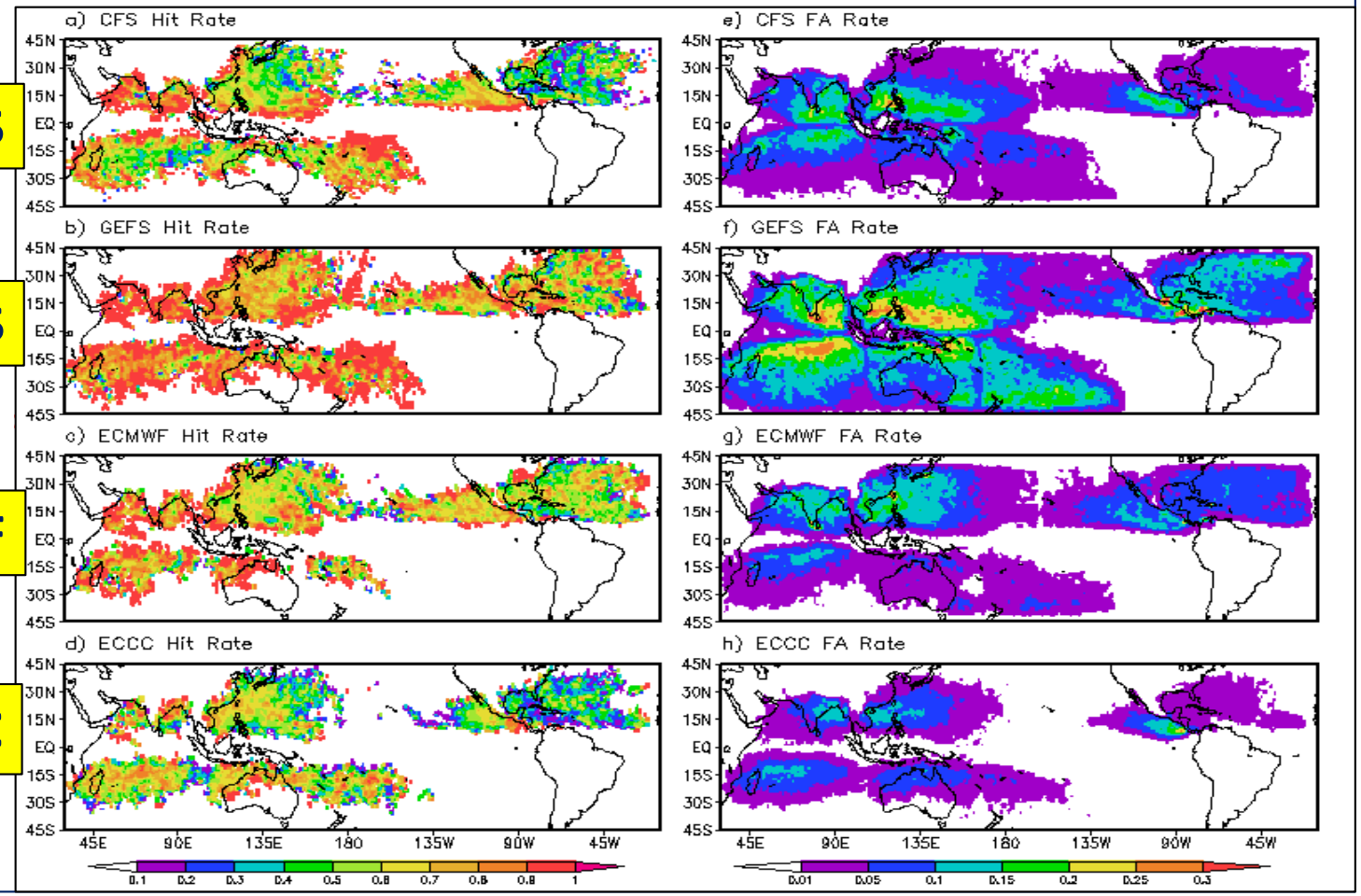
| Obs \ Model | Yes | No |
|---|---|---|
| **Yes** | "a" Hit | "c" Miss |
| **No** | "b" False Alarm | "d" Correct Null |

