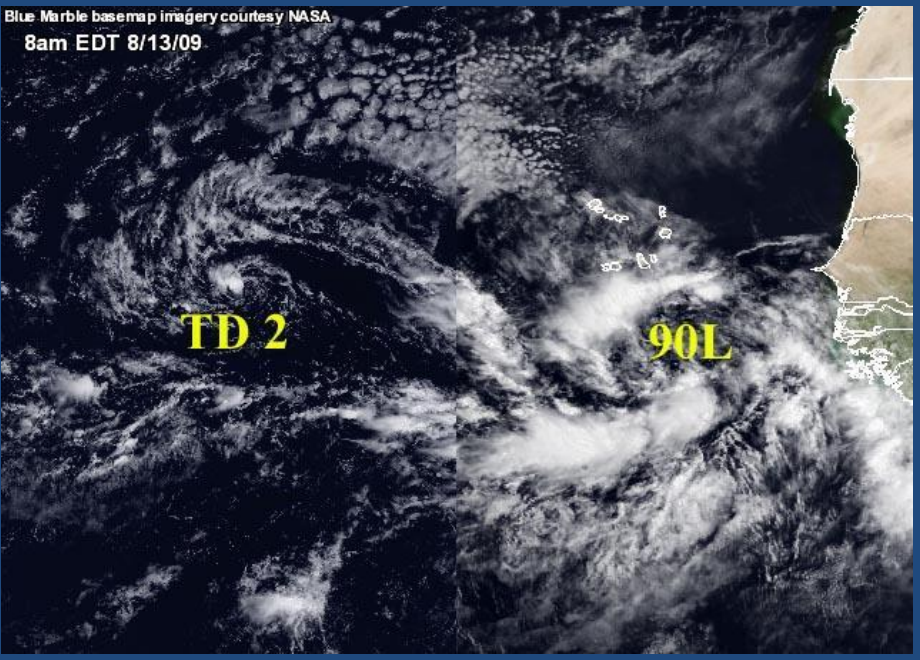
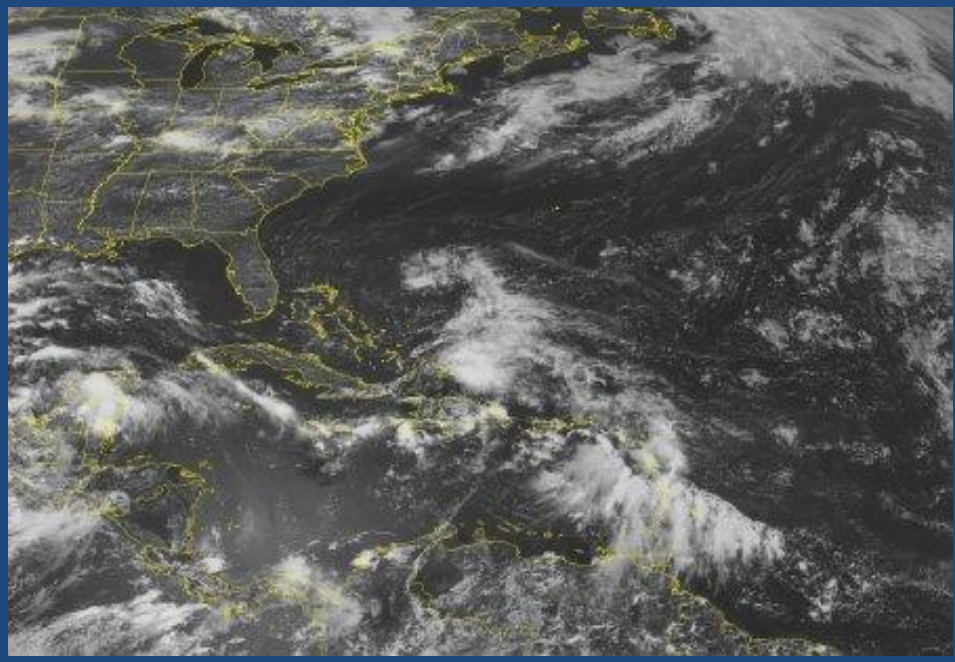
Tropical Waves





John Cangialosi and Lixion Avila
National Hurricane Center

WMO Region IV
Tropical Cyclone Workshop

Outline

- Basic definition
- Schematic diagrams/Interactions
- Operational products/forecasts
- Tools for tracking
- Exercise

What are tropical waves?

* Perturbations / disturbances in the tropical easterlies that typically move from east to west.

* Often seen as inverted troughs of low pressure (inverted-V pattern in satellite imagery). Significant rain producers.

* Convection typically on the east side. Subsidence/clearing on the west side.

* Convection highly modulated by atmospheric moisture, upper level features, topography, etc.

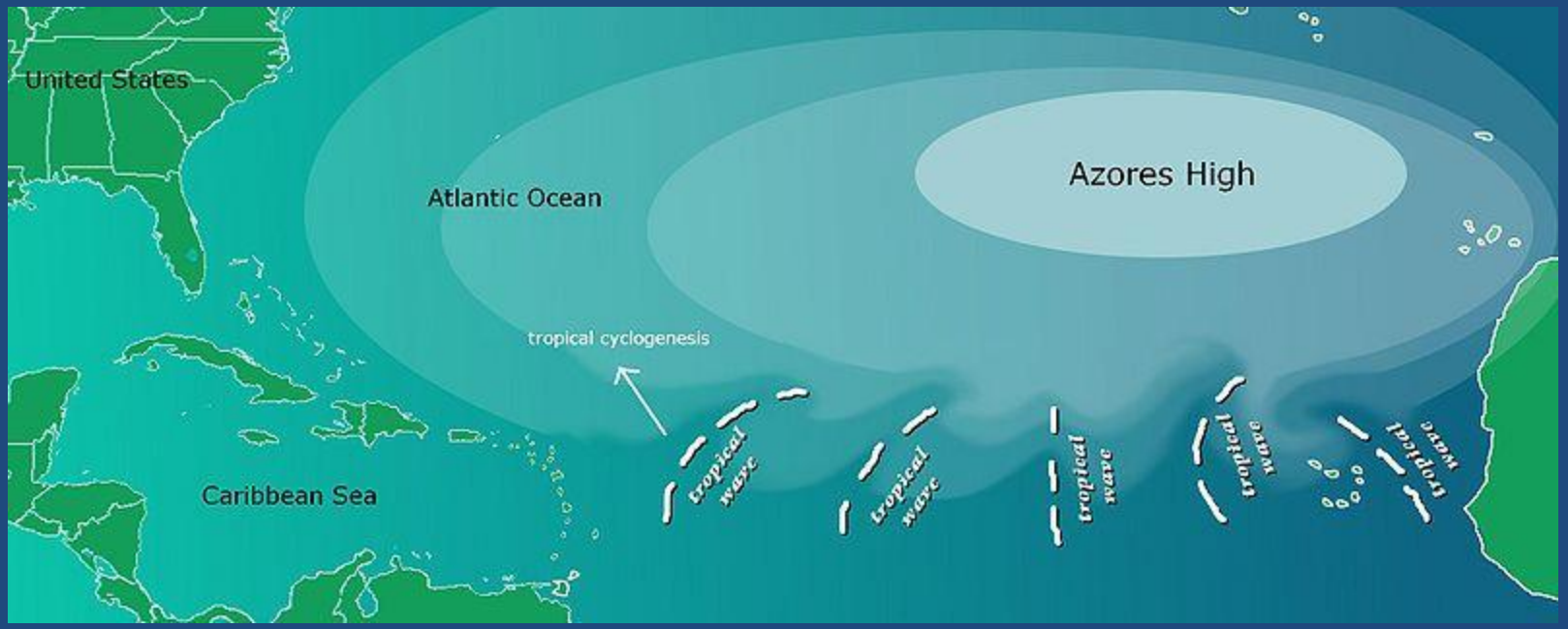
* Develop into tropical cyclones.

* Around 60 tracked per year (little annual variability)

How/where they form

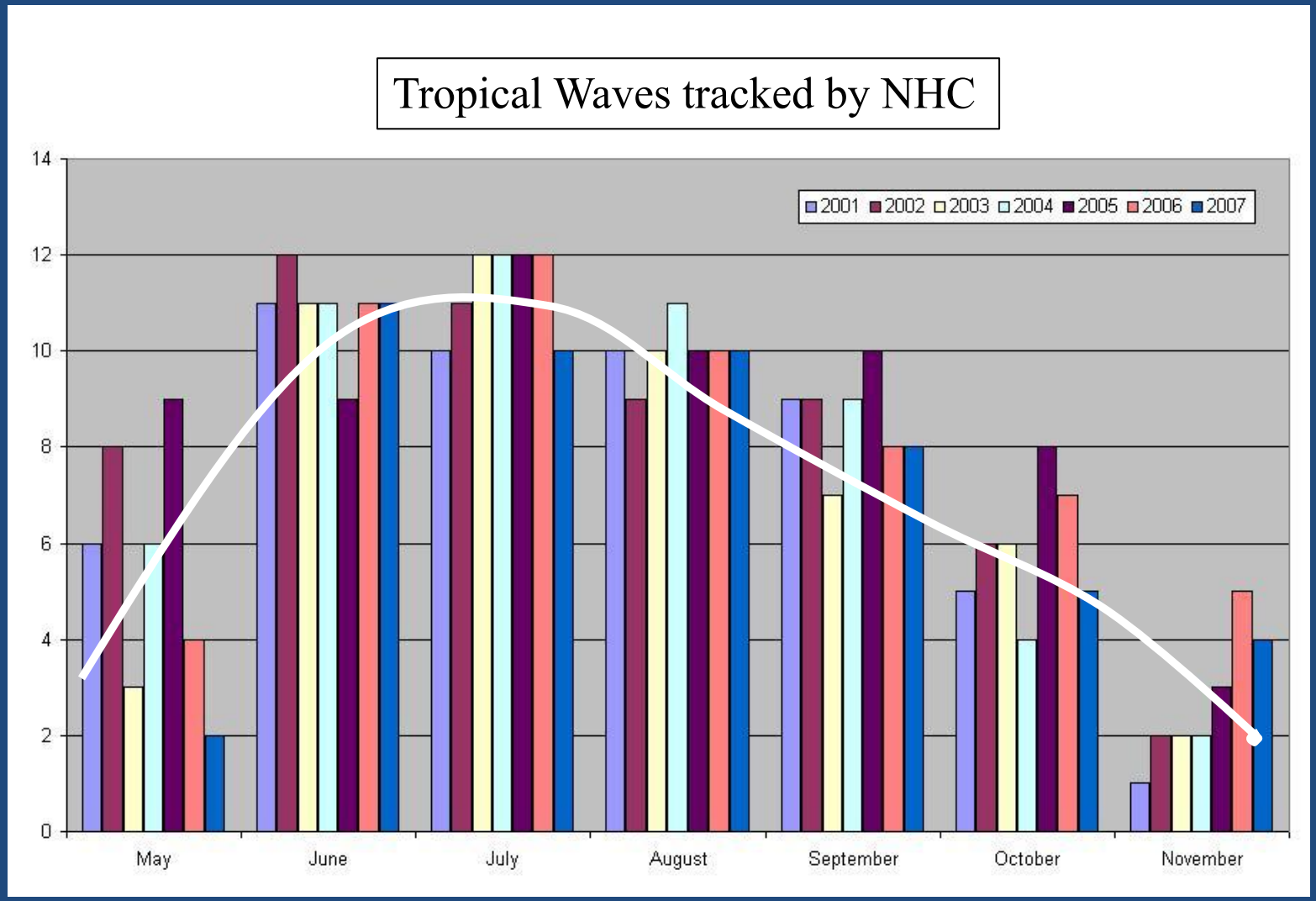
- Generated by an instability (baroclinic-barotropic)of the African easterly jet
- Jet arises as a result of reversed lower tropospheric temperature gradient over west-central north Africa due to extremely warm temperatures over the Sahara Desert and substantially cooler temperatures along the coast of Guinea.

Typical Synoptic Setup



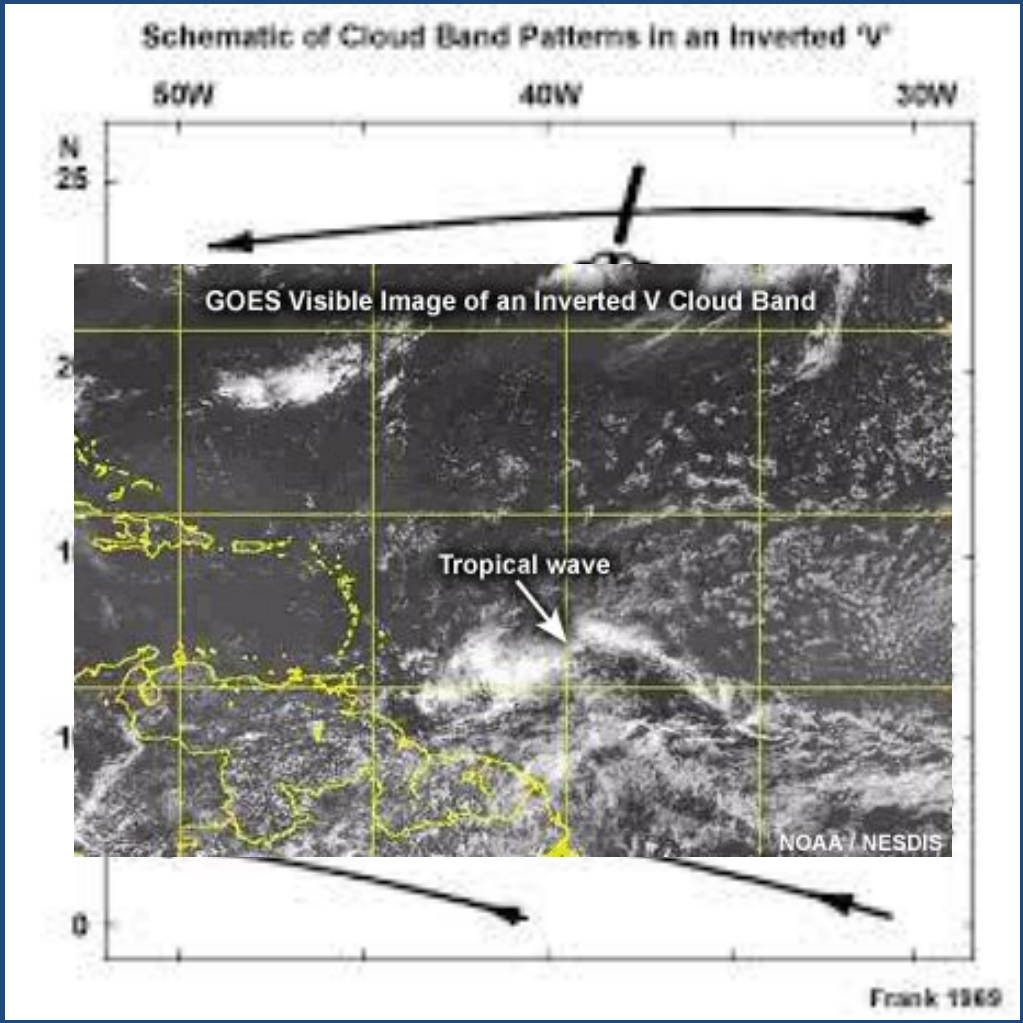
Tropical waves/African easterly waves move westward within the trade wind flow south of the Bermuda-Azores high

Frequency by month



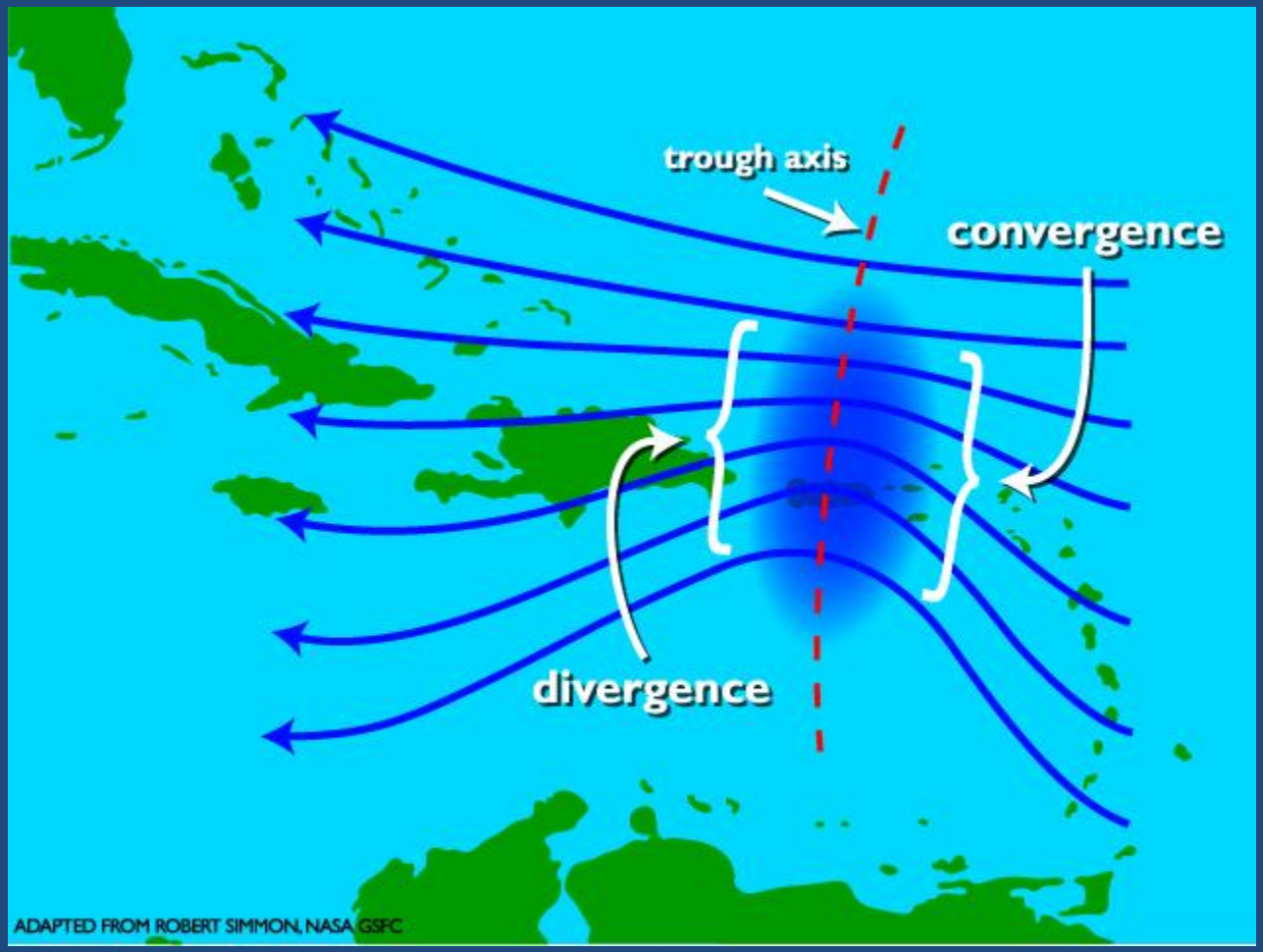
Tropical wave activity in terms of numbers is highest June-August

