Trinidad and Tobago

Devastating Floods of October 2018 –
"The Mother of All Floods"

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Assistant Director.
TTMS.

Outline

- Introduction
- Visual Overview Of Flooding & impacts
- TTMS New Early Warning Framework
- Rainfall Pattern & Warning Products
- Weather & Circulation Pattern During the Event

Introduction

- 17 – 19, October: Trinidad and Tobago experienced torrential rainfall
- Trinidad alone received a full month's worth of rain during the three days
- 80% of the country was affected by flooding
- 19 October: Government activated its National Emergency Operations Centre and opened 13 shelter-centers
- ODPM estimated that flooding impacted 100,000 to 150,000 persons (Damage Assessments still on-going)….Total Losses still not quantified
- 800 people sought shelter at shelter-centers during the peak of the emergency event
- Over 300 persons were evacuated from their homes

CCRIF Payment following October 2018 Flooding:

- Trinidad and Tobago has been a member of The Caribbean Catastrophe Risk Insurance Facility, a Segregated Portfolio Company (CCRIF SPC) since 2007 and has purchased CCRIF policies for tropical Cyclones and Earthquakes since 2007.

- CCRIF made its first payment of US $ 7.07 Million following Heavy rainfall and Widespread Flooding – Trinidad and Tobago in October 2018.

Mother Of All Floods

Flood of 2018 was unprecedented

- Record rainfall amounts
- River levels
- Areal extent of flooding
- Persons displaced
- Crop and property damage
- Flood duration

Event surpassed all floods in Trinidad and Tobago during modern times

Prime Minister called it a National Disaster

TTMS Performs Superbly

- Superior performance of the Trinidad and Tobago Meteorological Service and its employees (A+)
- Extra-ordinary efforts under stressful conditions spanned the whole event
- Devotion to high quality services and protection of life and property was well understood and outstanding
- Services provided by TTMS was collaborative team work

Many Roads Became Impassable

Both lanes of the Uriah Butler Highway became waterways

North Trinidad cut-off from south Trinidad

Really Mother Of All Floods

Submerged-suburbs in the Tunapuna/Piarco Regional Corporation became Inundated by flood water

Greenvale, La Horquetta

Engulfed- flood waters engulfed homes

Swamped – vehicles became trapped and swamped on roadways

First Responders Assist Those Stranded

Neighbours became first responders

Babies Were Saved

Anguished: Some Could Not Help Themselves

Overwhelmed: Others were overwhelmed

Evacuated: Many Had To Be Evacuated To Save Lives

Consternation:
People Braved Fast Moving Waist-High Water To Save Themselves

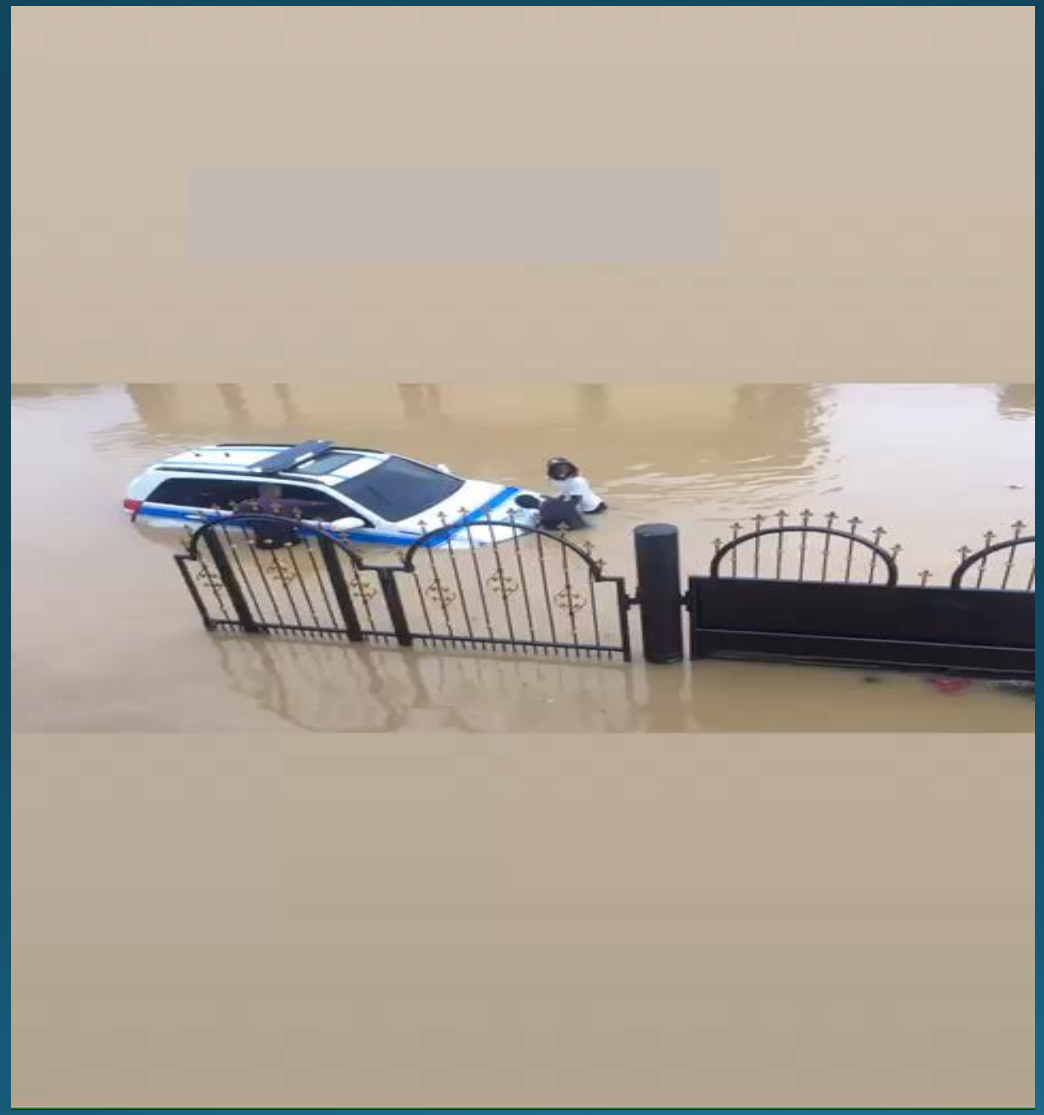
The Young, Elderly & Pets Rescued

Defense Force Help On Its Way! Perhaps Not!

Defense Force Assisted With Evacuation Using Dingy

Marooned: citizens rescued by national security personnel

First Responders Stalled & Need Assistance



Inundated: KFC and American Stores 2 of a large number of businesses inundated when the Caroni river banks failed

All Creatures Big & Small Were Impacted

Some Creatures Fled The Scene

Others Not So Lucky

Defiant Drivers Stalled- No where to go

Exhausted and Drained- Families forced on a roof top to get away from rising water

Warning and Forecast Services

- Flood event made unprecedented demands on the TTMS for warning and forecasts under extremely complicated hydro-meteorological conditions
- As stated in the introduction, the general finding is the TTMS , given the size of the event and constraints, provided outstanding forecasts and warning services
- Was critical to the success of evacuation and emergency mitigation actions
- Certainly played a large role for no casualty during the event

NEW CAP-COMPLIANT HYDRO-MET EARLY WARNING SYSTEM

Trinidad & Tobago Meteorological Service

		URGENCY
Alert	• Remote possibility or possible occurrence • *Beyond 2 days lead time*	FUTURE
Watch	• Likely or will probably occur • *12-48 hours lead time (48 hours for T. Cyclones)*	EXPECTED
Warning	• Observed, or almost certain/imminent occurrence • *< 12 hours lead time (<36 hours for T. Cyclones)*	IMMEDIATE

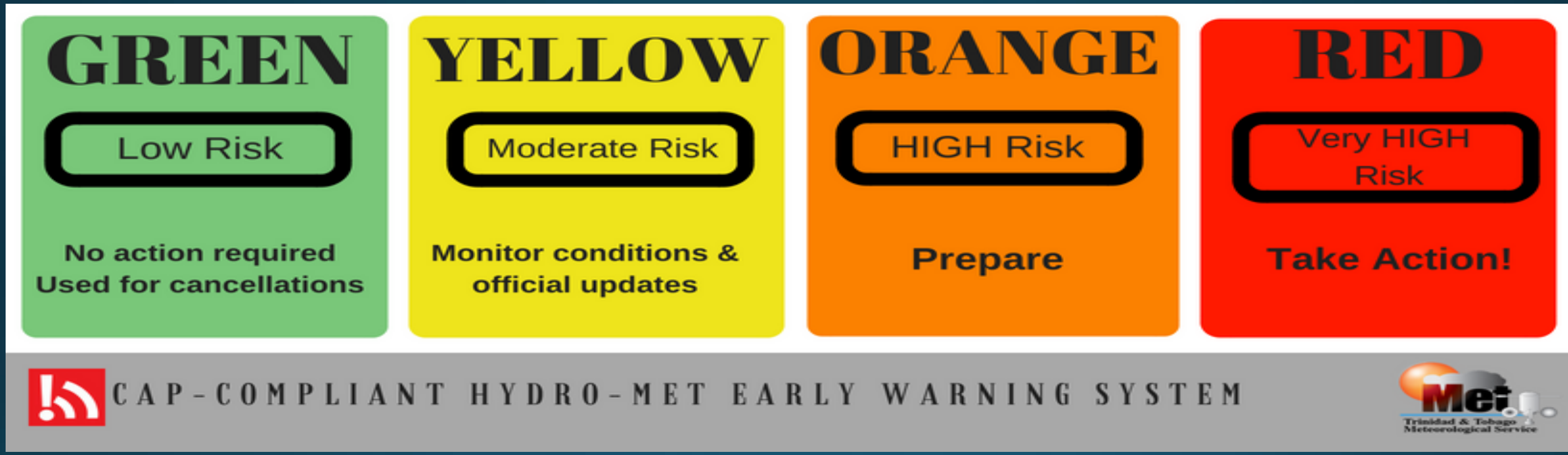
Risk Level	What we mean	What you should do
Green	No hazards expected.	You should always have emergency supplies and an emergency plan prepared, just in case.
Yellow	Hazard is possible. Be aware of the potential impacts of the hazard.	Monitor conditions & official updates.
Orange	We're more certain that there's risk to personal and property safety.	Get prepared to safeguard yourself & your family, including your property and livelihood.
Red	Significant risk to lives exist & significant damage and disruption.	Take immediate action to protect lives, property, and livelihoods. Safeguard your property.

Common Terms Used

SEVERITY	CERTAINTY
MINOR	UNLIKELY
MODERATE	POSSIBLE
SEVERE	LIKELY
EXTREME	OBSERVED

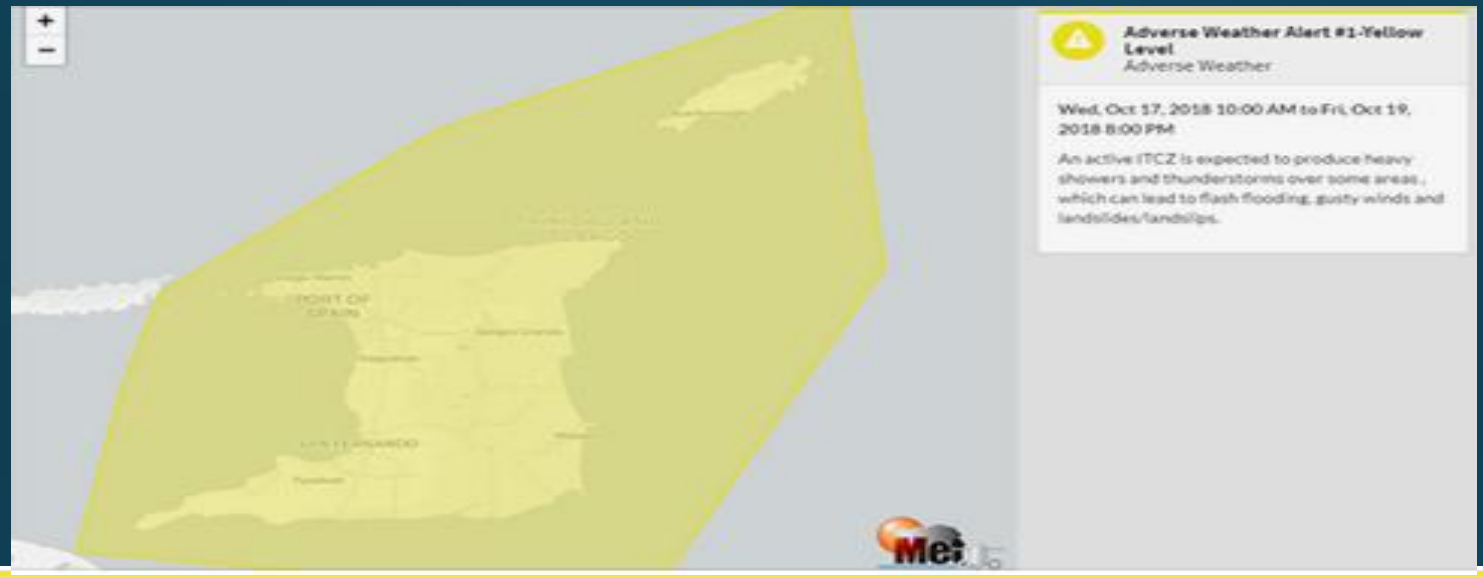
RESPONSE	HAZARDS
MONITOR CONDITIONS	TROPICAL CYCLONES
PREPARE	ADVERSE WEATHER
TAKE SHELTER	HAZARDOUS-SEAS
EVACUATE	FLOODING
TAKE NO ACTION	CLIMATE HAZARDS

