

Second WMO RCC-Washington International Training Workshop

Demonstration Extreme Heat Outlooks

8 – 10 November 2021

Outline

- Introduction
 - Extreme Heat Definition
 - Causes of Extreme Heat
- Forecasting Tools
- Week-1 Extreme Heat Forecast Demonstration

Introduction

- How to define weekly extreme/excessive heat?
 - There is no standard definition
 - It is location and season dependent ... different definitions for different regions
- In this training, we focus on exceedance probability forecasts with respect to a wide range of thresholds:
 - HI and Tmax exceeding a given amount (eg. $HI > 39^{\circ}C$, $HI > 41^{\circ}C$ or $Tmax > 37^{\circ}C$, $Tmax > 39^{\circ}C$ for at least 2 or 3 consecutive days ...)
 - HI and Tmax in excess of a given percentile climatology (eg. 80th, > 85th, >90th, > 95th percentiles for at least 2 or 3 consecutive days)
- Please refer to the Heat Index (HI) equation @ https://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml

Introduction (Cont.)

- Combination of different factors may lead to excessive heat condition:
 - High insolation/clear sky condition (inland locations)
 - Calmer wind
 - Moist but stable atmosphere (coastal and island areas)
 - Large scale atmospheric patterns related to atmospheric blocking

Conducive Atmospheric Conditions for Excessive Heat

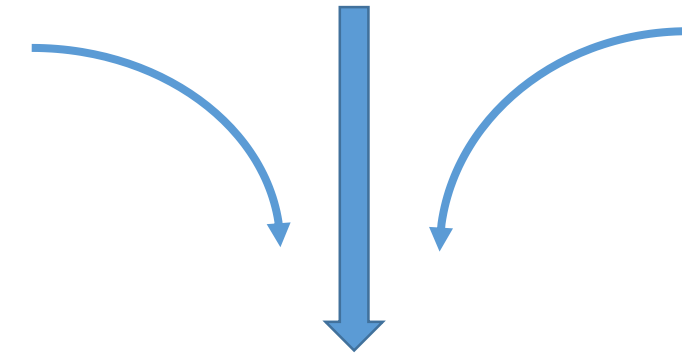
Wind Convergence => descending motion

200-hPa

500-hPa

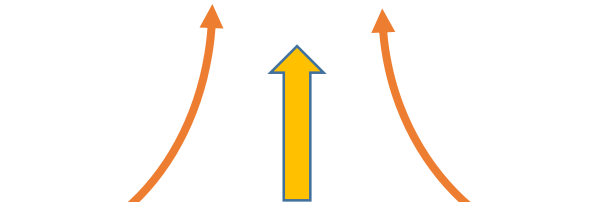
Surface

Heat Low



Higher
geopotential
height

Upward motion
is suppressed



Surface Heating

Shallow ascending motion

Calm wind (less ventilation)

Forecasting Tools

- NWP Tools
 - Large scale atmospheric patterns
 - Mean Sea Level Pressure anomalies
 - 10m wind speed, 500-hPa height, 700-hPa and 200h-hPa wind and divergence anomalies.
 - Tmax/HI exceedance probability forecasts with respect to fixed thresholds ($\geq 39^{\circ}\text{C}$, $\geq 41^{\circ}\text{C}$... $\geq 49^{\circ}\text{C}$)
 - Exceedance probability forecasts with respect to percentile climos ($\geq 80^{\text{th}}$, $> 85^{\text{th}}$, $\geq 85^{\text{th}}$, $> 90^{\text{th}}$ percentiles)
 - These exceedance probability forecasts need to be used along with the corresponding percentile climos.

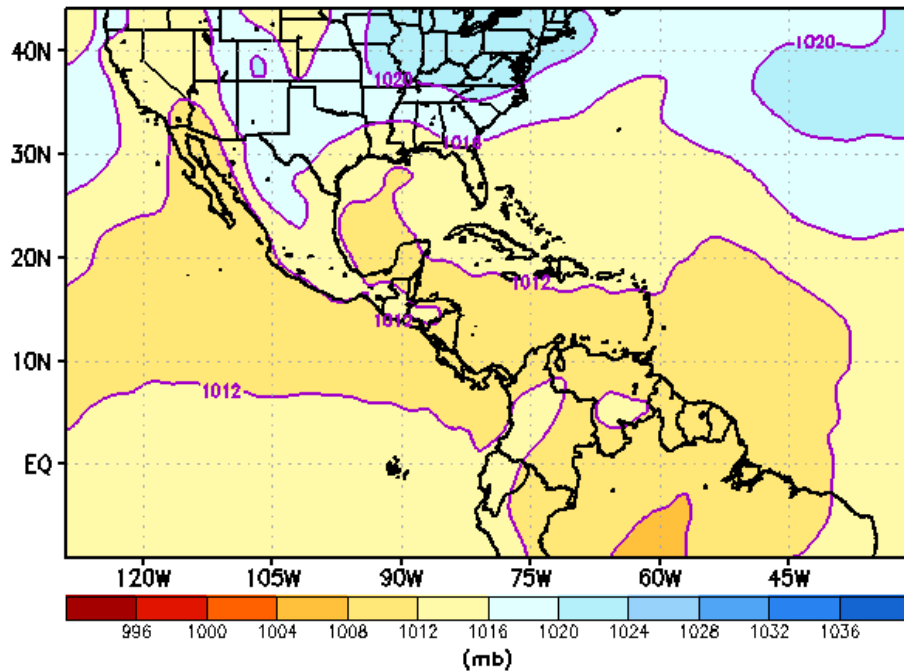
Forecast Demonstration, 14 – 20 September 2020

- Week-1 extreme Heat outlooks
 - **Date of issue:** 13 September 2020
 - **Valid period:** 14 – 20 September 2020
- Produce the week-1 extreme Heat outlook map for the Lesser RA IV region.
- Tools:
 - GEFS NWP tools

Mean Sea Level Pressure

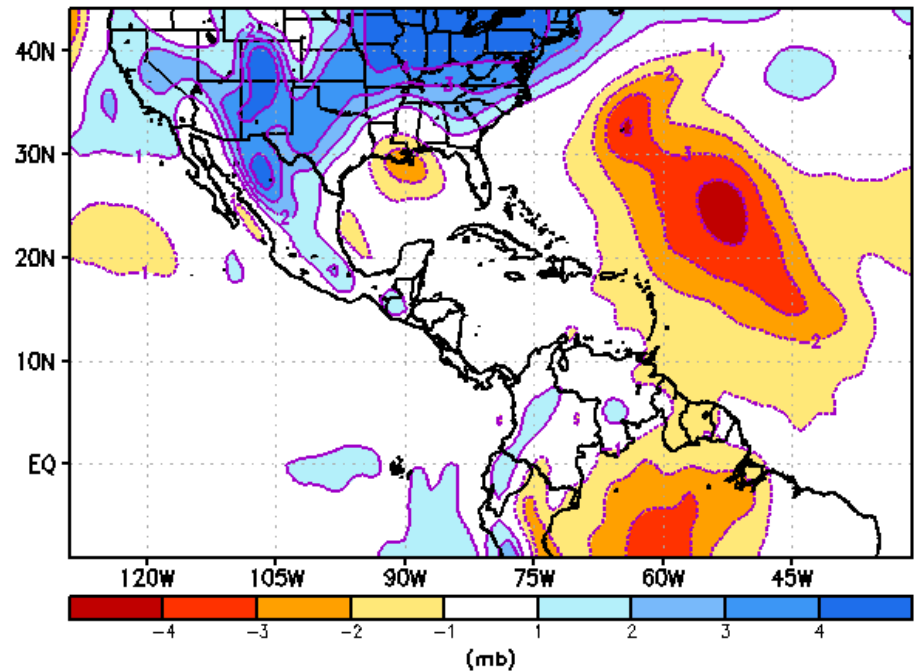
Total

GEFS Week-1 Mean Sea Level Pressure Total
Valid: 20200914 - 20200920



Anomaly

GEFS Week-1 Mean Sea Level Pressure Anomaly
Valid: 20200914 - 20200920

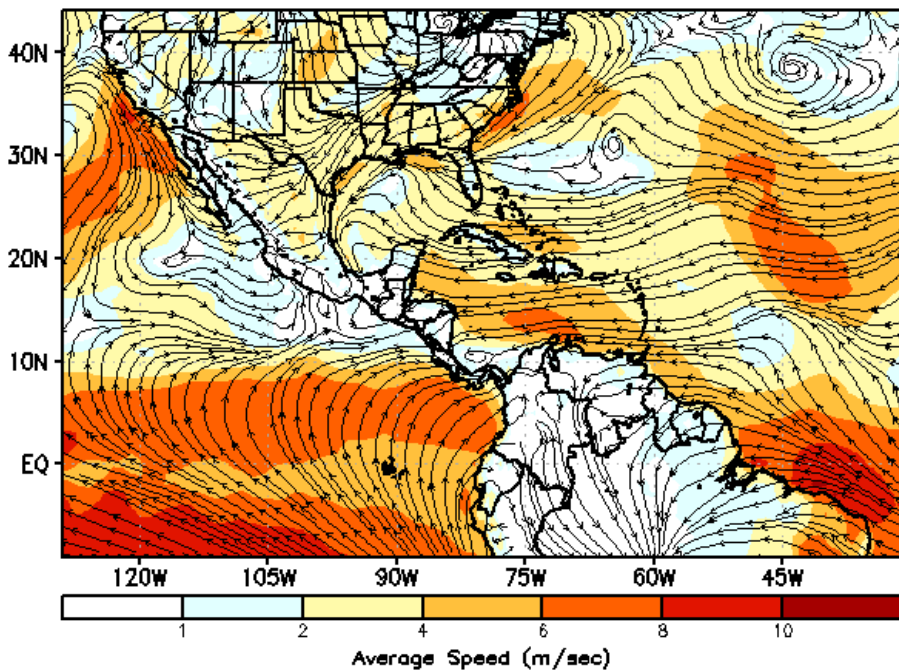


- An area of positive mean sea level pressure anomaly is located over southern US, while an area of negative mean sea level pressure is located over western Atlantic, extending into the southern Caribbean and northern South America.

