The CPC Global Tropics Hazards Outlook: Overview, current operational products and work to transition to probabilistic format targeting Week 2-3

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Week 3-4 Seminar Series
October 4, 2021

Outline

- ✓ Background, current product preparation and forecast basis
- ✓ Transition of product to probabilistic format targeting Weeks 2-3
- ✓ Overview of applied research and development of dynamical and statistical forecast guidance and tools to inform new outlook format

1. Precipitation
2. Tropical cyclones

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Background

- ✓ 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.

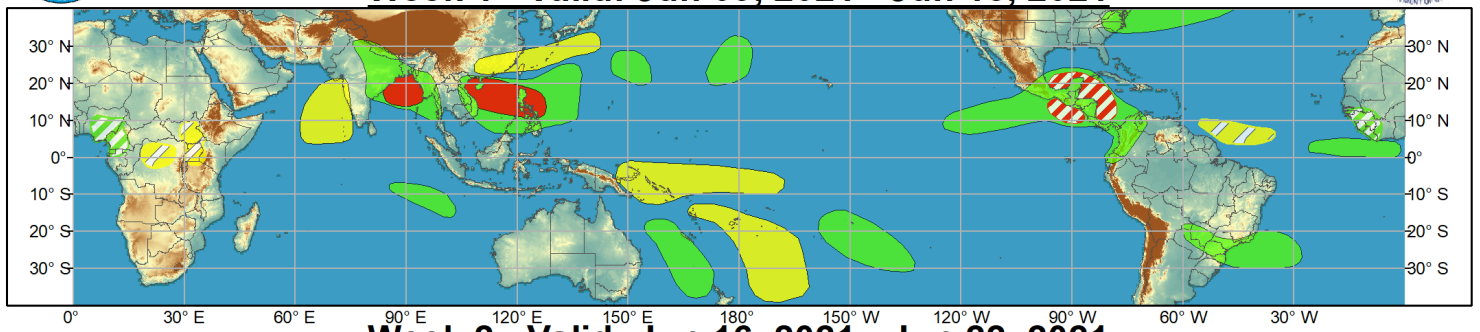
- ✓ Commerce and economic stability is global in nature and many sectors of the U.S. economy have international links, requirements and interests. The product supports NOAA, the NWS and other federal agencies by:

  - Assessing and evaluating the forecast distribution of anomalous tropical convection 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

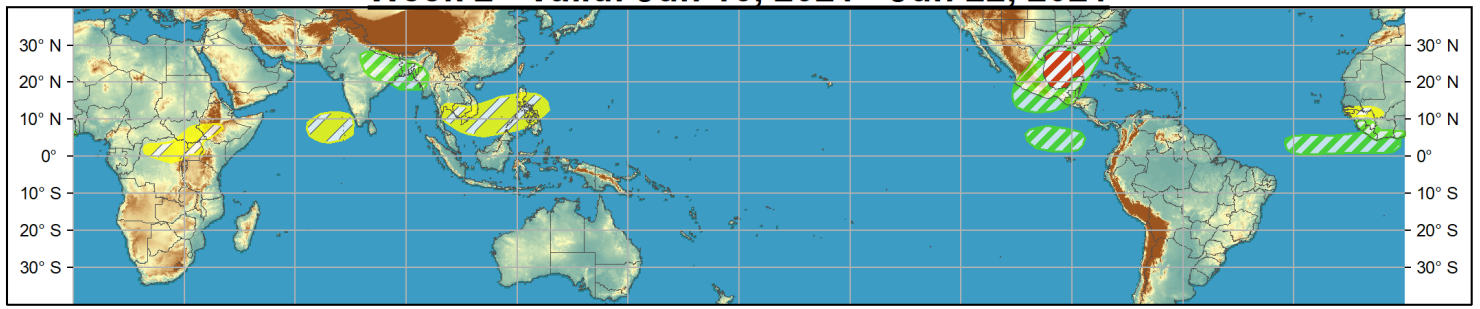
Background

Global Tropics Hazards and Benefits Outlook - Climate Prediction Center

Week 1 - Valid: Jun 09, 2021 - Jun 15, 2021



Week 2 - Valid: Jun 16, 2021 - Jun 22, 2021



Produced: 06/08/2021

Forecaster: Novella

	Confidence (High / Moderate)	
Tropical Cyclone Formation		Development of a tropical cyclone (tropical depression - TD, or greater strength).
Above-average rainfall		Weekly total rainfall in the upper third of the historical range.
Below-average rainfall		Weekly total rainfall in the lower third of the historical range.
Above-normal temperatures		7-day mean temperatures in the upper third of the historical range.
Below-normal temperatures		7-day mean temperatures in the lower third of the historical range.

Product is updated once per week, except from 6/1 - 11/30 for the region from 120E to 0, 0 to 40N. The product targets broad scale conditions integrated over a 7-day period for US interests only. Consult your local responsible forecast agency.

Global Tropics Hazards and Benefits Outlook Discussion

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

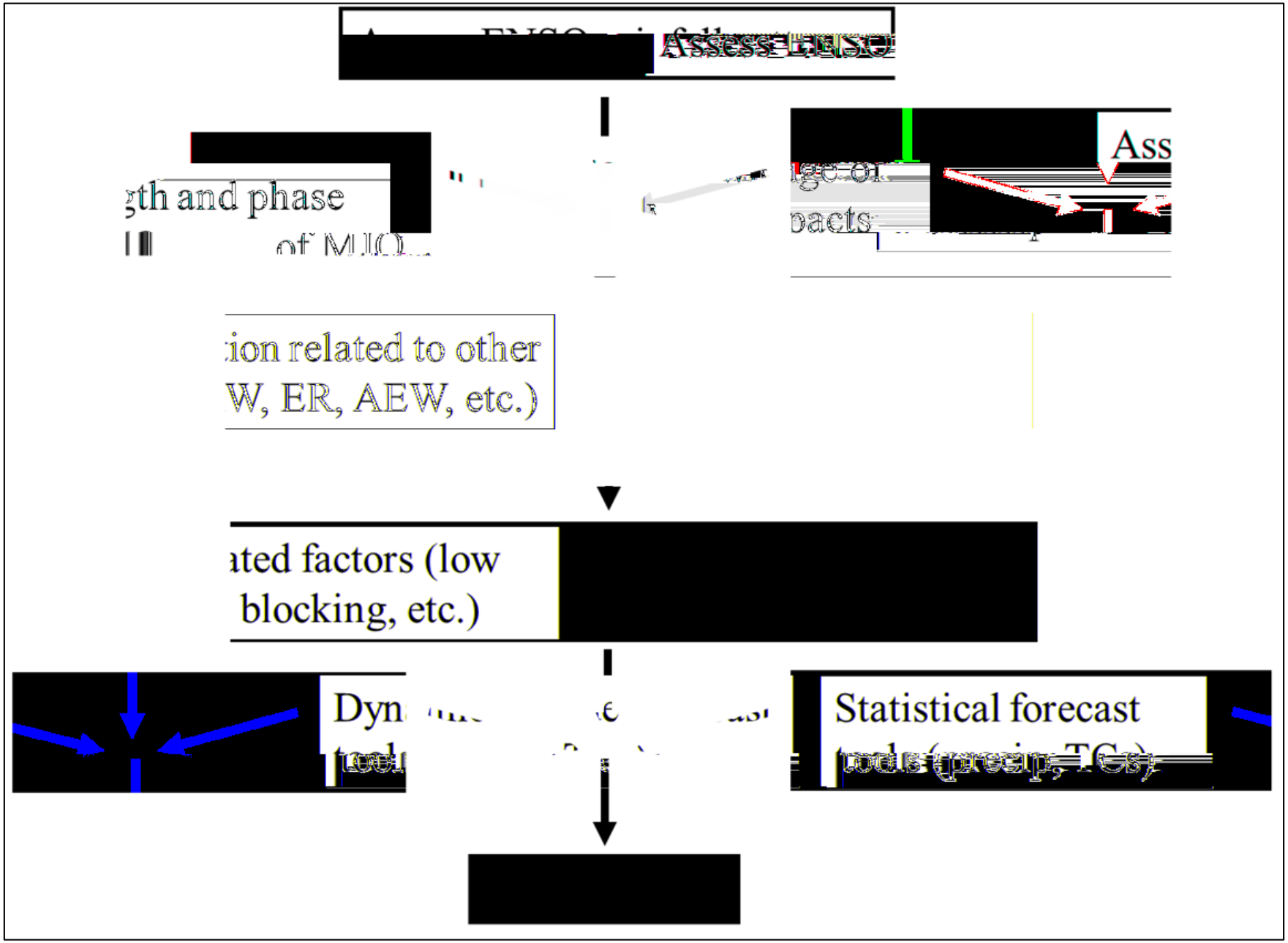
There is a weak MJO signal apparent in both the RMM-based and CPC velocity potential-based indices, with the enhanced (suppressed) phase over Africa and the far western Indian Ocean (western and central Pacific). The presence of an intraseasonal signal is more apparent in the wind field than the convective 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 forecasts a 90 percent chance of tropical cyclone formation over the next 5 days. Additionally, a tropical wave currently over Central America has a 90 percent chance of development per NHC during the next 5 days after emerging over the East Pacific and moveing westward to the south of El Salvador, Guatemala, and Mexico. The GFS forecasts both of these systems to become intense hurricanes, and also shows a third tropical cyclone formation during late Week-1 or early Week-2. Based on these forecasts, a broad high confidence tropical cyclone formation area is depicted on the outlook during Week-1. A smaller moderate confidence region is maintained during Week-2, in case the potential third system develops at the beginning of that period. Over the West Pacific, the GFS ensembles show potential development early in the period east of the Philippines, with a second potential tropical cyclone forming near or north of Guam. Both of these potential formation regions were covered with a single high confidence shape during Week-1 of the outlook period. For Week-2, additional tropical cyclone development is possible once again in the vicinity of Guam, with the threat extending northwestward well east of the Philippines. No tropical cyclone formation is anticipated over the Atlantic basin, but NHC is monitoring a non-tropical low pressure system anticipated to move offshore of the Carolinas along a frontal boundary, with a low potential existing for tropical or subtropical development.