Schematic diagrams



Classic inverted V-shape near the eastern Caribbean

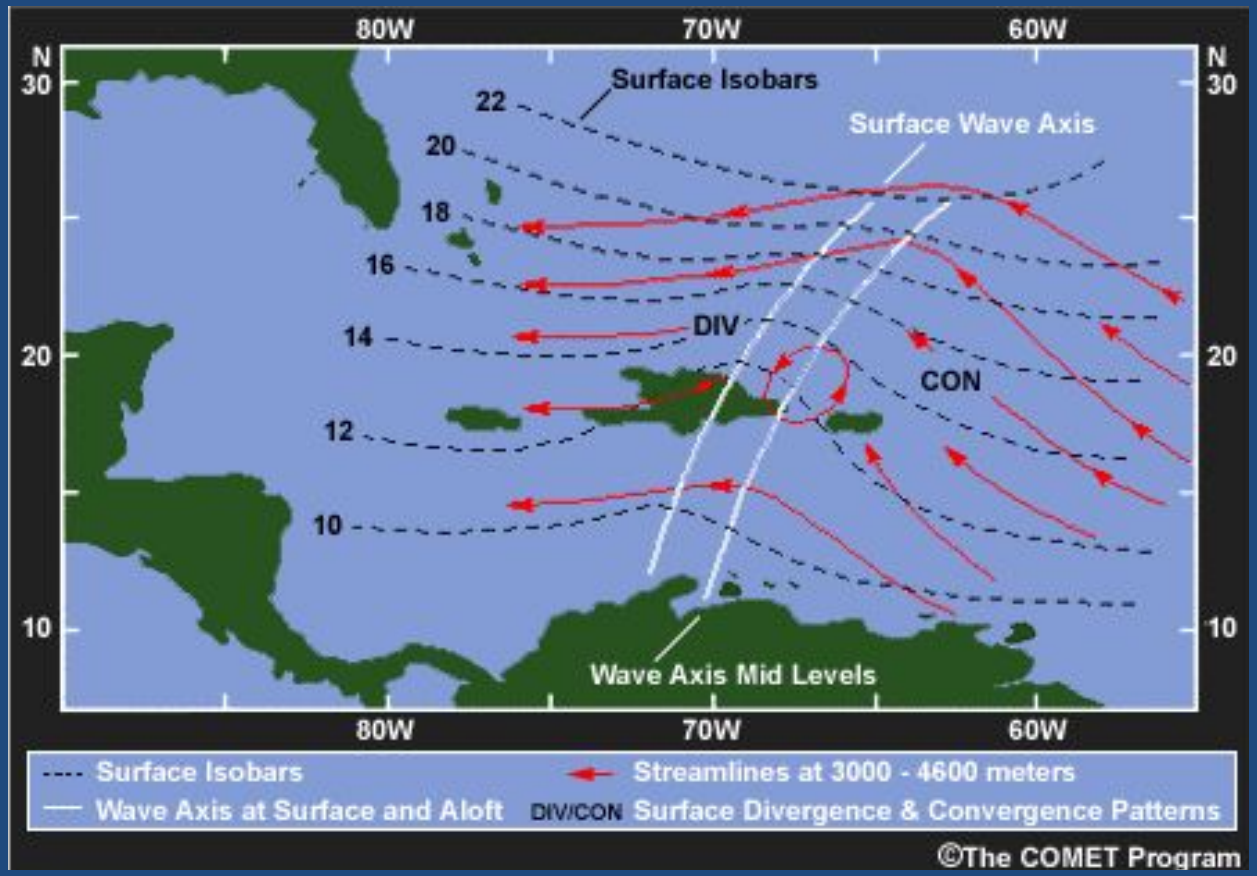
Schematic diagram



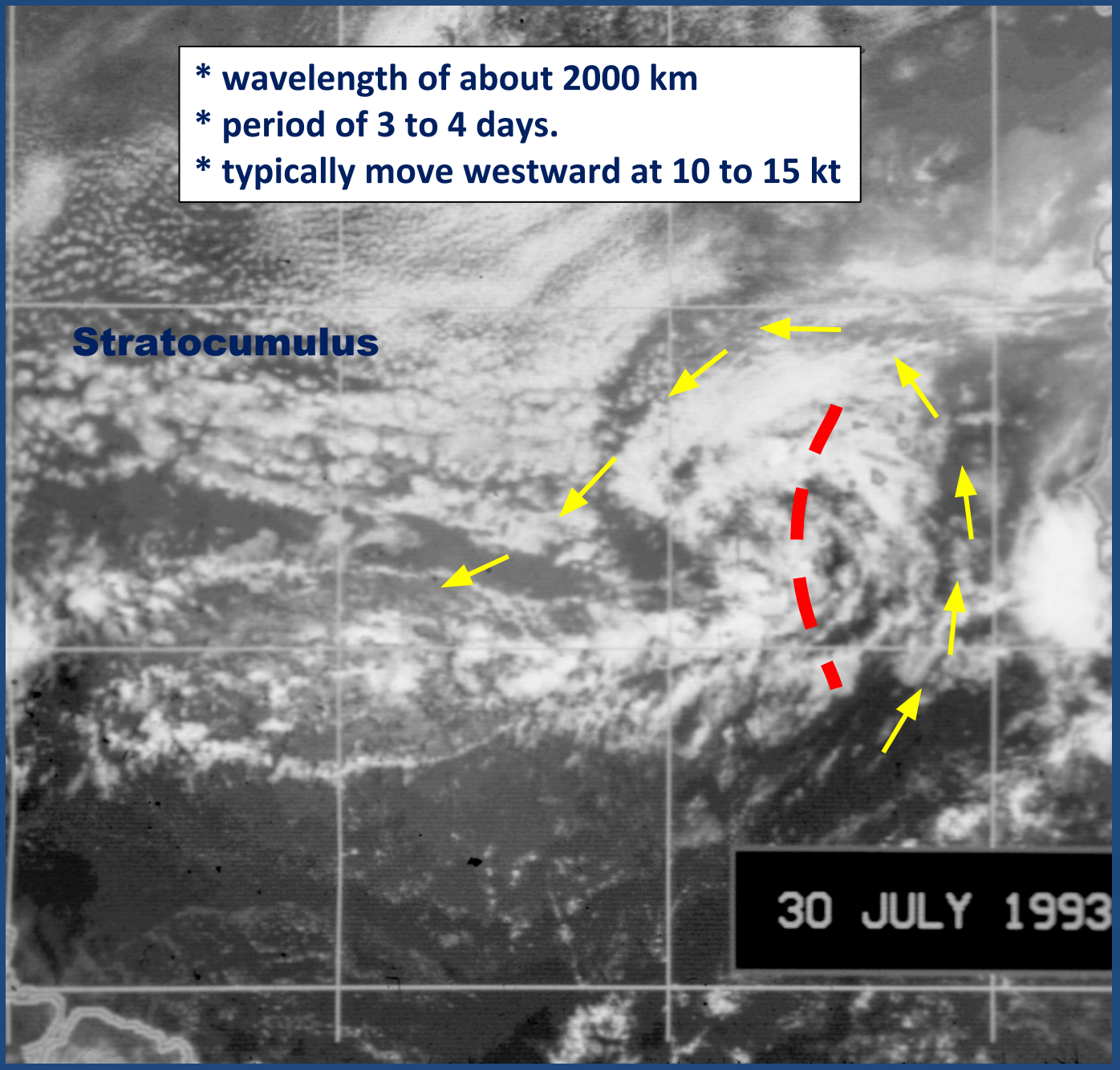
At what pressure level is the maximum amplitude?

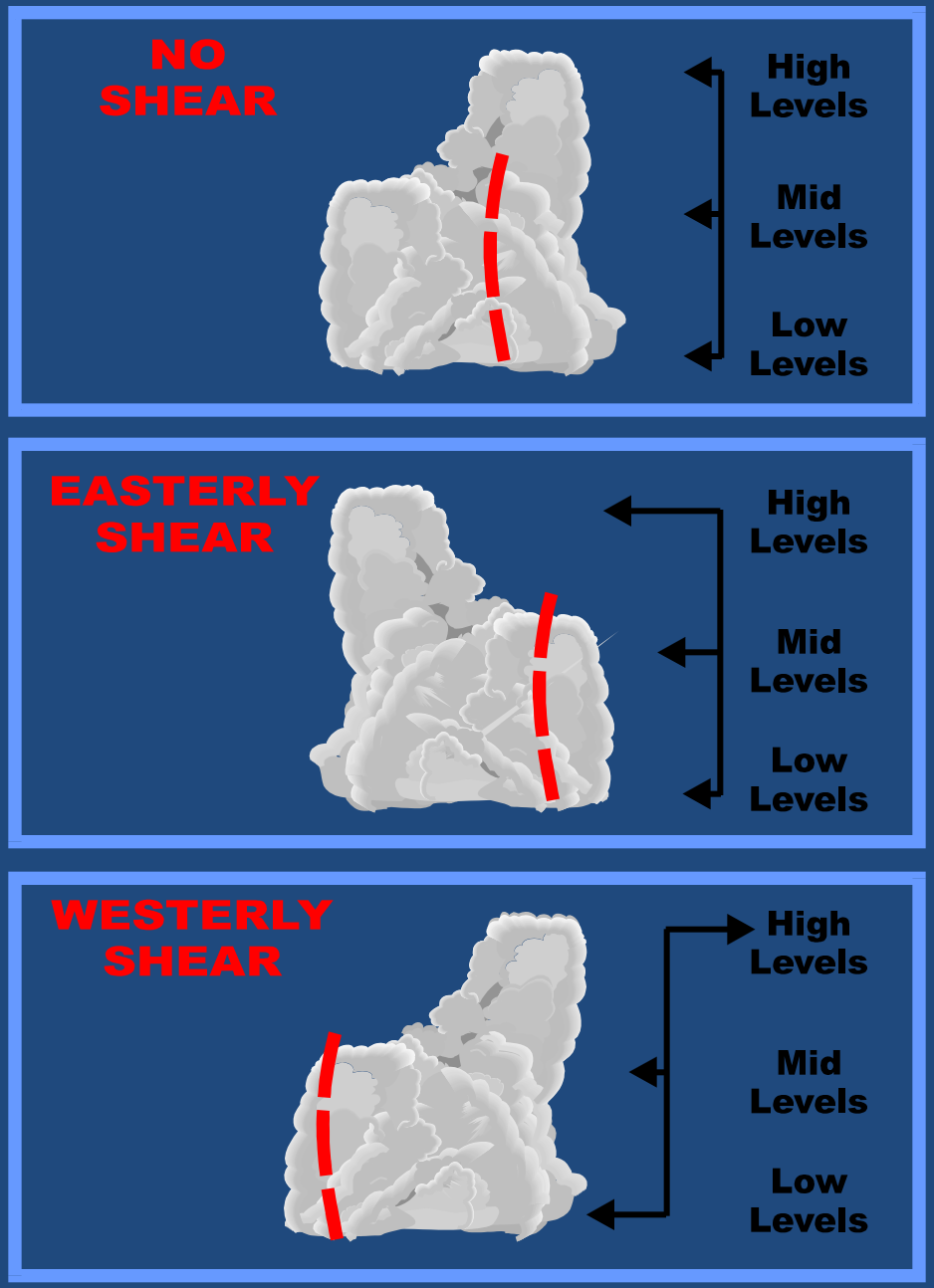
(a) 700 mb
(b) 500 mb
(c) 200 mb
(d) surface