10m Wind

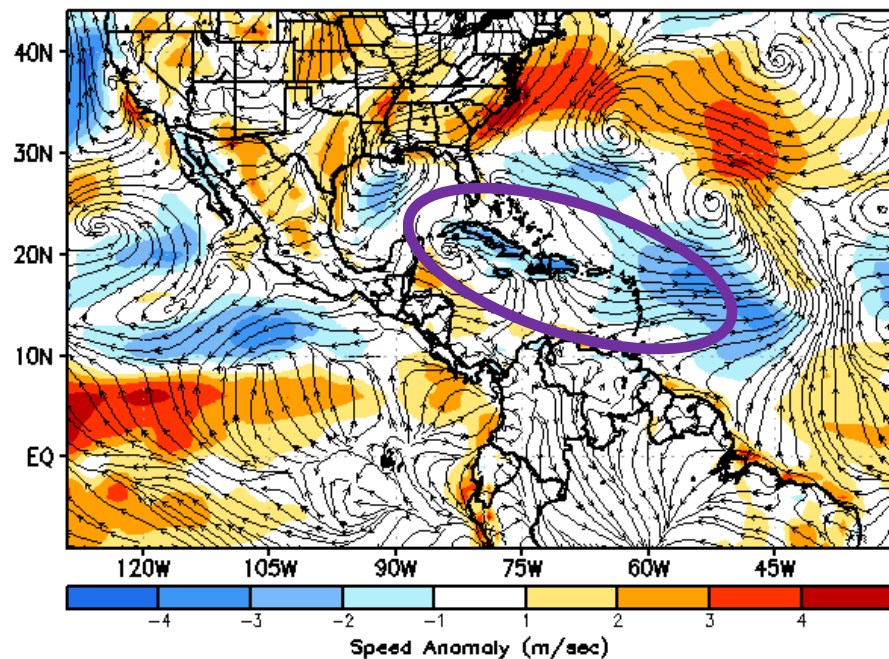
Total

GEFS Week-1 10m Wind Speed Total
Valid: 20200914 - 20200920



Anomaly

GEFS Week-1 10m Wind Speed Anomaly
Valid: 20200914 - 20200920

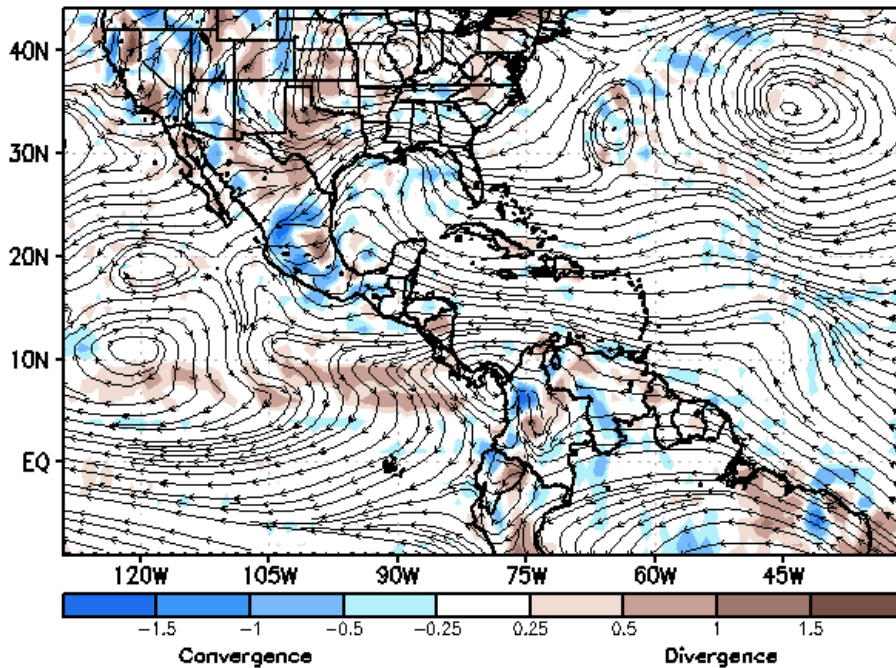


- An area of weaker than normal wind speed across much of the Caribbean Islands.

850-hPa Wind

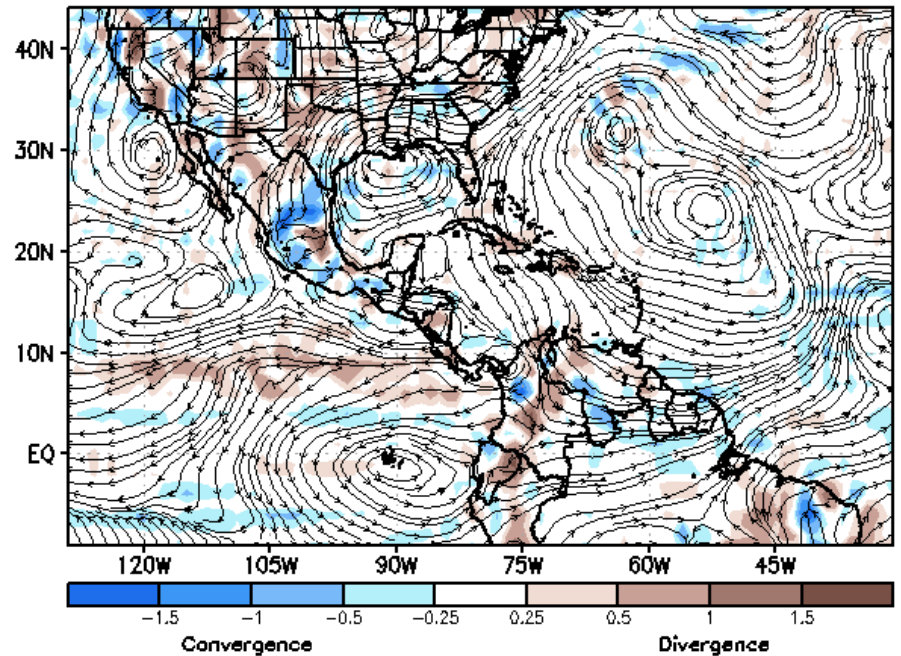
Total

GEFS Week-1 850-hPa Divergence and Wind Total
Valid: 20200914 - 20200920



Anomaly

GEFS Week-1 850-hPa Divergence and Wind Anomaly
Valid: 20200914 - 20200920

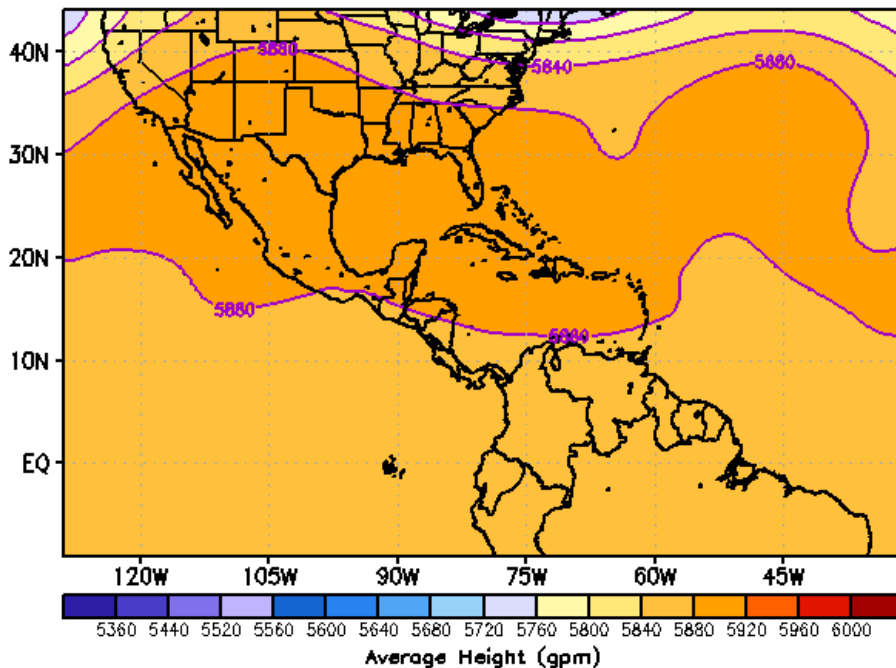


- A broad area of cyclonic circulation across western Atlantic, with localized areas of divergence anomaly at 700-hPa in the Caribbean Islands and northern South America.