**CFS**

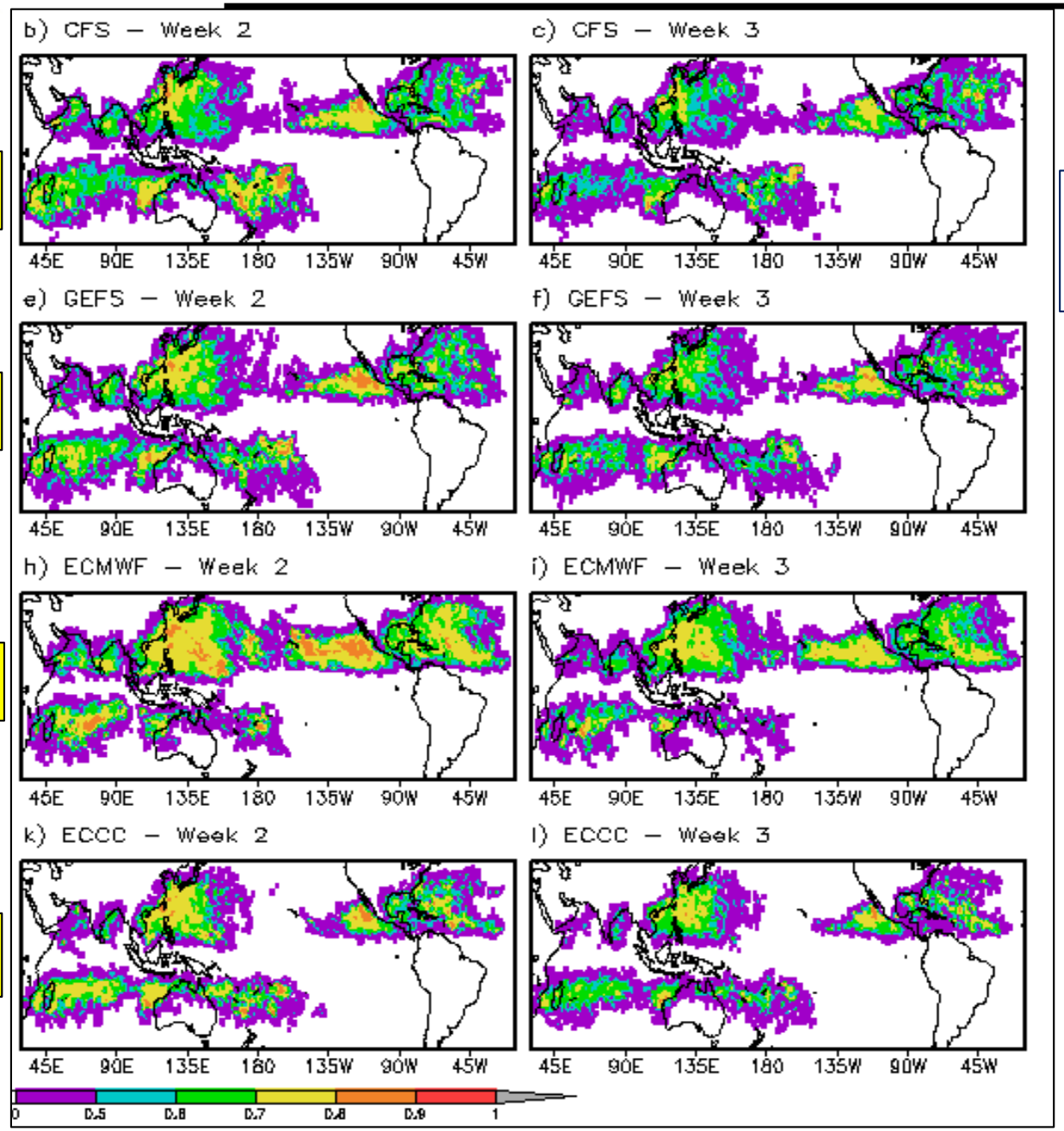
**GEFS**

**ECMWF**

**ECCC**



# Week 2-3 Probabilistic GTH Outlook




CFS

GEFS

ECMWF

ECCC

- Symmetric Extreme Dependency Score (SEDS)
- Broken up into months for forecaster reference

$$SEDS = \frac{\ln[(a+b)/n] + \ln[(a+c)/n]}{ln\,[a/n]} - 1$$

Week-2 and Week-3 SEDS based on reforecast data from CFS, GEFS, ECMWF and ECCC ensemble model forecast systems.

# Summary

- ✓ CPC operationally releases the Global Tropics Hazards Outlook each week that targets potential tropical cyclone development / impacts for the upcoming Week 1-2 period.

- ✓ The product is released on Tuesday's at 2:30 PM ET and is accompanied by a live briefing of about 15 minutes in length which allows the opportunity to ask any questions. Please contact Jon.Gottschalck@noaa.gov if you wish to learn how to attend this release briefing each week.

- ✓ The extended-range GTH product (Weeks 2-3) is grounded in strong scientific principles with numerous forecast tools available to the CPC forecast team. The current and proposed new product shows forecast skill in various basins, during certain times of the year for Weeks 2-3.