Schematic diagram

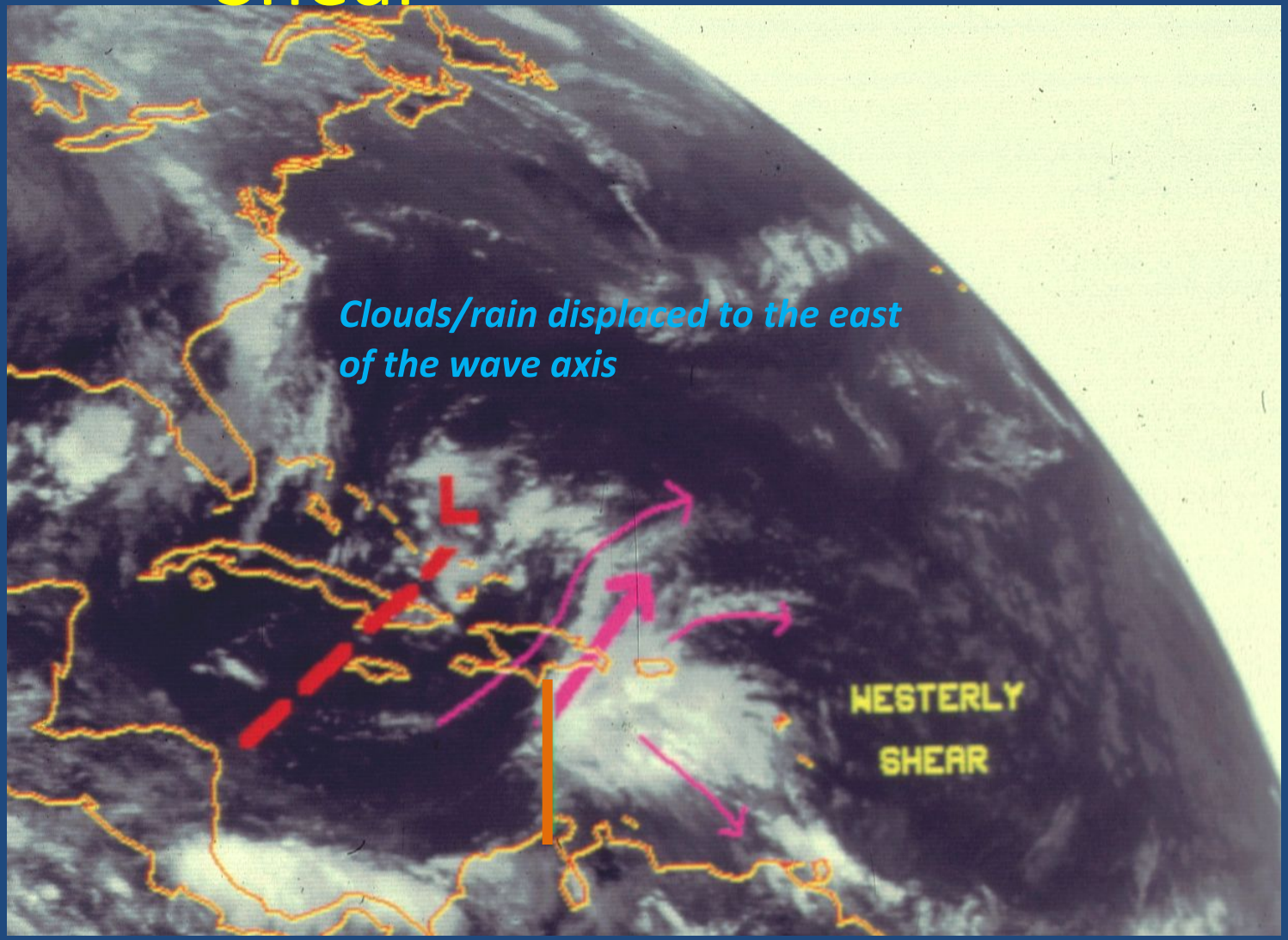


- Notice eastward slope will height
- Maximum amplitude is around 700 mb

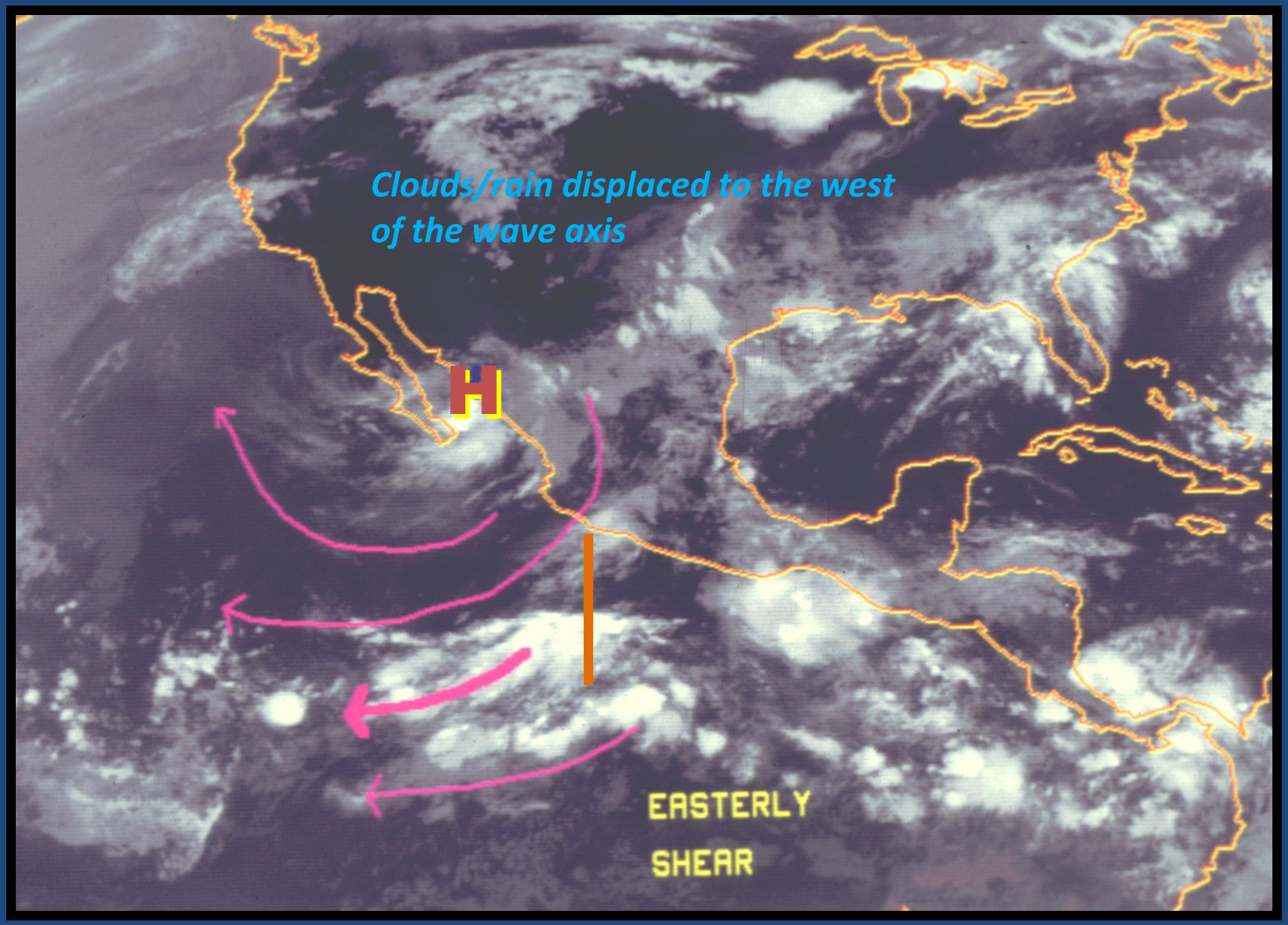

* wavelength of about 2000 km
* period of 3 to 4 days.
* typically move westward at 10 to 15 kt
Stratocumulus
30 JULY 1993


NO SHEAR
High Levels
Mid Levels
Low Levels
EASTERLY SHEAR
High Levels
Mid Levels
Low Levels
WESTERLY SHEAR
High Levels
Mid Levels
Low Levels

Waves in Westerly Shear

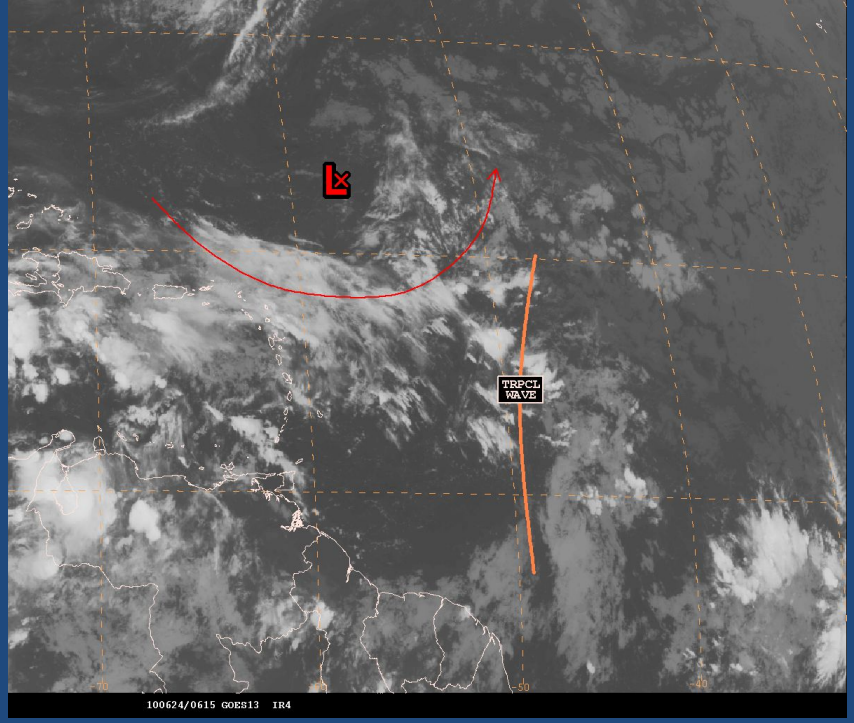


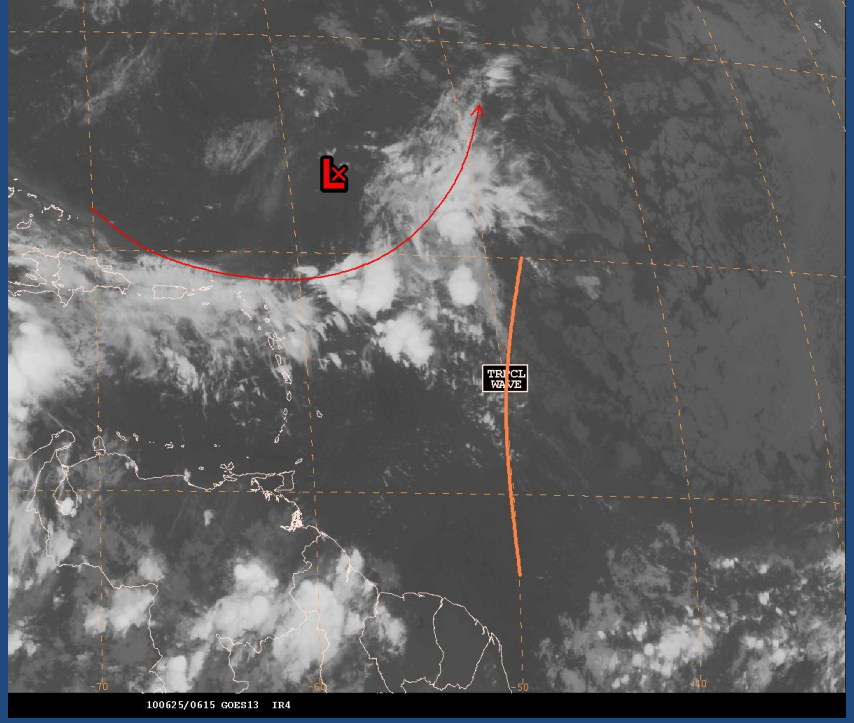
Waves in Easterly Shear

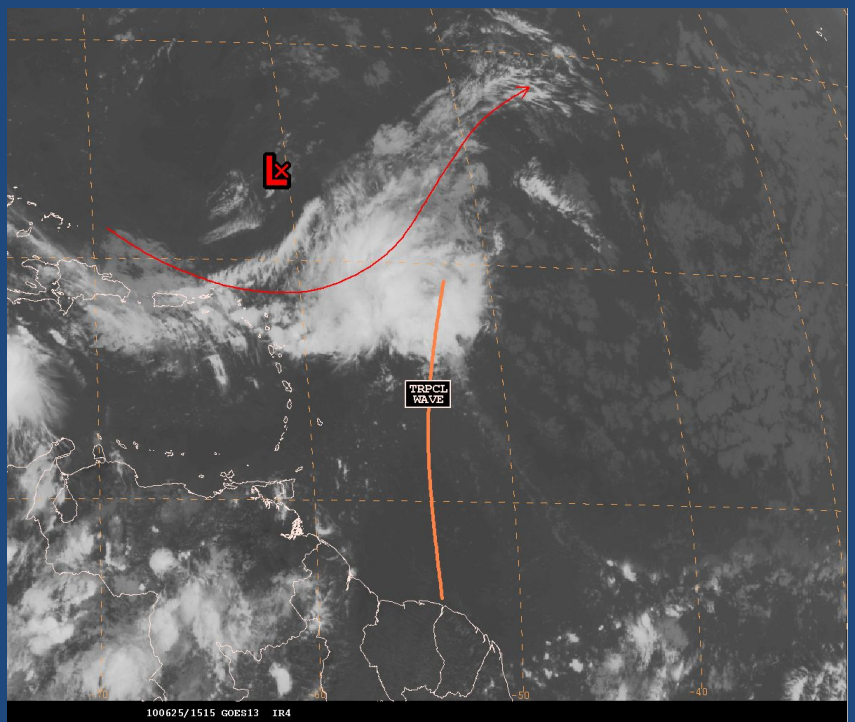


What happens when tropical waves interact with upper-level lows and troughs?

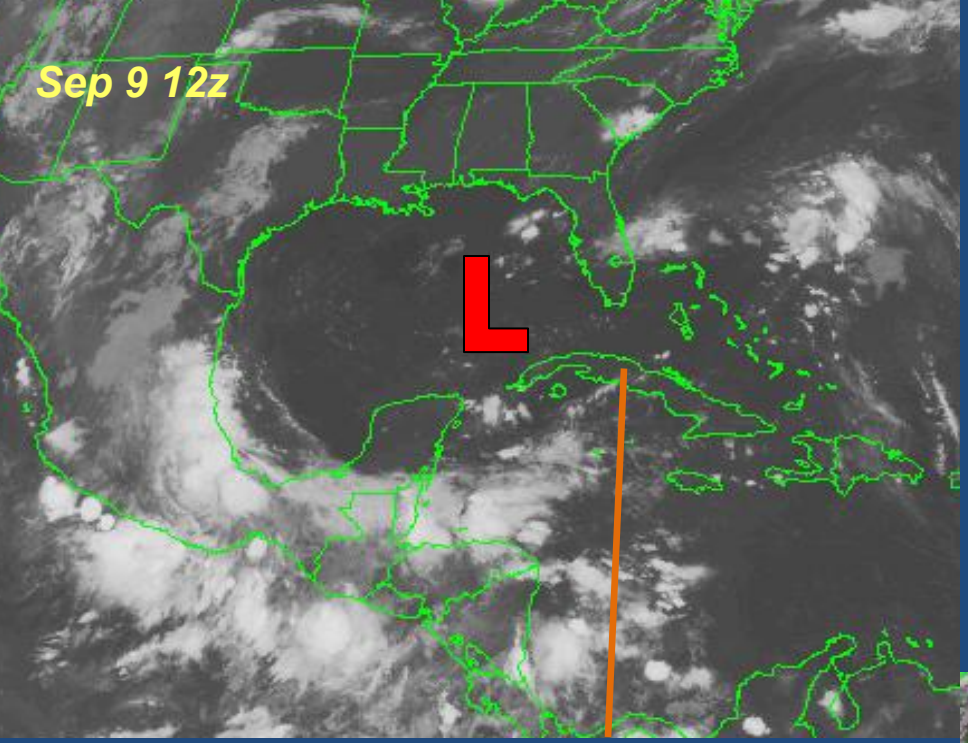
(a) Convection decreases
(b) Convection increases
(c) A tropical cyclone forms



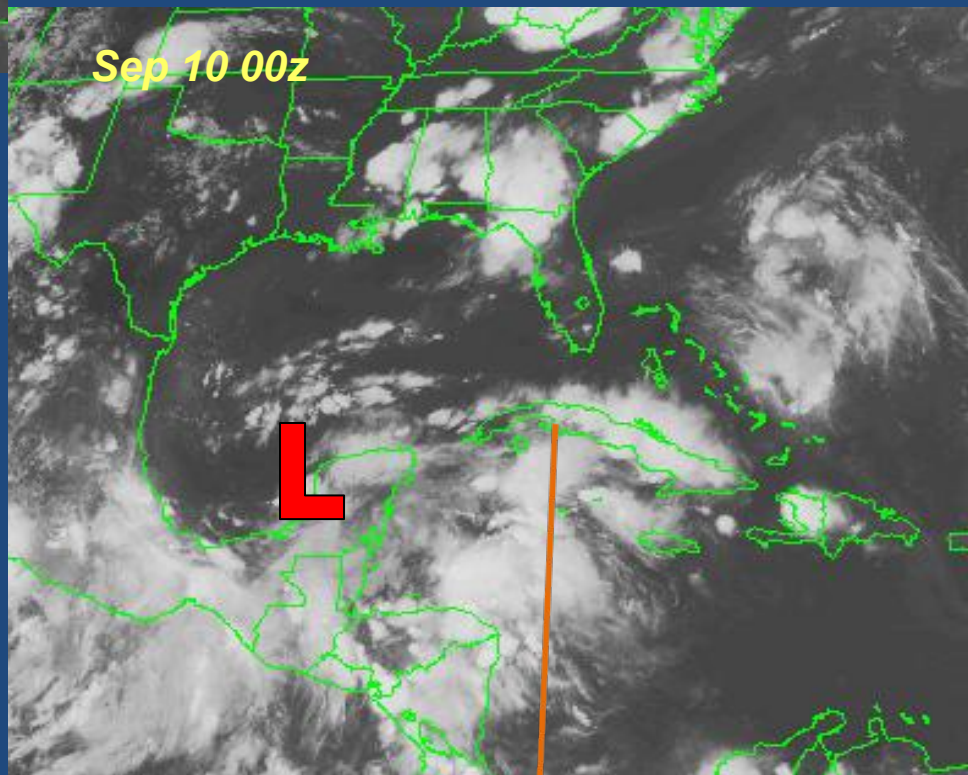




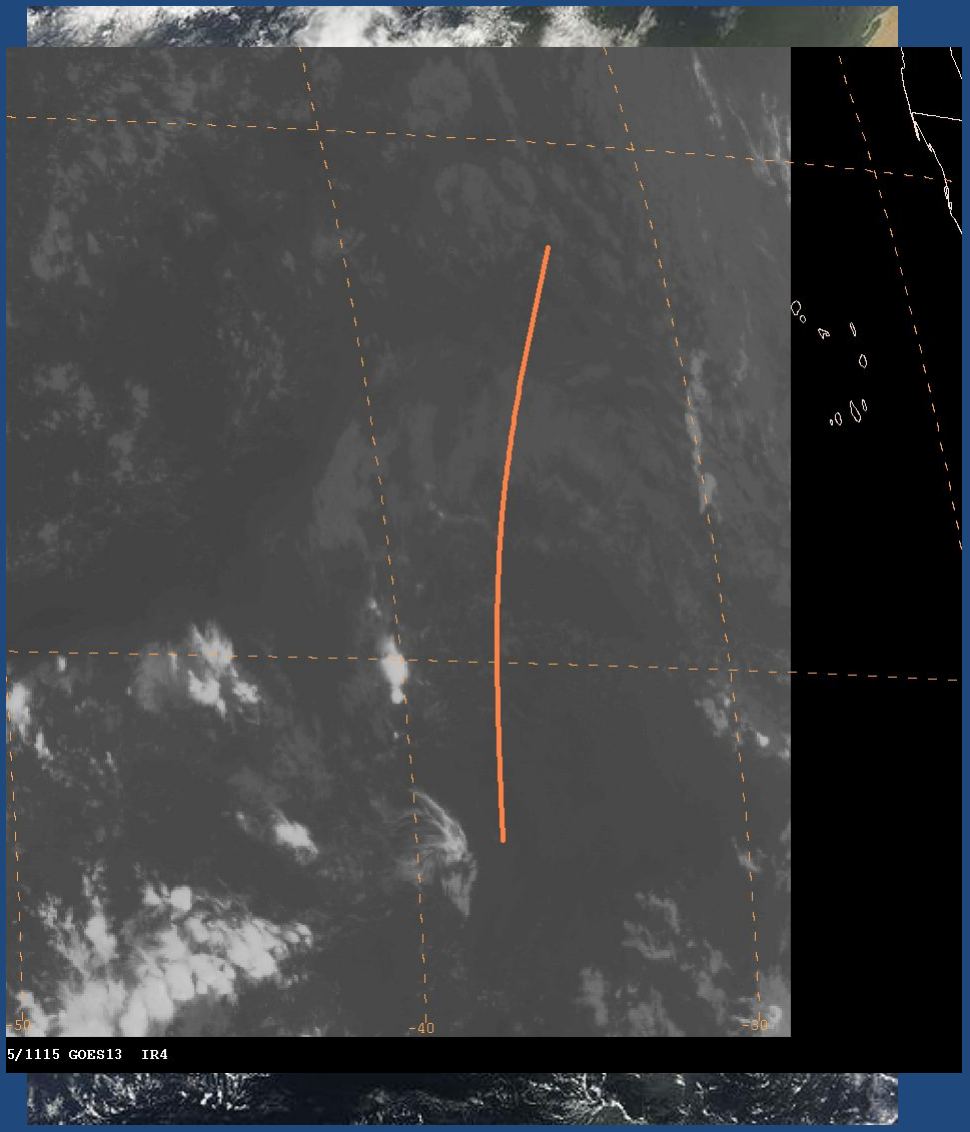
Although interaction with upper-level lows are unfavorable for tropical cyclogenesis, it can often induce heavy rainfall.