500-hPa Height

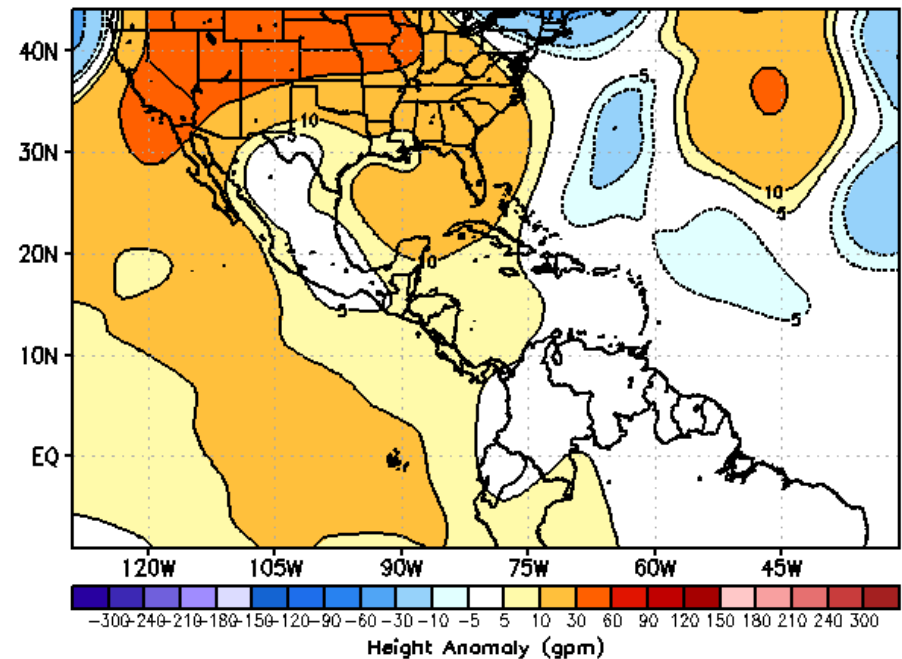
Total

GEFS Week-1 500-hPa Geo-Potential Height Total
Valid: 20200914 - 20200920



Anomaly

GEFS Week-1 500-hPa Geo-Potential Height Anomaly
Valid: 20200914 - 20200920

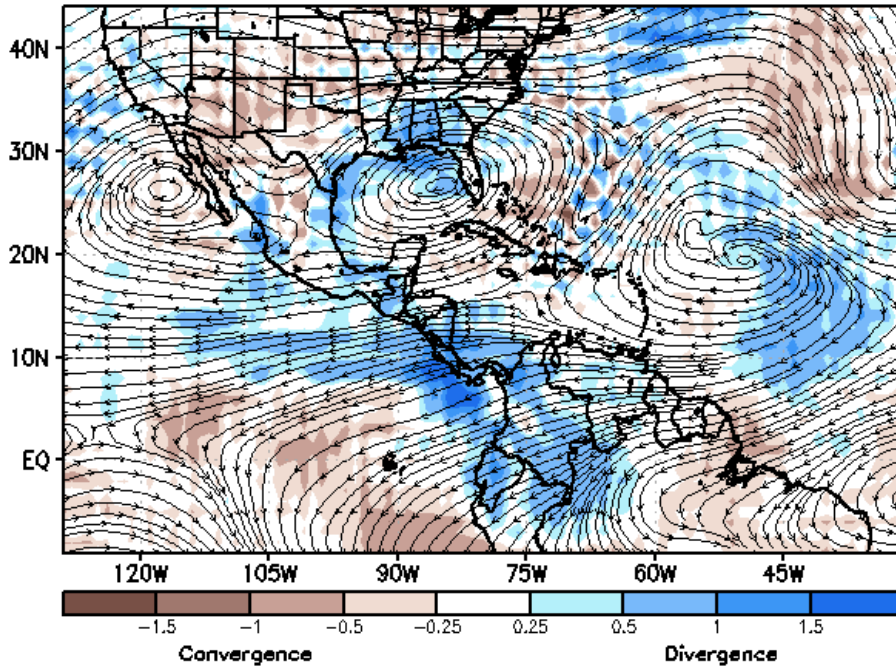


- A broad area of positive height anomaly at 500-hPa is expected to prevail across many places in the Central America and the Caribbean.

200-hPa Wind

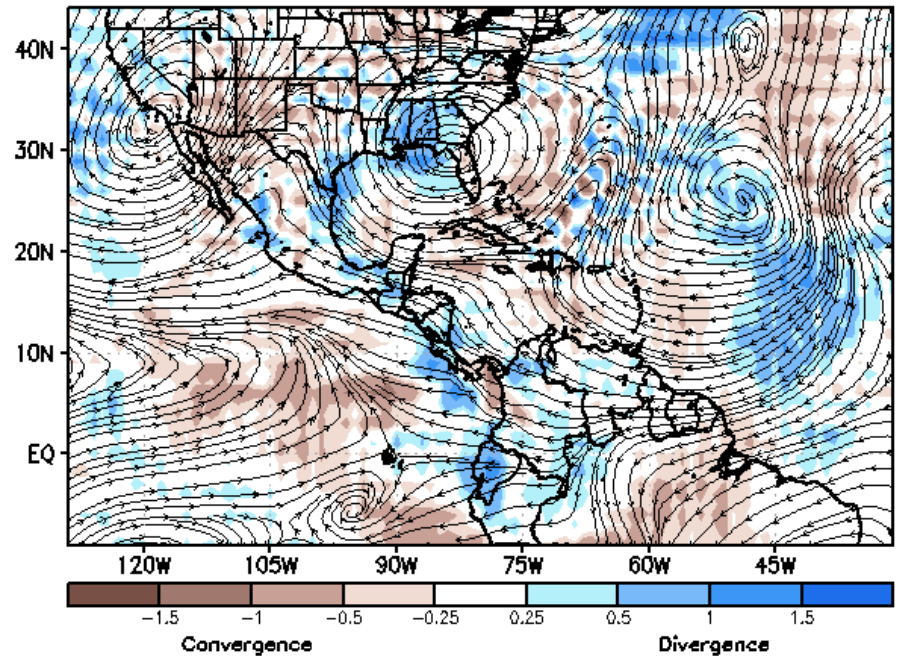
Total

GEFS Week-1 200-hPa Divergence and Wind Total
Valid: 20200914 - 20200920



Anomaly

GEFS Week-1 200-hPa Divergence and Wind Anomaly
Valid: 20200914 - 20200920

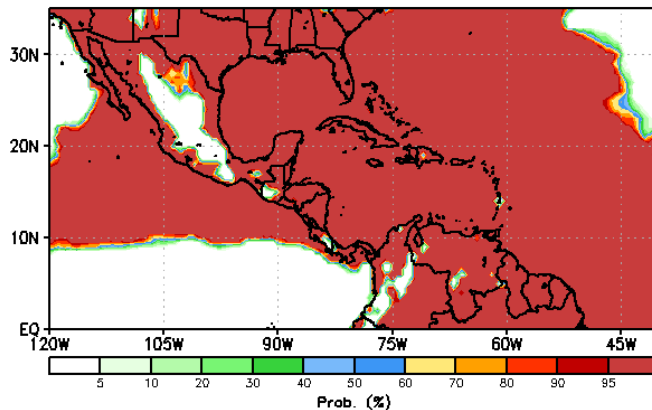


- An area of upper-level convergence (brown shaded) over portions of the Caribbean.

Tmax Exceedance Probability, for at least 2 Consecutive Days

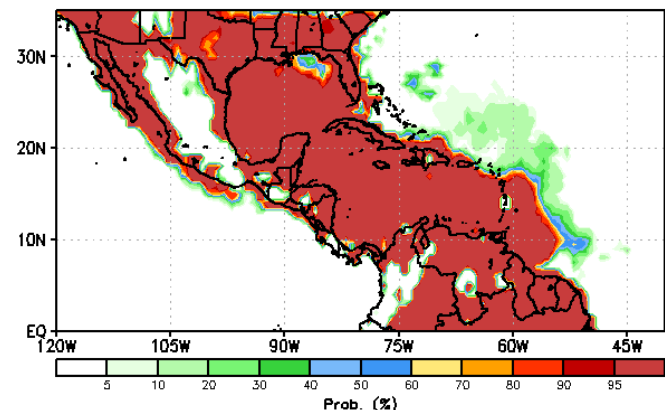
$\geq 35^{\circ}\text{C}$

GEFS Week-1 Tmax Exceedance Prob. > 35 Cels.
>2 Consec. Days, Valid: 20200914 - 20200920



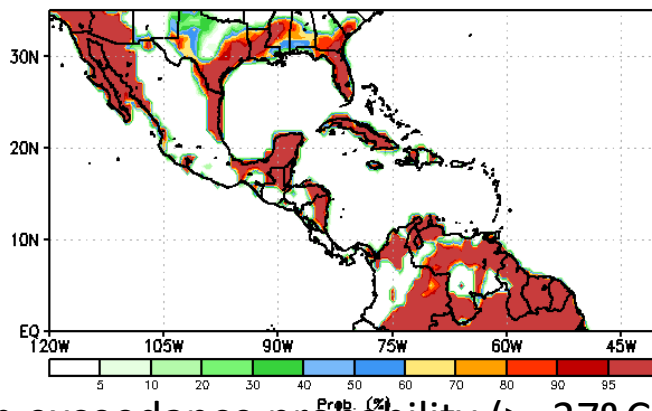
$\geq 37^{\circ}\text{C}$

GEFS Week-1 Tmax Exceedance Prob. > 37 Cels.
>2 Consec. Days, Valid: 20200914 - 20200920