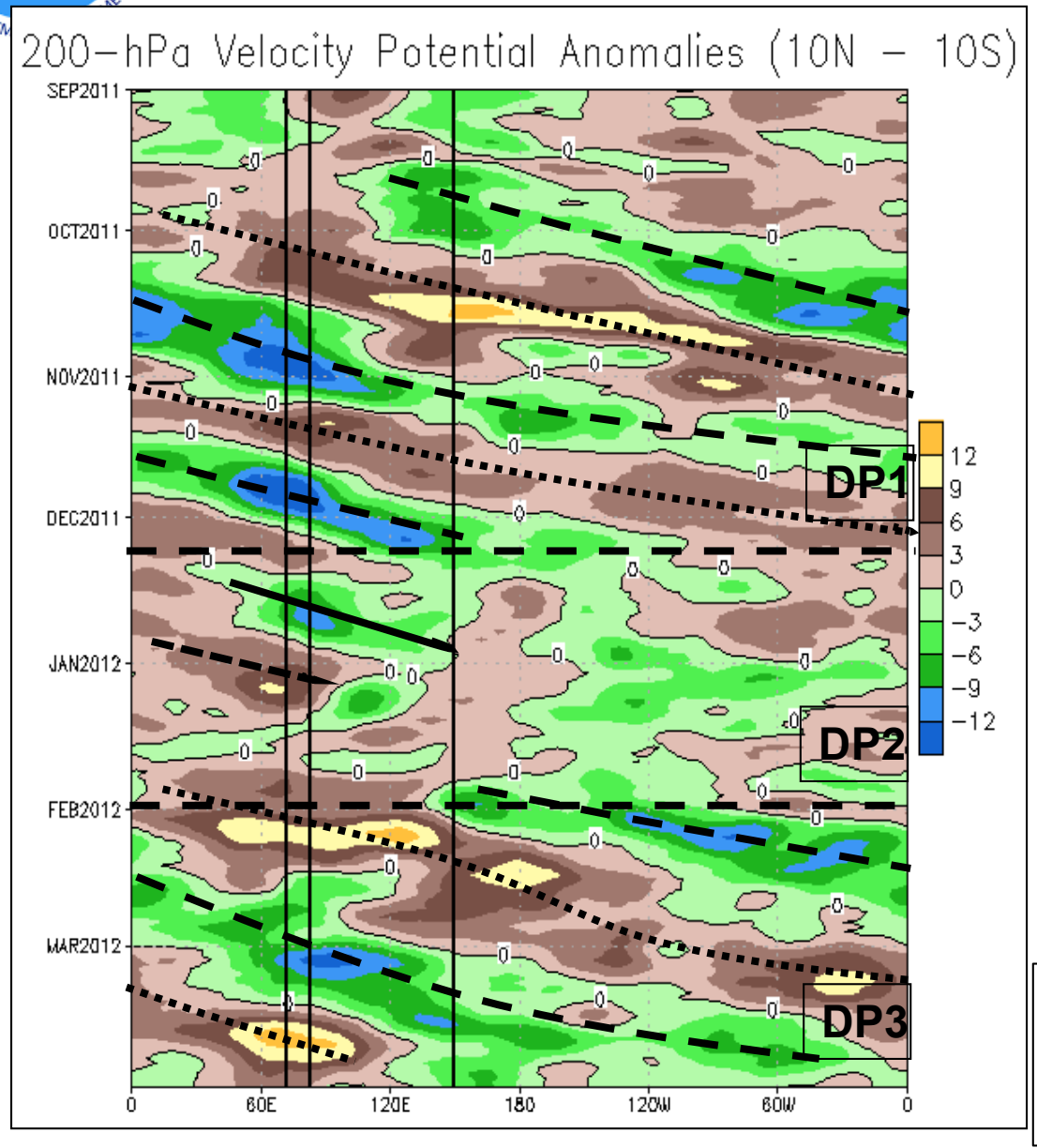
GIS Ready Formats

	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

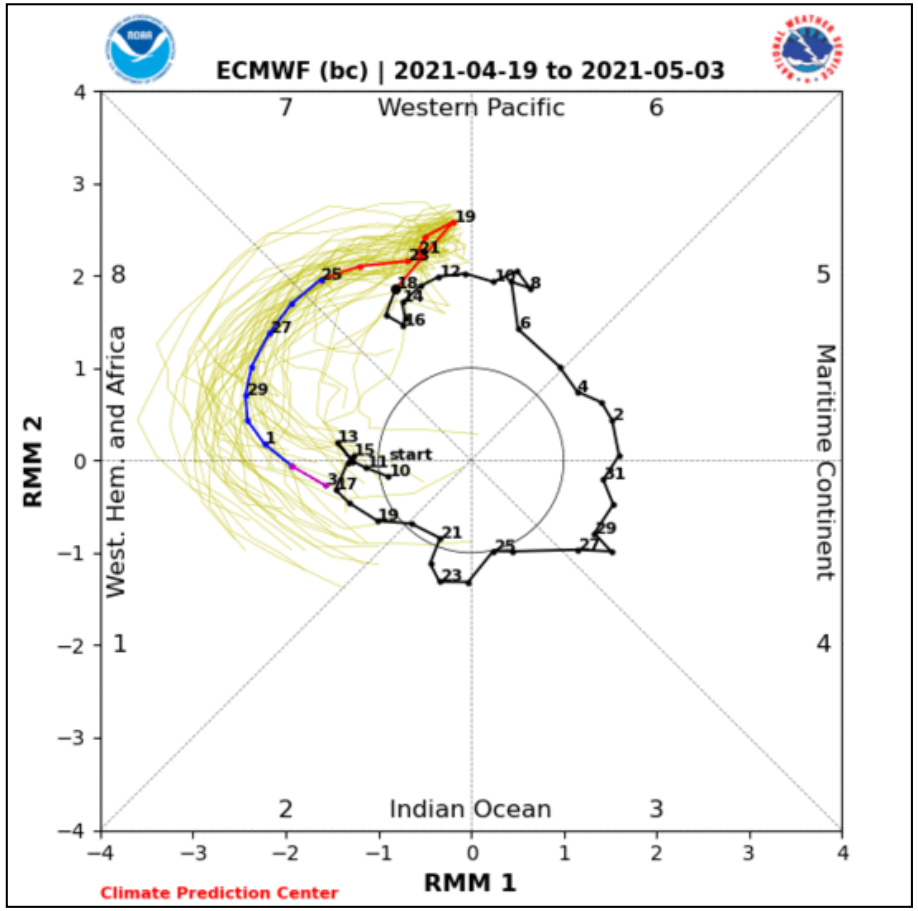
GTH Preparation – Forecast Basis



GTH Preparation – Subseasonal Climate Modes



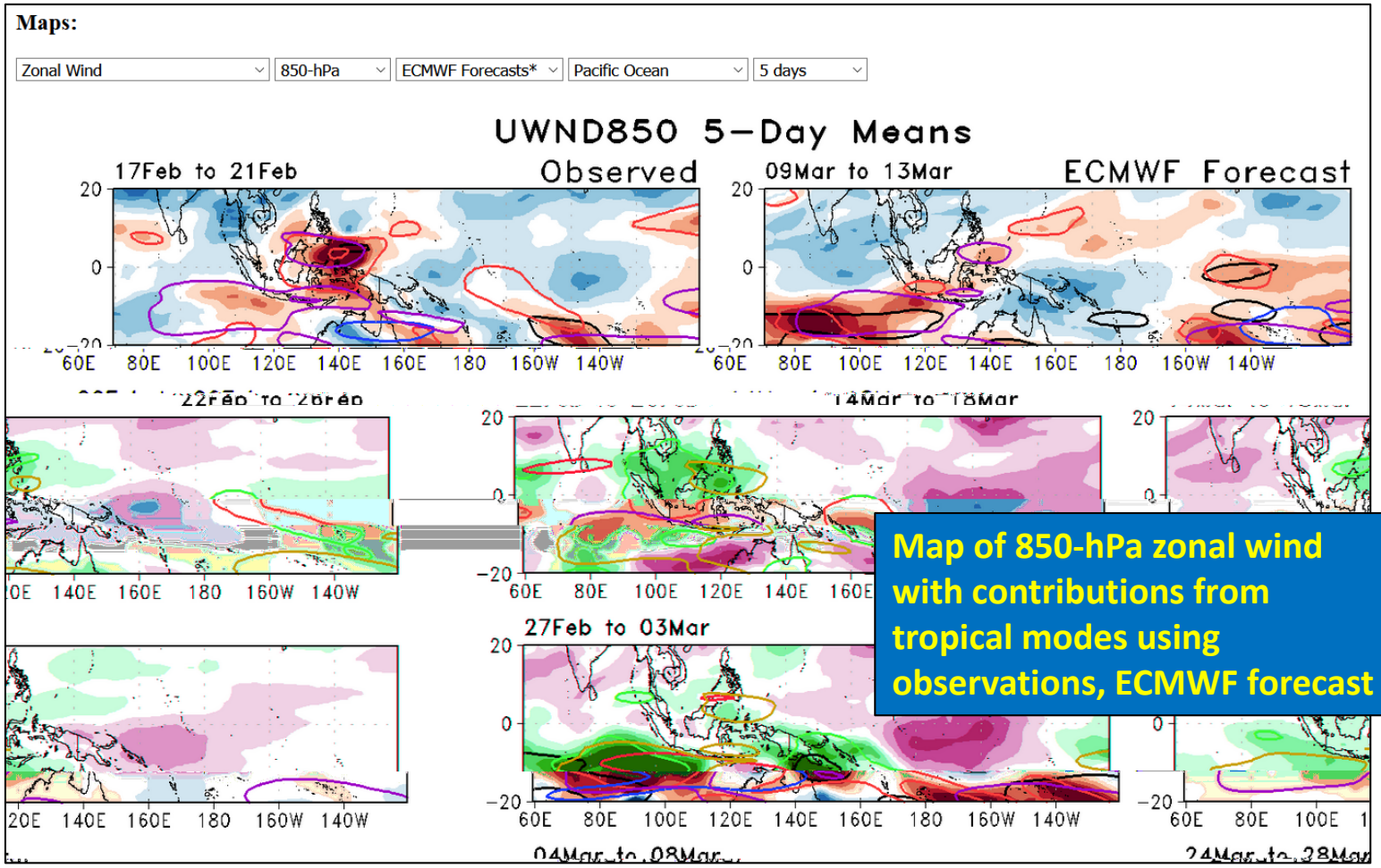
MJO plays a major role in the GTH outlook



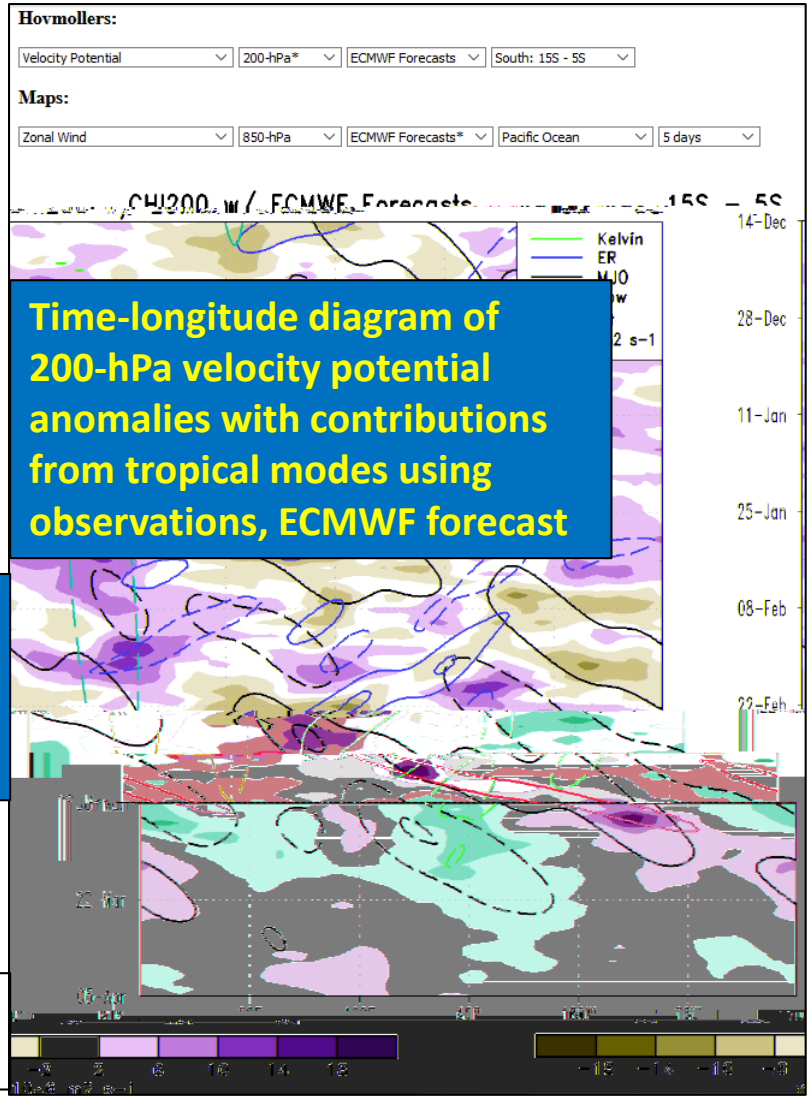
Madden and Julian (1971,1972); Rui and Wang (1990); Wheeler and Hendon (2004); Zhang (2005); Gottschalck et al. (2010); Gottschalck et al. (2013)

GTH Preparation – Subseasonal Climate Modes

Atmospheric Kelvin Waves (KWs), Equatorial Rossby Waves (ERW) and African Easterly Waves (AEWs) play substantial roles in the outlook



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

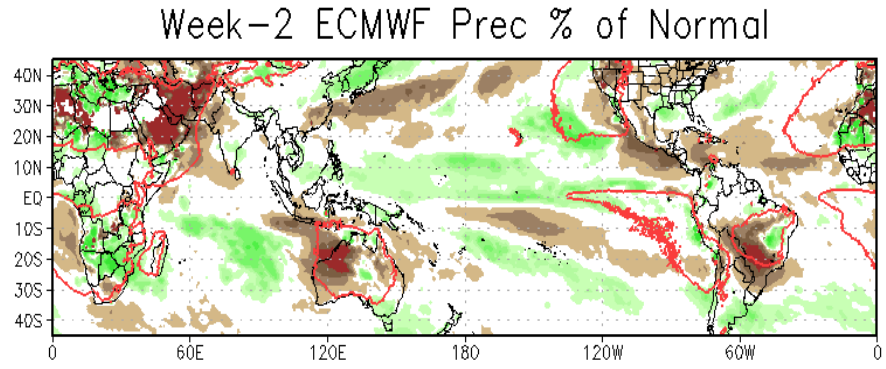


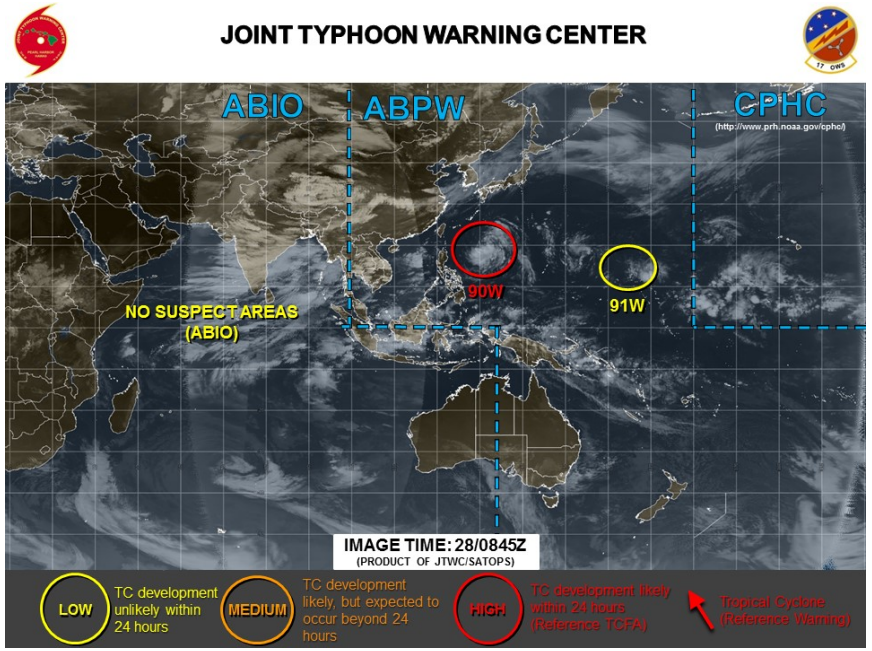
Time-longitude diagram of 200-hPa velocity potential anomalies with contributions from tropical modes using observations, ECMWF forecast

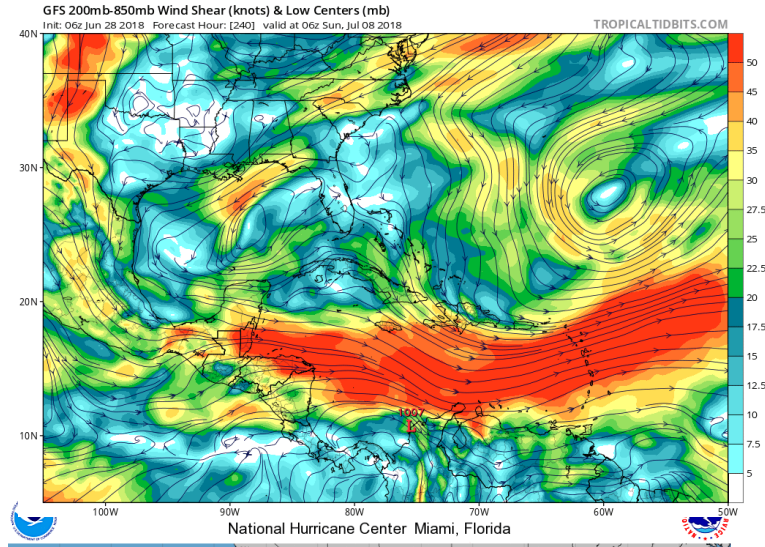
Wheeler and Kiladis (1999); Wheeler and Weickmann (2001); Maloney and Hartmann (2000); Schreck and Molinari (2011); Schreck et al. (2012); Schreck (2015); Janiga et al. (2018), etc.