Sea-breeze convergence, upslope flows, and afternoon heating can cause convection to become chaotic and difficult to predict.

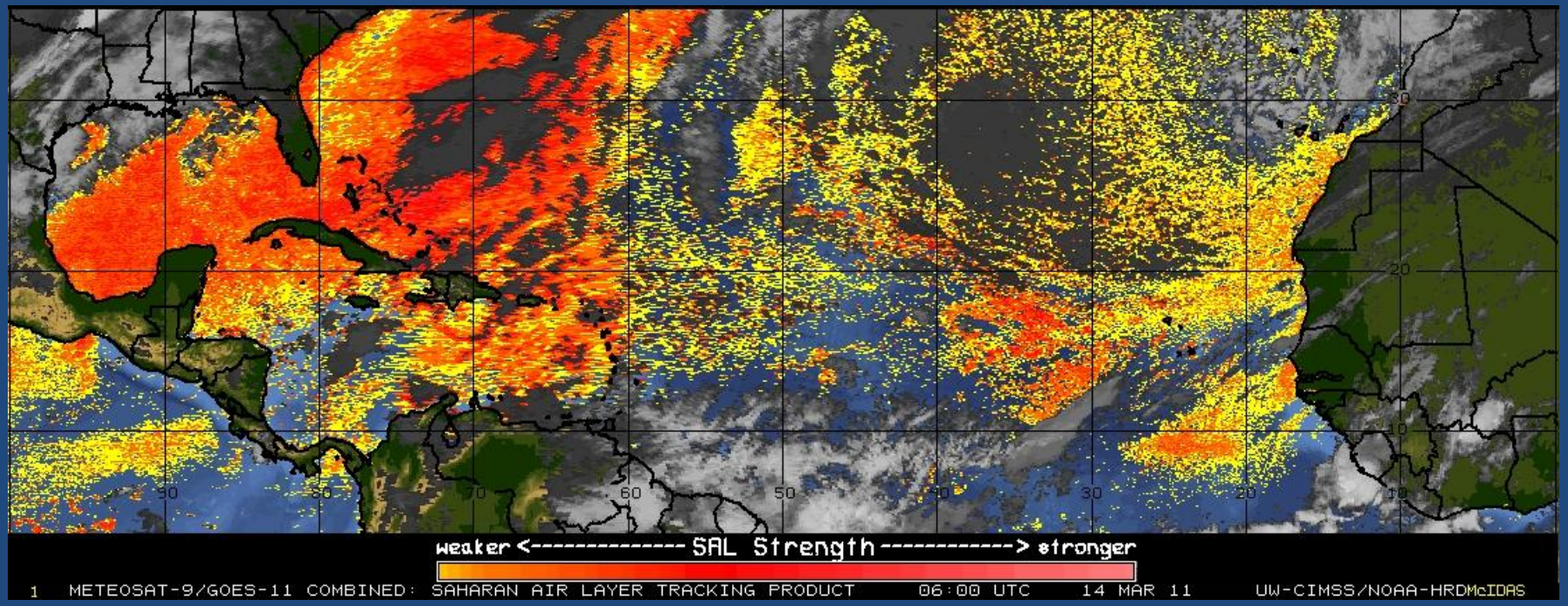


Saharan Air Layer



Very dry/warm air in the low-mid levels of the atmosphere limits convection.

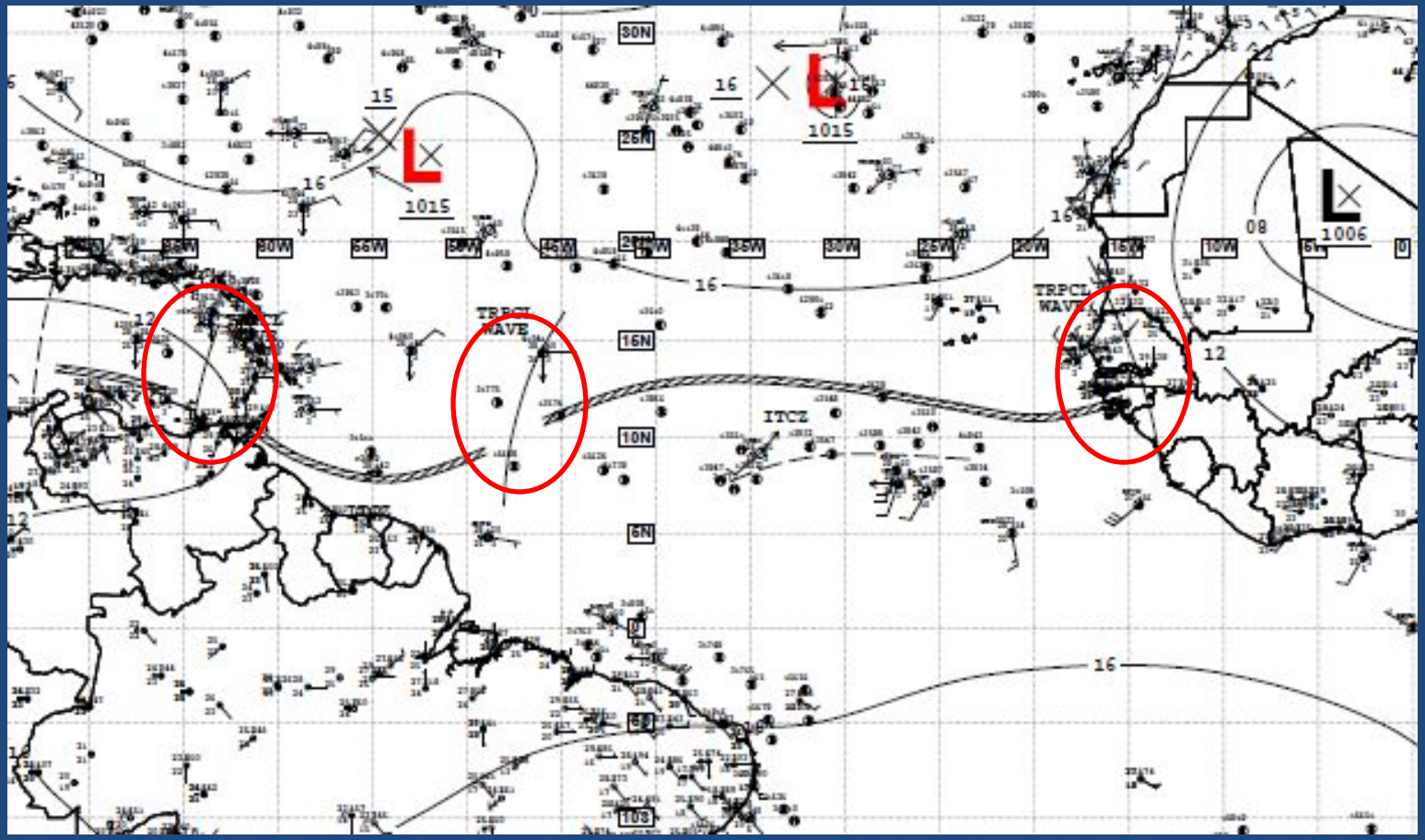
Saharan Air Layer



Tool to help track the strength and position of the SAL

NHC Products

TAFB products: Surface Analysis



Analyze current positions

TAFB products: Tropical Weather Discussion

TROPICAL WEATHER DISCUSSION FOR NORTH AMERICA...CENTRAL AMERICA...GULF OF MEXICO...CARIBBEAN SEA...NORTHERN SECTIONS OF SOUTH AMERICA...AND ATLANTIC OCEAN TO THE AFRICAN COAST FROM THE EQUATOR TO 32N. THE FOLLOWING INFORMATION IS BASED ON SATELLITE IMAGERY...METEOROLOGICAL ANALYSIS...WEATHER OBSERVATIONS...AND RADAR.

BASED ON 1800 UTC SURFACE ANALYSIS AND SATELLITE IMAGERY THROUGH 2315 UTC.

..TROPICAL WAVES...

A TROPICAL WAVE IS ALONG 32W S OF 17N MOVING W NEAR 13 KT. THIS WAVE COINCIDES WITH A DEEP LAYER MOISTURE MAXIMUM OBSERVED IN TOTAL PRECIPITABLE WATER IMAGERY. ISOLATED MODERATE CONVECTION IS FROM 13N-15N BETWEEN 30W-34W.

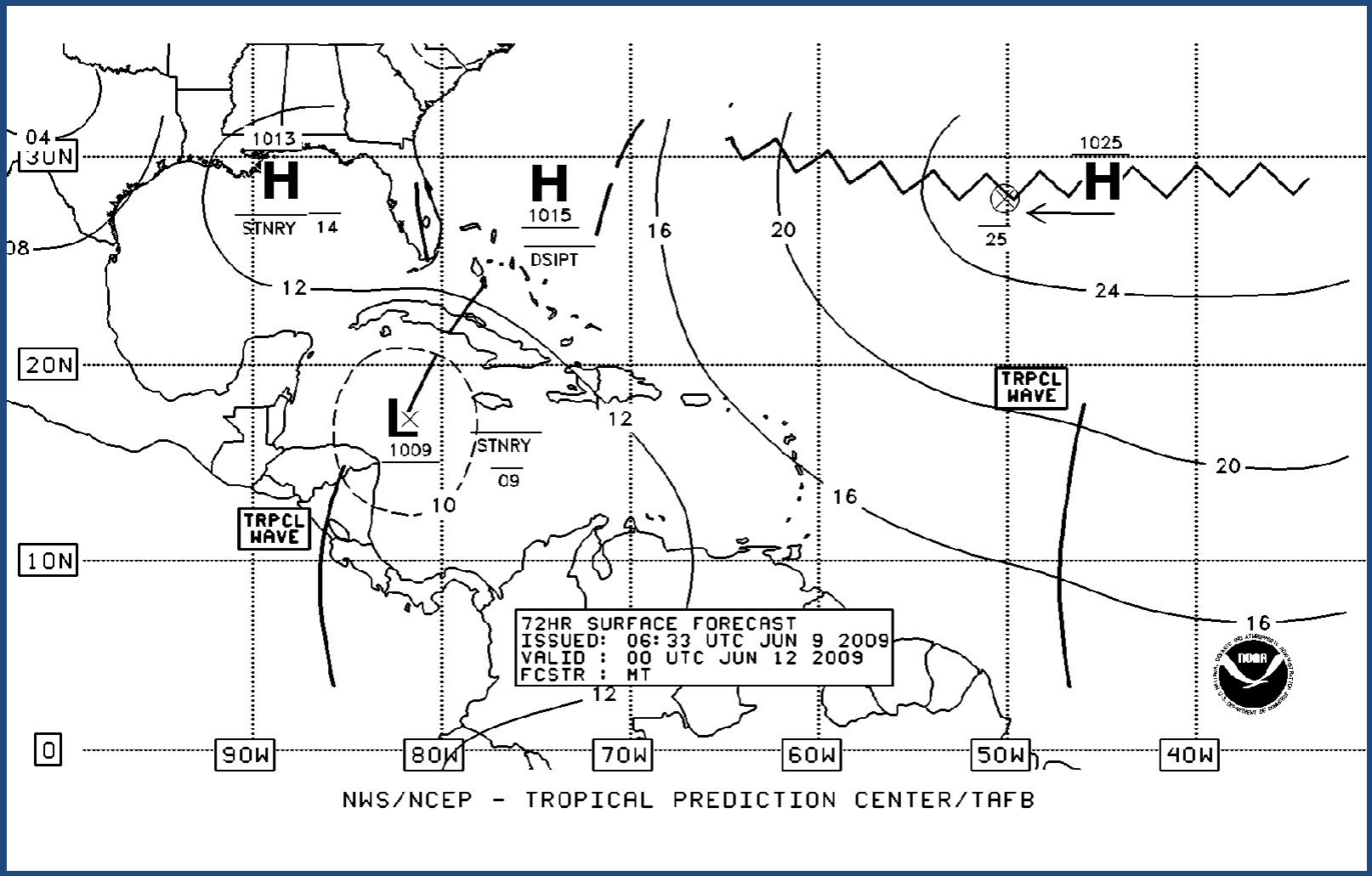
A TROPICAL WAVE IS ALONG 49W S OF 14N MOVING W NEAR 18 KT. THIS WAVE REMAINS ON THE LEADING EDGE OF DRY SAHARAN AIR AND DUST INHIBITING DEEP CONVECTION ALONG THE WAVE AXIS. HOWEVER... SCATTERED SHOWERS ARE FROM 10N-12N BETWEEN 46W-50W.

A TROPICAL WAVE IS ALONG 66W S OF 18N MOVING W NEAR 15 KT. THIS WAVE COINCIDES WITH A DEEP LAYER MOISTURE MAXIMUM THAT STRETCHES NWD INTO THE SW NORTH ATLC DUE TO AN UPPER LEVEL LOW CENTERED NEAR 23N67W. INTERACTIONS BETWEEN THE TROPICAL WAVE AND UPPER LEVEL LOW ARE PRODUCING SCATTERED SHOWERS AND ISOLATED MODERATE CONVECTION FROM 10N-19N BETWEEN 60W-70W.

A TROPICAL WAVE IS ALONG 82W S OF 21N MOVING W NEAR 15 KT. THIS WAVE LIES IN A BROAD AREA OF DEEP LAYER MOISTURE OBSERVED IN TOTAL PRECIPITABLE WATER IMAGERY. THIS WAVE CONTINUES MOVING BENEATH A DIFFLUENT PATTERN ALOFT ENHANCING SCATTERED MODERATE CONVECTION OVER THE SW CARIBBEAN S OF 12N AND ACROSS PANAMA AND COSTA RICA. ALSO SCATTERED MODERATE/ISOLATED STRONG CONVECTION IS OVER THE NW CARIBBEAN N OF 18N BETWEEN 80W-89W...INCLUDING PORTIONS OF WRN CUBA AND THE YUCATAN PENINSULA.