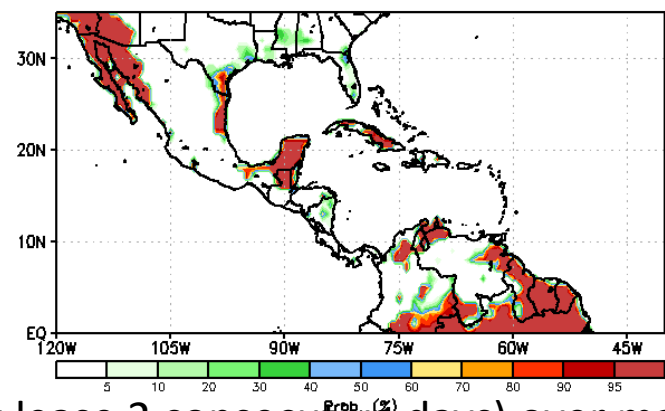
$\geq 39^{\circ}\text{C}$

GEFS Week-1 Tmax Exceedance Prob. > 39 Cels.
>2 Consec. Days, Valid: 20200914 - 20200920



$\geq 41^{\circ}\text{C}$

GEFS Week-1 Tmax Exceedance Prob. > 41 Cels.
>2 Consec. Days, Valid: 20200914 - 20200920

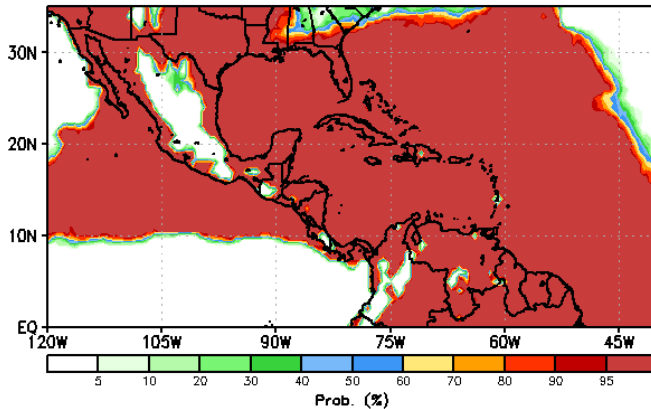


- High exceedance probability ($\geq 37^{\circ}\text{C}$ for at least 2 consecutive days) over many places in Central America, the Caribbean, and the far northern South America.

Tmax Exceedance Probability, for at least 3 Consecutive Days

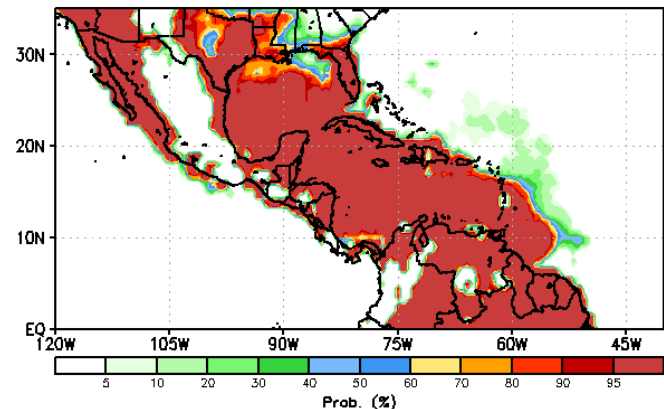
$\geq 35^{\circ}\text{C}$

GEFS Week-1 Tmax Exceedance Prob. > 35 Cels.
>3 Consec. Days, Valid: 20200914 - 20200920



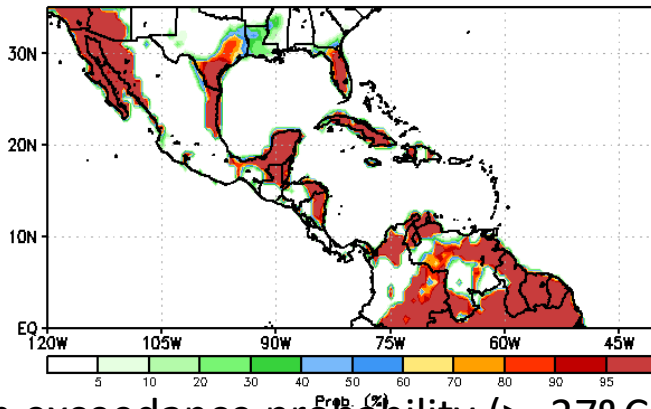
$\geq 37^{\circ}\text{C}$

GEFS Week-1 Tmax Exceedance Prob. > 37 Cels.
>3 Consec. Days, Valid: 20200914 - 20200920



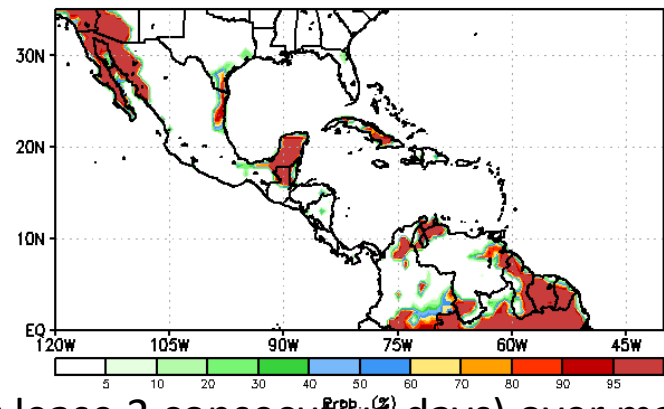
$\geq 39^{\circ}\text{C}$

GEFS Week-1 Tmax Exceedance Prob. > 39 Cels.
>3 Consec. Days, Valid: 20200914 - 20200920



$\geq 41^{\circ}\text{C}$

GEFS Week-1 Tmax Exceedance Prob. > 41 Cels.
>3 Consec. Days, Valid: 20200914 - 20200920

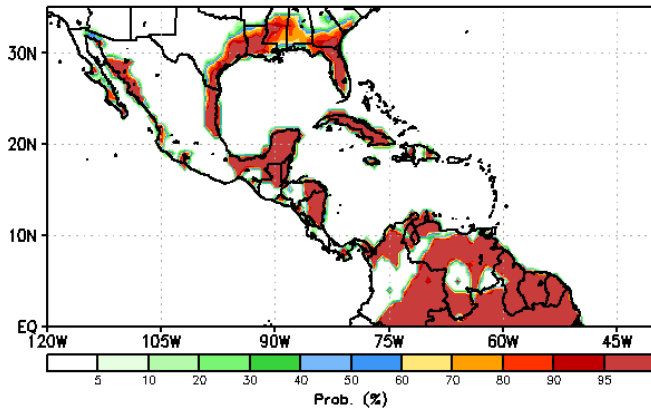


- High exceedance probability ($\geq 37^{\circ}\text{C}$ for at least 3 consecutive days) over many places in Central America, the Caribbean, and the far northern South America.

HI Exceedance Probability with respect to fixed Thresholds, for at least 2 Consecutive Days

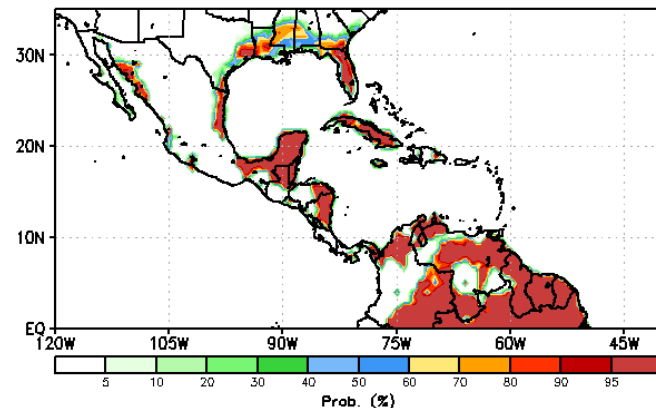
$\geq 41^\circ\text{C}$

GEFS Week-1 HI Exceedance Prob. > 41 Deg. Cels.
>2 Consec. Days, Valid: 20200914 - 20200920



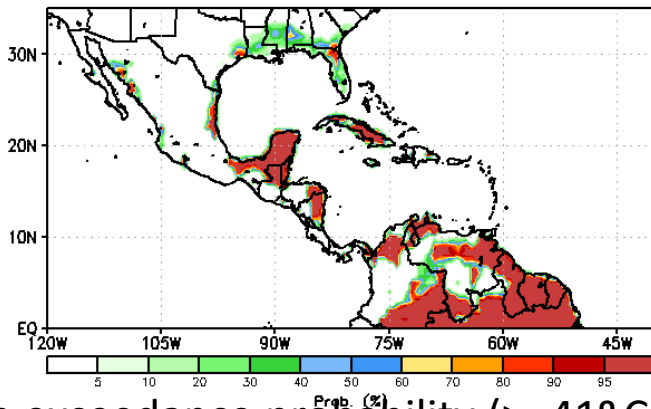
$\geq 43^\circ\text{C}$

GEFS Week-1 HI Exceedance Prob. > 43 Deg. Cels.
>2 Consec. Days, Valid: 20200914 - 20200920