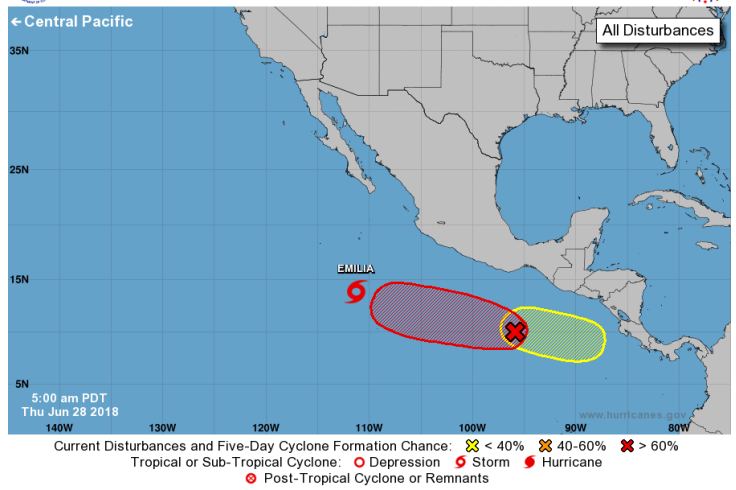
GTH Preparation – Model Guidance / Coordination

- Model guidance from NCEP (GEFS, CFS), ECMWF and ECCC inform the GTH outlook
- Current assessments and coordination with tropical cyclone operational centers that wish to collaborate
- Statistical / hybrid forecast tools inform the GTH outlook









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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.

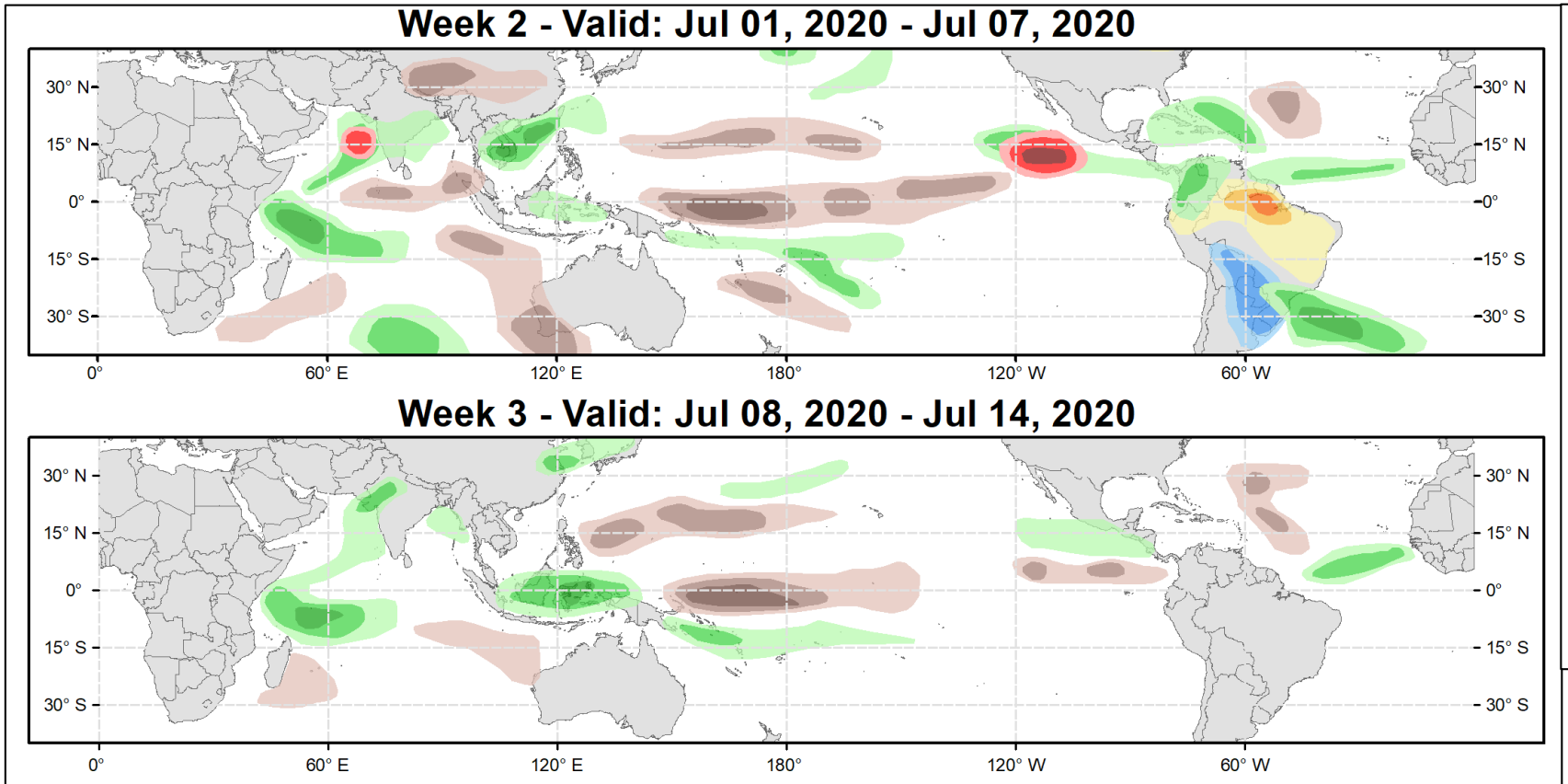
To support these changes, objectively derived probabilistic dynamical model and statistical / hybrid forecast tool information has been derived to inform the new GTH product.

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



Issued: 06/23/2020
Forecaster: Novella

This product is updated once per week and targets broad scale conditions integrated over a 7-day period for US interests only.
Consult your local responsible forecast agency.

- ✓ 3-tiered probability ranges
- ✓ TC probability ranges of >20%, >40% and >60% corresponding to low, medium and high risk
- ✓ Precipitation and temperature forecasts range from >50% to >80% probabilities

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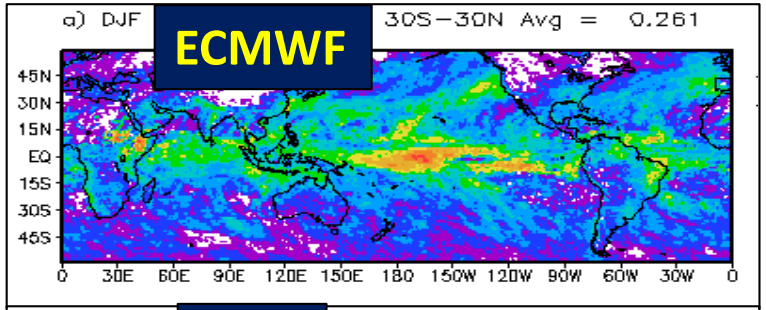
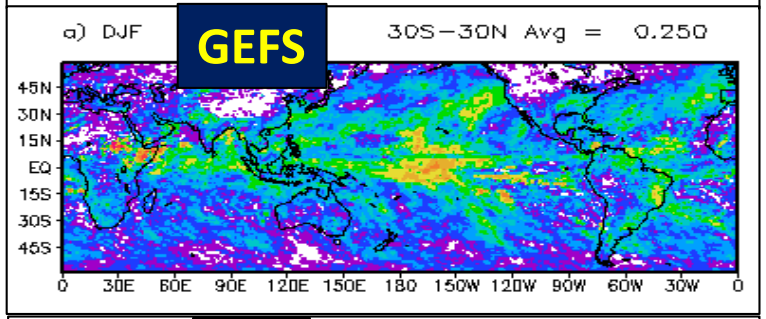
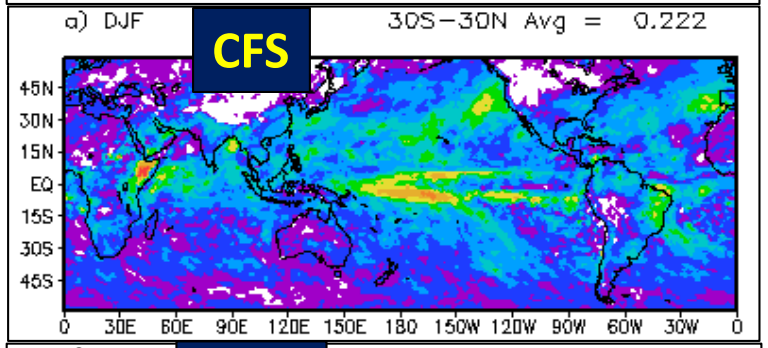
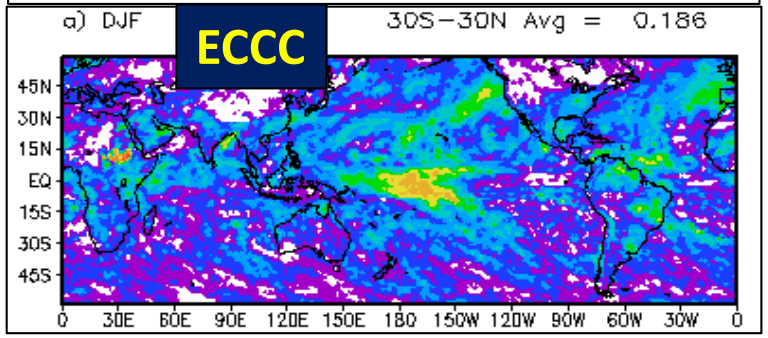
Model Guidance and Tools -- Precipitation