Common Alert Protocol(CAP)-Based Early Warning System for Adverse Weather



Based on the impact the weather will have and the likelihood of those impacts occurring

Rainfall Pattern During the Event & Action Taken by the TTMS

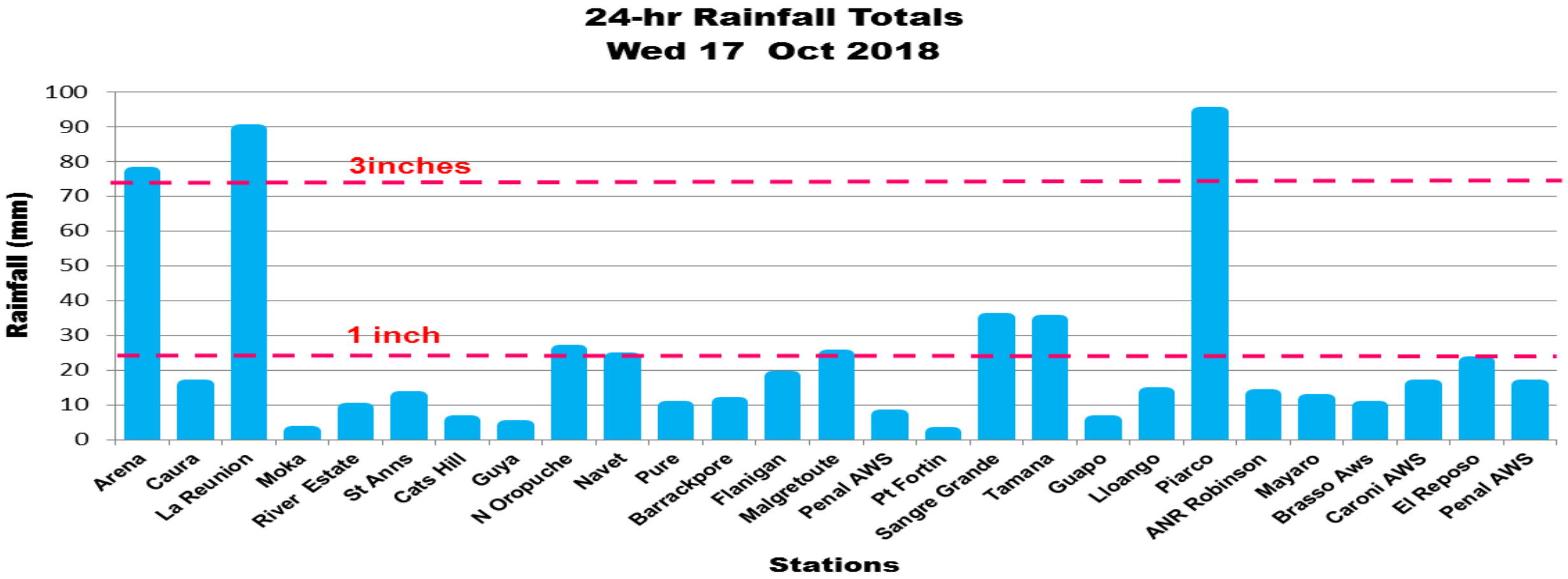


Adverse Weather Alert #1-Yellow Level
Adverse Weather - Wed, Oct 17, 2018 10:00 AM to Fri, Oct 19, 2018 8:00 PM

Status - Actual | Message Type - Alert | Alert - Adverse Weather | Response - Monitor Conditions
Urgency - Expected | Severity - Moderate | Certainty - Likely | Category - Met

Start date (local time)	Wed, Oct 17, 2018 10:00 AM
End date (local time)	Fri, Oct 19, 2018 8:00 PM
Headline	Adverse Weather Alert #1-Yellow Level
Description	An active ITCZ is expected to produce heavy showers and thunderstorms over some areas , which can lead to flash flooding, gusty winds and landslides/landslips.
Instructions	Monitor weather conditions and official updates. More information: www.odpm.gov.tt
Area description	Trinidad and Tobago

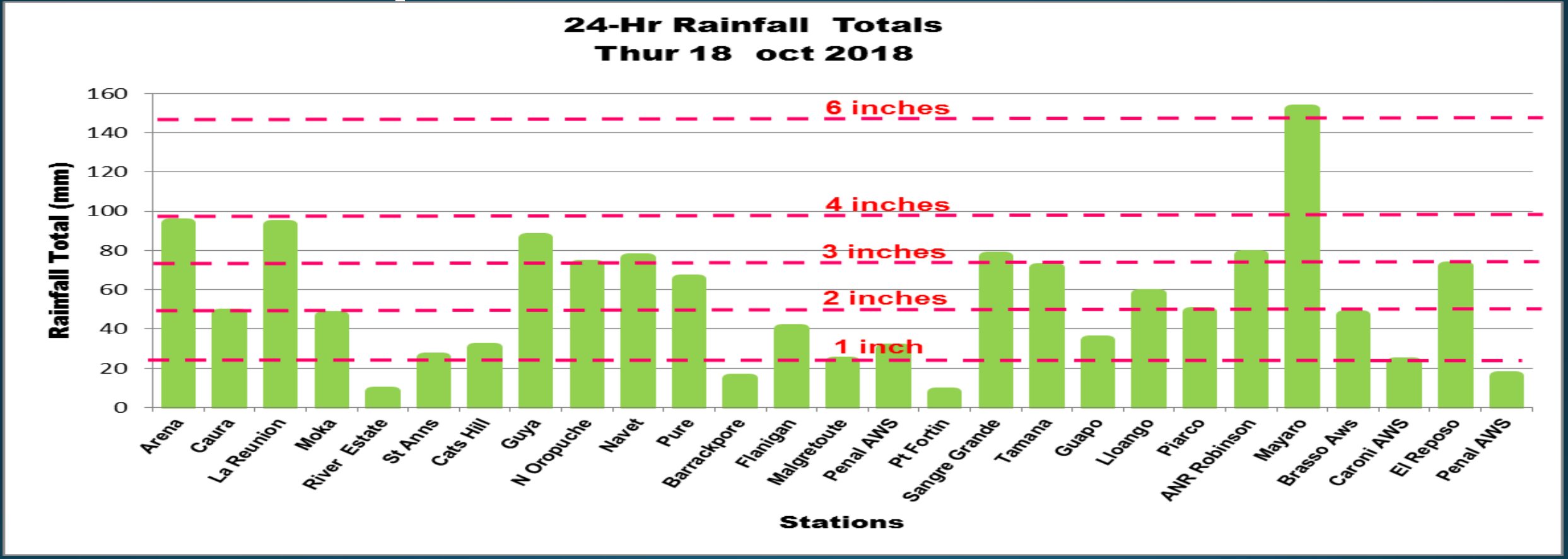
First 24 Hours



9 stations exceeded 1 inch

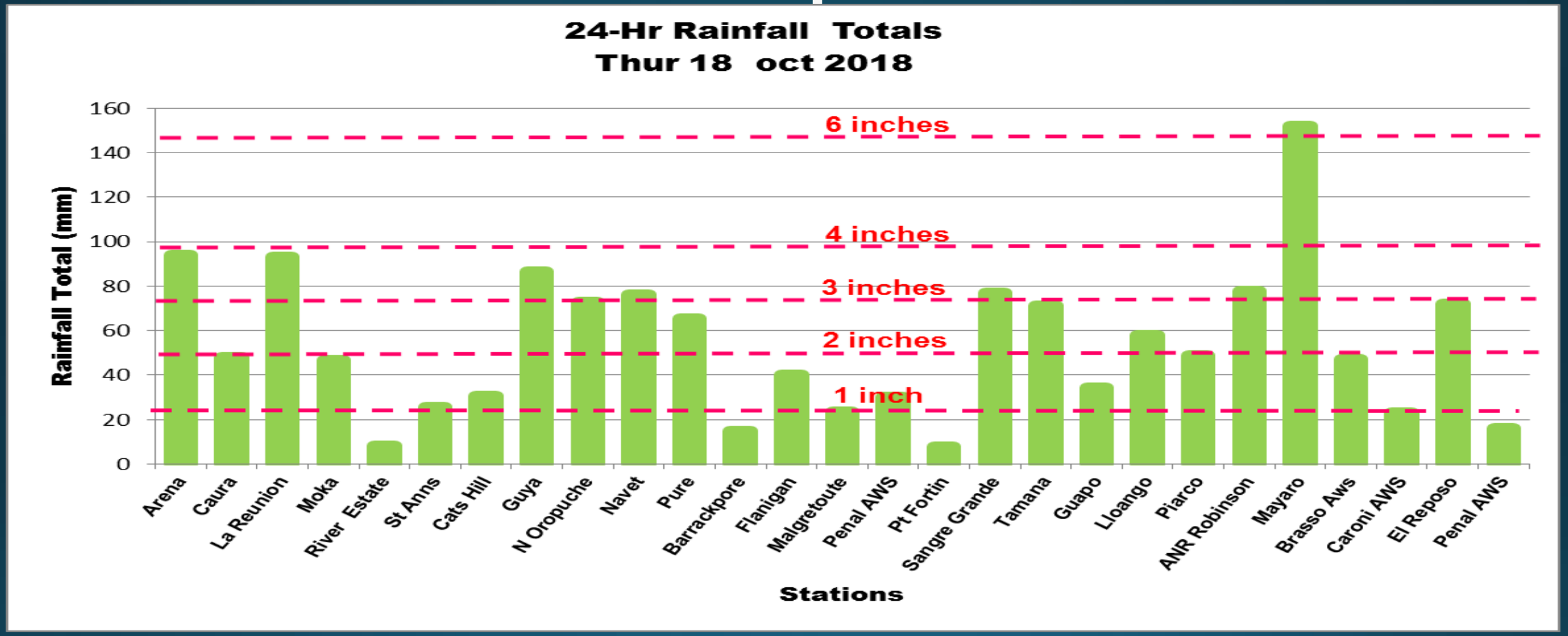
3 stations exceeded 3 inches

Second 24 Hours



- Conditions are wetter with an increasing number of stations receiving rainfall exceeding 2, 3 and 4 inches in 24 hours
- Increasing wetness covered a much larger geographical area
- Mayaro in the southeast getting upward of 6 inches

Second 24 Hours



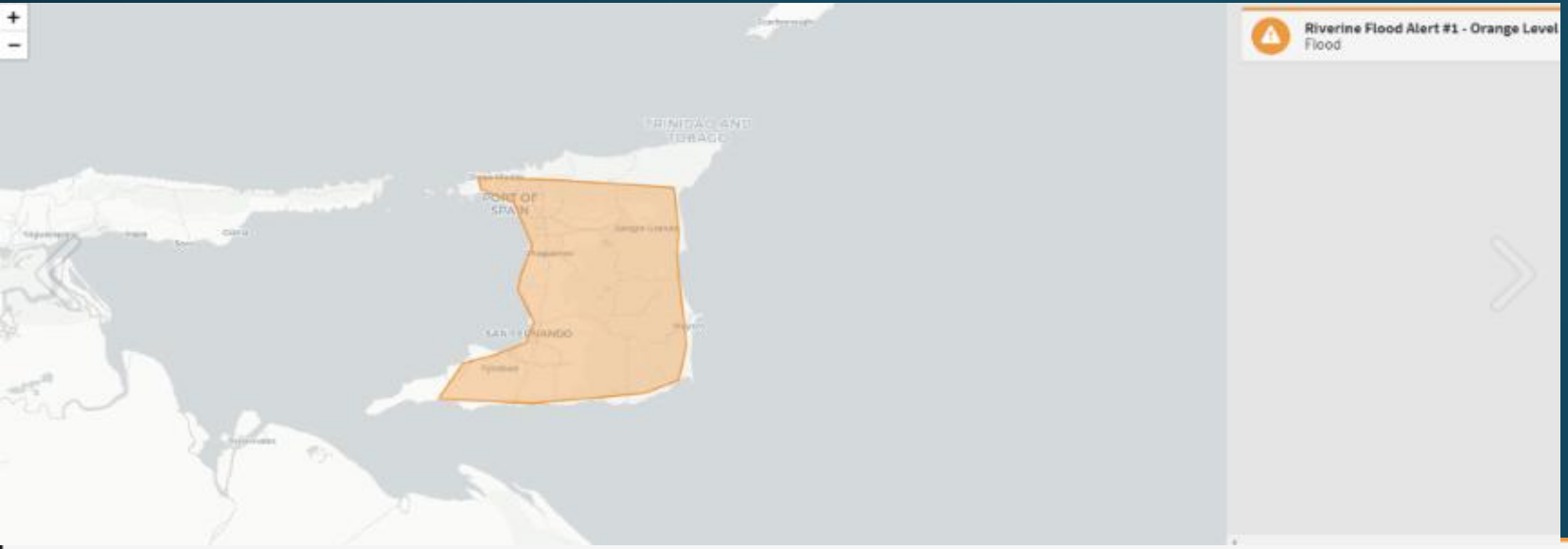
- Concentration of this high volume of rainfall within the eastern half of Trinidad on day two was indicative of what was to follow
- Widespread flooding was became inevitable and was obvious

Adverse Weather Alert #2 Orange Level

Adverse Weather Alert #2-Orange Level
Adverse Weather - Thu, Oct 18, 2018 10:00 AM to Sun, Oct 21, 2018 8:00 PM

Status - Actual | Message Type - Alert | Alert - Adverse Weather | Response - Prepare
Urgency - Immediate | Severity - Severe | Certainty - Likely | Category - Met