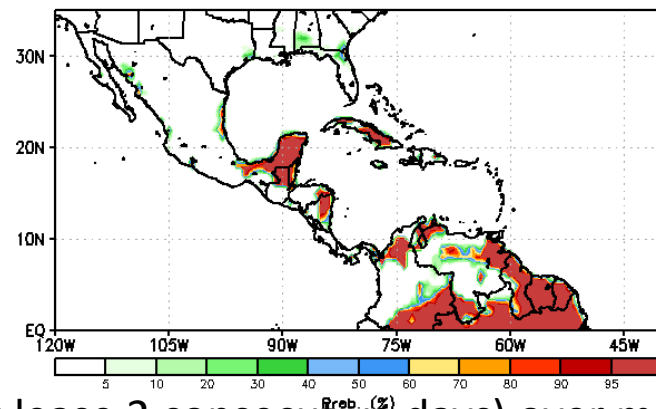
$\geq 45^\circ\text{C}$

GEFS Week-1 HI Exceedance Prob. > 45 Deg. Cels.
>2 Consec. Days, Valid: 20200914 - 20200920



$\geq 47^\circ\text{C}$

GEFS Week-1 HI Exceedance Prob. > 47 Deg. Cels.
>2 Consec. Days, Valid: 20200914 - 20200920

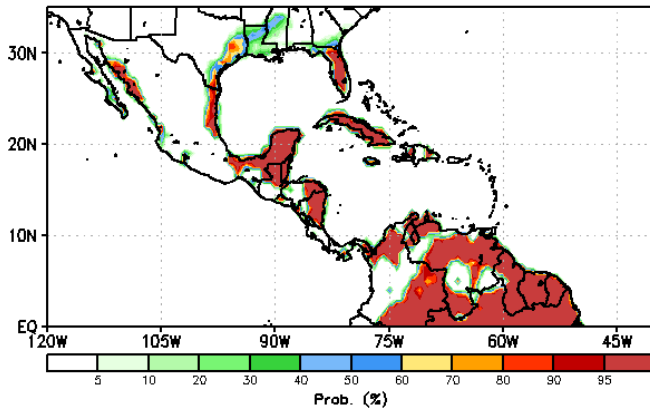


- High exceedance probability ($\geq 41^\circ\text{C}$ for at least 2 consecutive days) over many places in Central America, the Caribbean, and the far northern South America.

HI Exceedance Probability with respect to fixed, for at least 3 Consecutive Days

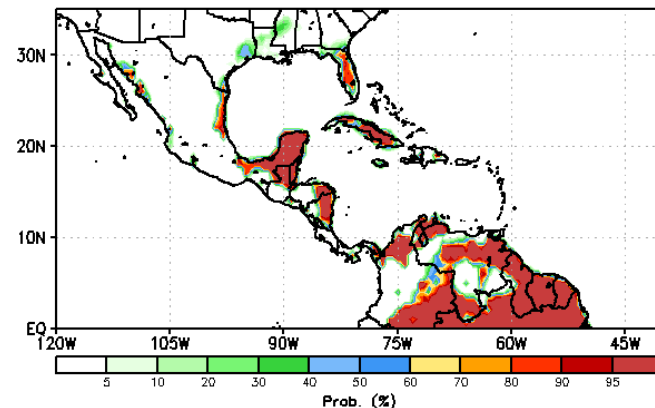
$\geq 41^{\circ}\text{C}$

GEFS Week-1 HI Exceedance Prob. > 41 Deg. Cels.
>3 Consec. Days, Valid: 20200914 - 20200920



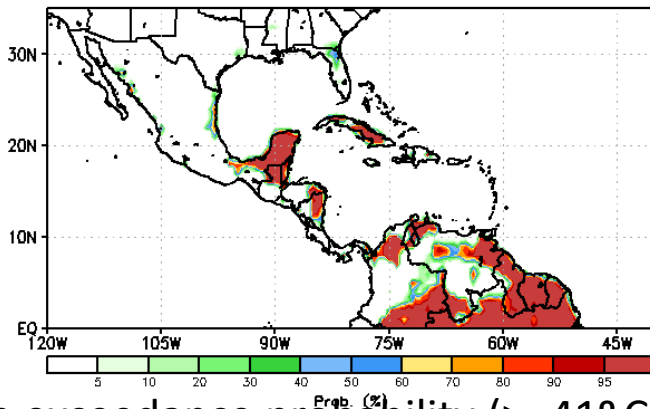
$\geq 43^{\circ}\text{C}$

GEFS Week-1 HI Exceedance Prob. > 43 Deg. Cels.
>3 Consec. Days, Valid: 20200914 - 20200920



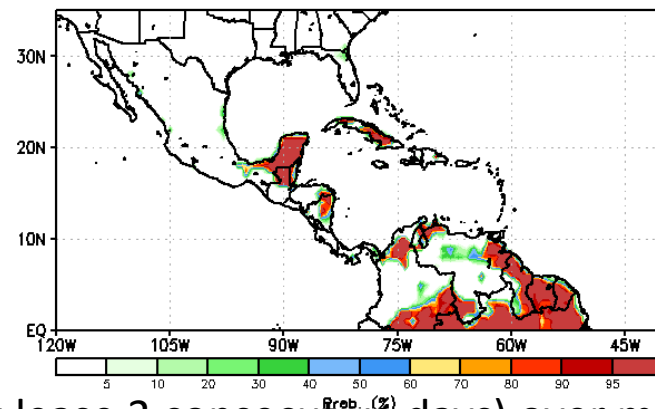
$\geq 45^{\circ}\text{C}$

GEFS Week-1 HI Exceedance Prob. > 45 Deg. Cels.
>3 Consec. Days, Valid: 20200914 - 20200920



$\geq 47^{\circ}\text{C}$

GEFS Week-1 HI Exceedance Prob. > 47 Deg. Cels.
>3 Consec. Days, Valid: 20200914 - 20200920

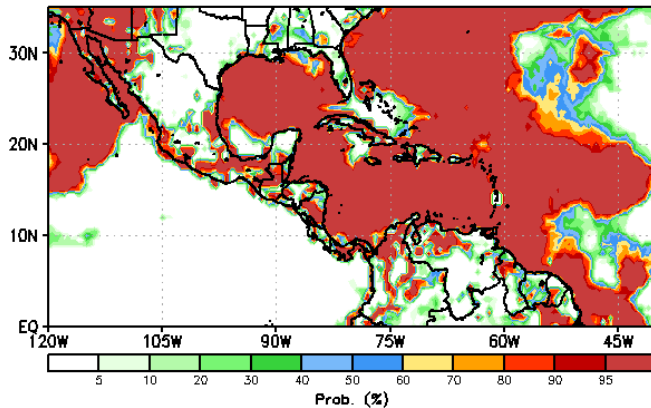


- High exceedance probability ($\geq 41^{\circ}\text{C}$ for at least 3 consecutive days) over many places in Central America, the Caribbean, and the far northern South America.

Tmax Exceedance Probability with respect to Percentiles, for at least 2 Consecutive Days

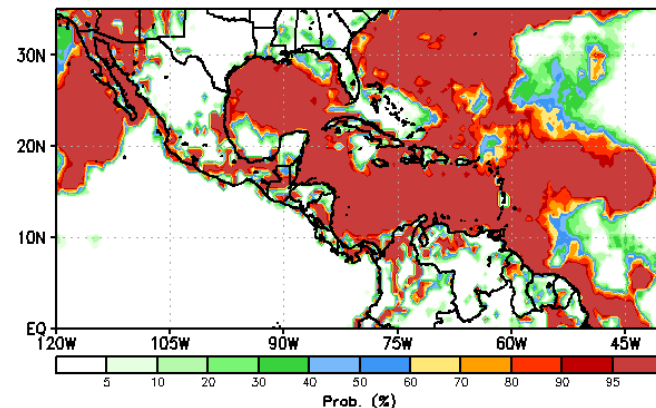
$\geq 80^{\text{th}}$ percentile.