Week 2

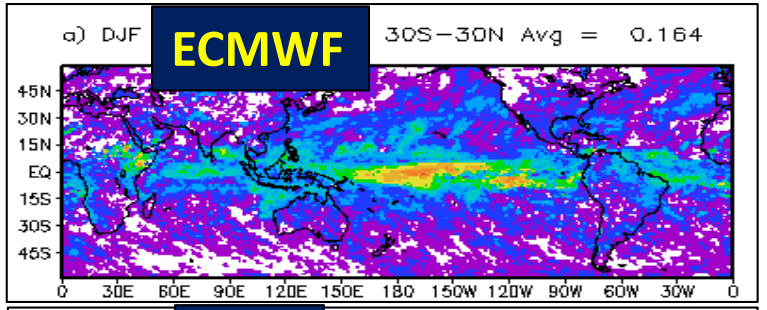


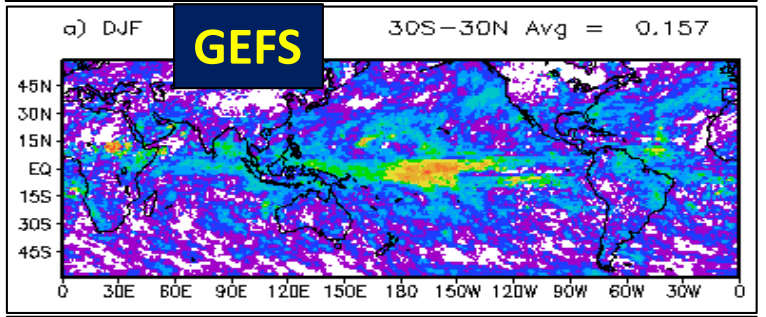


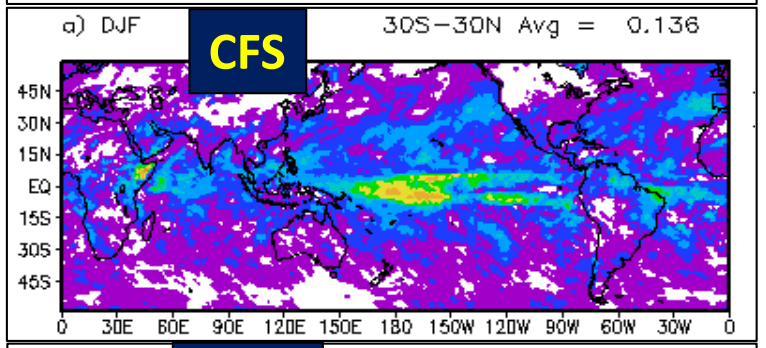


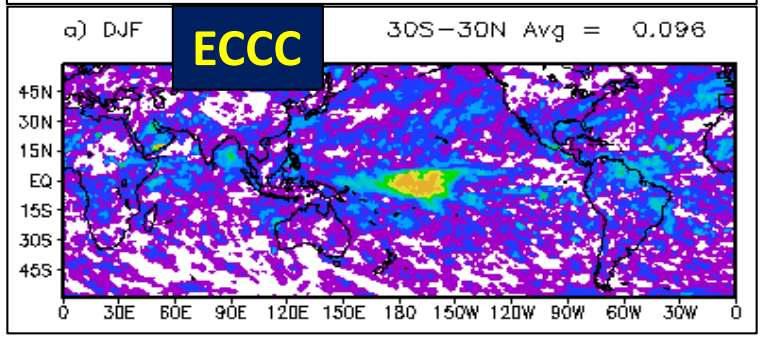


Week 3

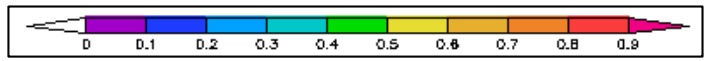








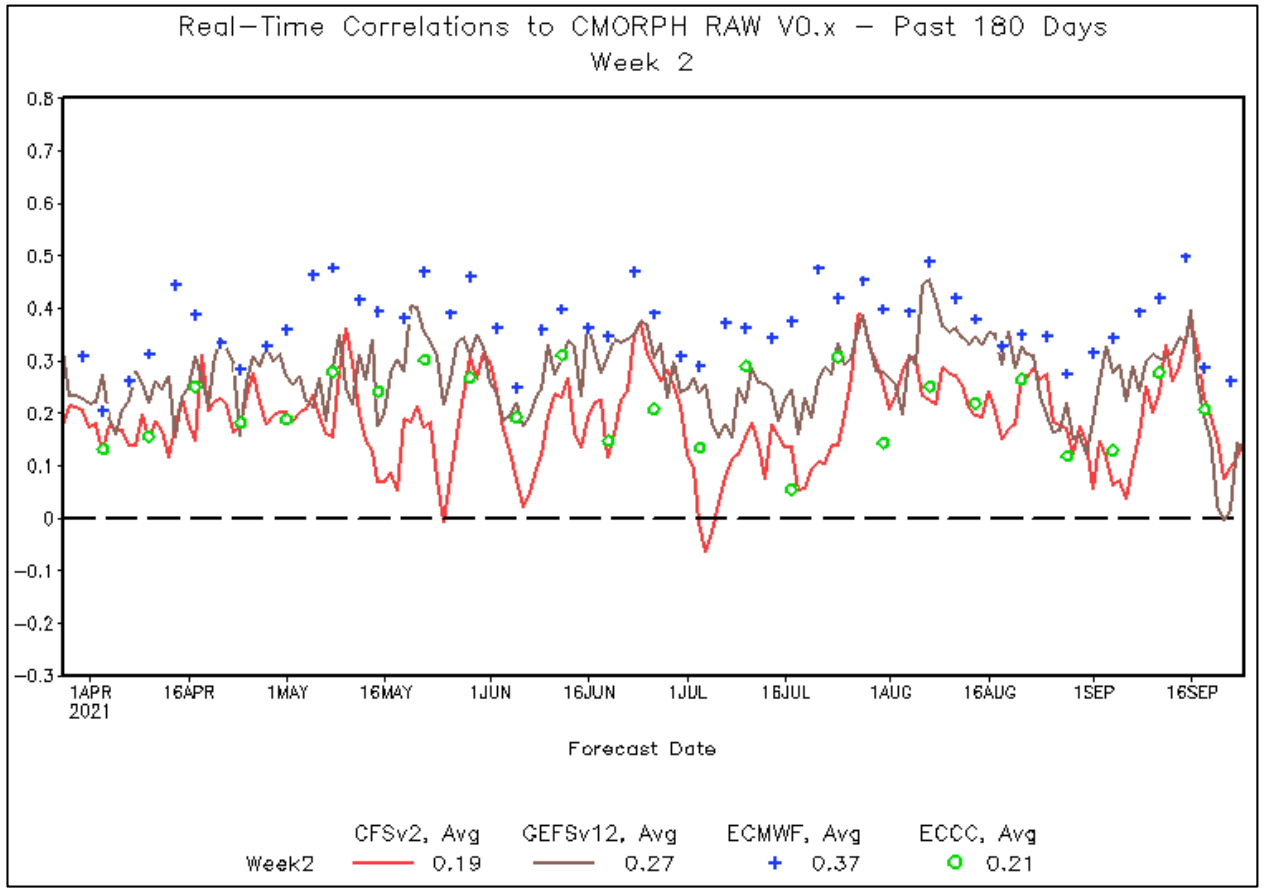
Week 2 (left) and Week 3 (right) precipitation forecast skill (AC) for Dec-Jan-Feb (DJF) from the ECMWF, GEFS, CFS, and ECCC reforecast data.



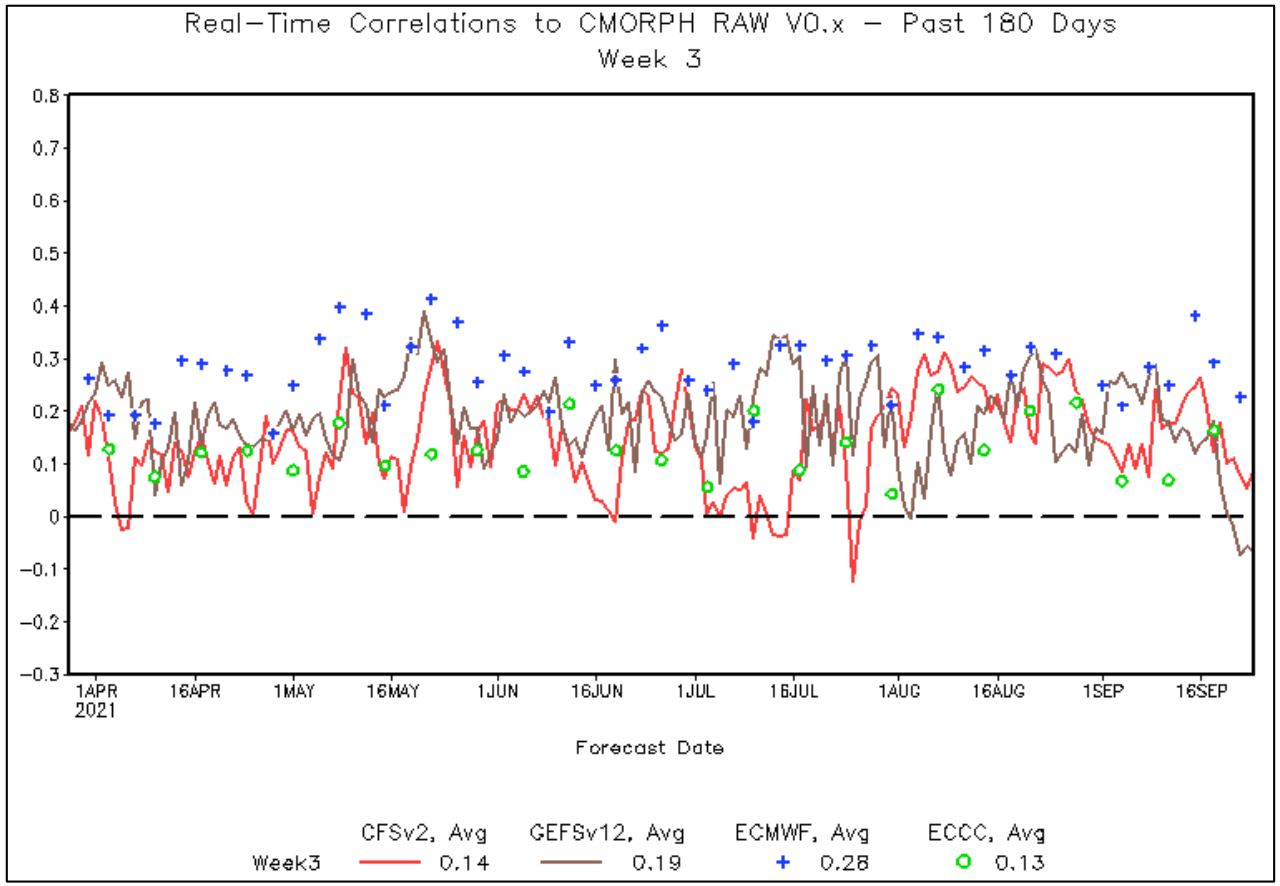
Courtesy: Lindsey Long, CPC

Model Guidance and Tools -- Precipitation

Week 2



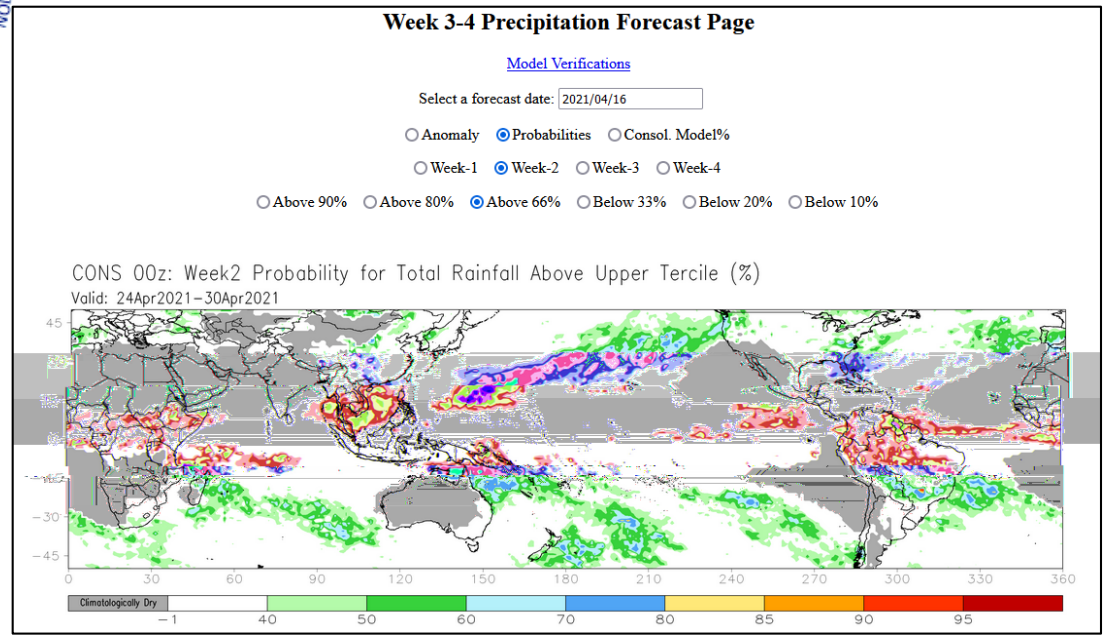
Week 3



Realtime weekly forecast skill (AC) for the tropical domain for Week 2 (left) and Week 3 (right) from the CFS(red), GEFS(brown), ECMWF(blue +) and ECCC (green circle) ensemble modeling systems over the last 180 day period from April to September 2021.

Courtesy: Lindsey Long, CPC

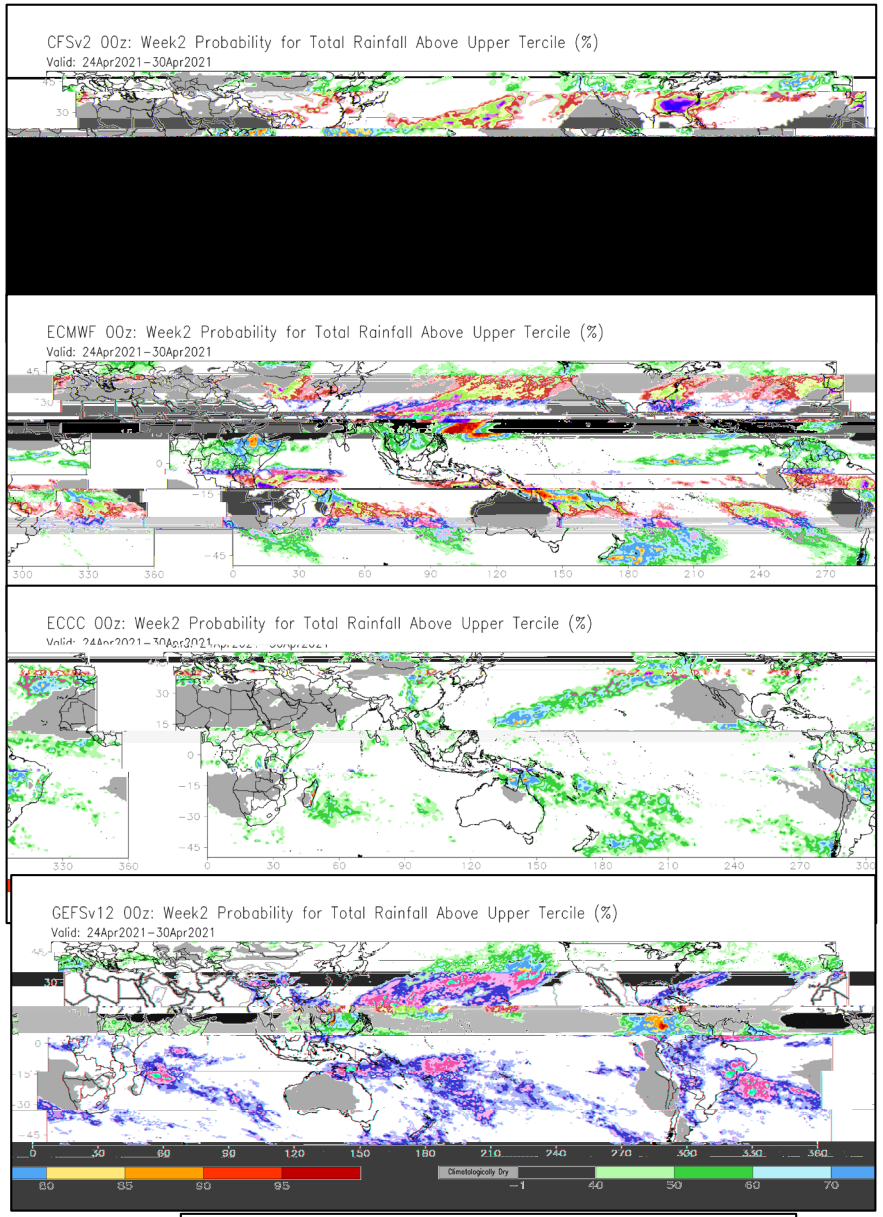
Model Guidance and Tools -- Precipitation



Forecast probability maps from the CFS, ECMWF, ECCC and GEFS for Weeks 1-4

Multiple probability thresholds available

Objective, historical skill-weighted consolidation anomaly and probability forecast available