Start date (local time)	Thu, Oct 18, 2018 10:00 AM
End date (local time)	Sun, Oct 21, 2018 8:00 PM
Headline	Adverse Weather Alert #2-Orange Level
Description	An active ITCZ continues to produce periods of rain/showers and thunderstorm activity which can lead to flash or riverine flooding as well as landslides/landslips in areas so prone. Gusty winds can be experienced in the vicinity of heavy downpours.
Instructions	Plan your emergency response to safeguard life and property. Pre-position sandbags if your area floods. Monitor official weather updates and news sources. More information: www.odpm.gov.tt
Area description	Trinidad and Tobago



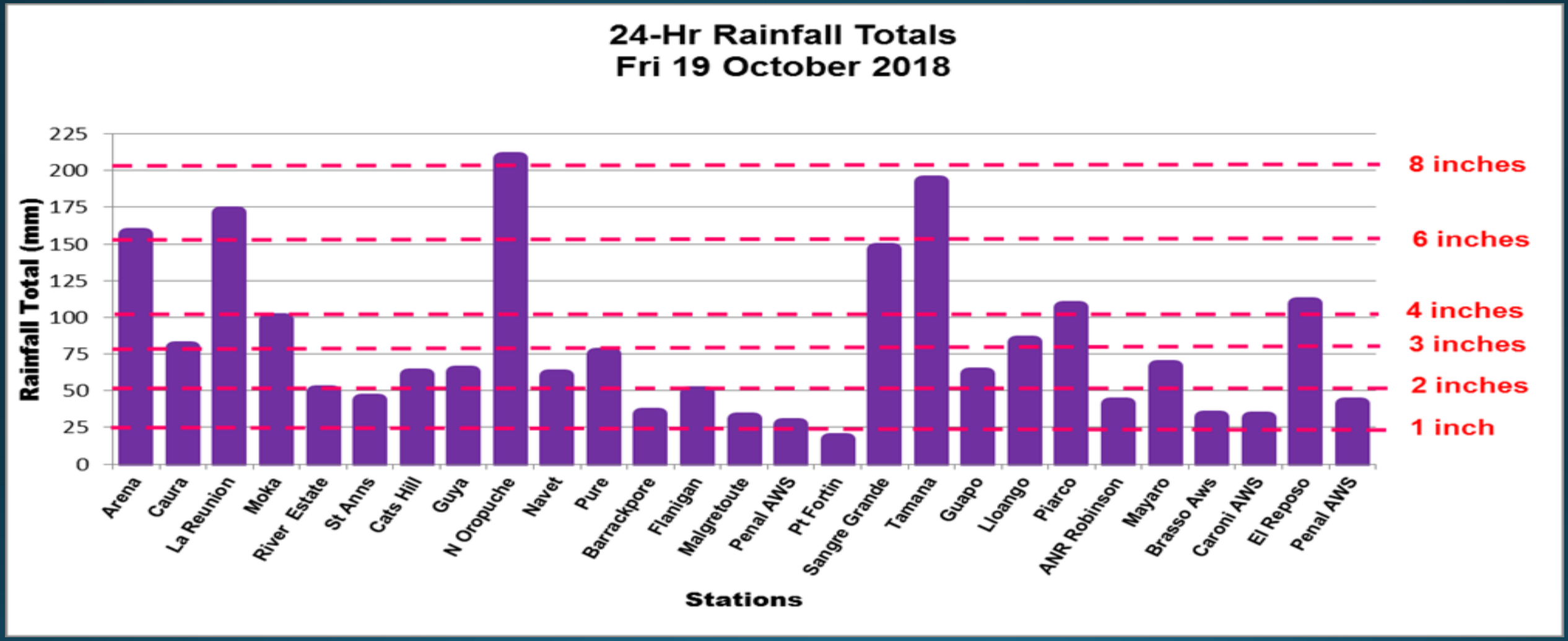
Riverine Flood Alert #1 Orange Level

Riverine Flood Alert #1 - Orange Level
Flood - Thu, Oct 18, 2018 6:00 PM to Tue, Oct 23, 2018 12:00 PM

Status - Actual | Message Type - Alert | Alert - Flood | Response - Prepare | Urgency - Expected
Severity - Severe | Certainty - Likely | Category - Met

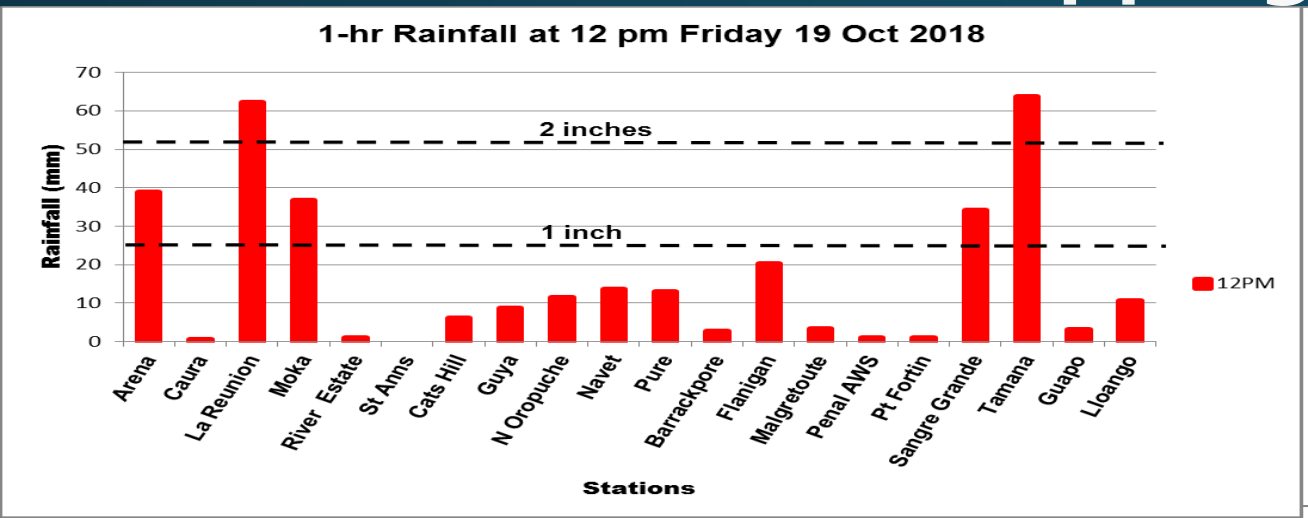
Start date (local time)	Thu, Oct 18, 2018 6:00 PM
End date (local time)	Tue, Oct 23, 2018 12:00 PM
Headline	Riverine Flood Alert #1 - Orange Level
Description	Riverine flooding occurs when water levels in a river over-tops its banks and spills onto surrounding areas. This type of flooding is more widespread and usually lasts for several days. Currently river levels are significantly high and are expected to rise further as more rainfall is forecast over the next several days.
Instructions	Make preparations to protect life and property especially those residing along the Caroni River Basin. Be on the alert for rising river levels and possible over-spill. Do not take unnecessary risks. Follow the instructions of government officials. Monitor official sources for information. More information: www.odpm.gov.tt
Area description	Along Trinidad's main river courses and associated tributaries.

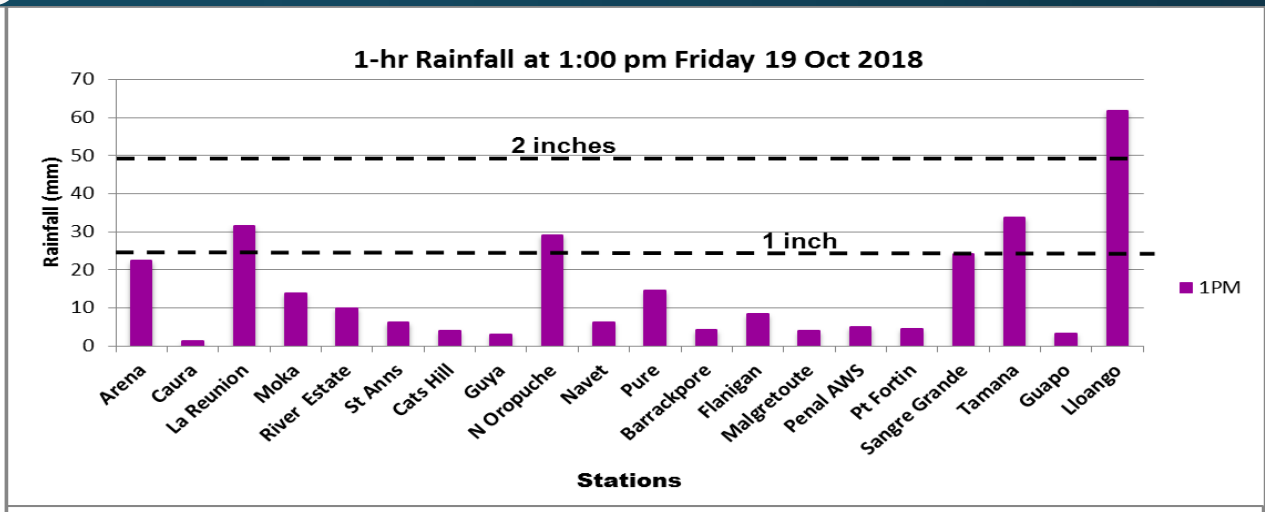
Third 24 Hours - Wettest Day

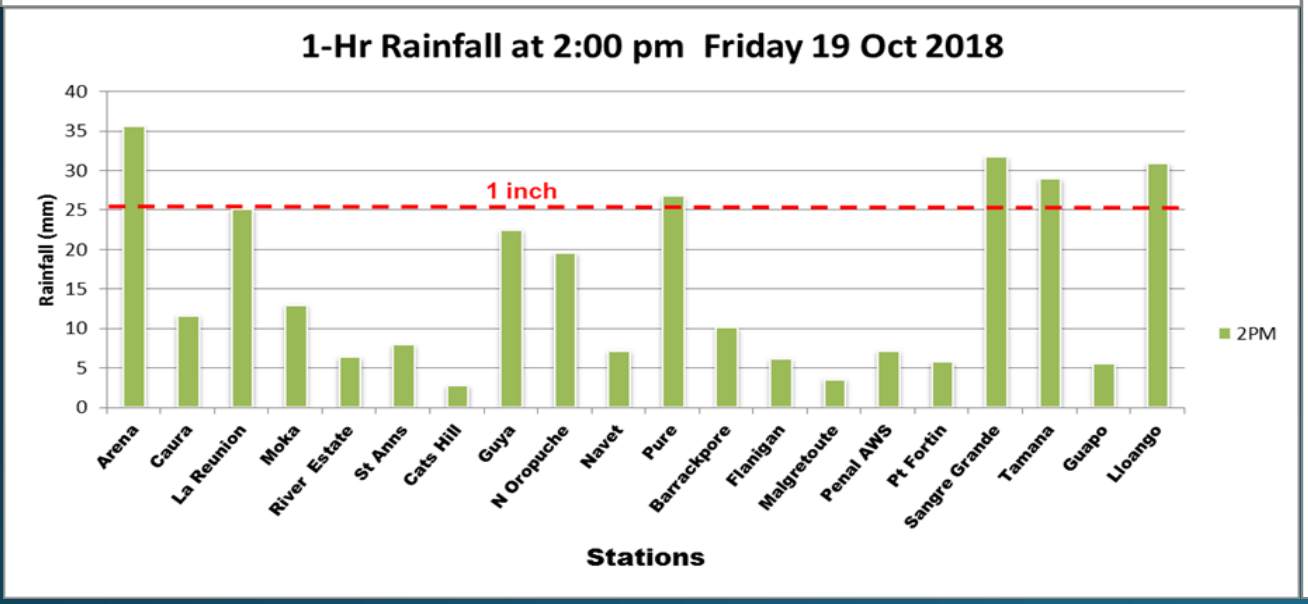


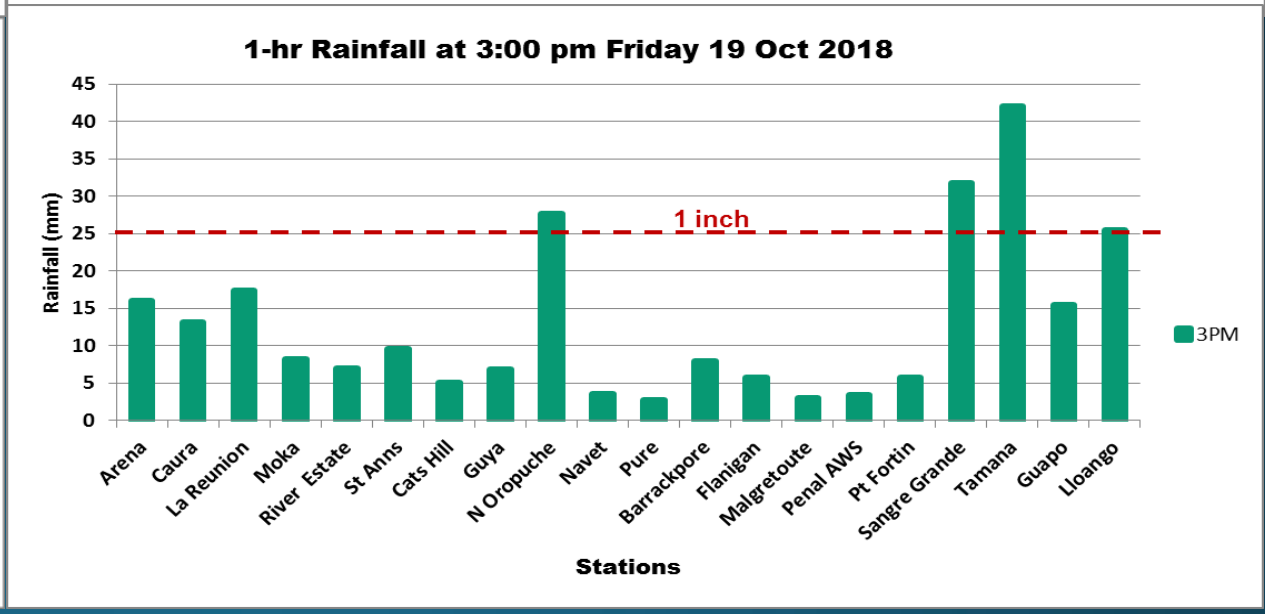
- By the morning of Friday 19, October, flooding was already occurring
- Areas surrounding the Caroni river and its feeding tributaries and streams recorded some of the highest rainfall totals on the third day

Tipping Point?