GEFS Week-1 Tmax Exceedance Prob. $> 80^{\text{th}}$ Pctl.
>2 Consec. Days, Valid: 20200914 - 20200920



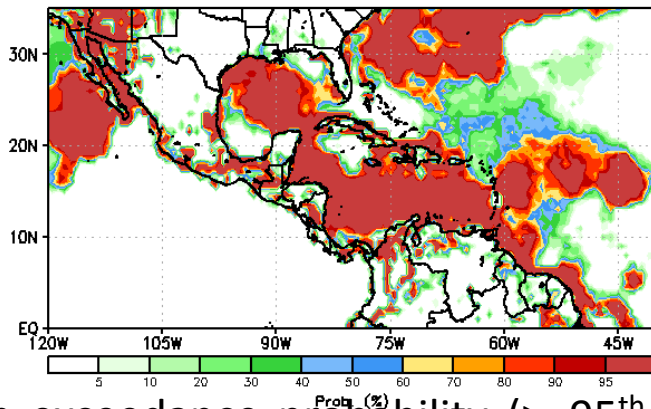
$\geq 85^{\text{th}}$ percentile

GEFS Week-1 Tmax Exceedance Prob. $> 85^{\text{th}}$ Pctl.
>2 Consec. Days, Valid: 20200914 - 20200920



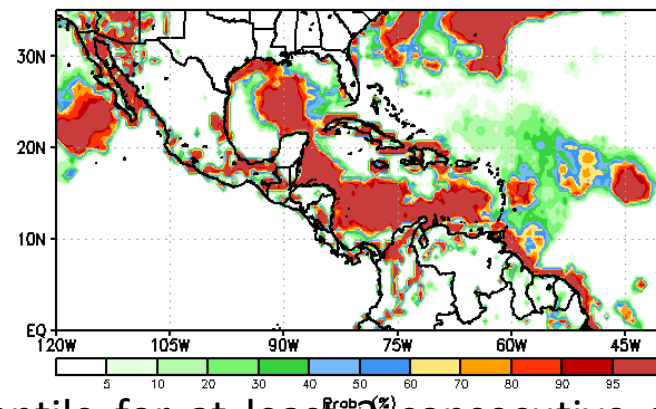
$\geq 90^{\text{th}}$ percentile

GEFS Week-1 Tmax Exceedance Prob. $> 90^{\text{th}}$ Pctl.
>2 Consec. Days, Valid: 20200914 - 20200920



$\geq 95^{\text{th}}$ percentile

GEFS Week-1 Tmax Exceedance Prob. $> 95^{\text{th}}$ Pctl.
>2 Consec. Days, Valid: 20200914 - 20200920

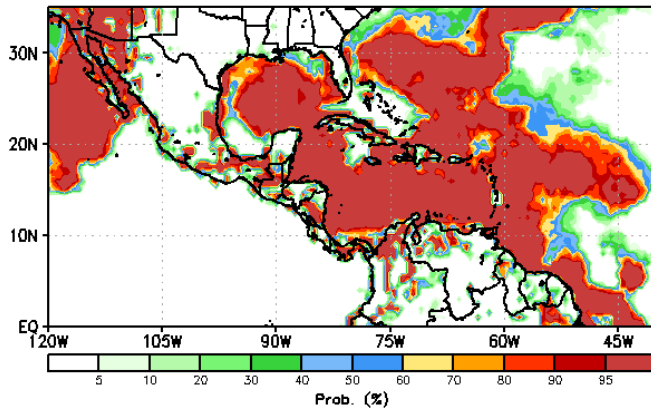


- High exceedance probability ($\geq 95^{\text{th}}$ percentile for at least 2 consecutive days) over many places in Central America, the Caribbean, and the far northern South America.

Tmax Exceedance Probability with respect to Percentiles, for at least 3 Consecutive Days

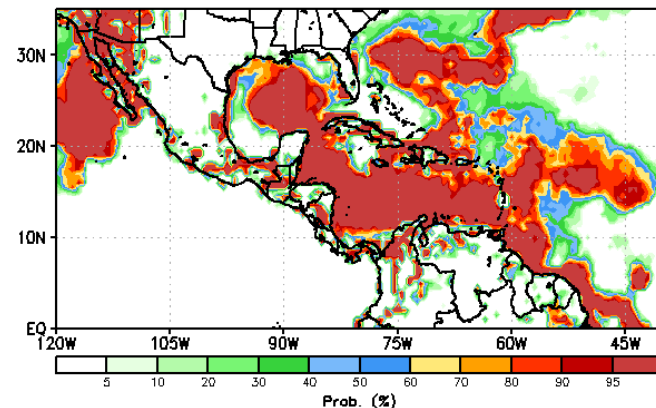
$\geq 80^{\text{th}}$ percentile.

GEFS Week-1 Tmax Exceedance Prob. $> 80^{\text{th}}$ Pctl.
>3 Consec. Days, Valid: 20200914 - 20200920



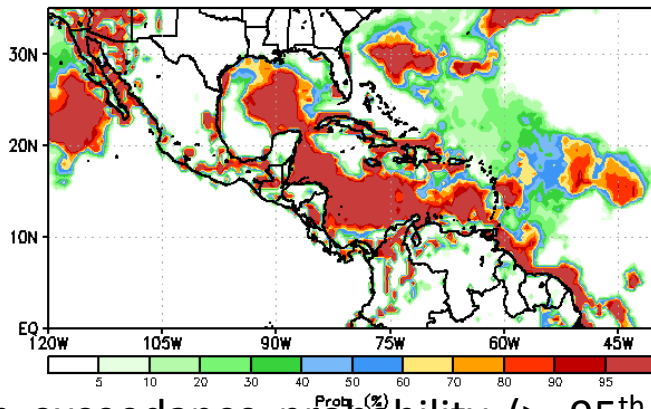
$\geq 85^{\text{th}}$ percentile

GEFS Week-1 Tmax Exceedance Prob. $> 85^{\text{th}}$ Pctl.
>3 Consec. Days, Valid: 20200914 - 20200920



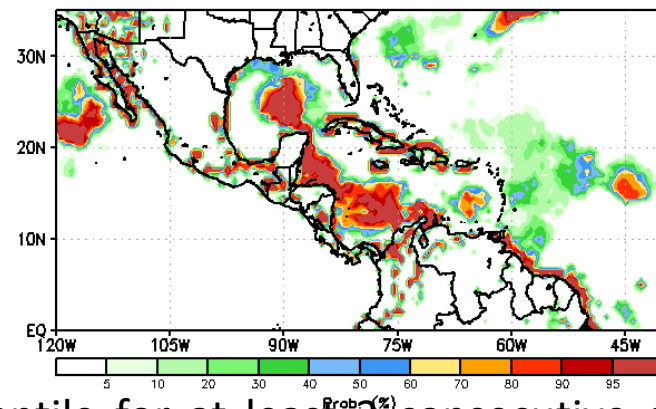
$\geq 90^{\text{th}}$ percentile

GEFS Week-1 Tmax Exceedance Prob. $> 90^{\text{th}}$ Pctl.
>3 Consec. Days, Valid: 20200914 - 20200920



$\geq 95^{\text{th}}$ percentile

GEFS Week-1 Tmax Exceedance Prob. $> 95^{\text{th}}$ Pctl.
>3 Consec. Days, Valid: 20200914 - 20200920

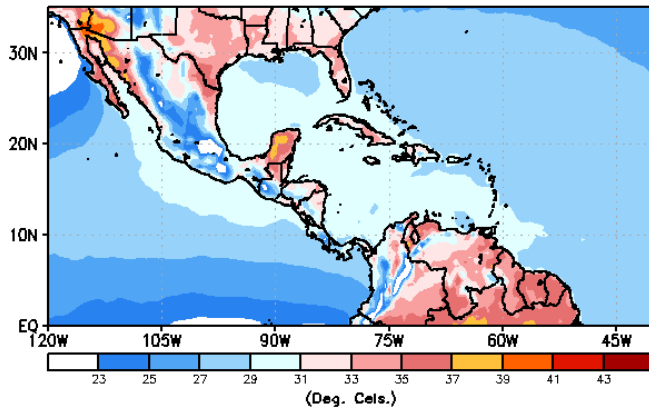


- High exceedance probability ($\geq 95^{\text{th}}$ percentile for at least 3 consecutive days) over many places in Central America, the Caribbean, and the far northern South America.

Tmax Percentile Climos

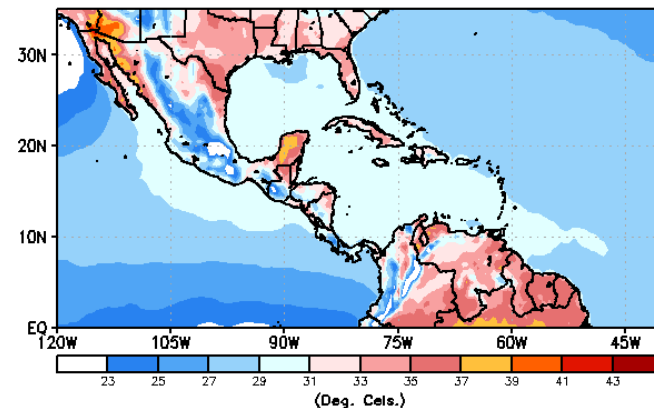
80th percentile.