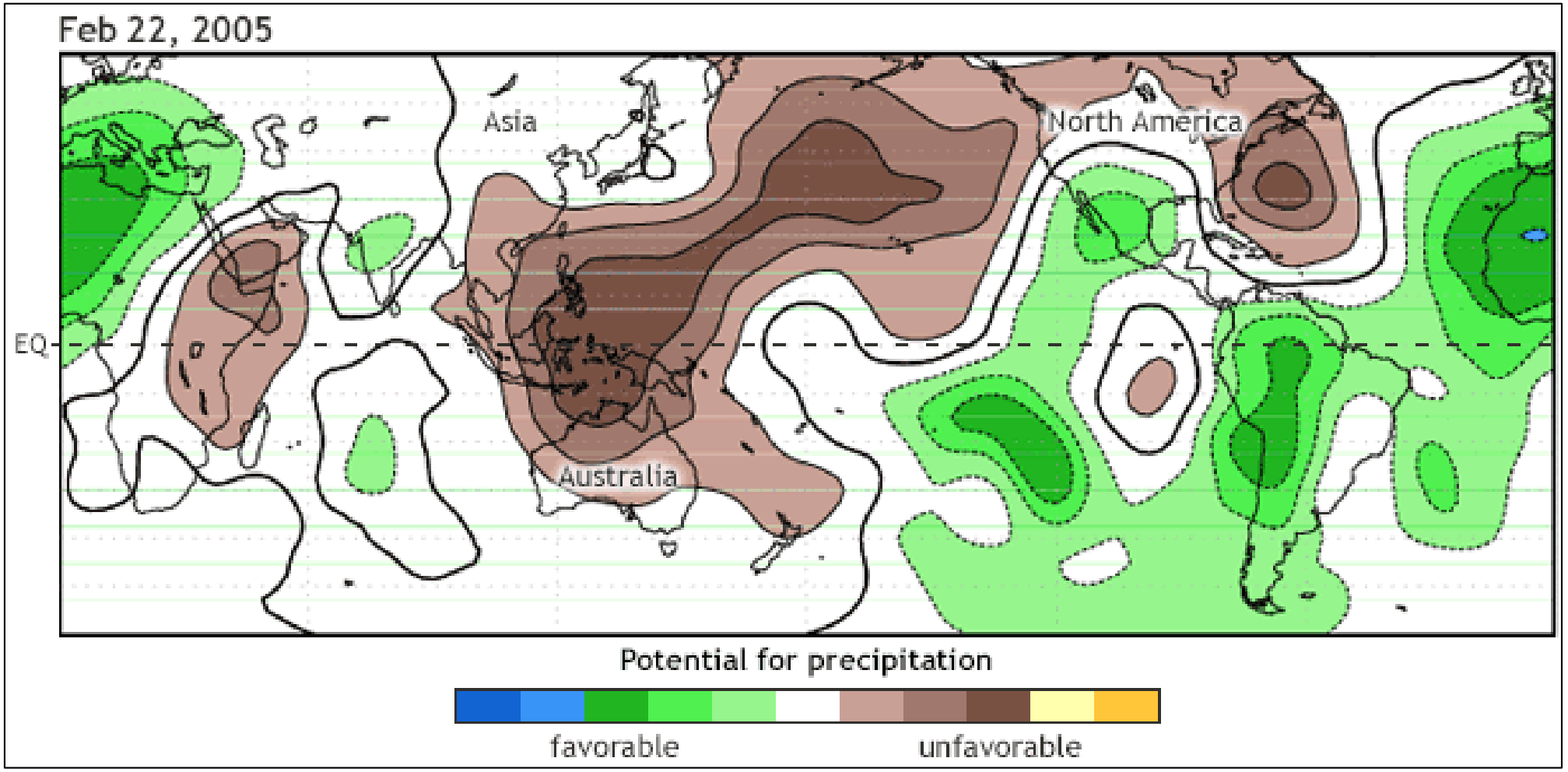
- ✓ With NWS support, forecast skill evaluation continues as does improvement in utilized forecast tools and information to support the potential transition to the Week 2-3 time period.

Thank you for your time and attention

Jon.Gottschalck@noaa.gov

# Outlook Scientific Basis - MJO

**MJO plays a major role in the extended-range GTH outlook**




Madden and Julian (1971,1972); Rui and Wang (1990); Wheeler and Hendon (2004); Zhang (2005); Gottschalck et al. (2010); Gottschalck et al. (2013)

# Outlook Scientific Basis – Hybrid Tools

- ✓ Predictions of tropical cyclone activity based on statistical relationships with large scale dynamical fields known to influence tropical cyclone development
- ✓ Above-, near- and below-normal weekly probabilities as characterized by tropical cyclone days for a MME forecast, CFS, ECMWF, GEFS and ECCC (left to right)
- ✓ ATL (top row), EPAC (bottom row) (Week-2 example)