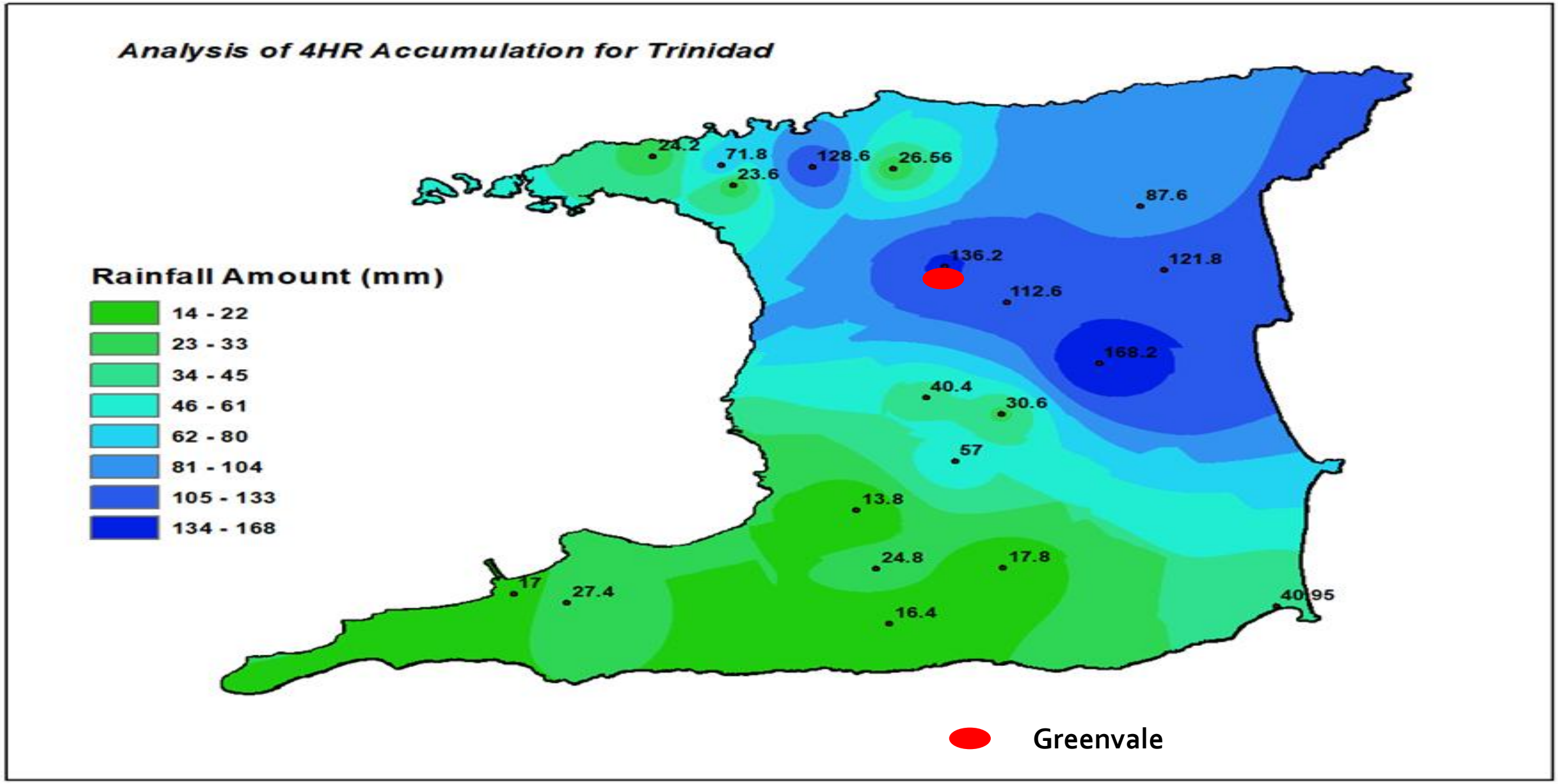




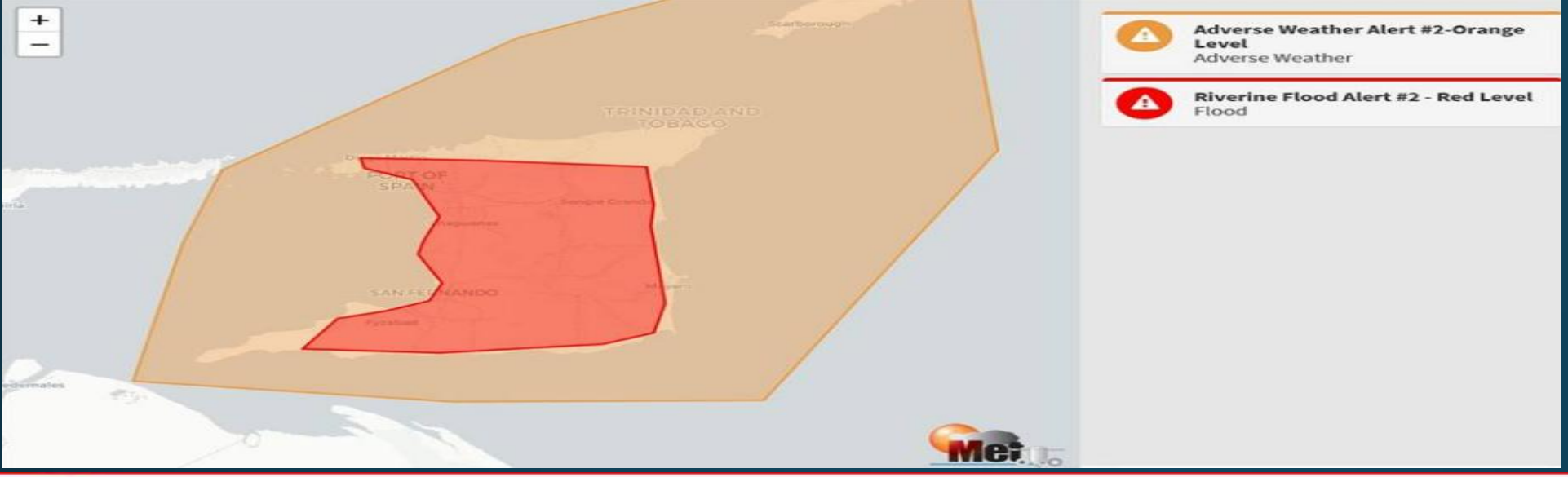




- Hourly rainfall on Friday provide telling information: Large portion of rain fell within a 4 hour period between 11:00am and 3:00pm
- May have been the tipping point for the catastrophic flooding



Between 4 - 6 ½ Inches (100 - 168.2 mm) fell in 4 hours in some locations



Adverse Weather Alert #2-Orange Level
Adverse Weather

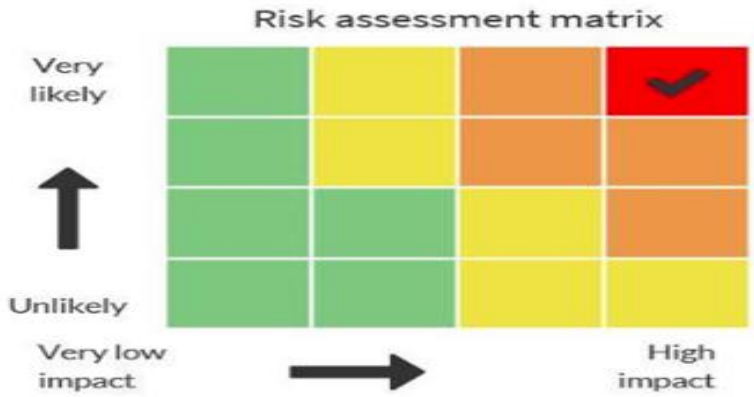
Riverine Flood Alert #2 - Red Level
Flood

Riverine Flood Alert #2 Red Level

Riverine Flood Alert #2 - Red Level
Flood - Fri, Oct 19, 2018 6:00 PM to Fri, Oct 26, 2018 12:00 PM

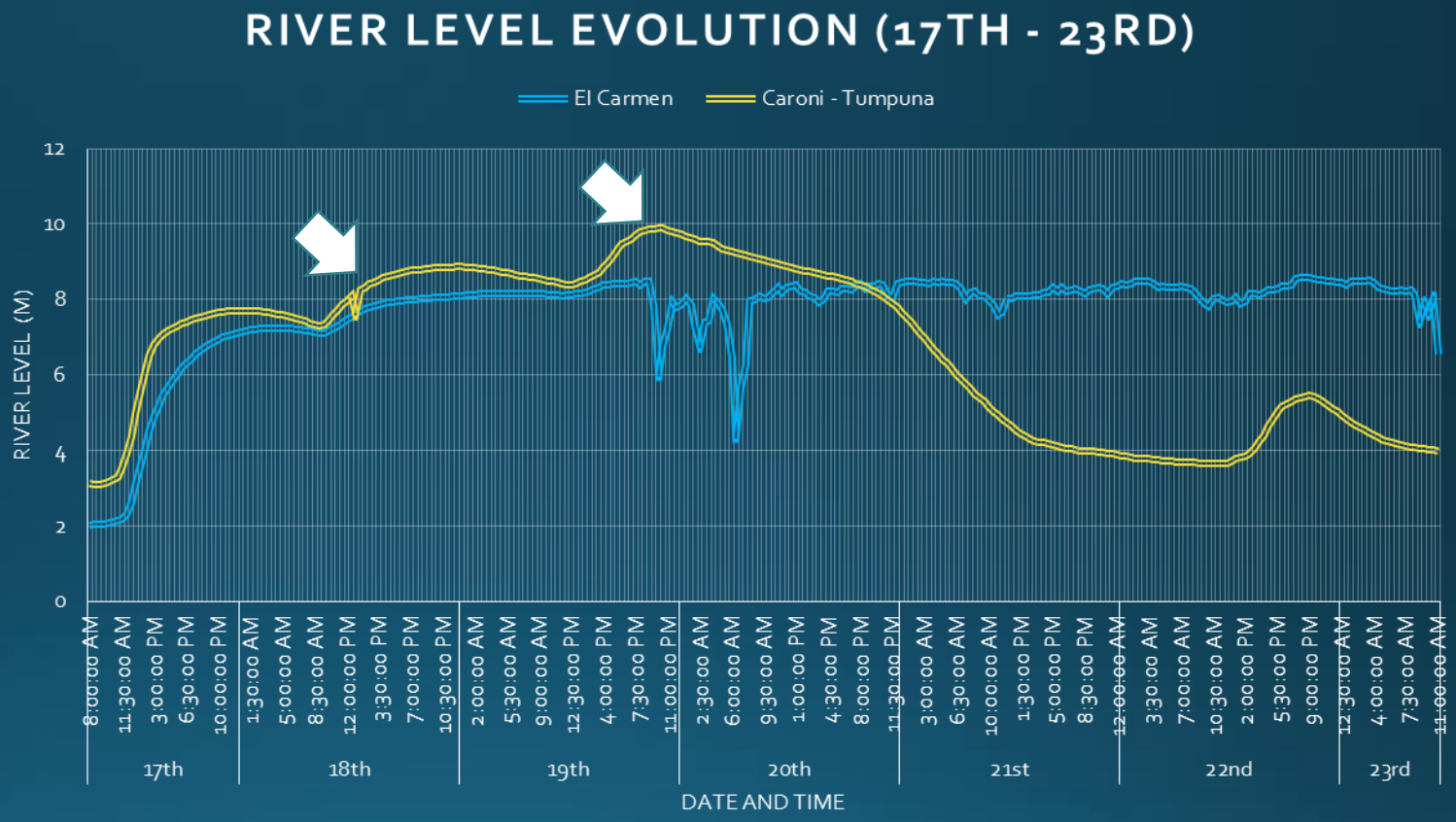
Status - Actual | Message Type - Alert | Alert - Flood | Response - Take Shelter | Urgency - Immediate | Severity - Extreme | Certainty - Observed | Category - Met

Start date (local time)	Fri, Oct 19, 2018 6:00 PM
End date (local time)	Fri, Oct 26, 2018 12:00 PM
Headline	Riverine Flood Alert #2 - Red Level
Description	Riverine flooding occurs when water levels in a river over-tops its banks and spills onto surrounding areas. This type of flooding is more widespread and usually lasts for several days. Currently river levels have exceeded threshold levels and some have already over-spilled their banks. Additional rainfall is expected hence river levels will remain at an elevated level over the next several days.
Instructions	Preparations to protect life, livelihood and property especially those residing along the Caroni River Basin should be rushed to completion immediately if it has not been completed as yet. Be on the alert for rising river levels and possible over-spill. Do not take unnecessary risks. There is a very high potential for major damage to property and infrastructure and for mulitple lives to be lost. It is advised to stay indoors until the all clear is given by government officials. In addition please follow the instructions given by government officials. Monitor official sources for information. More information: www.odpm.gov.tt
Area description	Along Trinidad's main river courses and associated tributaries.