GEFS Tmax 80th . Model Climo.
Valid: 14Sep - 20Sep



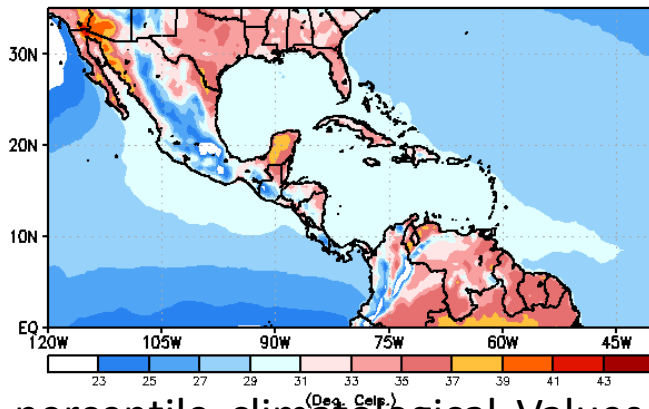
85th percentile

GEFS Tmax 85th . Model Climo.
Valid: 14Sep - 20Sep



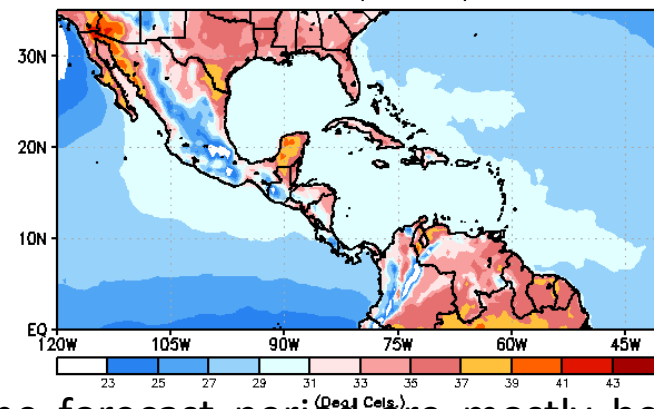
90th percentile

GEFS Tmax 90th . Model Climo.
Valid: 14Sep - 20Sep



95th percentile

GEFS Tmax 95th . Model Climo.
Valid: 14Sep - 20Sep

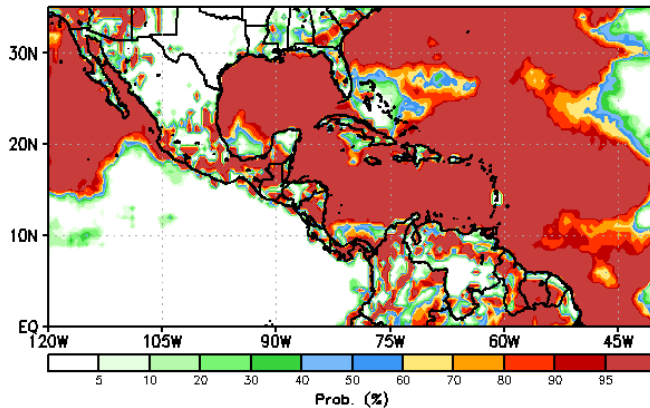


- The percentile climatological values for the forecast period are mostly below 39°C, while the predicted Tmax is likely to exceed the percentile climos.

HI Exceedance Probability with respect to Percentiles, for at least 2 Consecutive Days

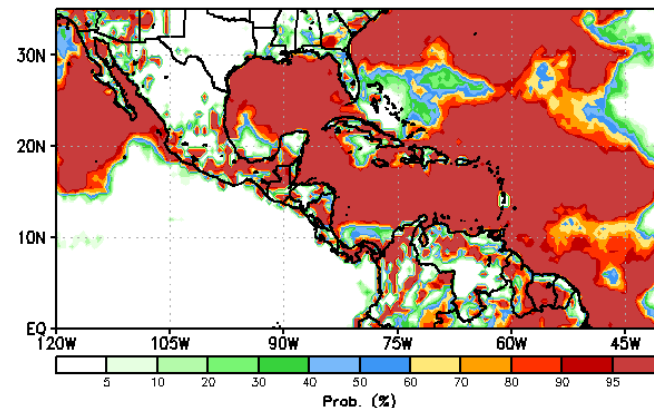
$\geq 80^{\text{th}}$ percentile.

GEFS Week-1 HI Exceedance Prob. $> 80^{\text{th}}$ Pctl.
>2 Consec. Days, Valid: 20200914 - 20200920



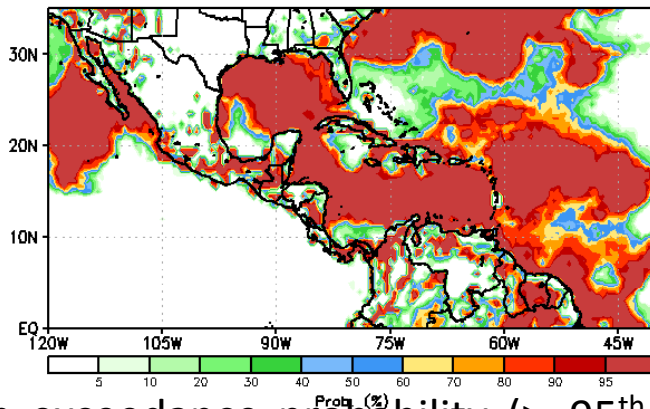
$\geq 85^{\text{th}}$ percentile

GEFS Week-1 HI Exceedance Prob. $> 85^{\text{th}}$ Pctl.
>2 Consec. Days, Valid: 20200914 - 20200920



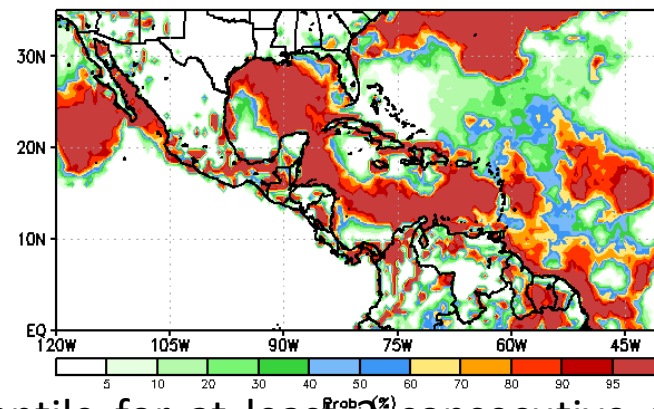
$\geq 90^{\text{th}}$ percentile

GEFS Week-1 HI Exceedance Prob. $> 90^{\text{th}}$ Pctl.
>2 Consec. Days, Valid: 20200914 - 20200920



$\geq 95^{\text{th}}$ percentile

GEFS Week-1 HI Exceedance Prob. $> 95^{\text{th}}$ Pctl.
>2 Consec. Days, Valid: 20200914 - 20200920

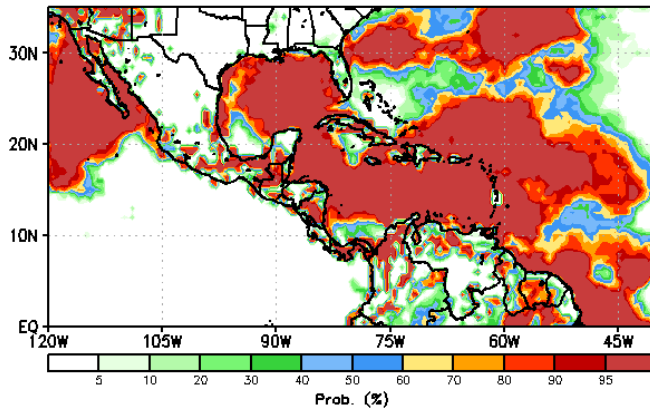


- High exceedance probability ($\geq 95^{\text{th}}$ percentile for at least 2 consecutive days) over many places in Central America, the Caribbean, and the far northern South America.

HI Exceedance Probability with respect to Percentiles, for at least 3 Consecutive Days

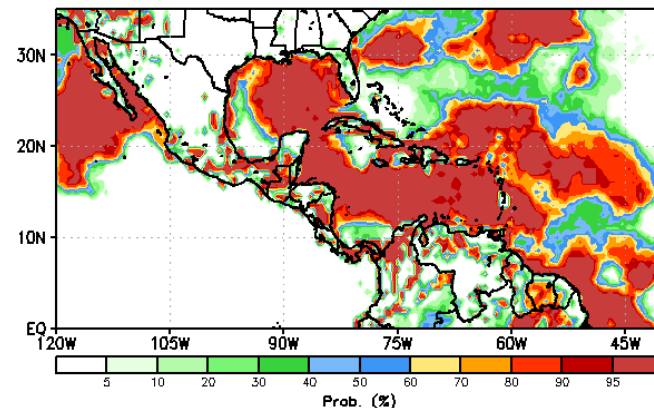
$\geq 80^{\text{th}}$ percentile.

GEFS Week-1 HI Exceedance Prob. $> 80^{\text{th}}$ Pctl.
>3 Consec. Days, Valid: 20200914 - 20200920



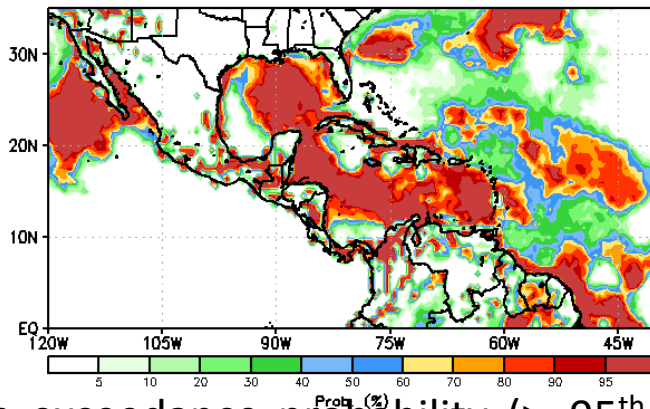
$\geq 85^{\text{th}}$ percentile

GEFS Week-1 HI Exceedance Prob. $> 85^{\text{th}}$ Pctl.
>3 Consec. Days, Valid: 20200914 - 20200920