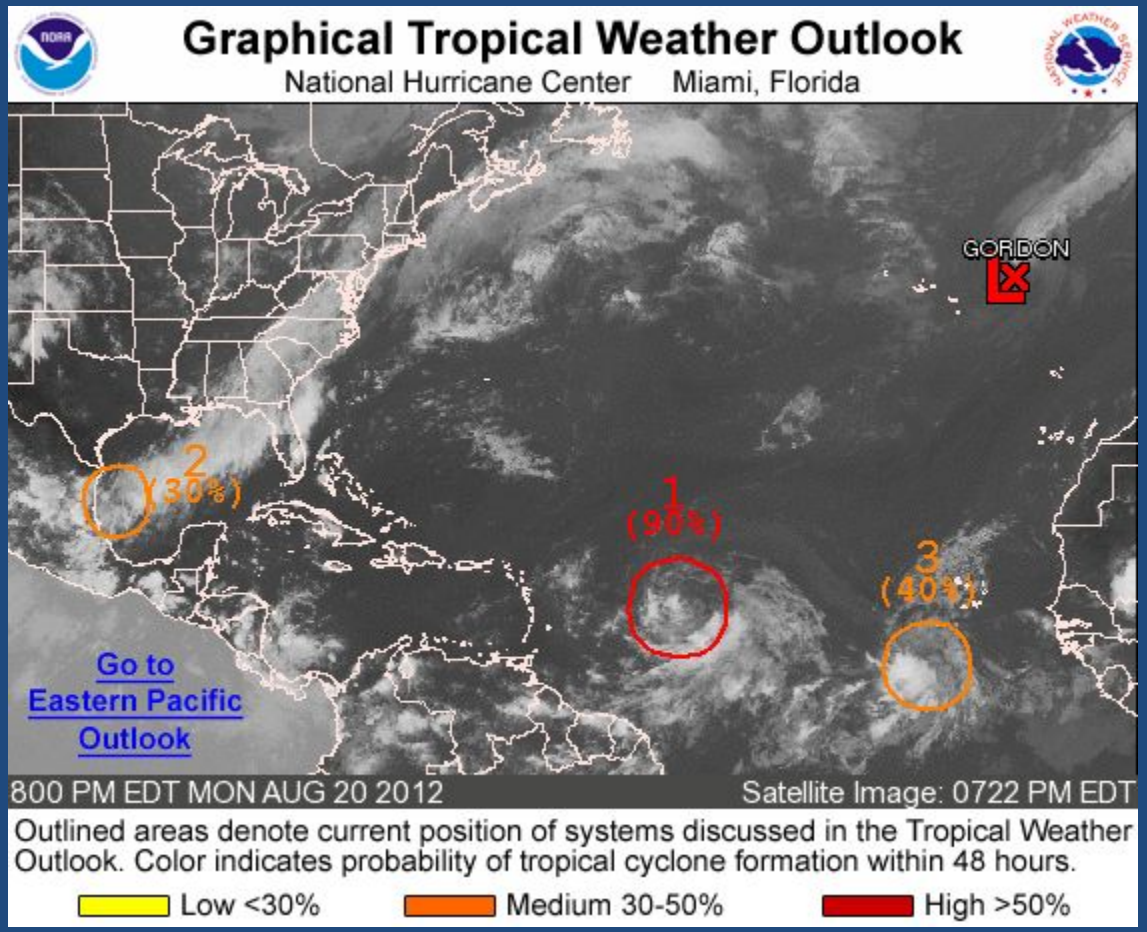
Discussion of tropical waves

TAFB products: graphical forecast



Predict future positions: 24h, 48h, and 72h

Tropical Weather Outlook

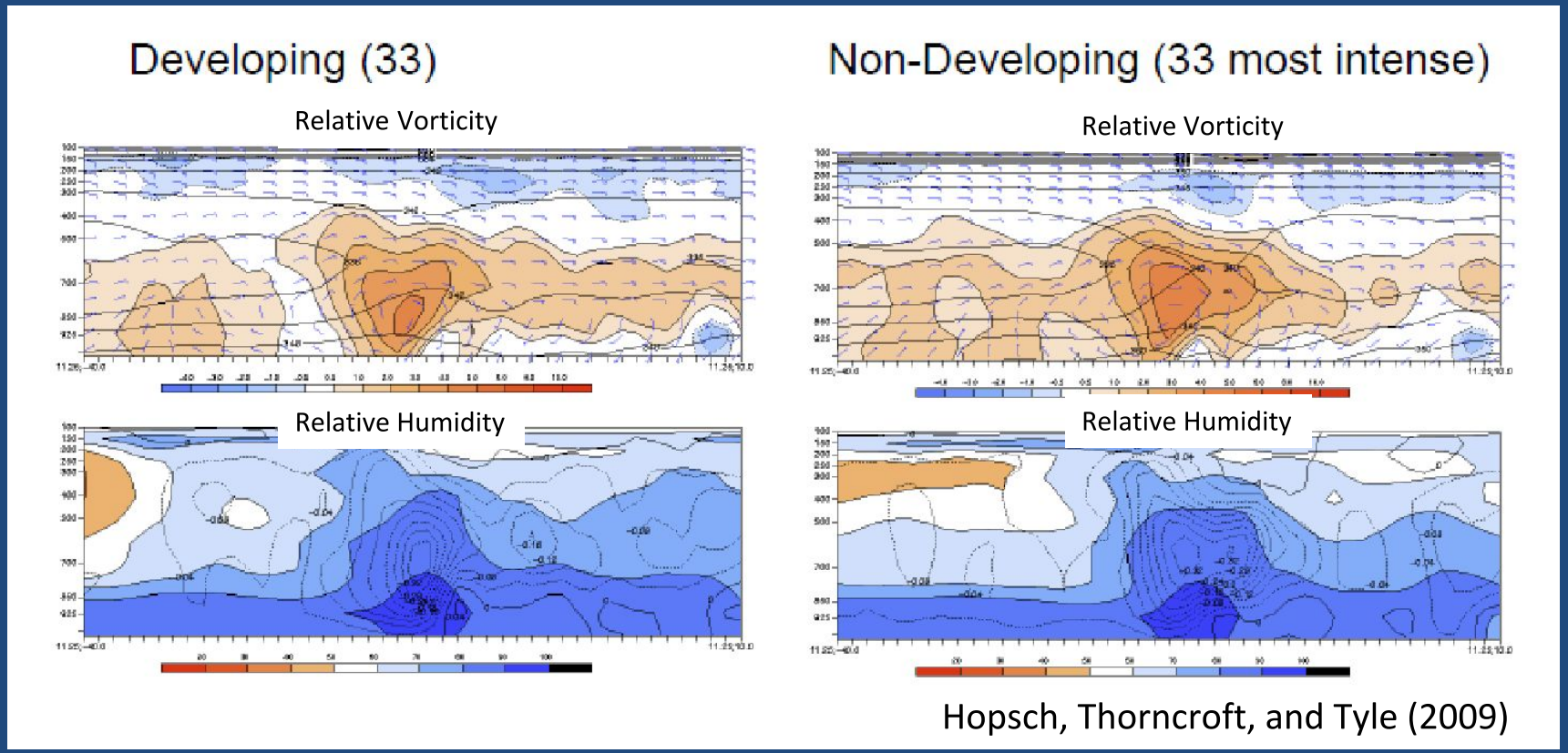


Approximately 70 % of Atlantic tropical cyclones and 85 % of major hurricanes originate from tropical waves

What is more important for tropical cyclogenesis?

(a) the wave structure
(b) the environment

Developing vs. Non-developing

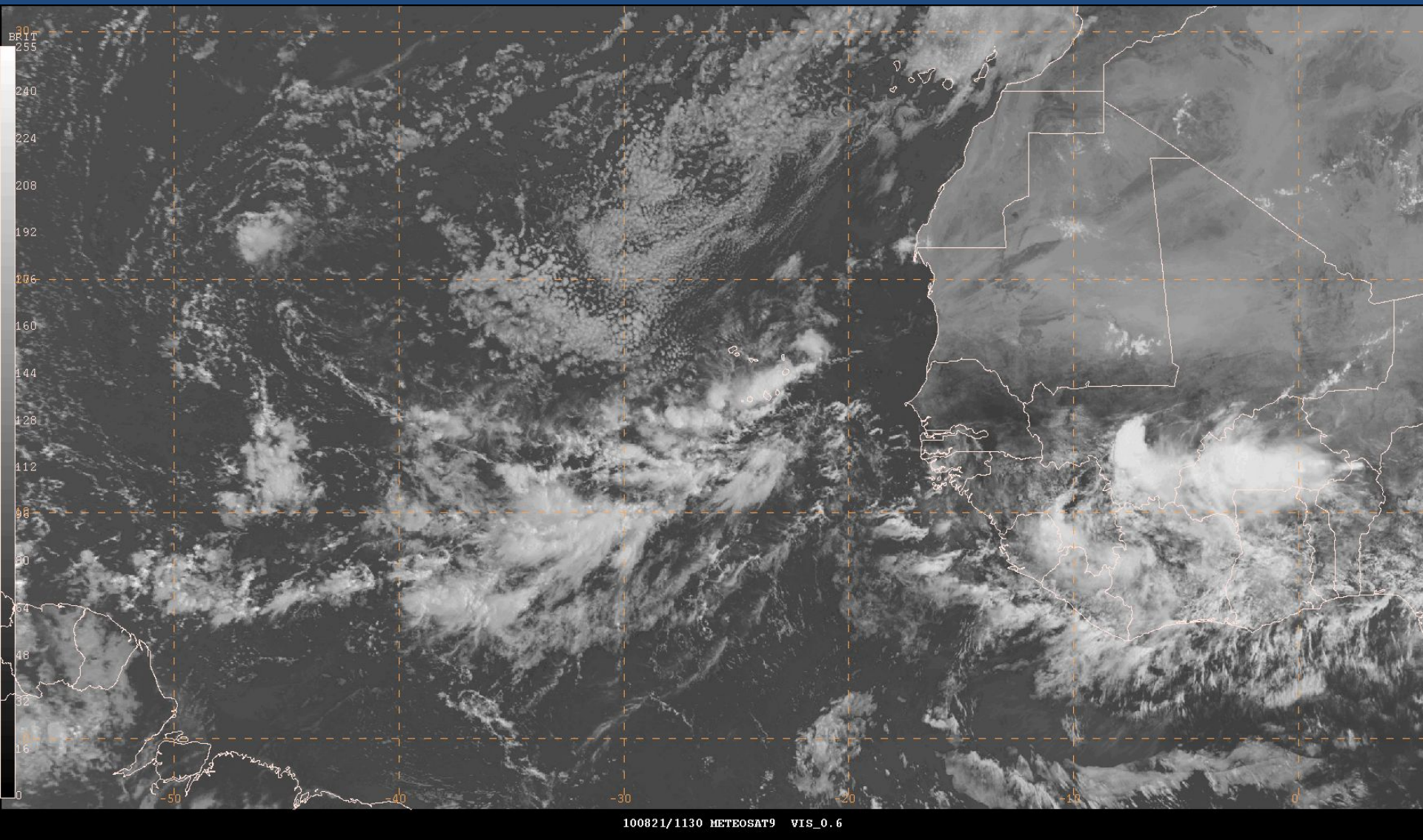


Hopsch, Thorncroft, and Tyle (2009)