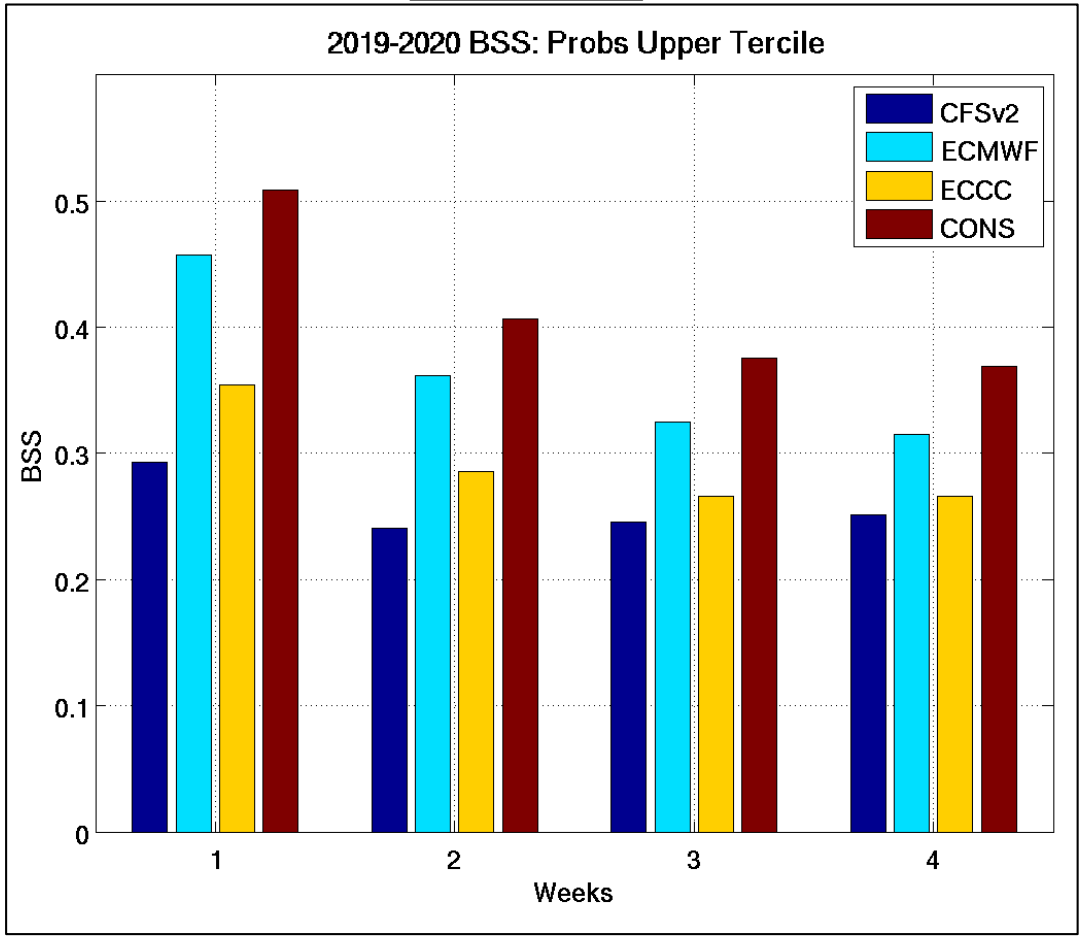


Week 2

Courtesy: Nick Novella, CPC

Model Guidance and Tools -- Precipitation

Above



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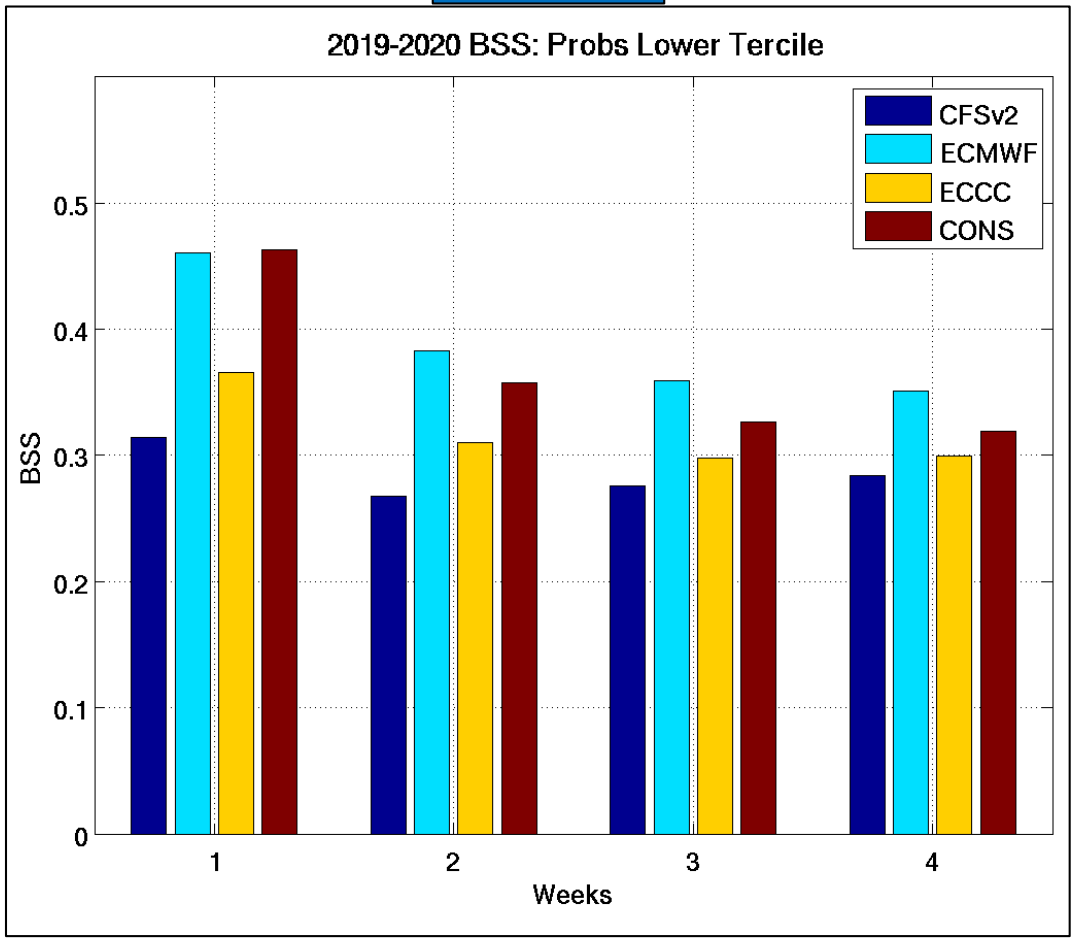
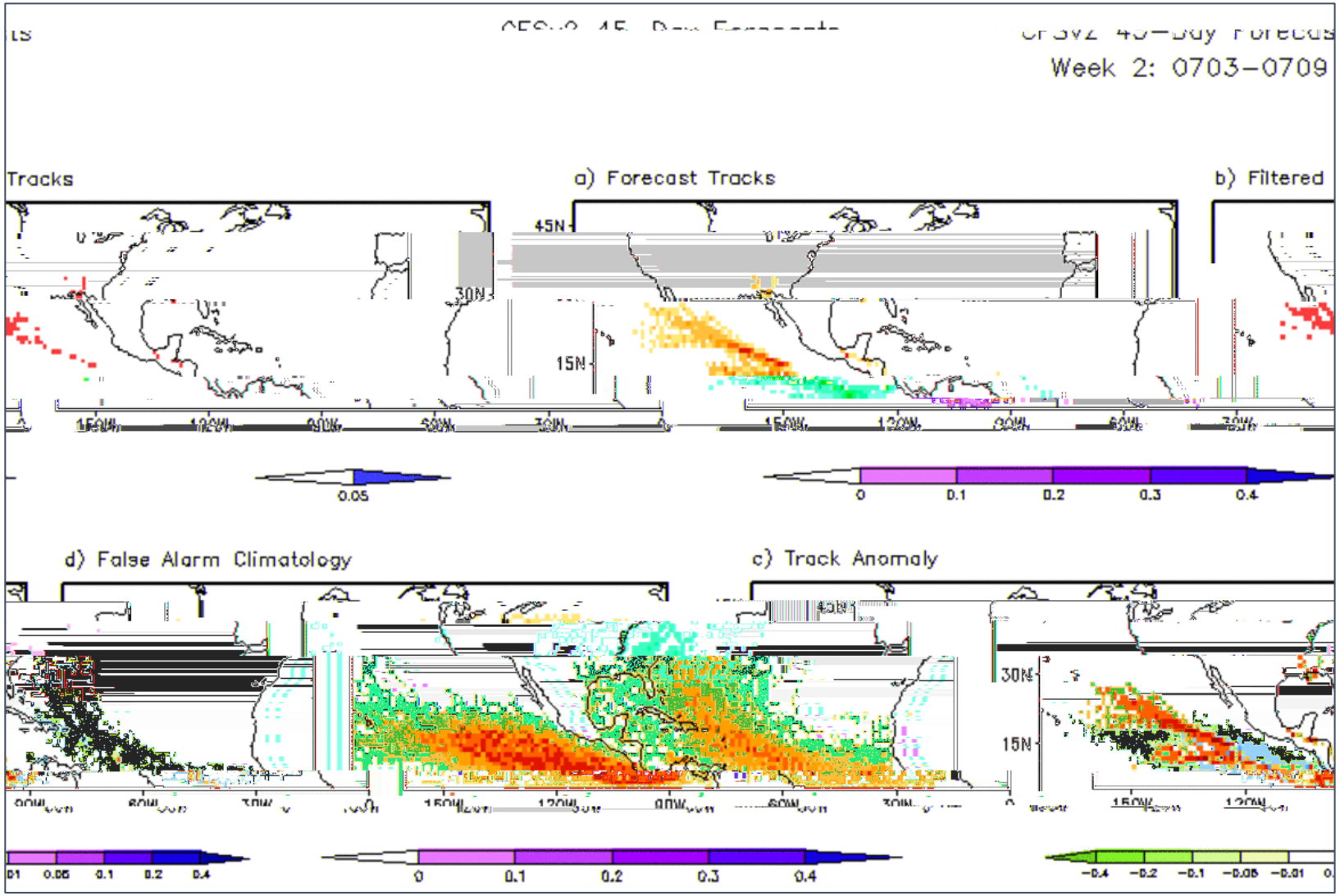


Weekly precipitation forecastskill (BSS) for 2019-2020 (DJF) for the CFS, ECMWF, ECCC and CON for Weeks 1-4.

Courtesy: Nick Novella, CPC

Model Guidance and Tools – Tropical Cyclones



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

Camargo and Zebiak (2002)