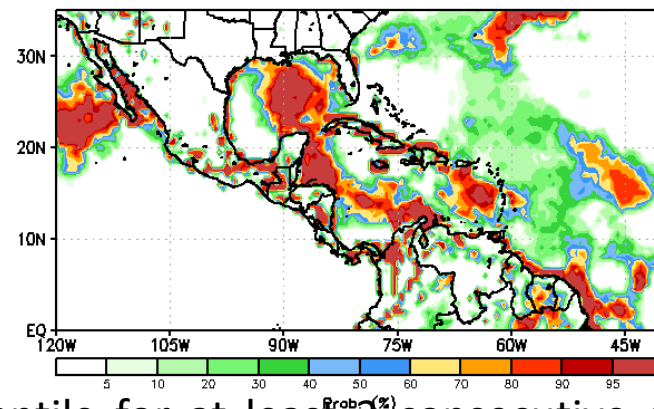
$\geq 90^{\text{th}}$ percentile

GEFS Week-1 HI Exceedance Prob. $> 90^{\text{th}}$ Pctl.
>3 Consec. Days, Valid: 20200914 - 20200920



$\geq 95^{\text{th}}$ percentile

GEFS Week-1 HI Exceedance Prob. $> 95^{\text{th}}$ Pctl.
>3 Consec. Days, Valid: 20200914 - 20200920

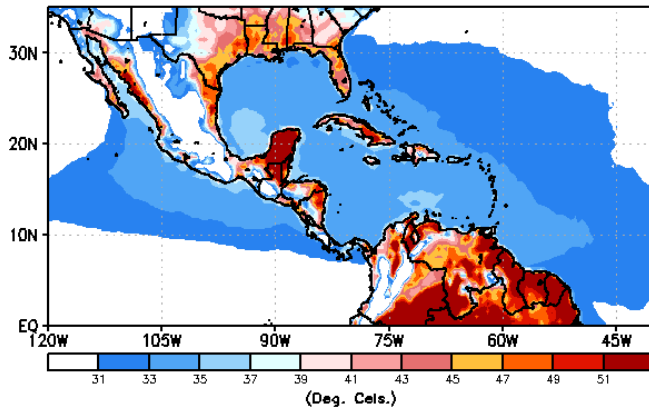


- High exceedance probability ($\geq 95^{\text{th}}$ percentile for at least 3 consecutive days) over many places in Central America, the Caribbean, and the far northern South America.

HI Percentile Climos

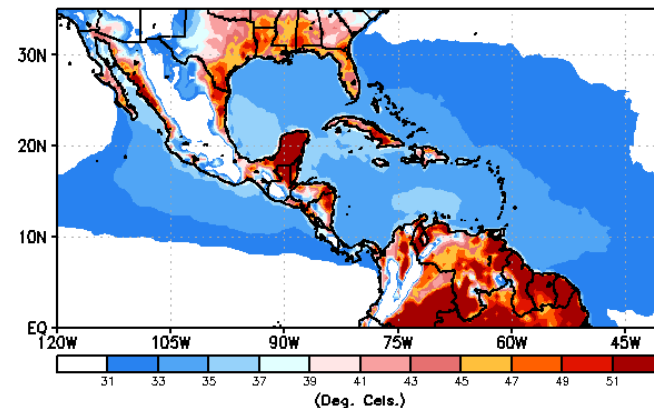
80th percentile.

GEFS HI 80th . Model Climo.
Valid: 14Sep - 20Sep



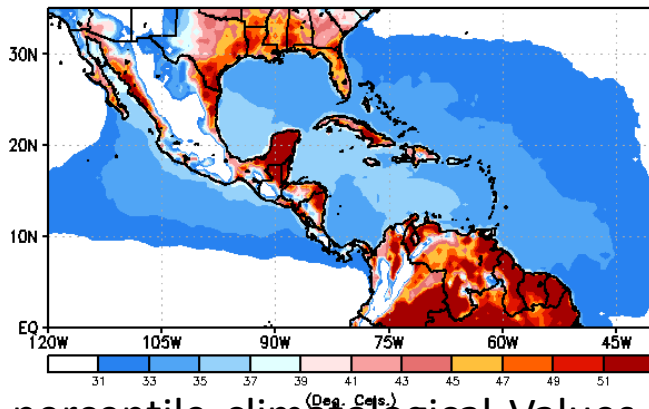
85th percentile

GEFS HI 85th . Model Climo.
Valid: 14Sep - 20Sep



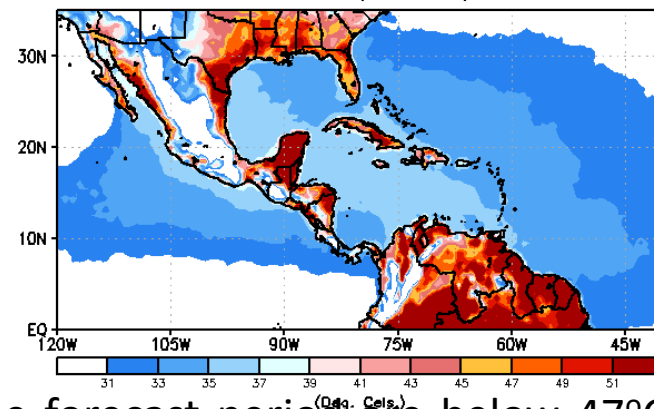
90th percentile

GEFS HI 90th . Model Climo.
Valid: 14Sep - 20Sep



95th percentile

GEFS HI 95th . Model Climo.
Valid: 14Sep - 20Sep



- The percentile climatological values for the forecast period are below 47°C over the Caribbean, while the predicted HI is likely to exceed these percentile climos.

Summary

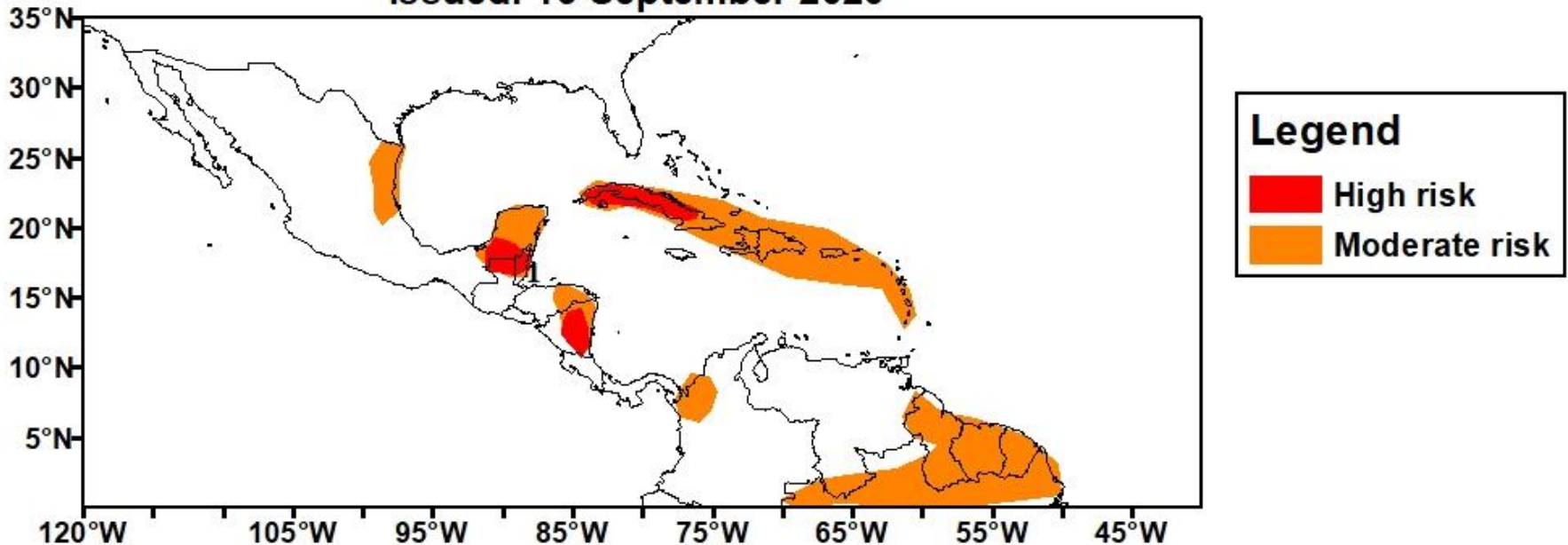
- **Convergence of evidences**
 - **Large Scale Circulation patterns** => A stationary Anti-cyclone / Cyclonic anomaly dipole over the US and Western Atlantic => leading to lower-level divergent flow in the region.
 - Below-average surface wind => calmer wind => less ventilation
 - Positive height anomaly at 500-hPa => leading to subsidence in the region
 - **Exceedance probability forecasts** = > higher probability of exceedance for Tmax & HI $\geq 80^{\text{th}}$, 85^{th} , 90^{th} and 95^{th} percentiles.
 - Higher probability of exceedance for Tmax $\geq 39^{\circ}\text{C}$.
 - Higher probability of exceedance for HI $\geq 41^{\circ}\text{C}$.

Excessive Heat Outlooks

Experimental Week-1 Heat Hazards Outlook

Valid: 14 - 20 September, 2020

Issued: 13 September 2020



- An area of anomalous weaker than normal surface wind, above-average mid-tropospheric height and upper level convergence is expected to create conducive atmospheric condition for occurrence of excessive heat.
- Model forecast suggest an increased chance for moderate to high heat hazards risk over portions of Central America, the Caribbean, and northeastern South America ($T_{max}/HI \geq 80$ percentile, and $T_{max}/HI \geq 95^{\text{th}}$ percentiles for at least 3 consecutive days ... in some areas).