Very little different in structure between developing and non-developing waves

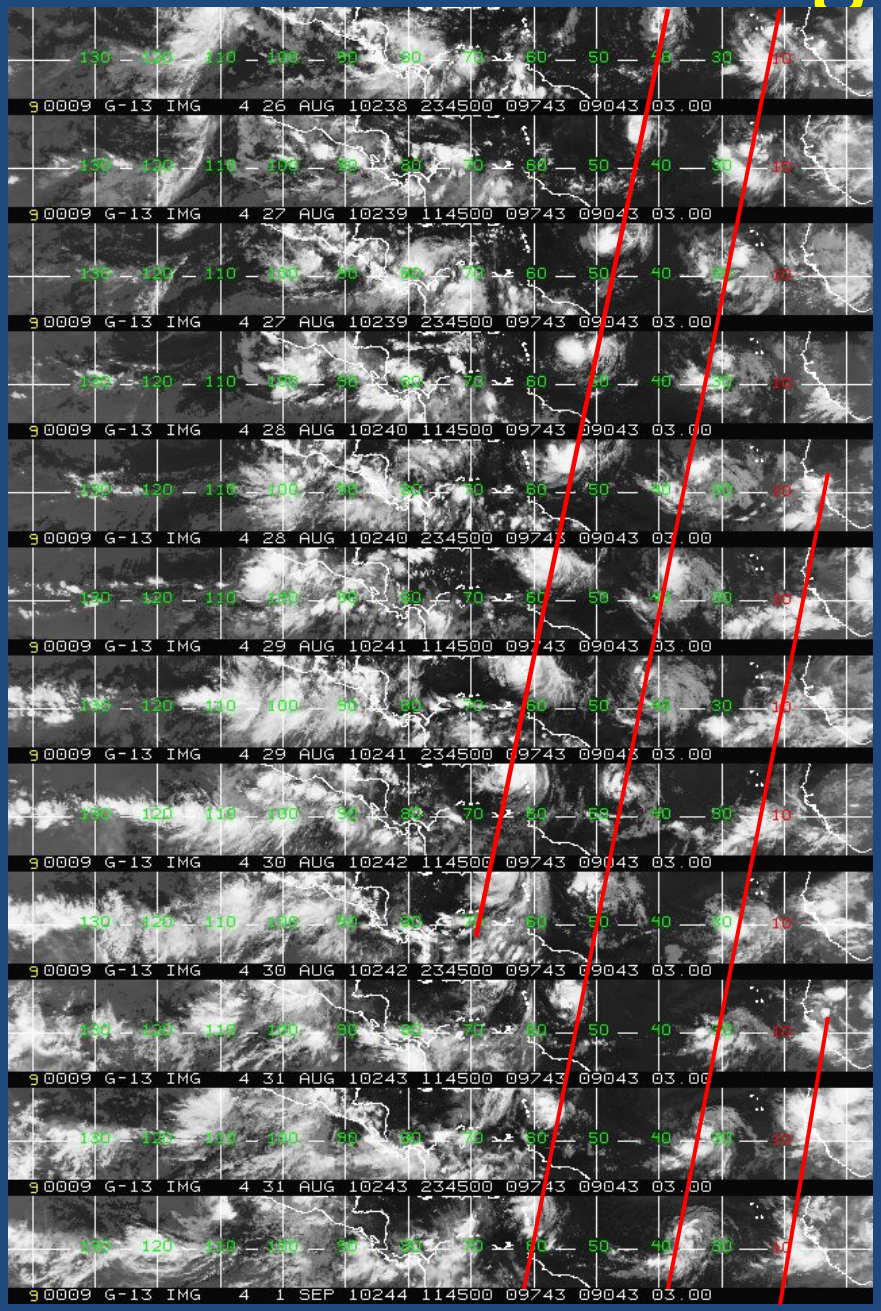
Tools to track tropical waves

Satellite Imagery



Satellite Hovmoller Diagrams

Time



Aug 26

Aug 27

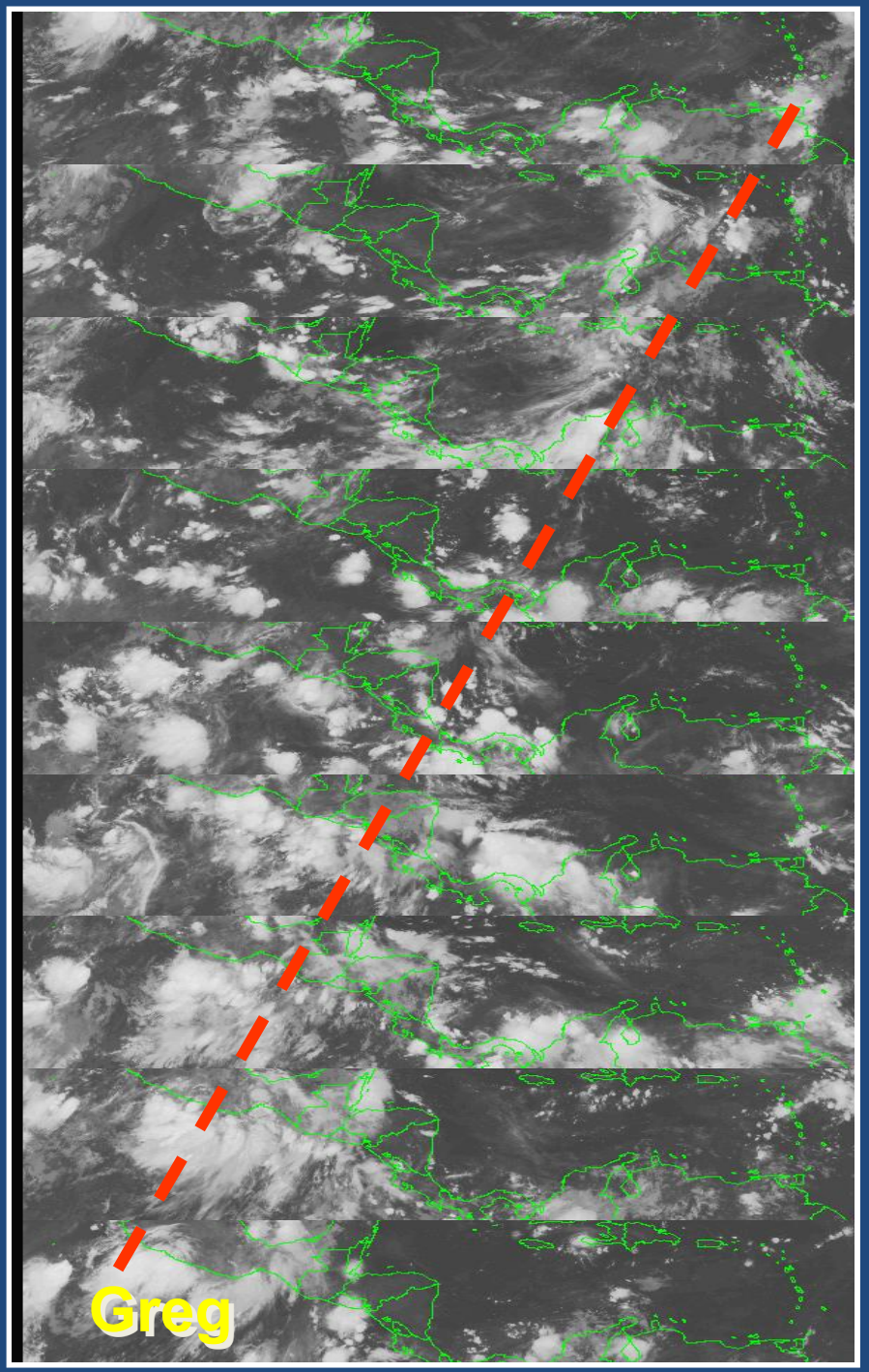
Aug 28

Aug 29

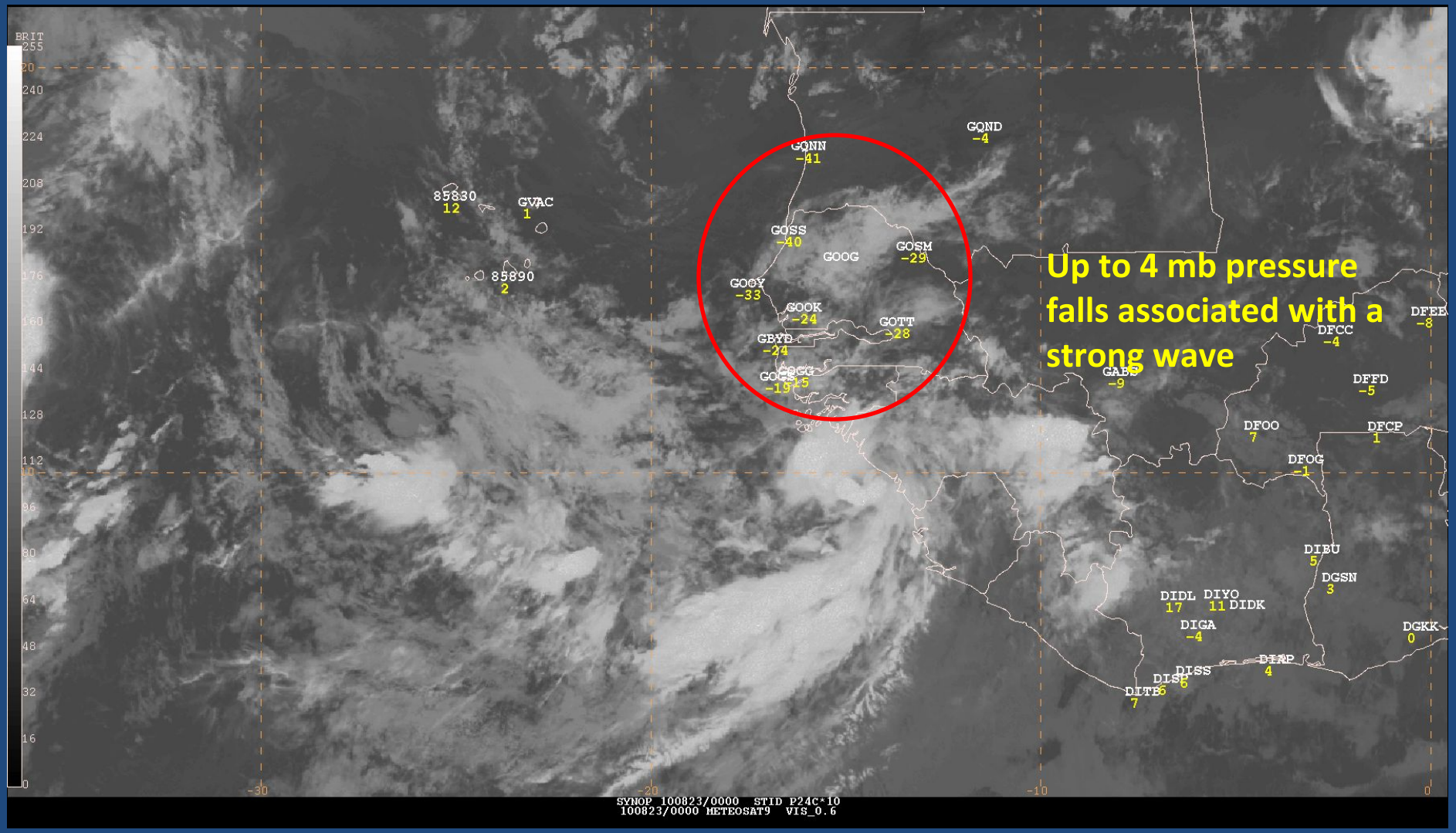
Aug 30

Aug 31

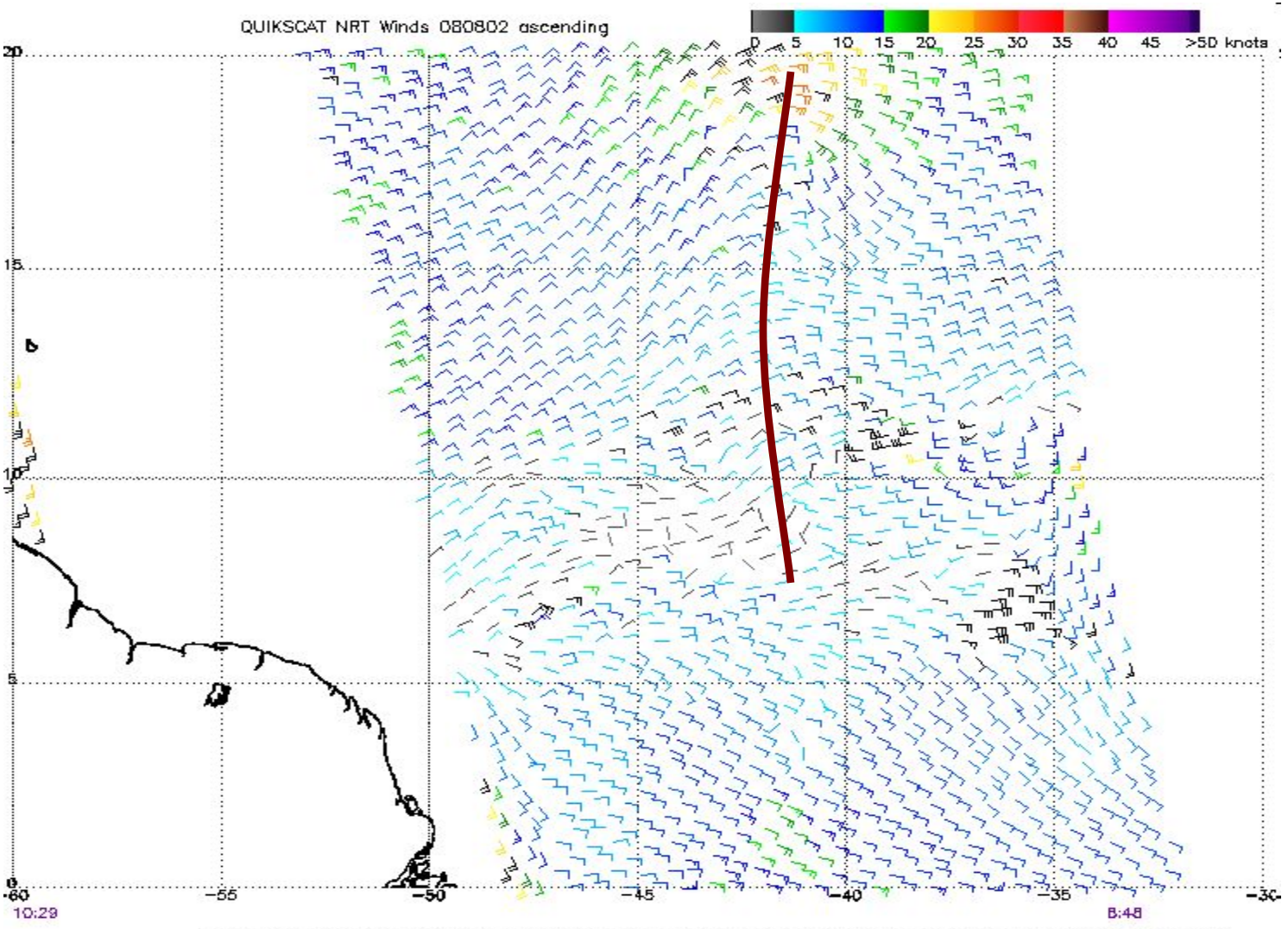
Sep 1


Greg
27
28
29
30
31
1
2
3
4

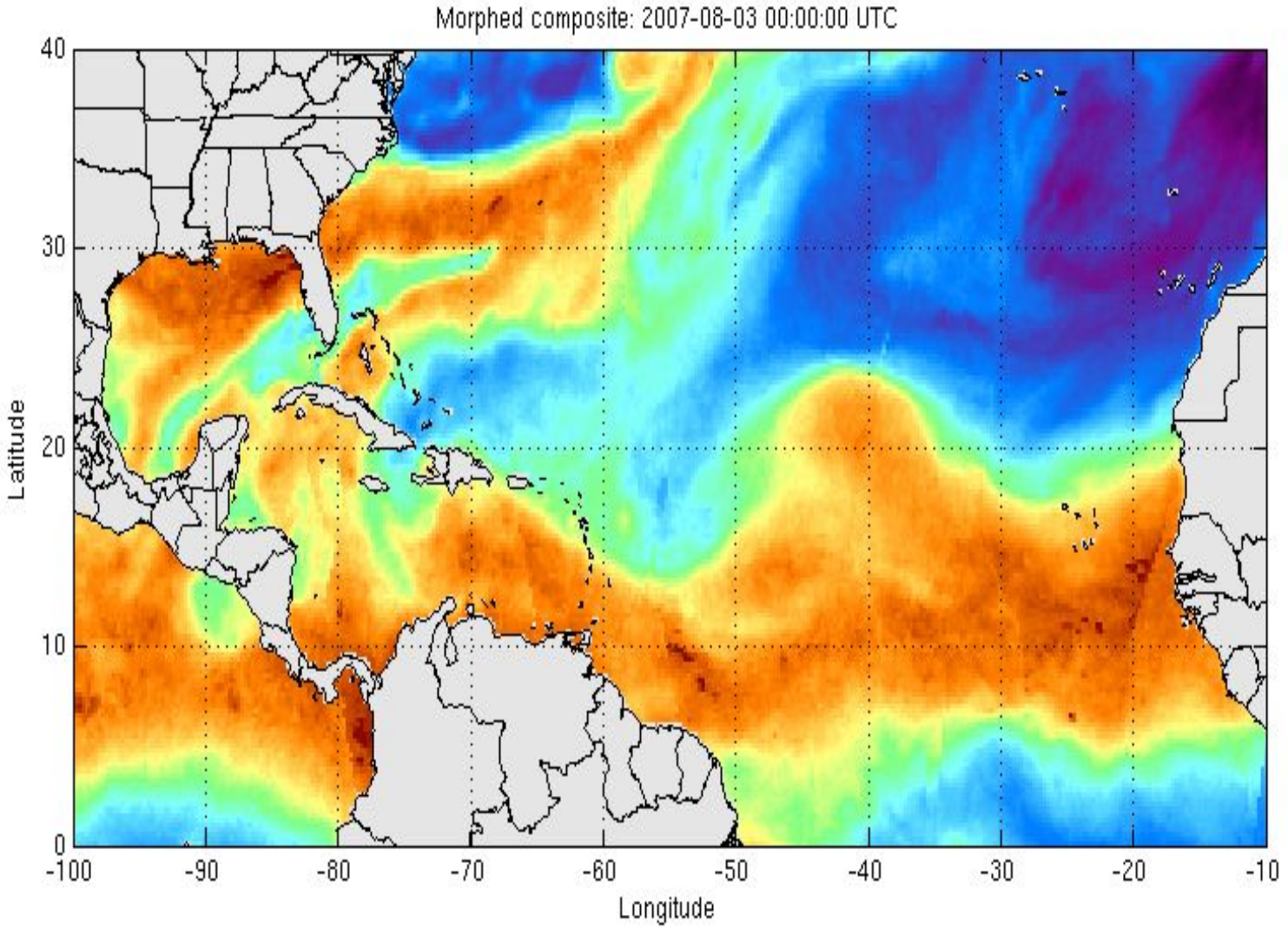
Surface Observations



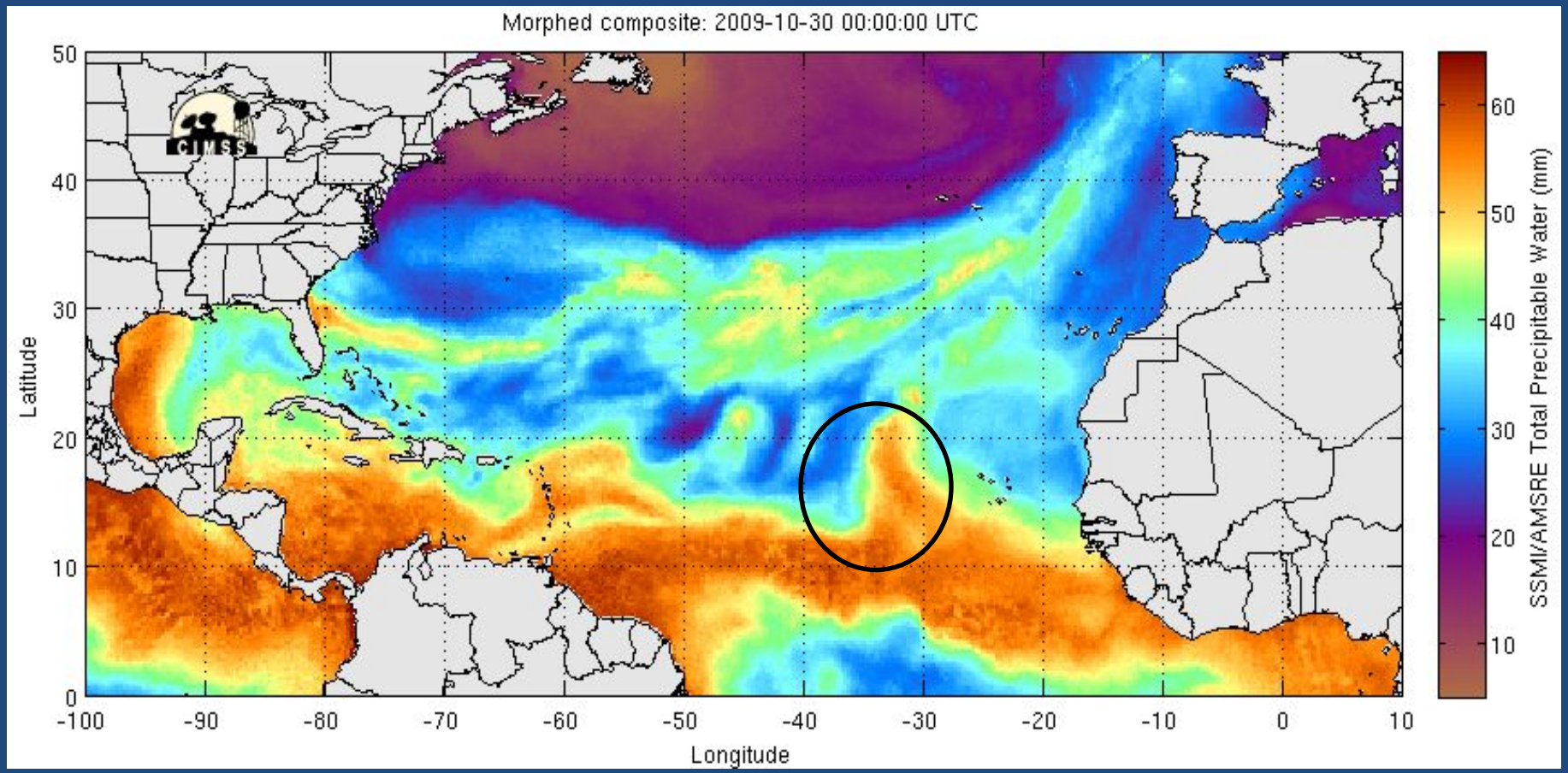
Scatterometer



Total Precipitable Water



Wave Splitting

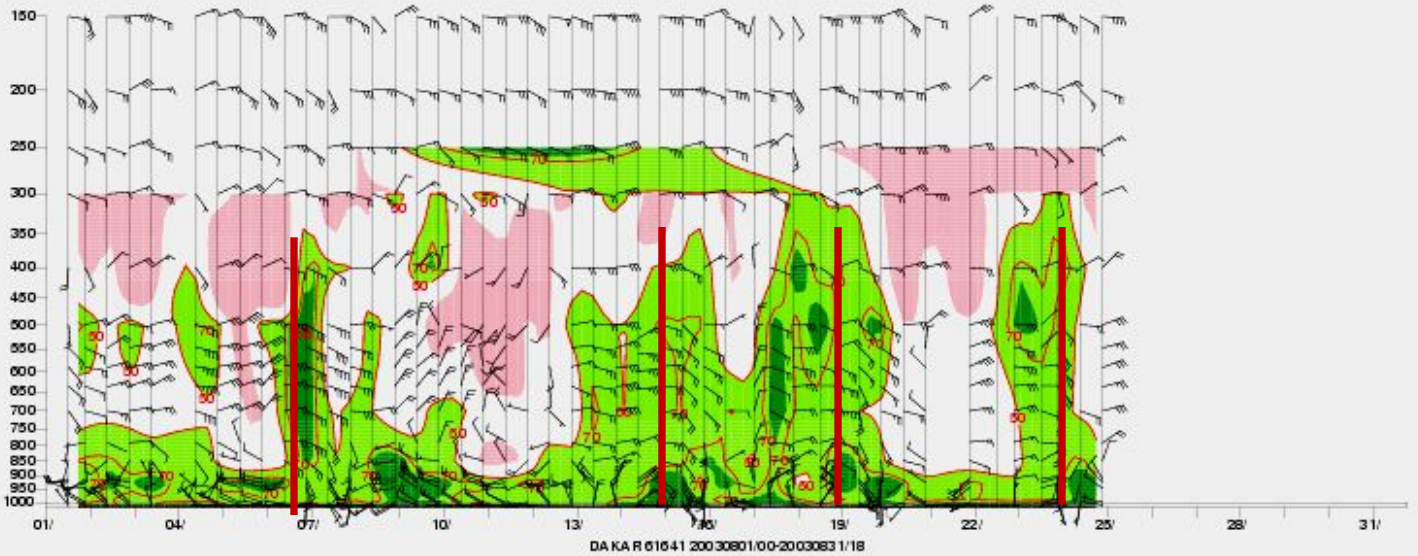


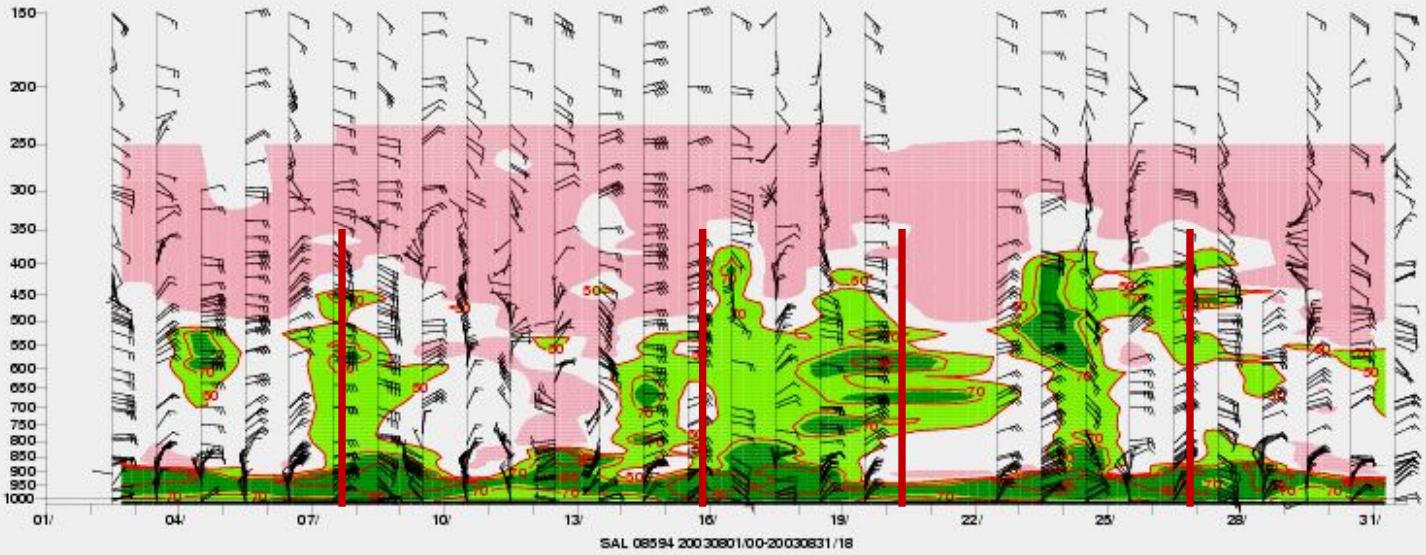
The northern portion of the wave often fractures but the southern extension continues moving westward