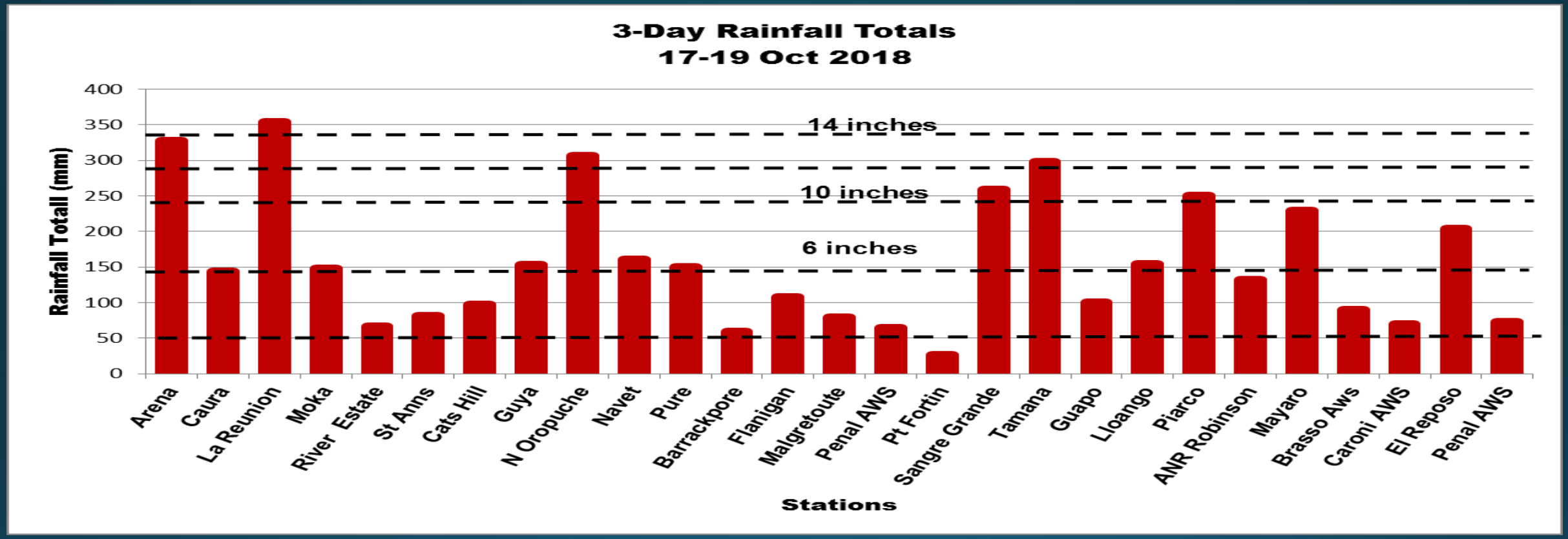


Flooding details 17th -23rd

- Oct 17: Only street flooding was reported
- Oct 18: Flash flooding over various areas across Trinidad
- Small tributaries started flooding during the afternoon
- Oct 19: Flash flooding increased
- Riverine flooding began & worsened



Records Broken: Upward of 12 inches
As much as 14 inches



- **Piarco had its largest three day rainfall total (250.2mm / 10 Inches) since records began in 1946**
- **Statistics suggest this amount over 3-days at Piarco has return period of occurring once every 50 years on average**
- **2% chance of occurring in any one year**

Adverse Weather Alert de-escalated

Adverse Weather Alert #4- Yellow Level
Adverse Weather - Tue, Oct 23, 2018 10:00 AM to Tue, Oct 23, 2018 6:00 PM

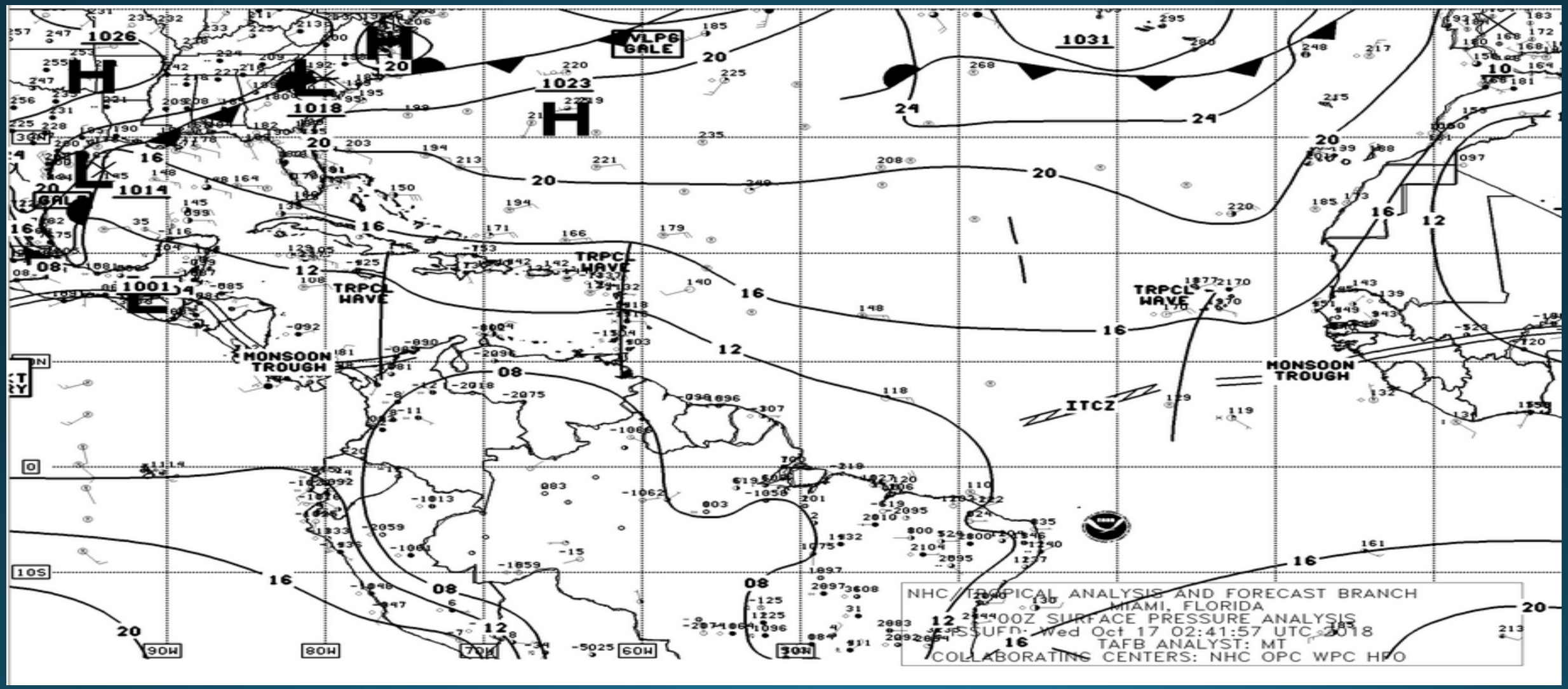
Status - Actual | Message Type - Update | Alert - Adverse Weather | Response - Monitor Conditions
Urgency - Expected | Severity - Moderate | Certainty - Likely | Category - Met

Start date (local time)	Tue, Oct 23, 2018 10:00 AM
End date (local time)	Tue, Oct 23, 2018 6:00 PM
Headline	Adverse Weather Alert #4- Yellow Level
Description	There is a 70 % chance of heavy showers or thunderstorm activity in few areas. This can result in street or flash flooding. Landslips or landslides are possible
Instructions	Persons should monitor weather conditions and official updates. More information: www.odpm.gov.tt
Area description	Trinidad

Forecasting Challenges

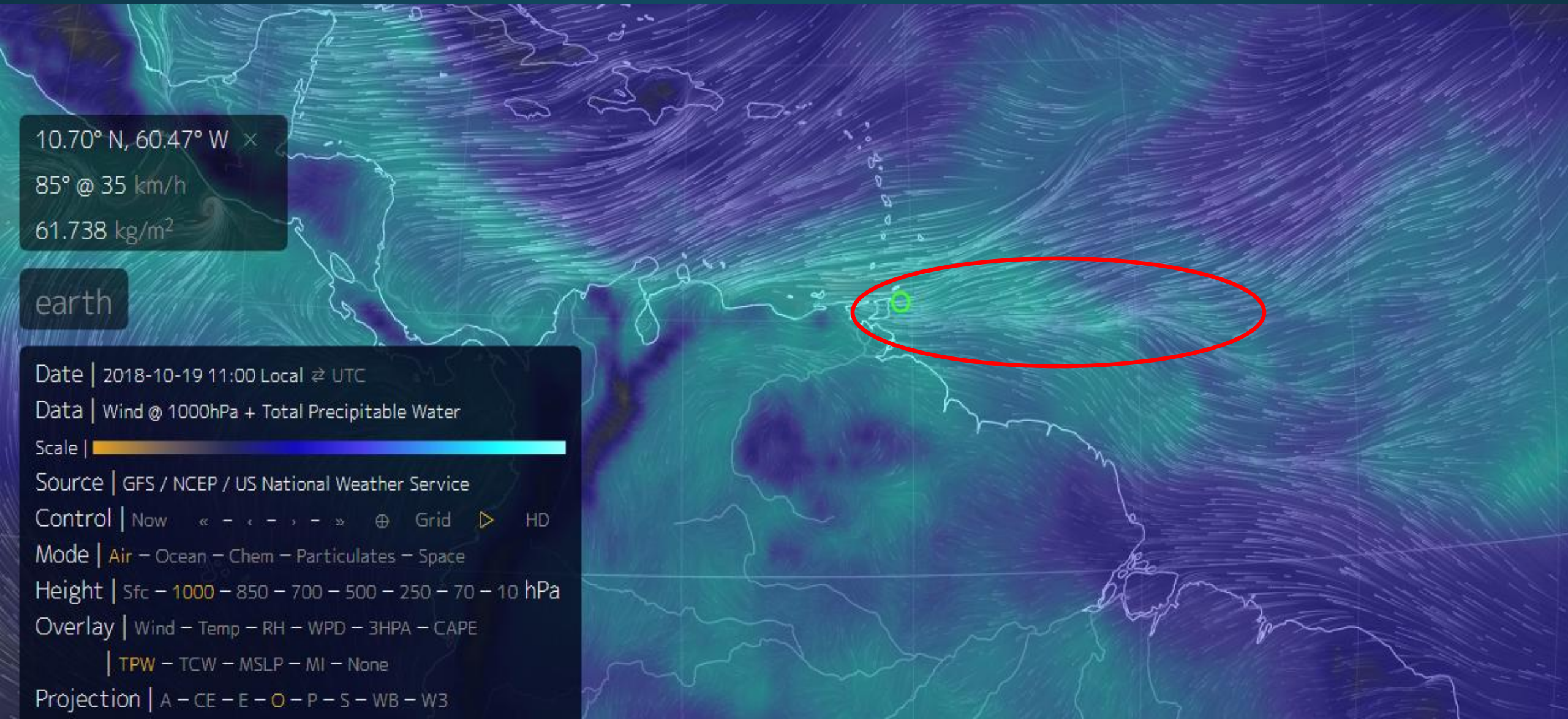
- Lag time between when rainfall occurred in key areas and when the observation became available to the forecast system
- Point source rainfall and radar estimation rainfall not always in sync
- Model output not in sync with rainfall early in the event; by day two it slightly lagged the observation; and by day 3/4 it was overestimating rainfall
- Observation data input from near real-time gauges from WRA was not always available for key areas and not as user friendly. Massive time and effort needed to assimilate large amount of hourly data
- River level observations automated but was not always available for key river levels, which meant difficulty in accounting for volume of water in the system
- Lack of knowledge of land use changes such as river course changes or levee location in Greenvale area and potential to fail
- Lack of more spatial rainfall, river level and land use data, such as inundated areas along the river , rather than single river level elevation
-