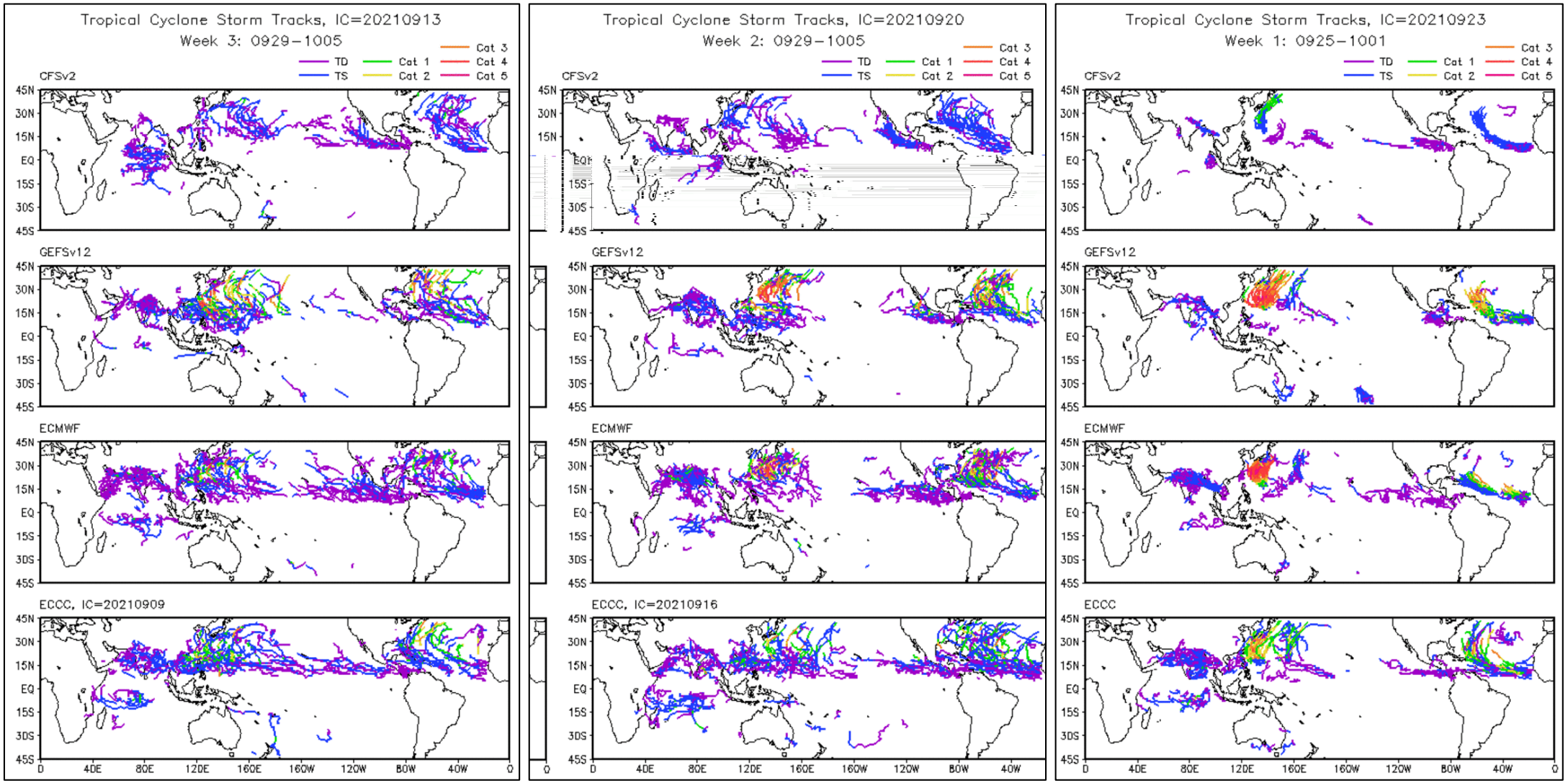
Courtesy: Lindsey Long, CPC

Model Guidance and Tools – Tropical Cyclones

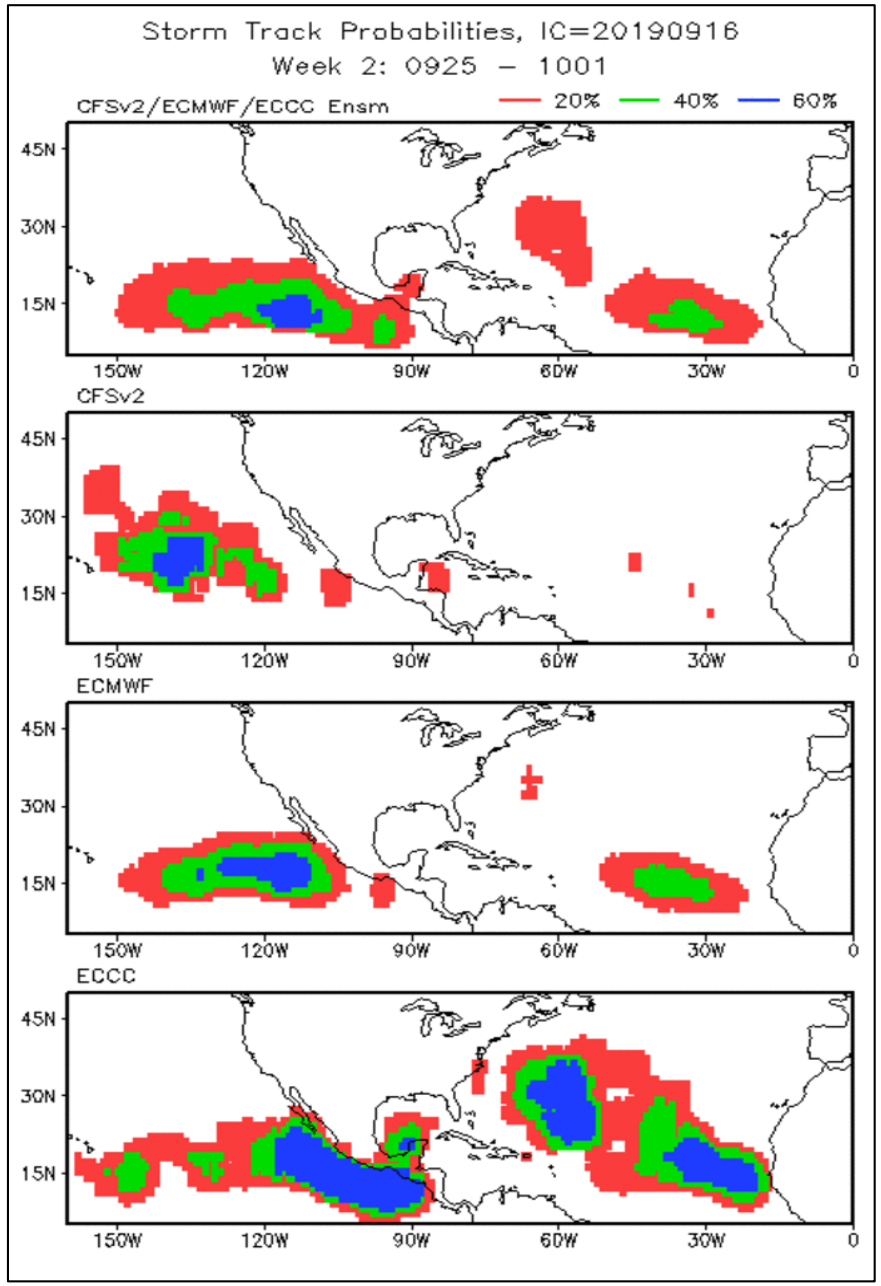
Valid Forecast Period: September 29 – October 5, 2021

Courtesy: Lindsey Long

Week 3 → **Week 2** → **Week 1**



Model Guidance and Tools – Tropical Cyclones



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).

Courtesy: Lindsey Long, CPC

Model Guidance and Tools – Tropical Cyclones

Long et al. (2021) (*to be submitted*)

Courtesy: Lindsey Long, CPC

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:

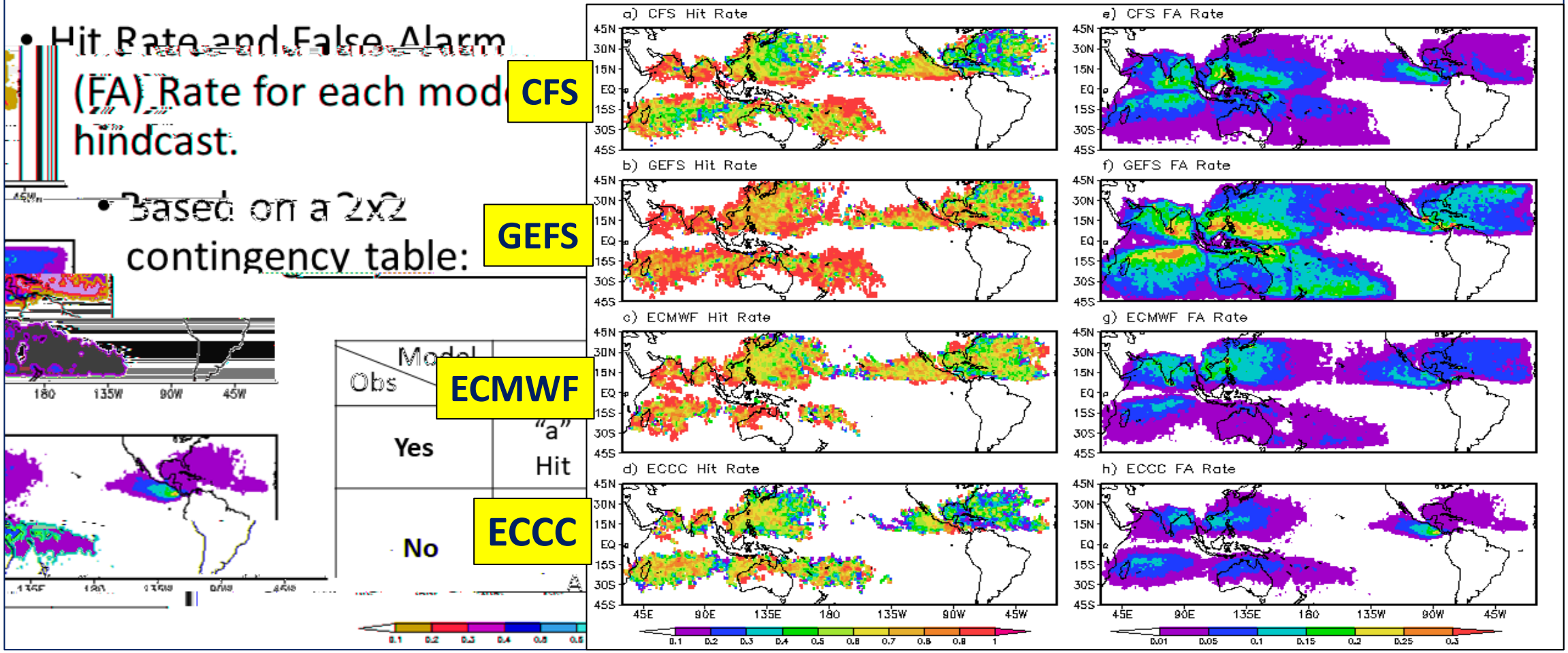
Obs \ Model	Yes	No
Yes	"a" Hit	
No		

CFS

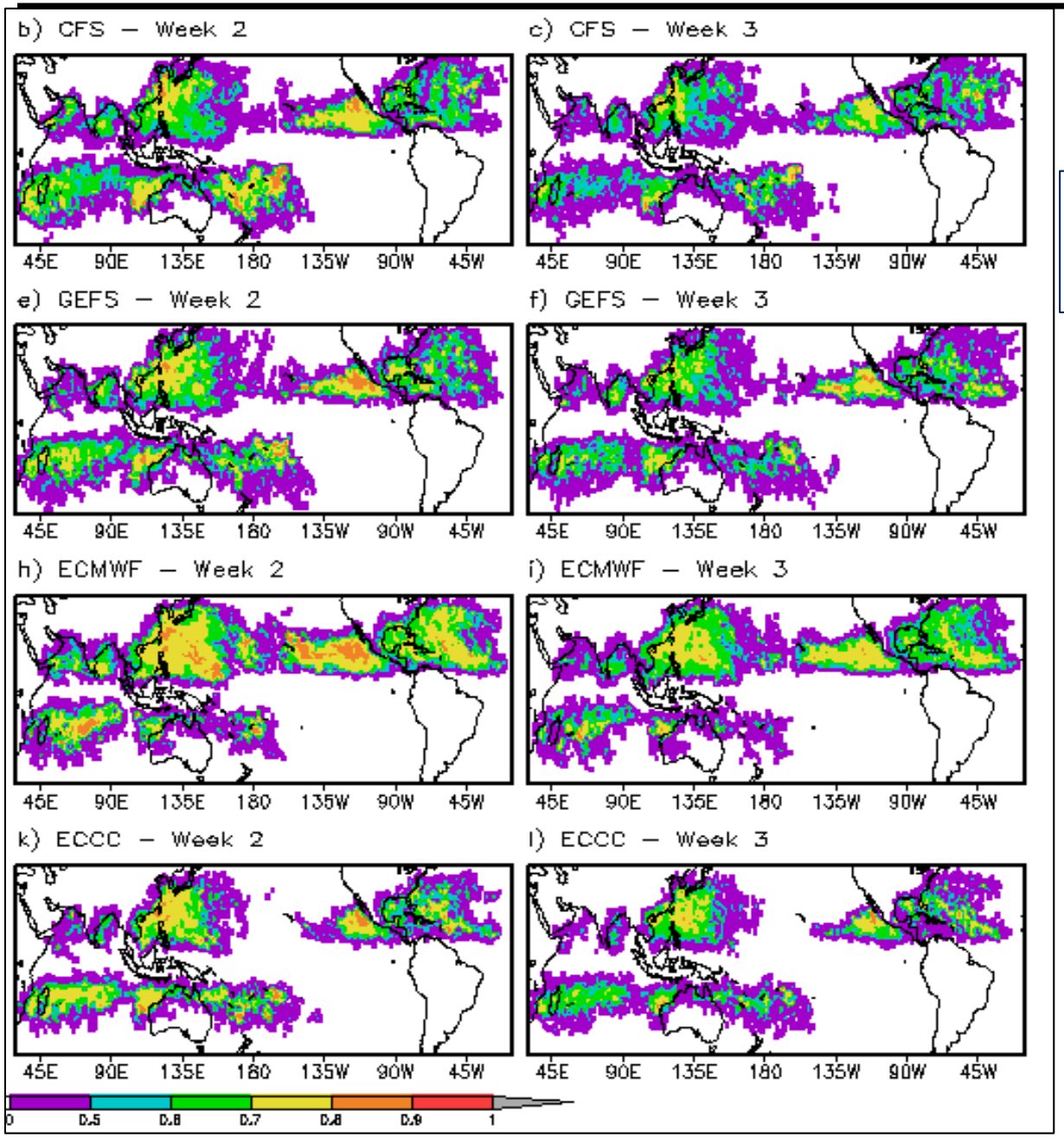
GEFS

ECMWF

ECCC



Model Guidance and Tools – Tropical Cyclones



CFS

GEFS

ECMWF

ECCC

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

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

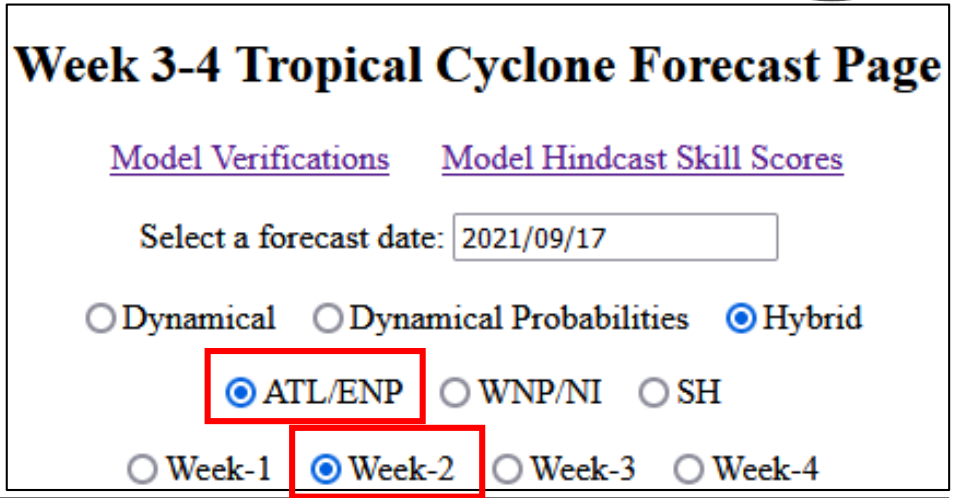
Week-2 and Week-3 SEDS based on reforecast data from CFS, GEFS, ECMWF and ECCC ensemble model forecast systems.