Upper-Air Time Sections

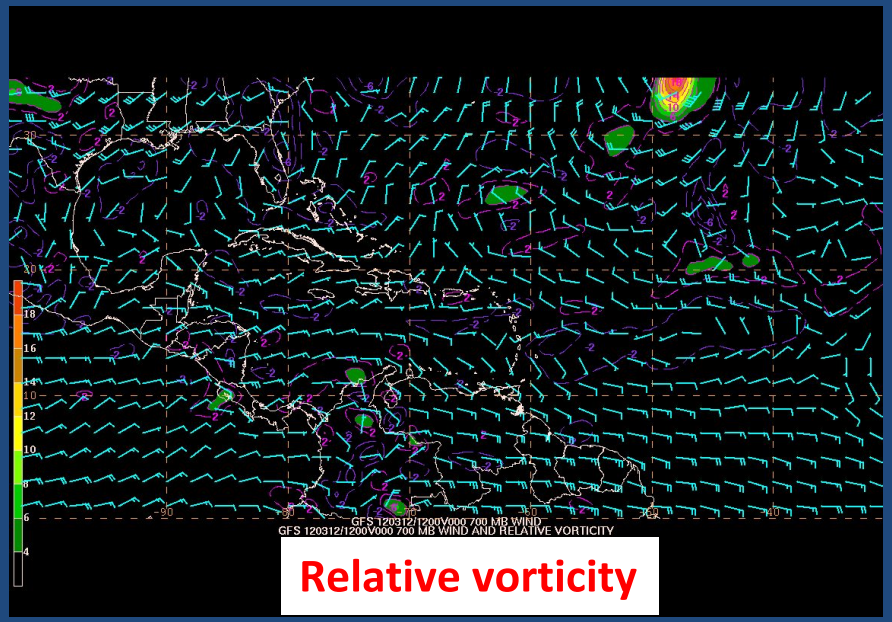
Dakar

Sal

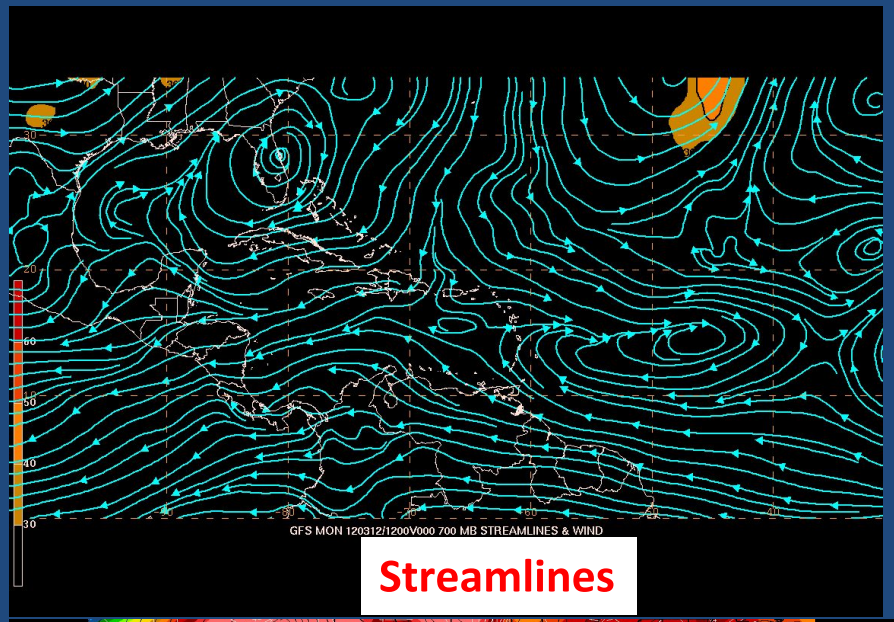




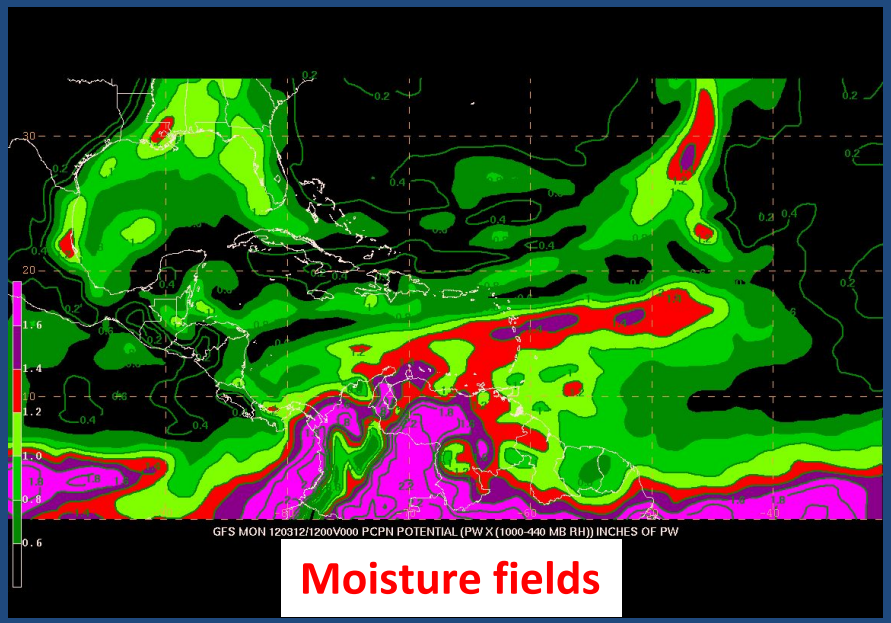
Models



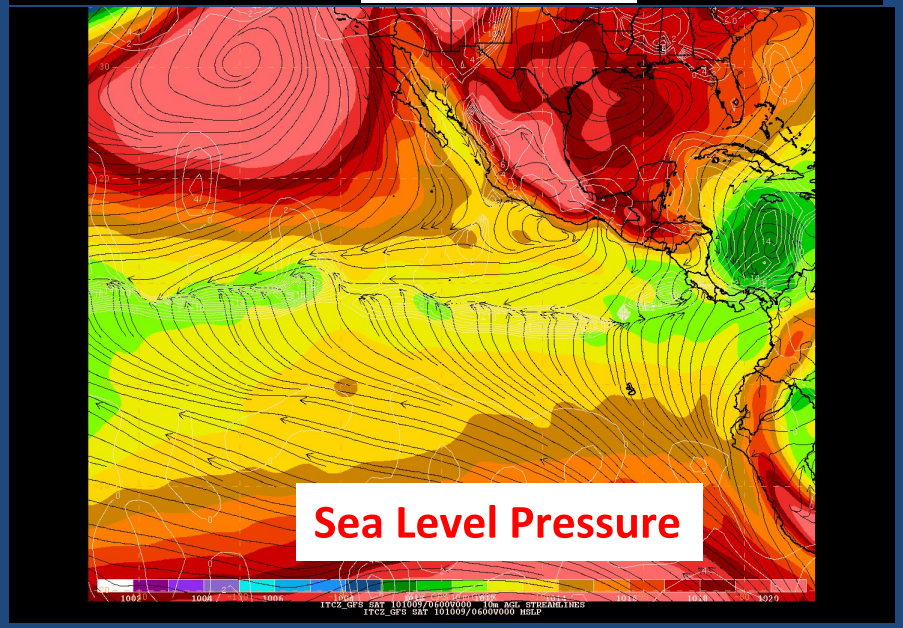
Relative vorticity



Streamlines



Moisture fields

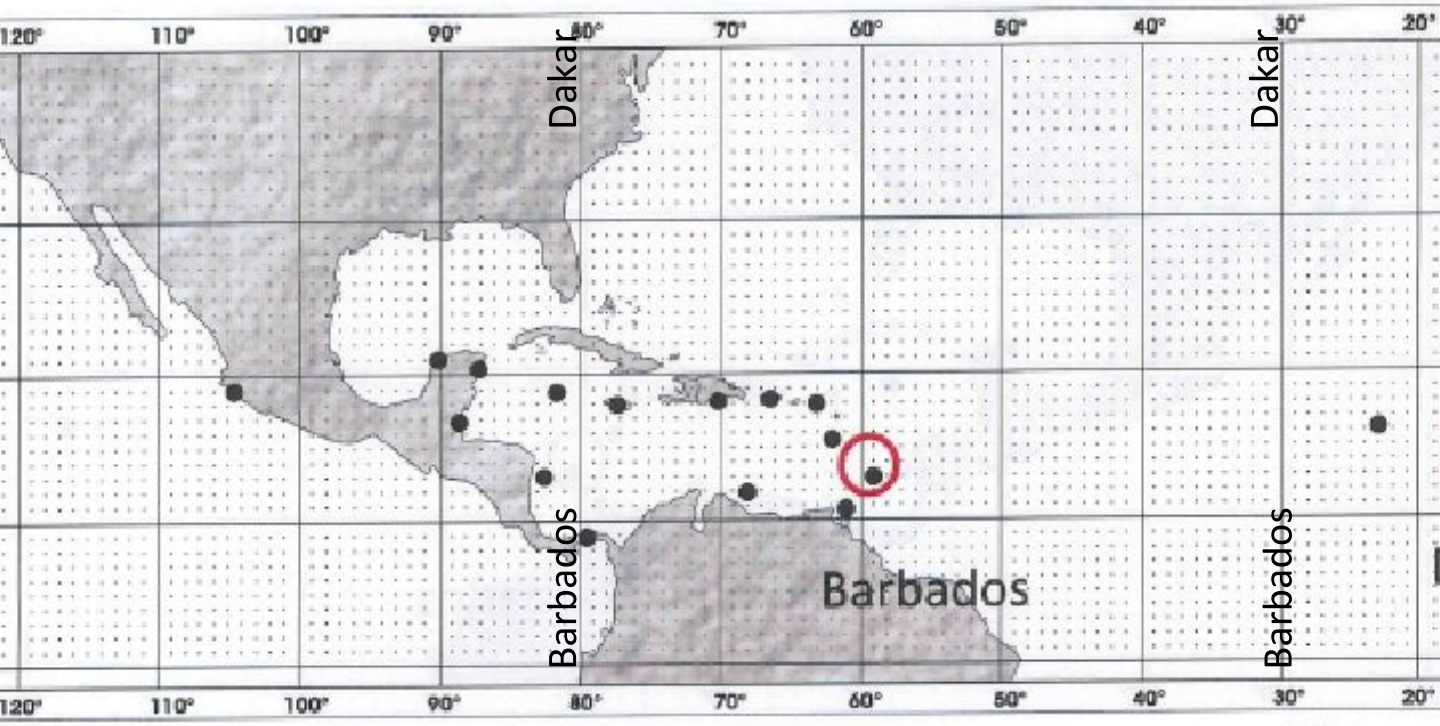


Sea Level Pressure

EXERCISE

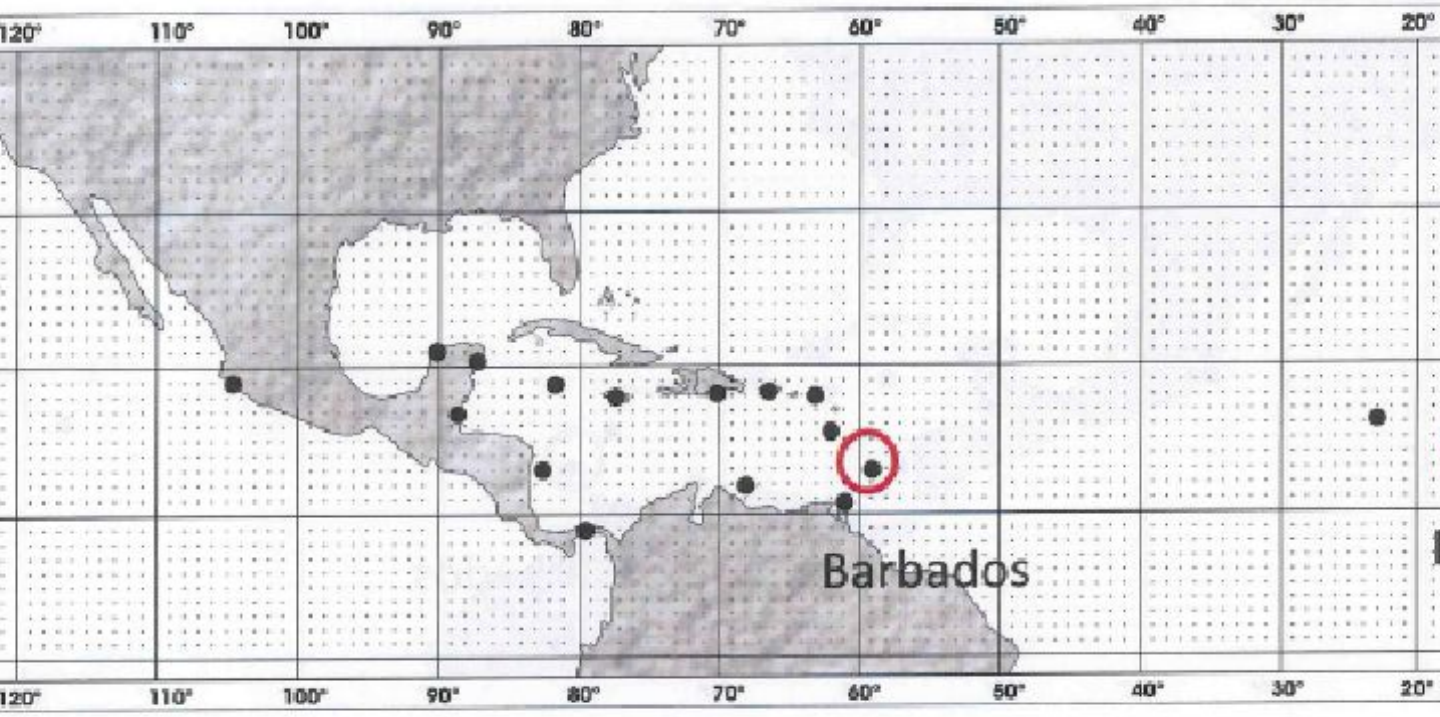
Date: _____

Wave Numb

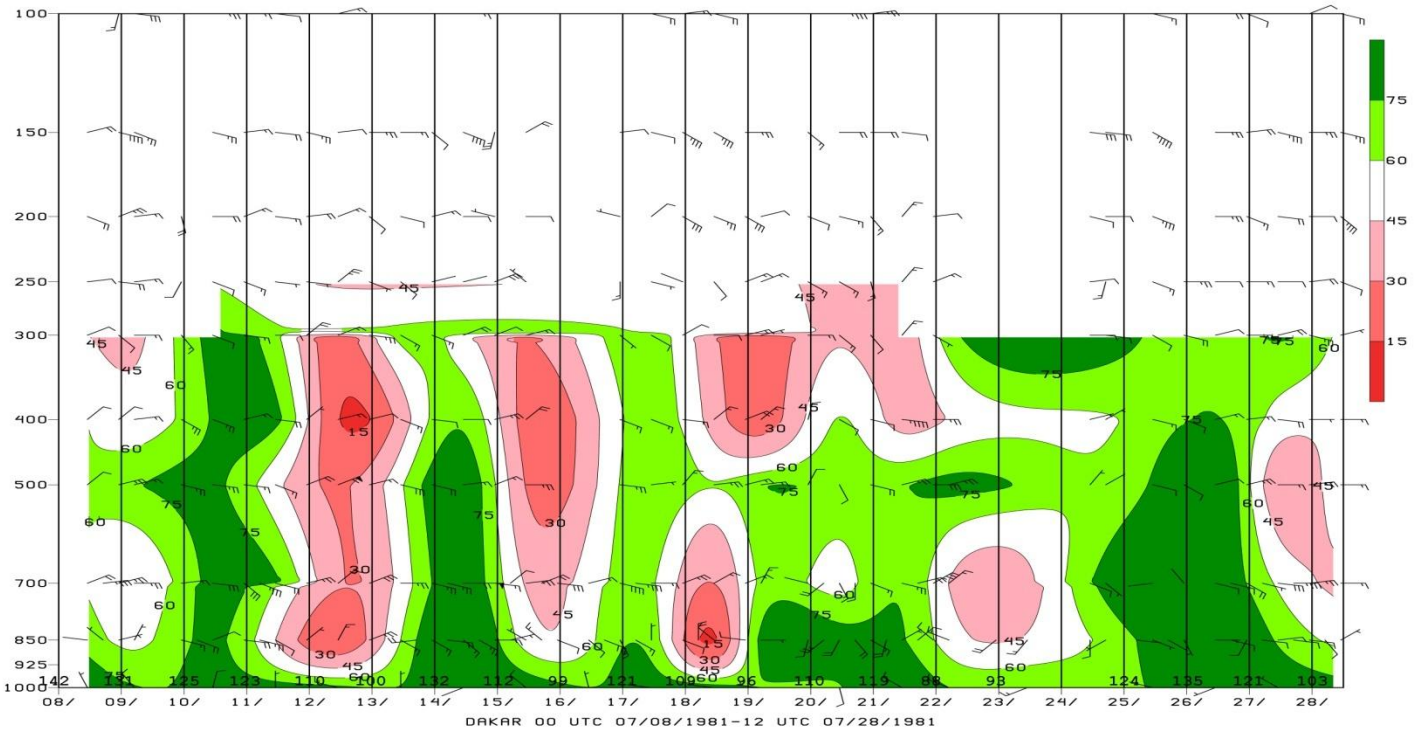


Date: _____

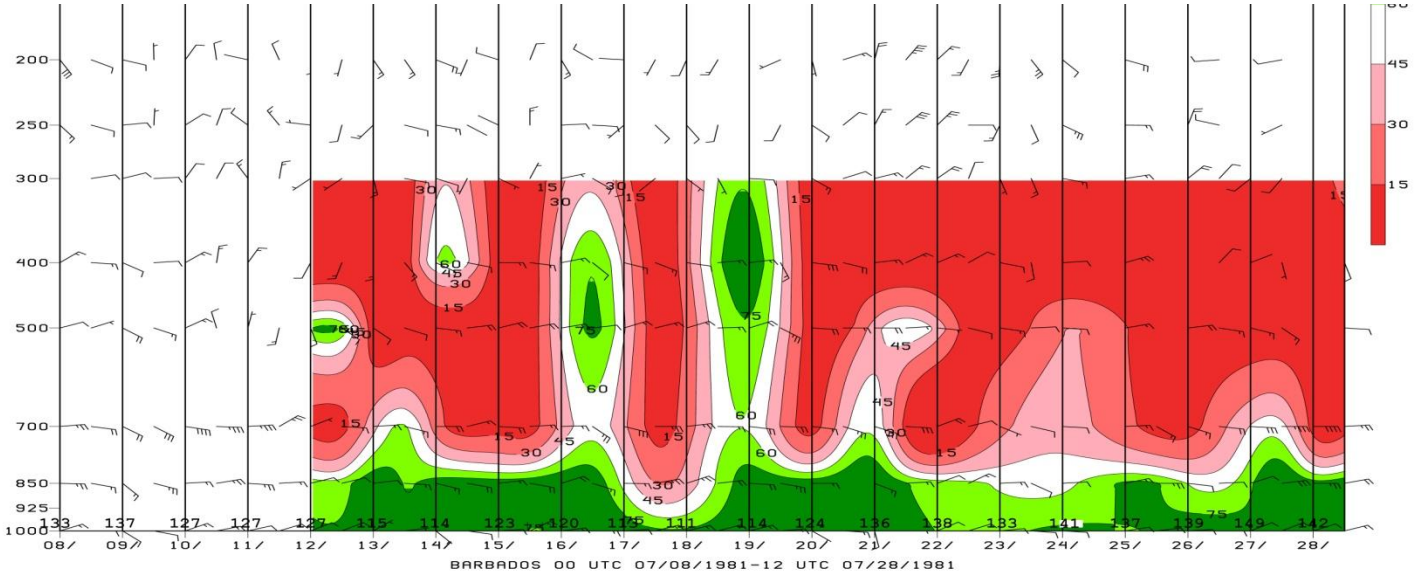
Wave Numb



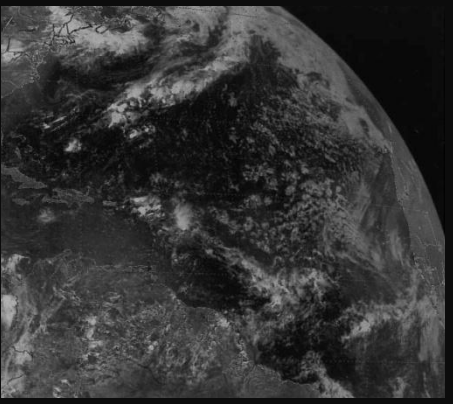
Dakar



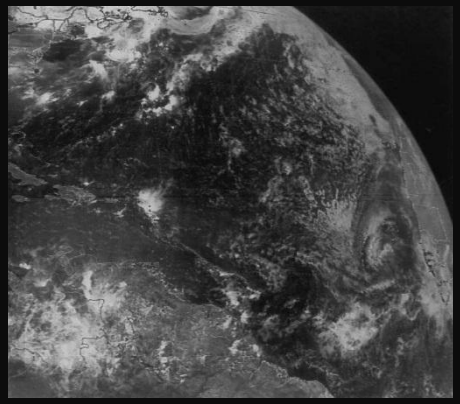
Barbados



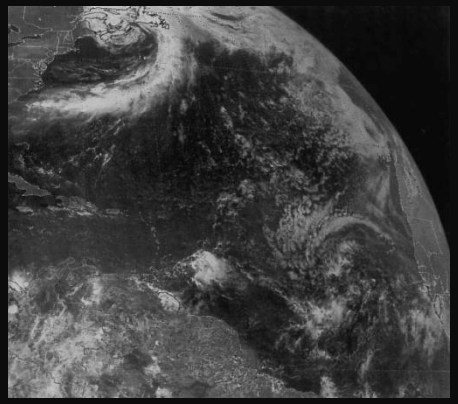