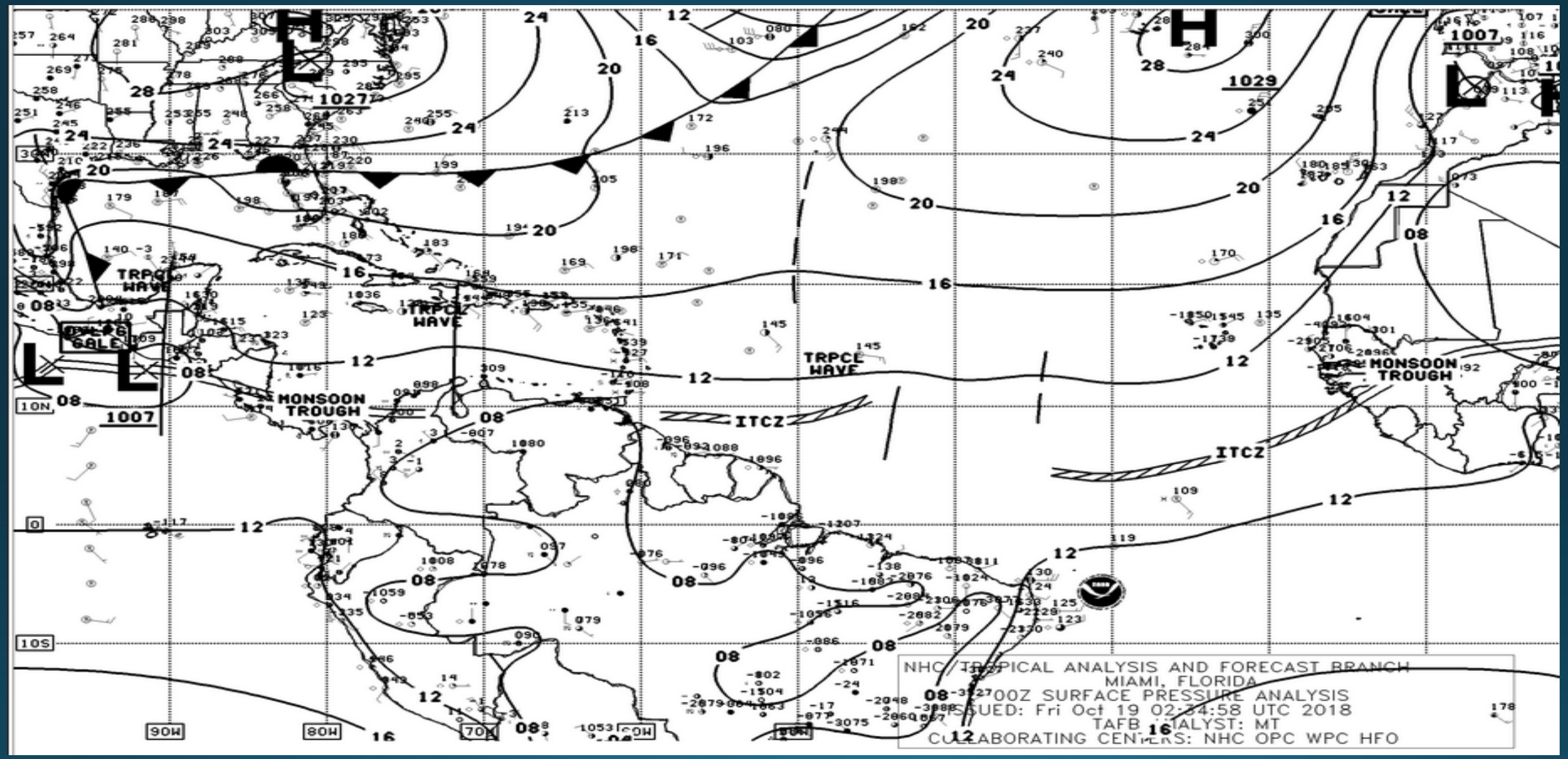
Existing Meteorological Conditions



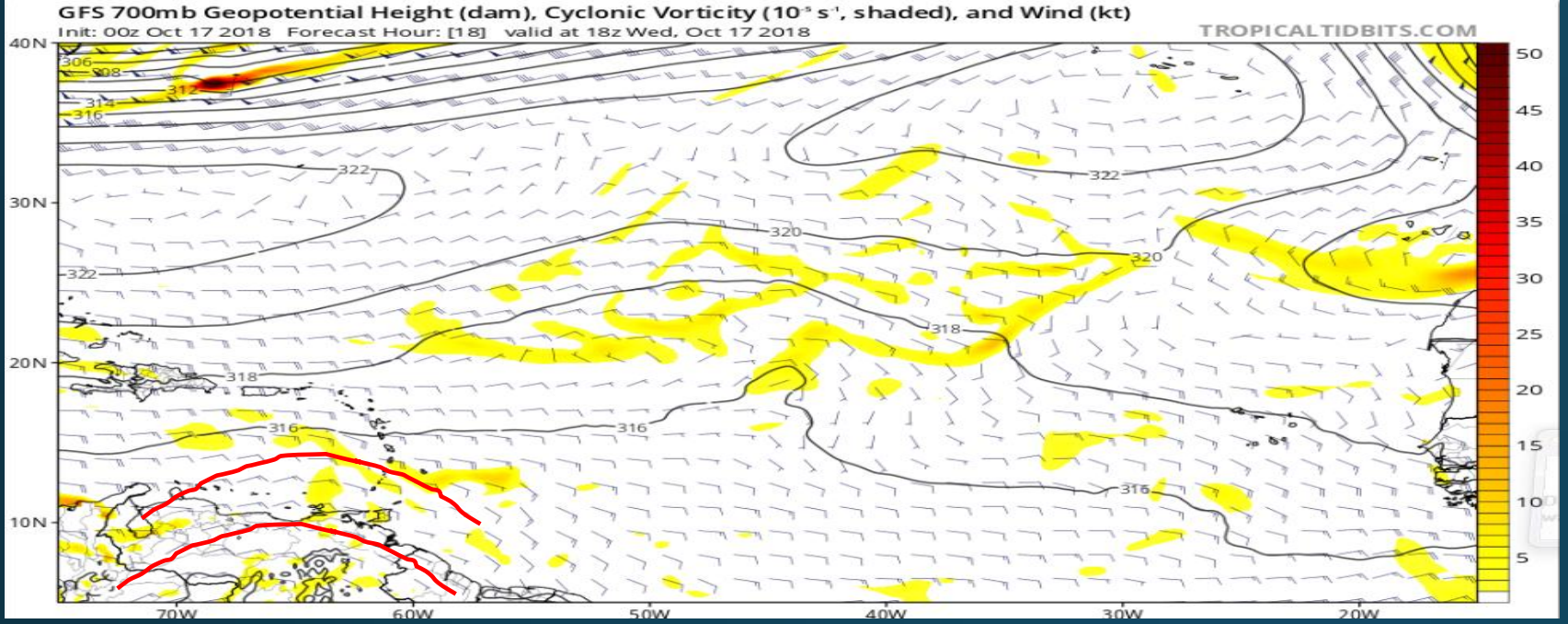
Tropical wave traversed across Trinidad and Tobago on Wednesday 17. Triggered the first wave of rainfall

Trades coming together as the ITCZ





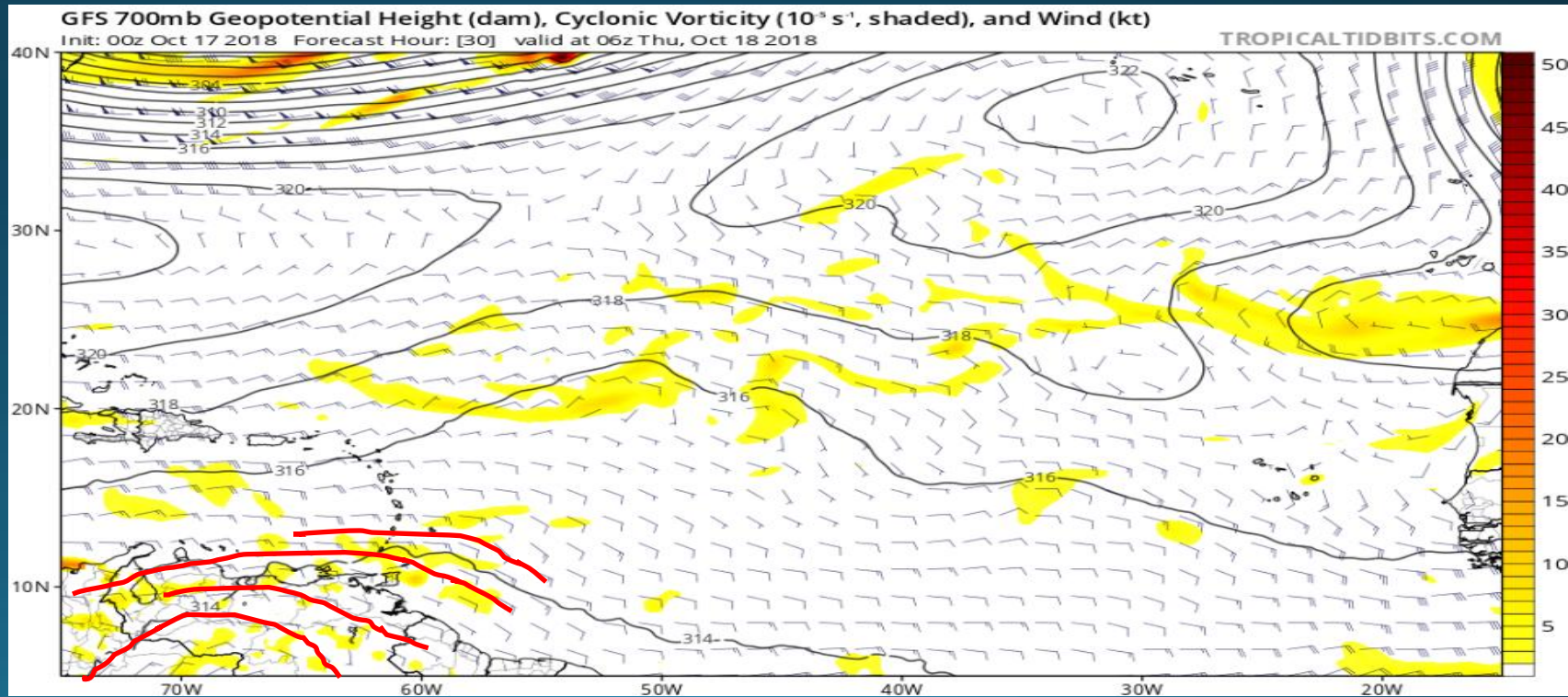
ITCZ was most present and very active

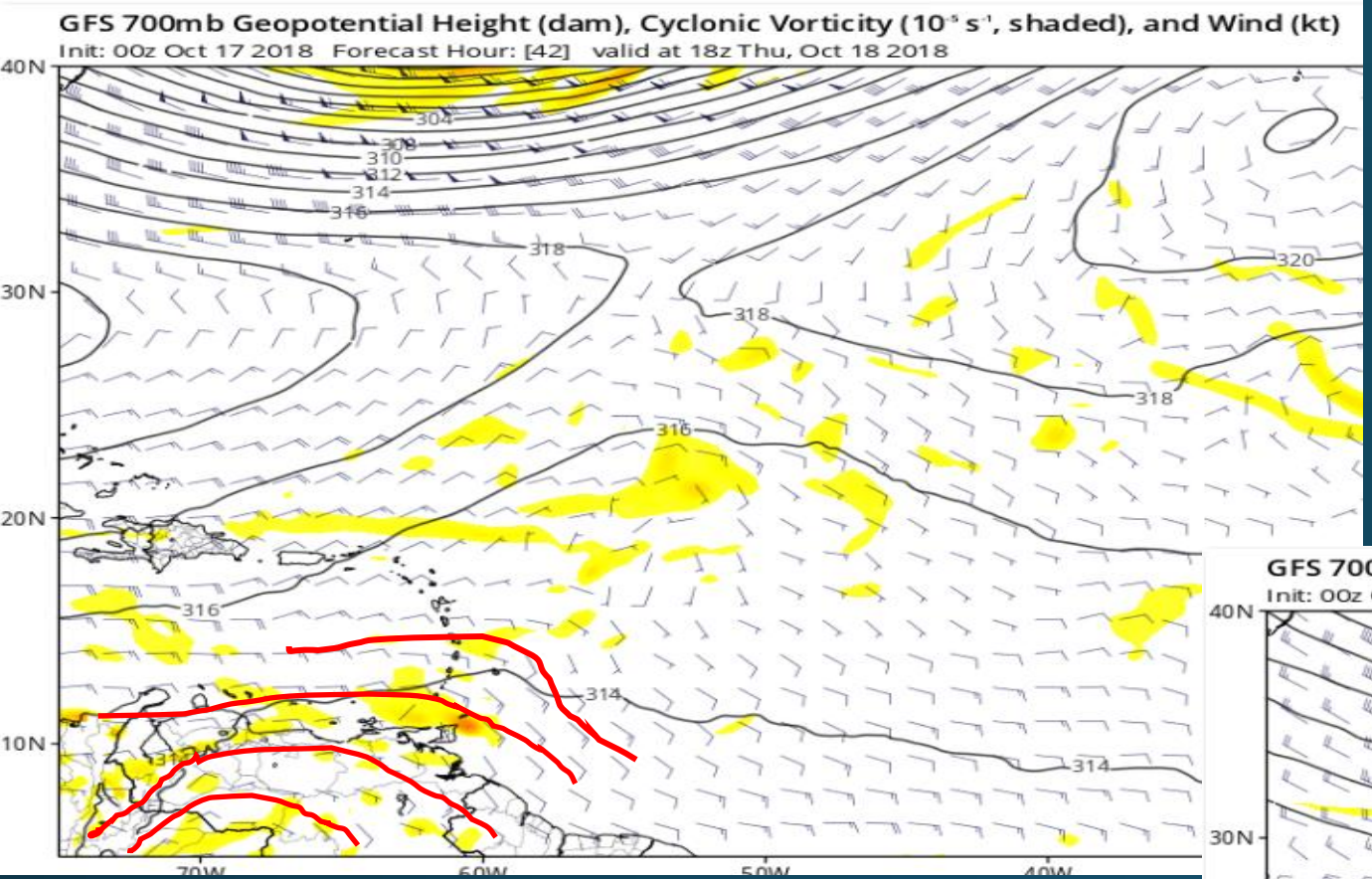


Co-occurring low to mid-level trough located in the vicinity of Trinidad and Tobago.