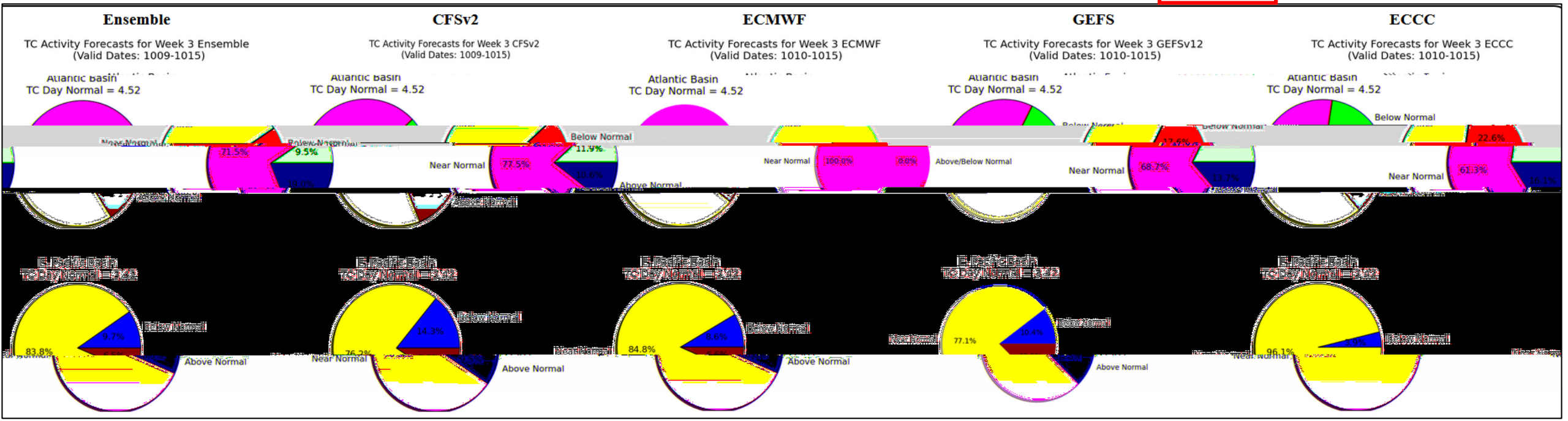
Courtesy: Lindsey Long, CPC

Long et al. (2021) (*to be submitted*)

Model Guidance and Tools – Tropical Cyclones

- ✓ 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)





Summary

- ✓ CPC operationally releases the Global Tropics Hazards Outlook each week that targets precipitation and temperature related hazards and regions of potential tropical cyclone development / impacts for the Week 1-2 period.

- ✓ CPC is converting the product to a probabilistic format targeting Week 2-3 with STI support

- ✓ CPC plans to release experimentally and publically during FY22. CPC is working with partners and collaborators to ensure they are comfortable with and how best to perform outreach.

- ✓ With STI support, forecast skill evaluation continues for both precipitation and TC related model guidance products utilizing CFS, ECMWF, GEFS and ECCC ensemble data from both a reforecast and realtime perspective.

Thank you for your time and attention

Jon.Gottschalck@noaa.gov

Backup Slides

Model Guidance and Tools – Tropical Cyclones

Long et al. (2021) (*to be submitted*)

Courtesy: Lindsey Long, CPC

Tropical Cyclone Skill – Track Week 3

$$Hit\ Rate = \frac{a}{a+c} \qquad False\ Alarm\ Rate = \frac{b}{b+d}$$

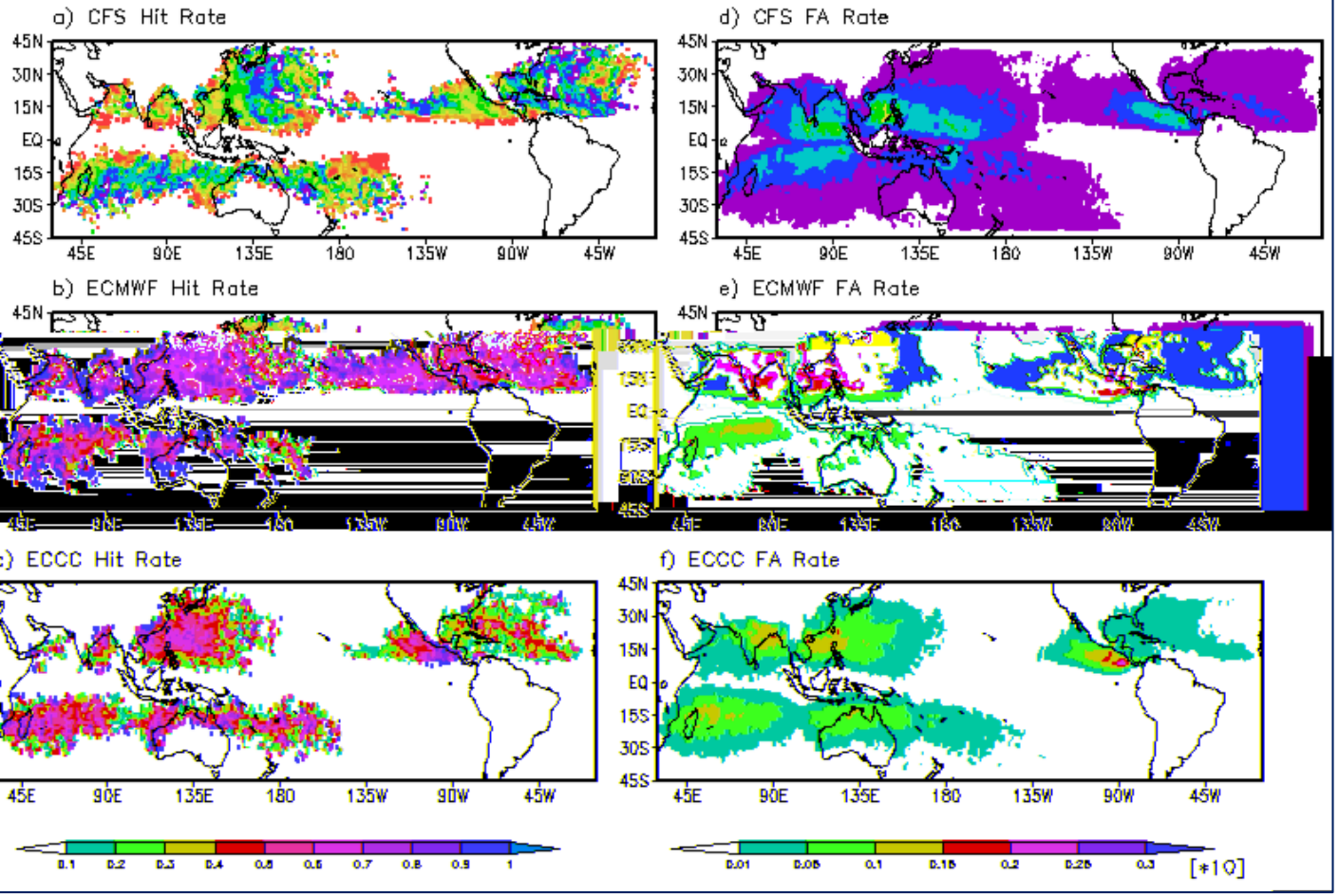
- Hit Rate and False Alarm (FA) Rate for each model hindcast.
- Based on a 2x2 contingency table:

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

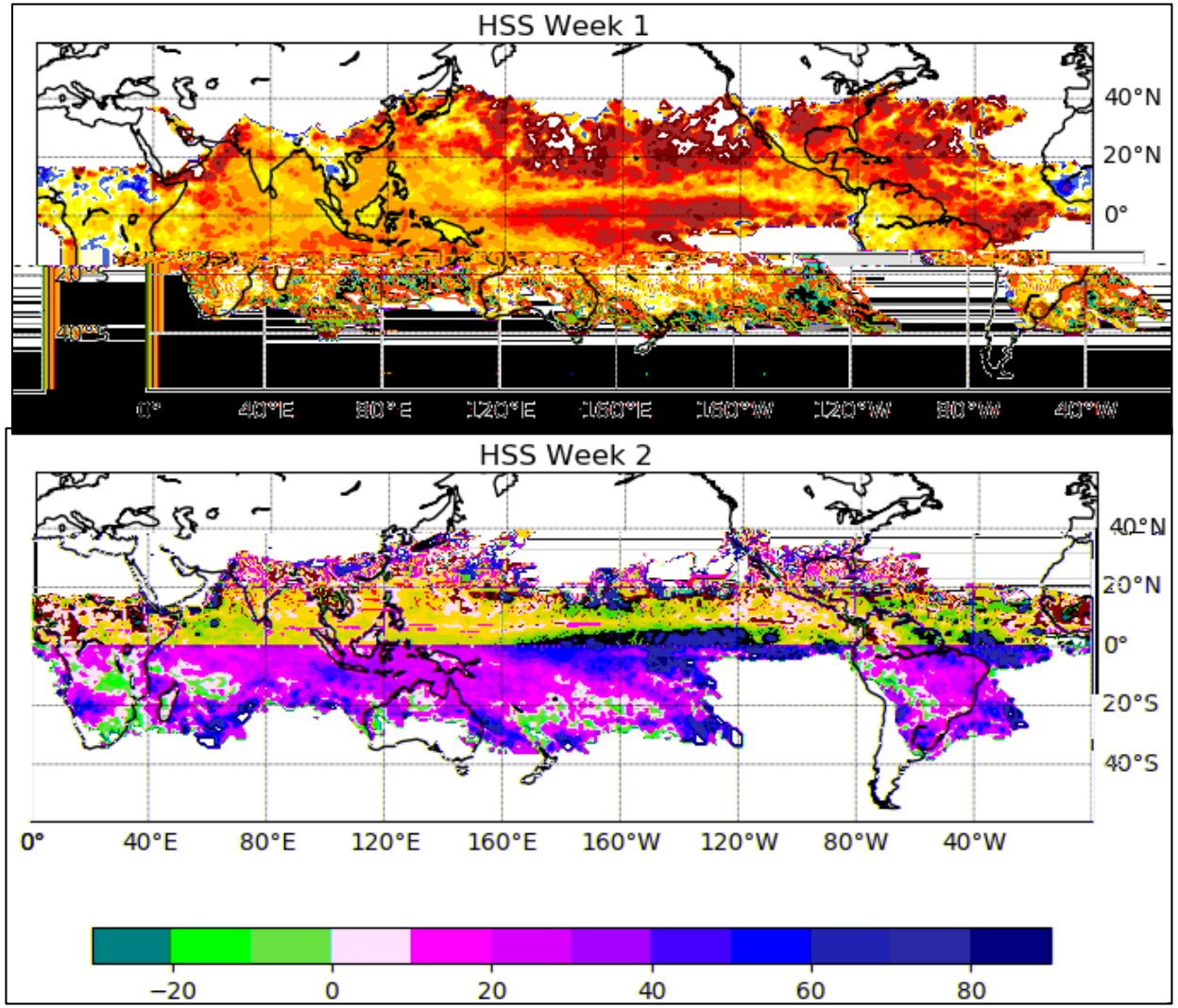
CFS

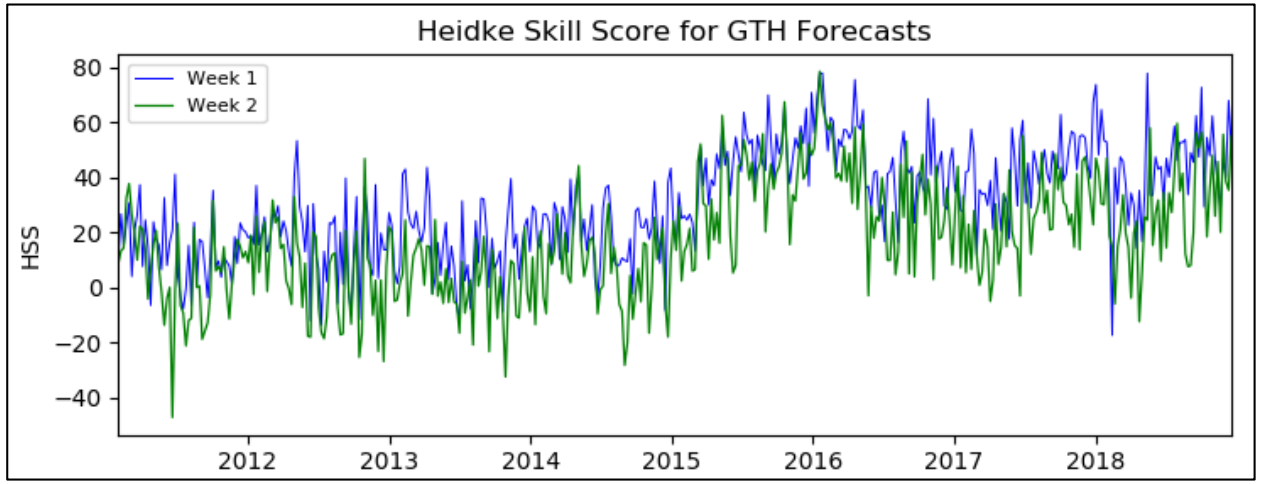
ECMWF

ECCC



GTH Operational Product Verification





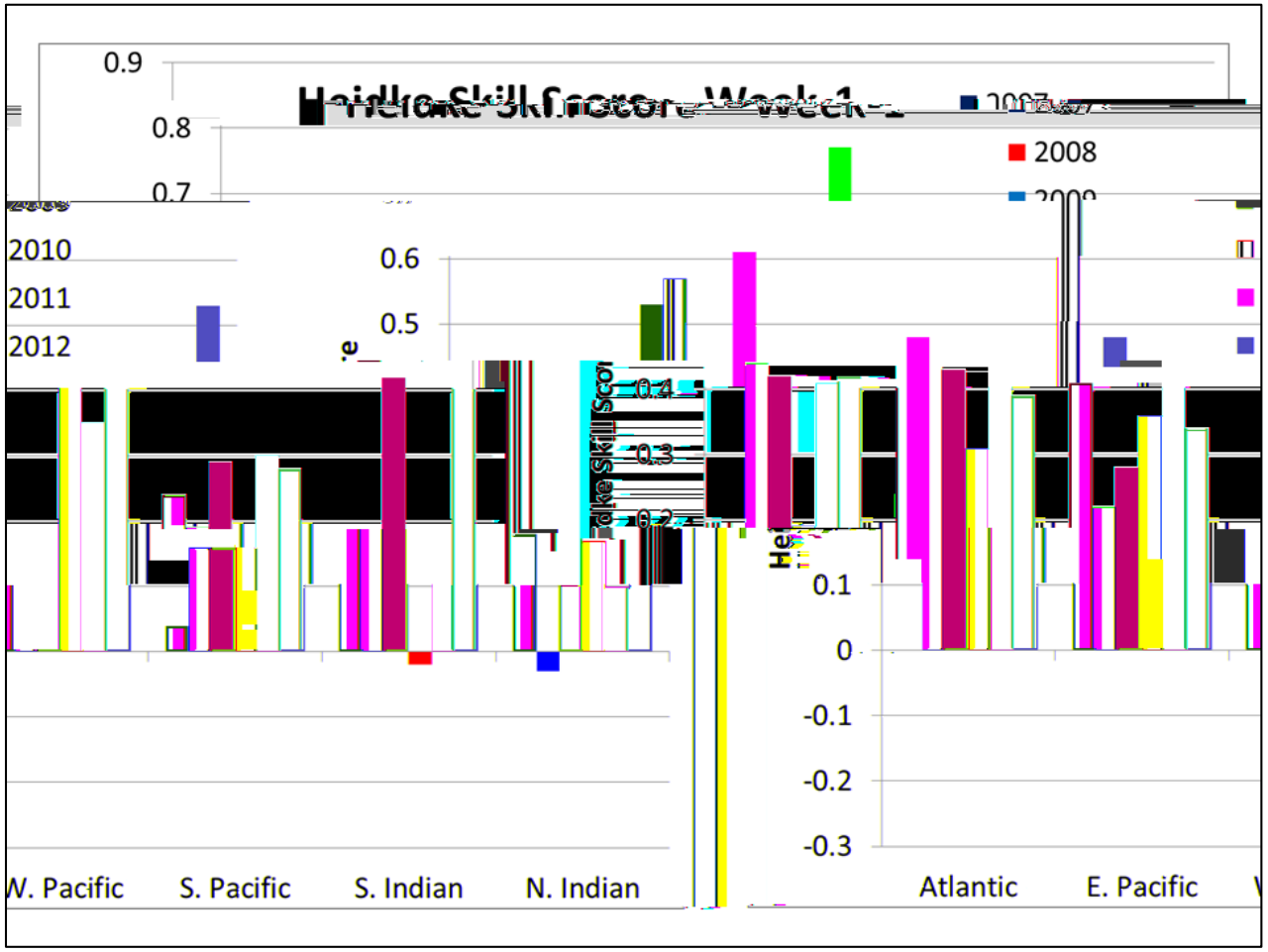
Official GTH Outlooks

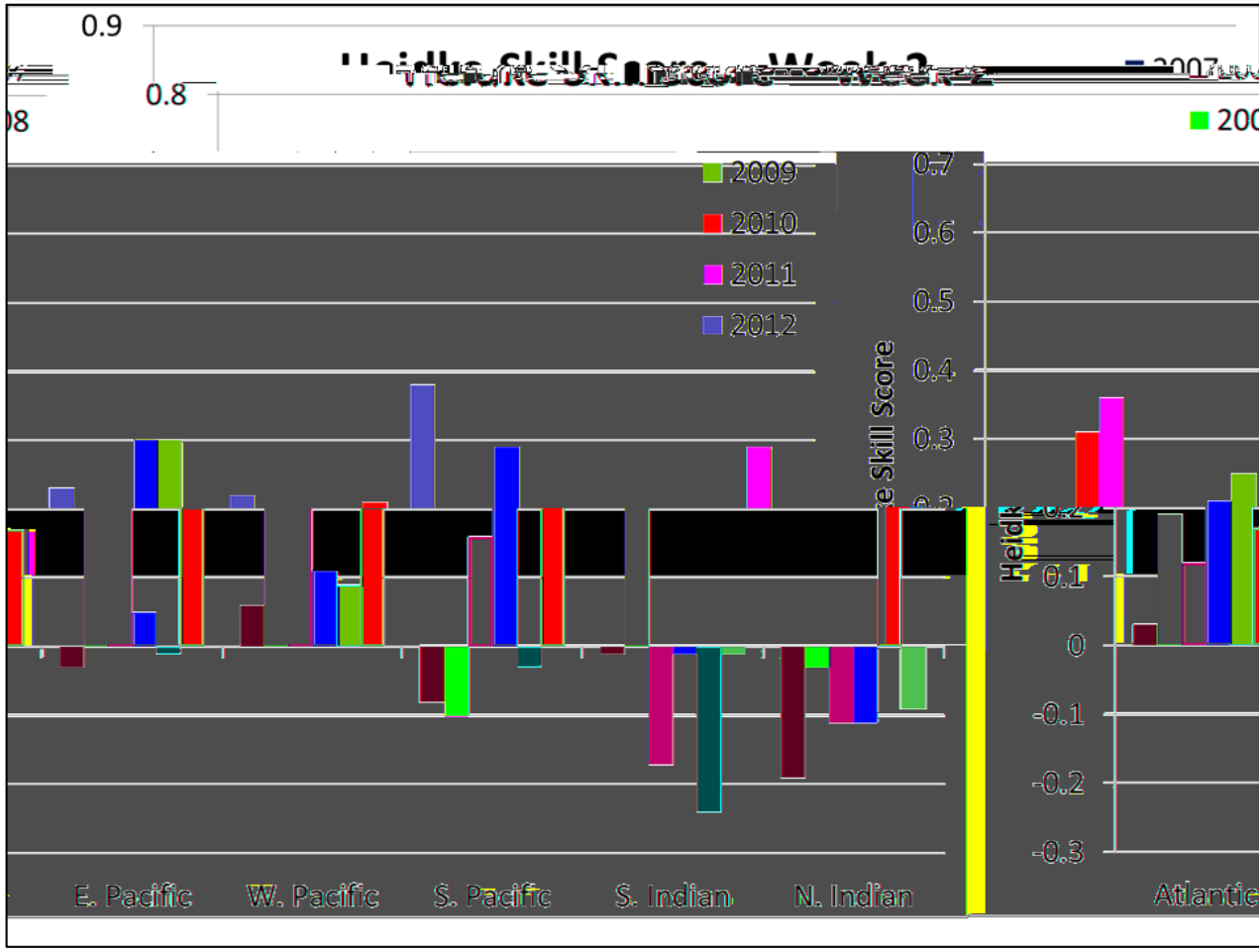
Forecast Precipitation Areas
(both above- and below-normal areas)

2011-2019 Period

Product Verification

GTH outlook TC forecast areas skill scores in the process of being updated

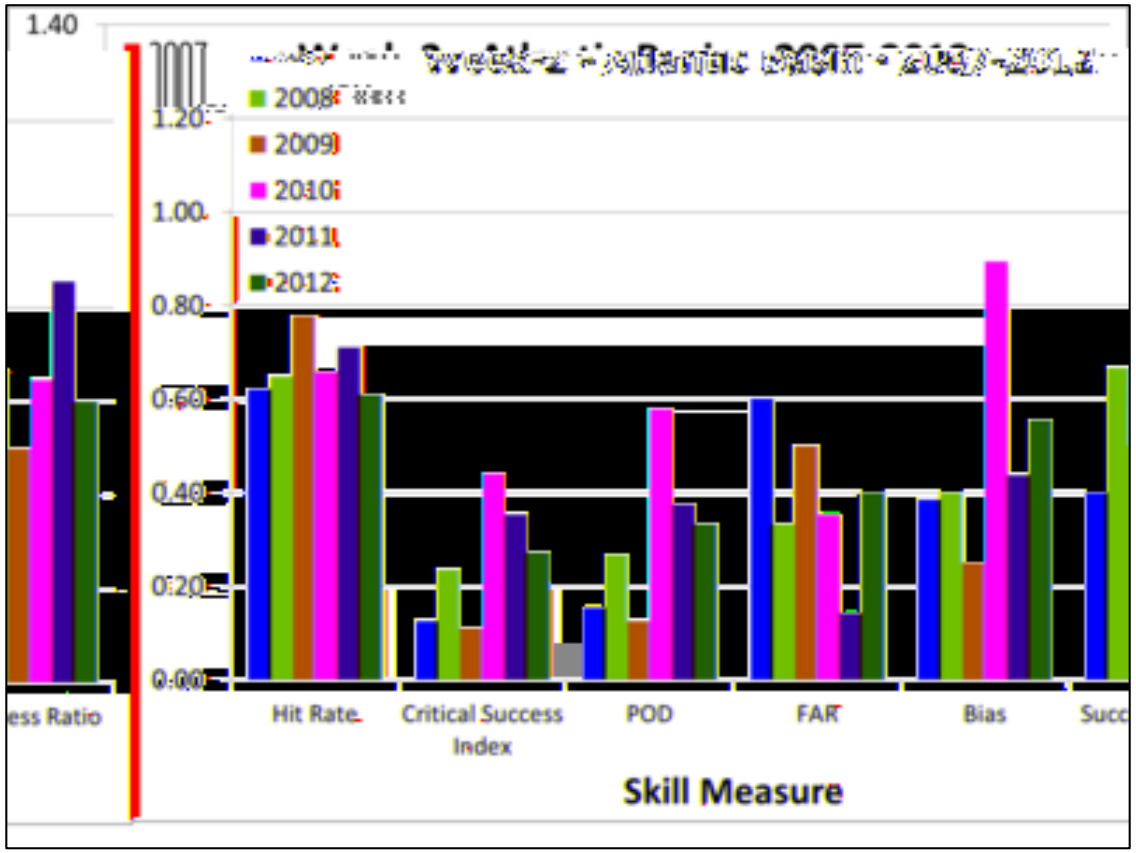


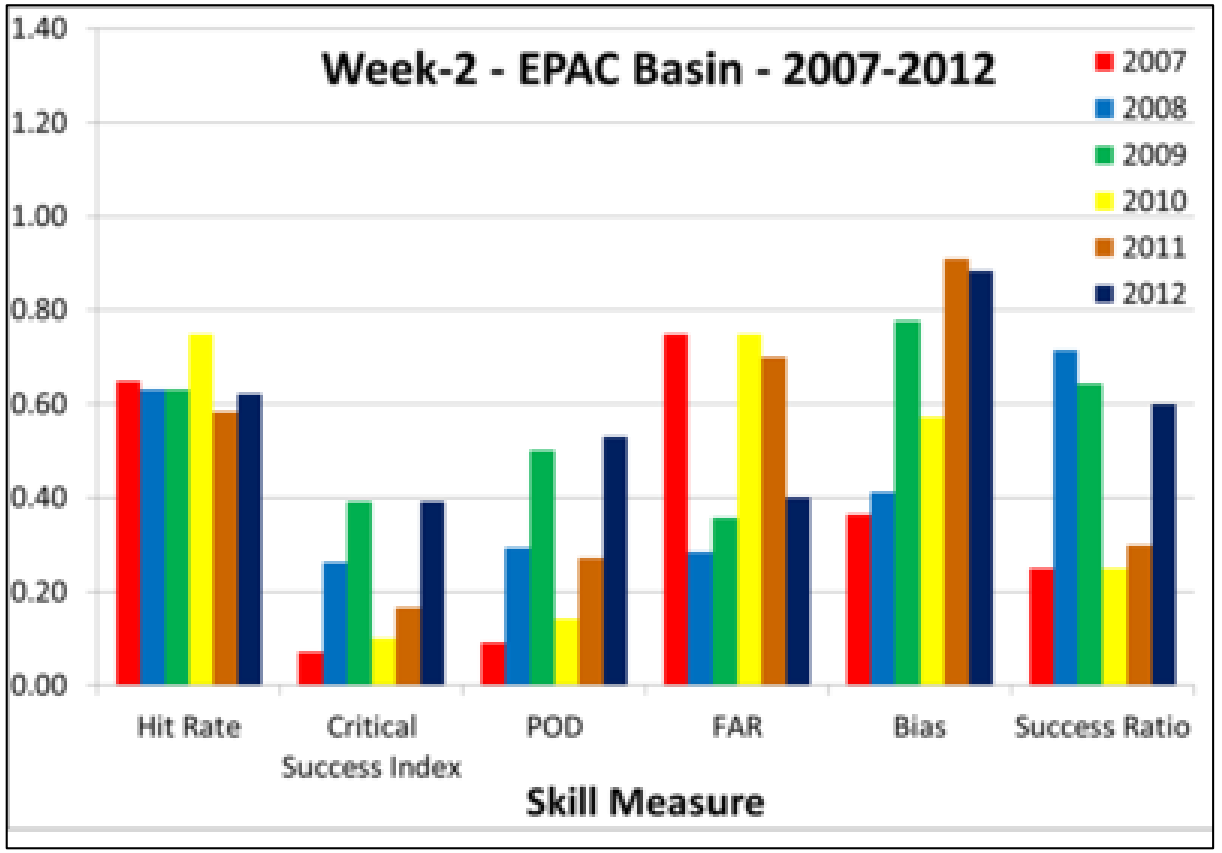


Official GTH Outlook - Tropical Cyclone Favored Development Areas, 2007-2012 Period

Product Verification

GTH outlook TC forecast areas skill scores in the process of being updated





Official GTH Outlook - Tropical Cyclone Favored Development Areas, 2007-2012 Period