July 13, 1981 1600 UTC



July 14, 1981 1600 UTC

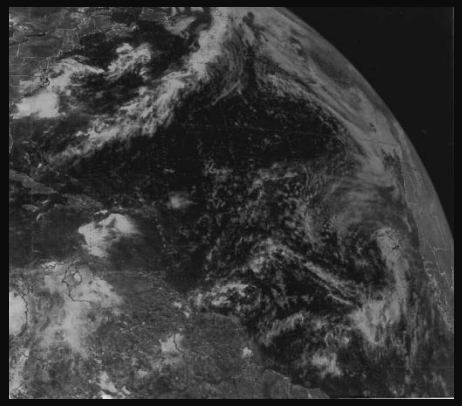


July 15, 1981 1600 UTC

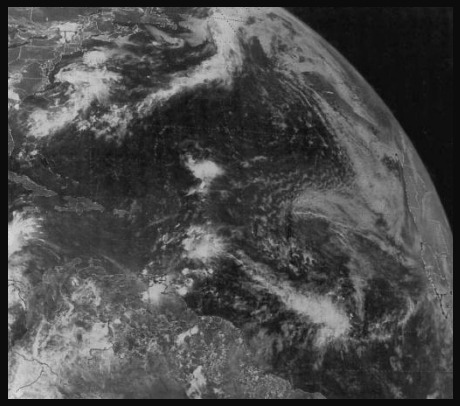


July 16, 1981 1600 UTC

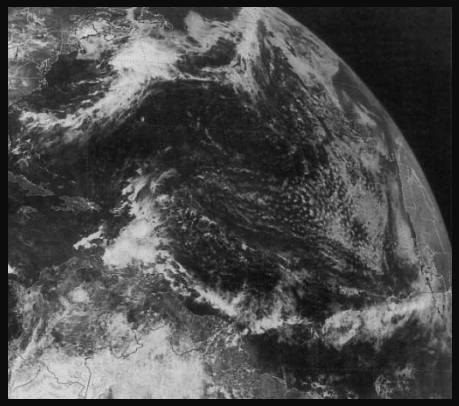
July 17, 1981 1600 UTC



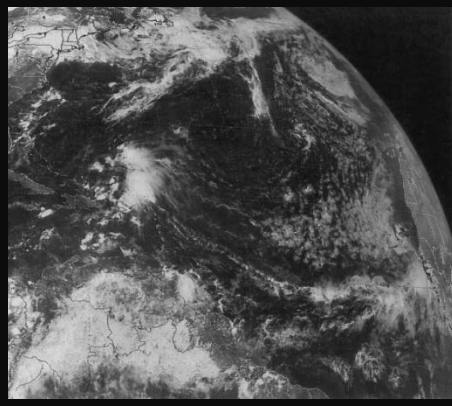
July 18, 1981 1600 UTC



July 19, 1981 1600 UTC



July 20, 1981 1600 UTC

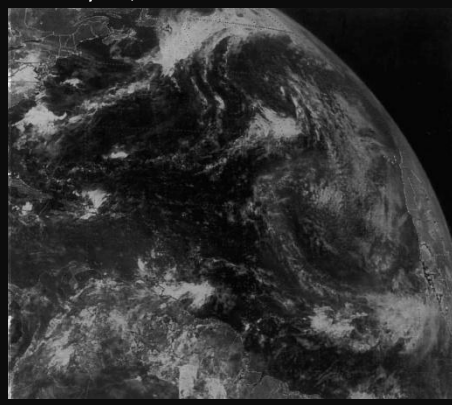


July 21, 1981 1600 UTC

July 22, 1981 1600 UTC

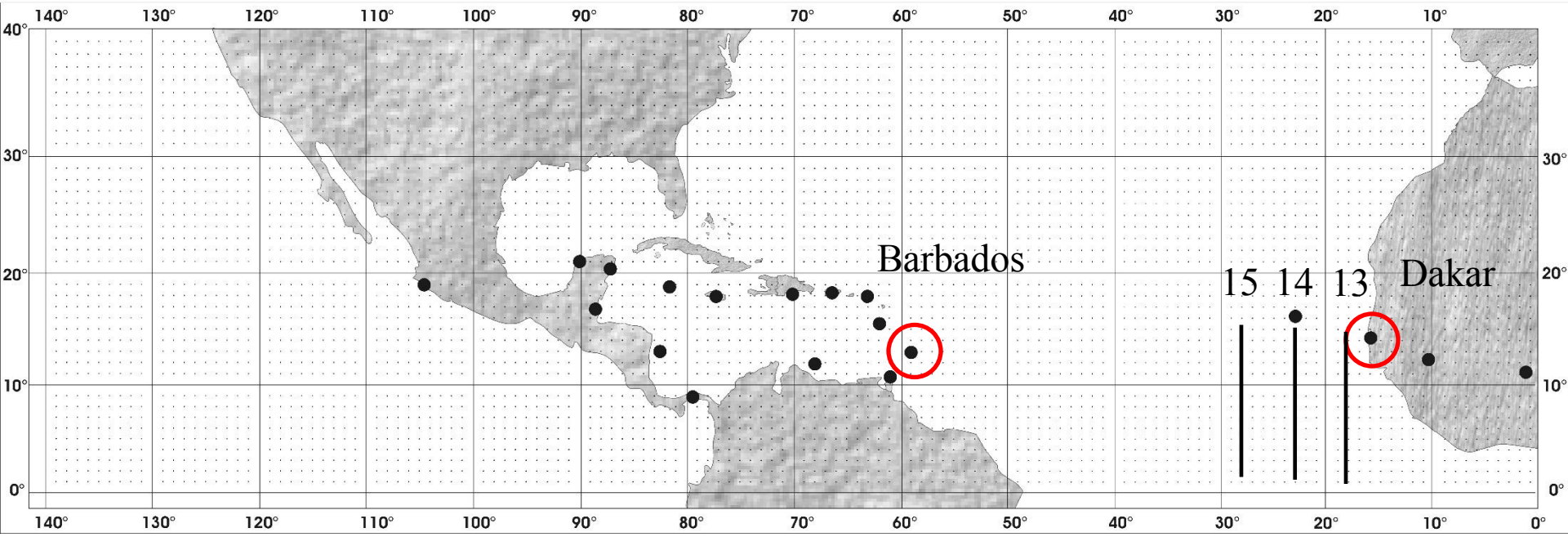
July 23, 1981 1600 UTC

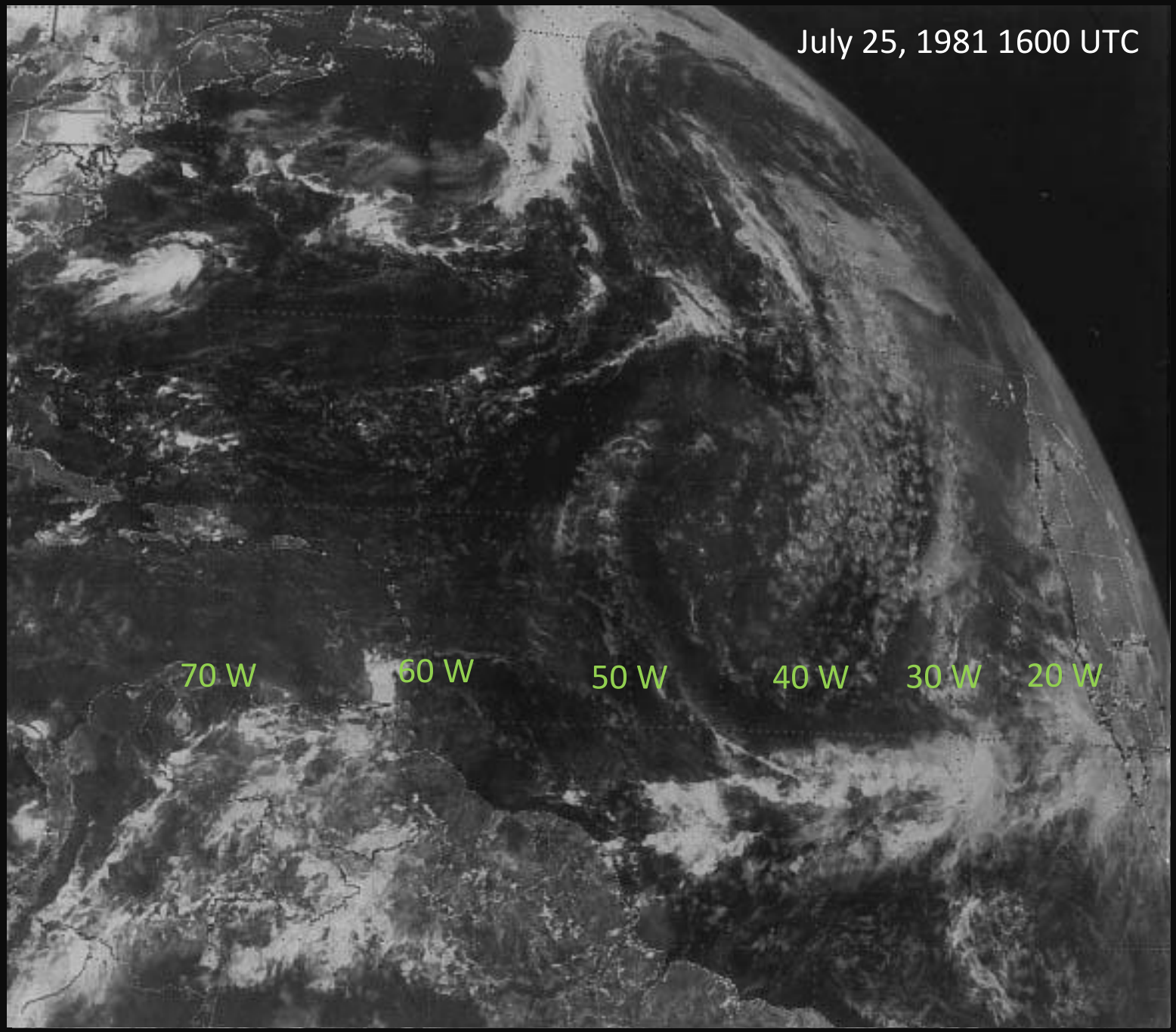
July 24, 1981 1600 UTC



Date: _____

Wave Number: _____




July 25, 1981 1600 UTC
70 W
60 W
50 W
40 W
30 W
20 W