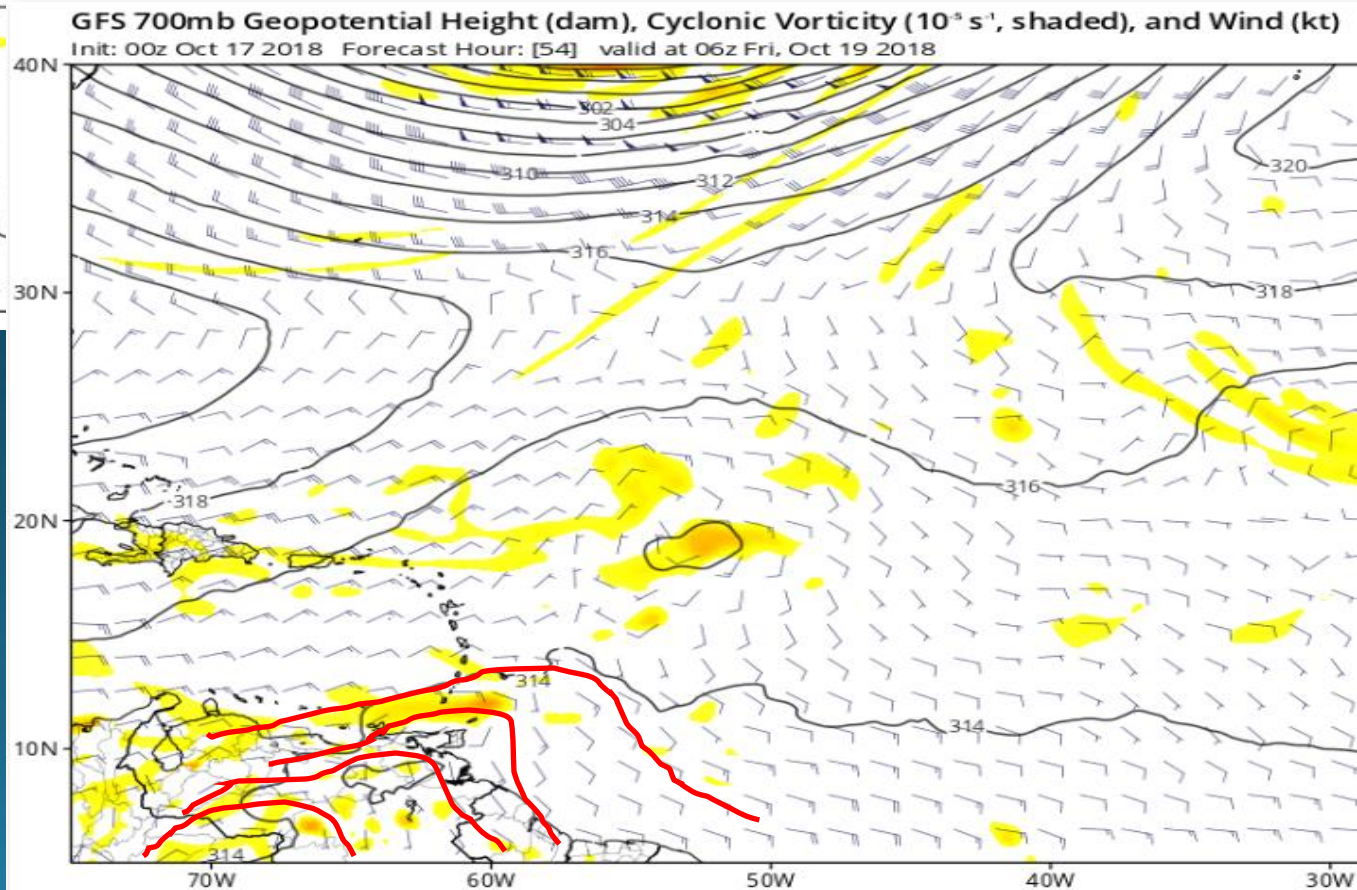
Well depicted on the model outputs

Trough increase in amplitude and space with time

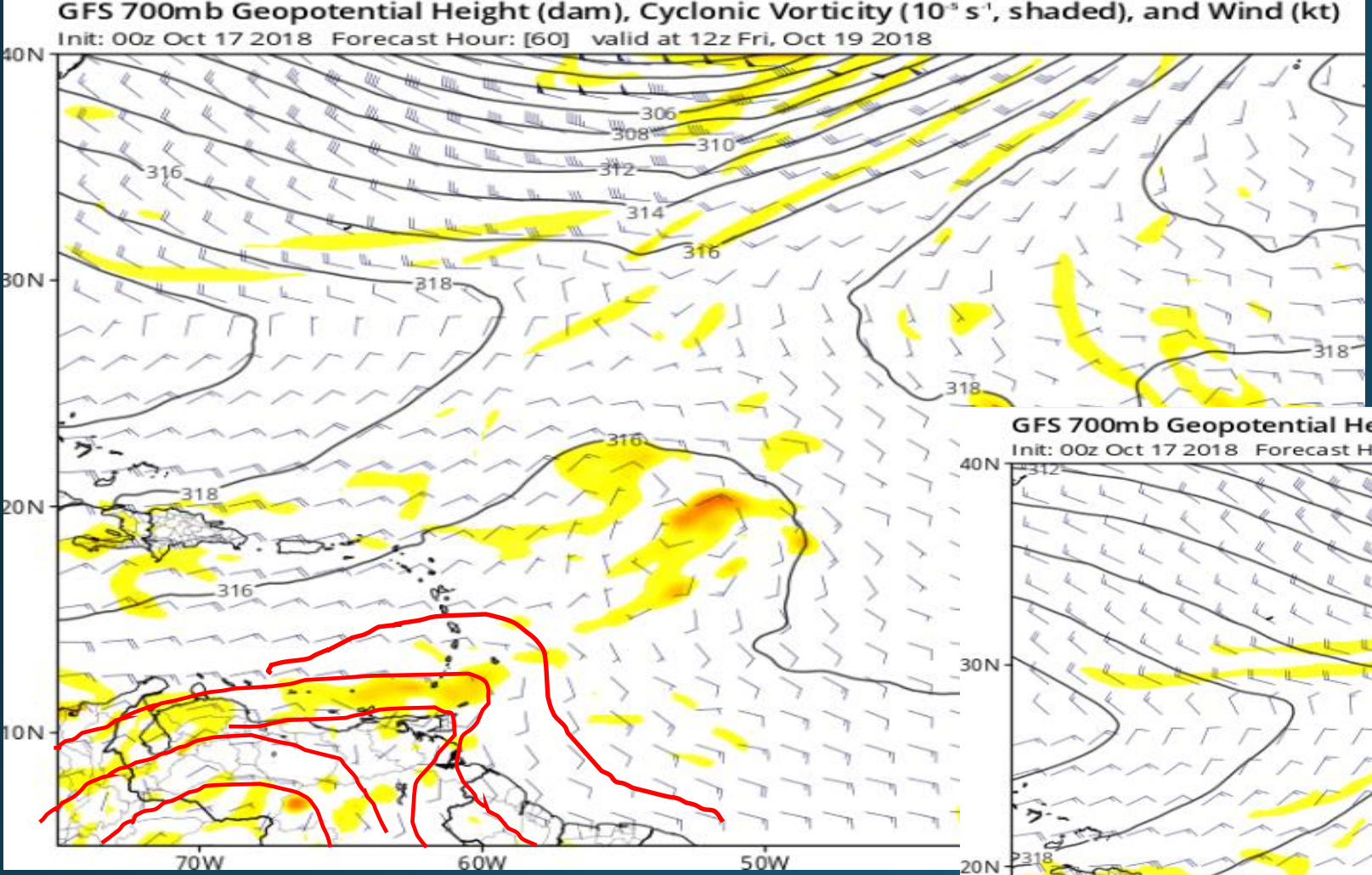




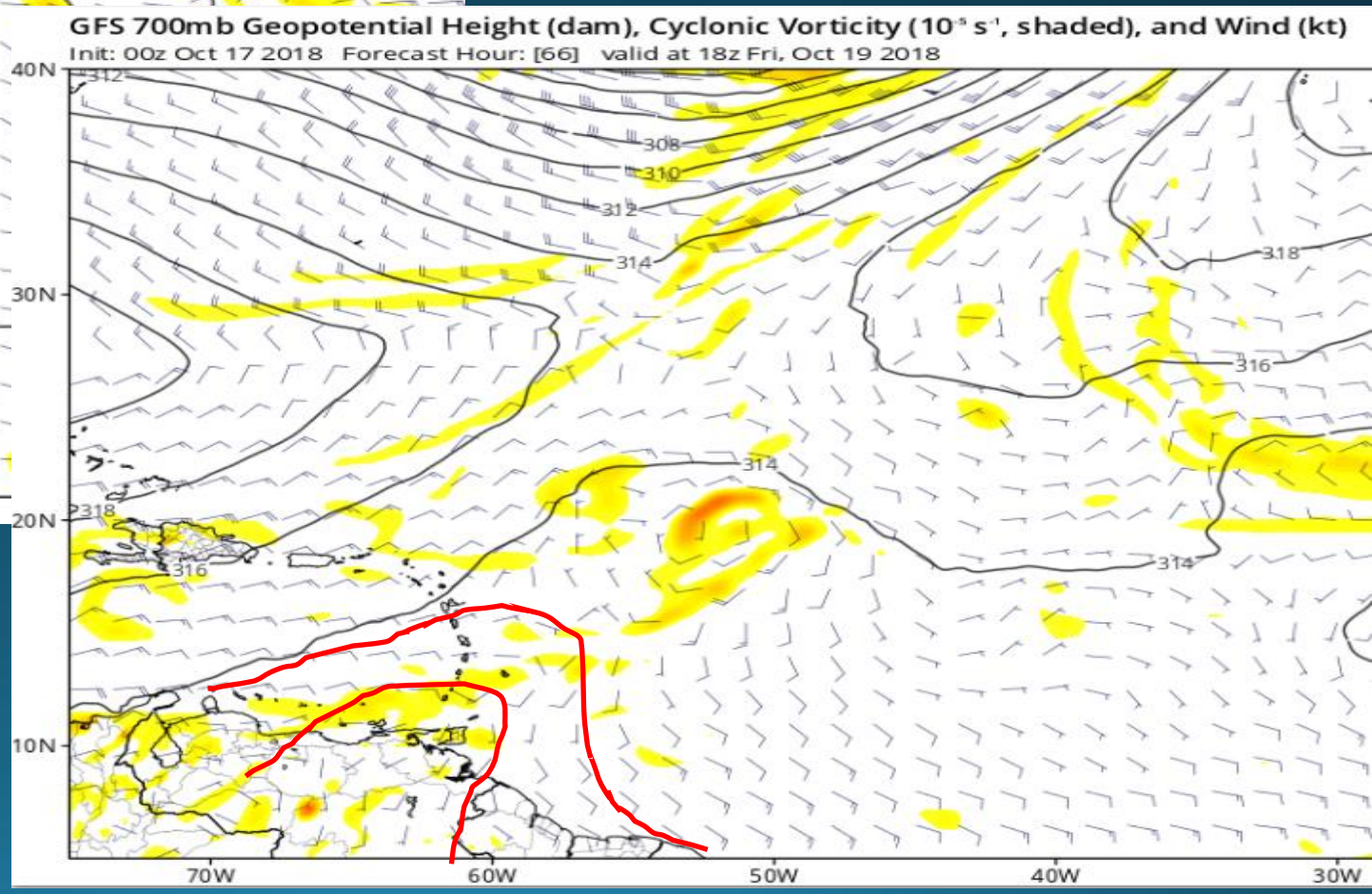
Trough became much more pronounced on Thursday according to model output



Vorticity enhanced on eastern Trinidad

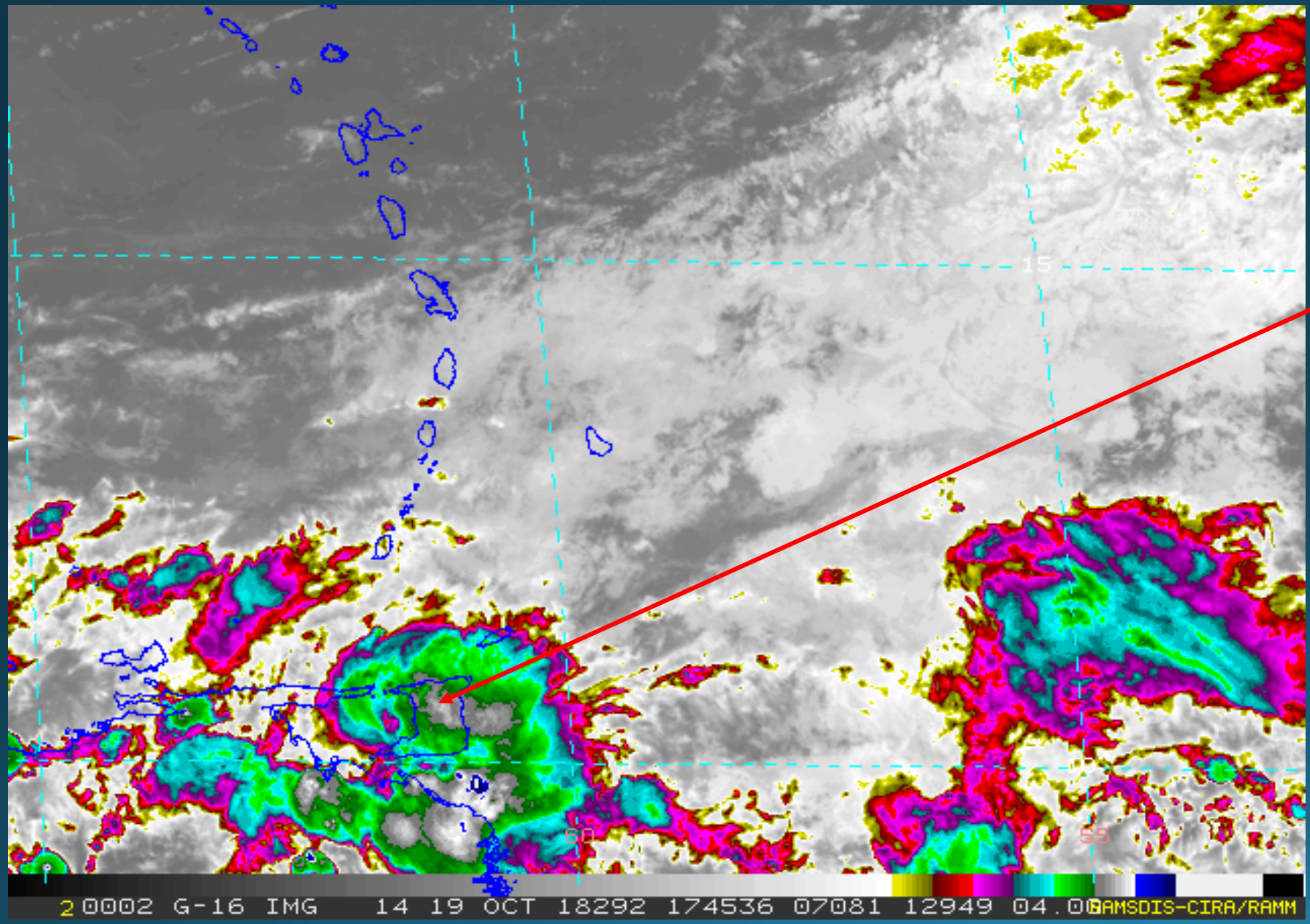


Deepening low to north east strengthens associated trough



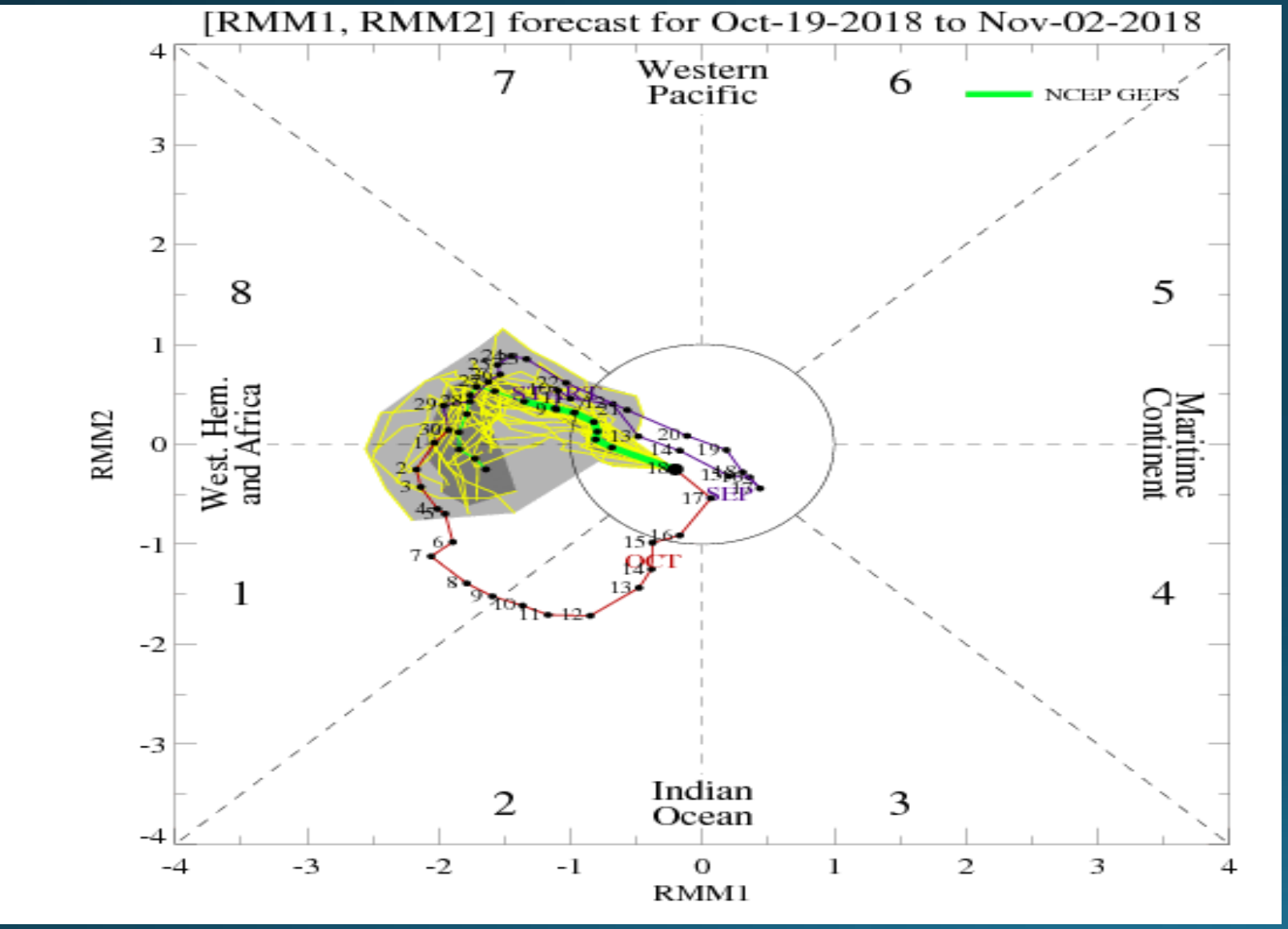
These features exist in lower, middle and upper atmosphere

Orientation of Cloudiness Became Important



Deep towering clouds with very cold tops oriented along the major rivers

Madden Julian Oscillation



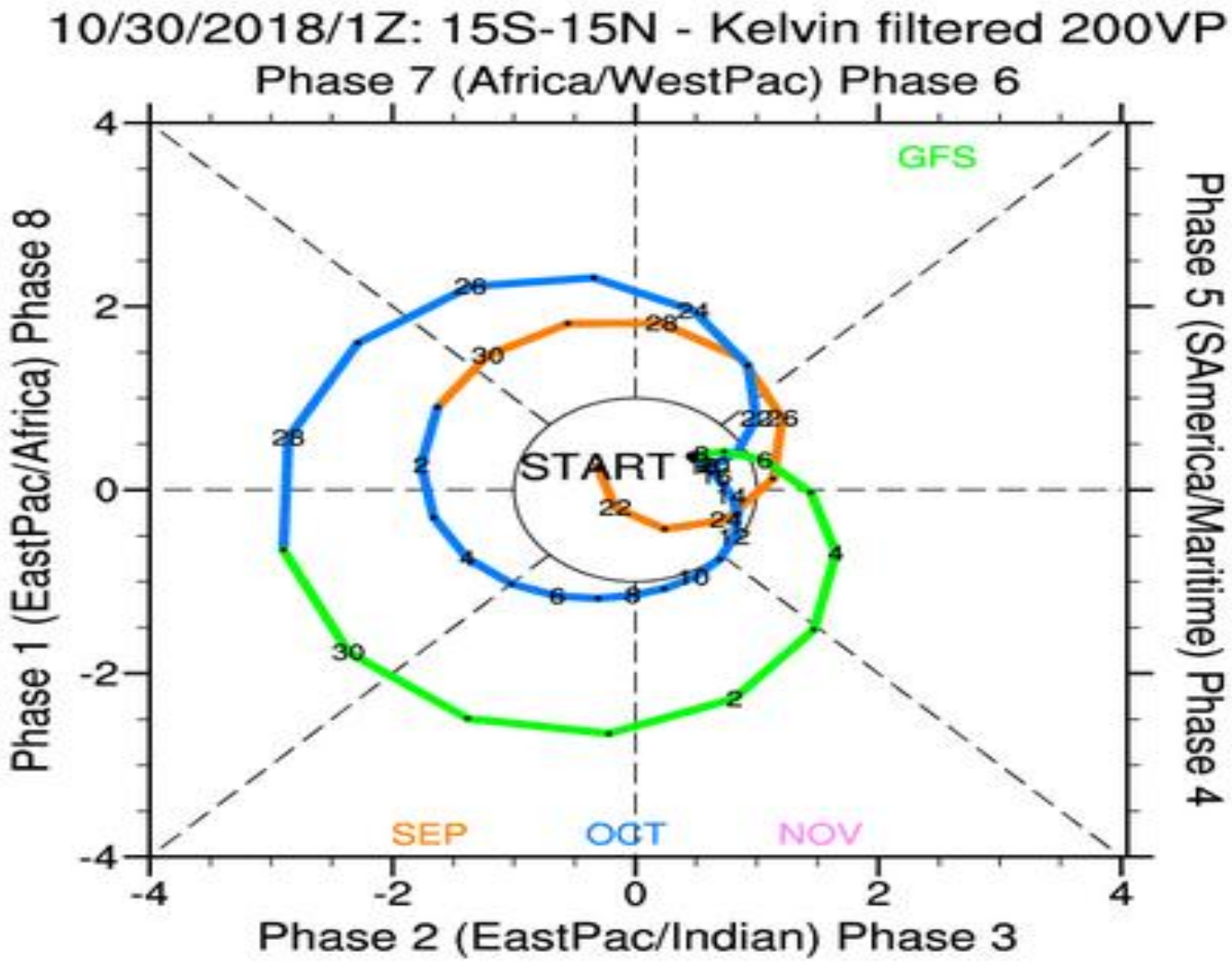
MJO & other eastward moving kelvin waves are major sub-seasonal influencers of local rainfall

The MJO remained weak during mid-October

It is possible that it may have modulated a Kelvin Wave to become active over Northern South America

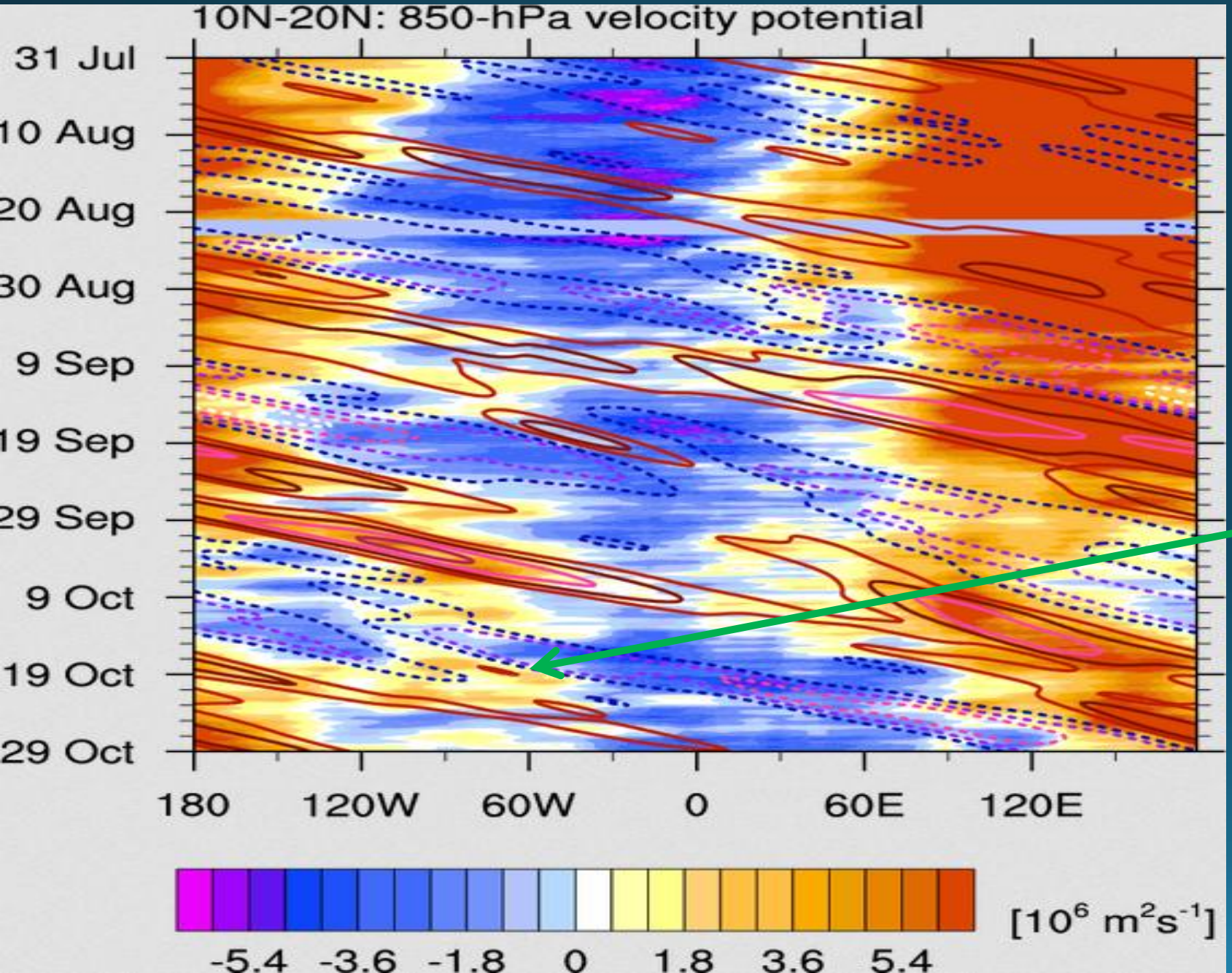
Source:
http://mikeventrice.weebly.com/tropical-waves.html

Kelvin Wave Phase Space Diagram



- Kelvin Wave in phase 5, somewhere over South America between 16-20, October shown by the blue line
- Kelvin waves are best depicted or located by the Velocity Potential or Divergent component of the wind only, as against the rotational component only or stream function

Velocity Potential : Divergent Component only of the wind

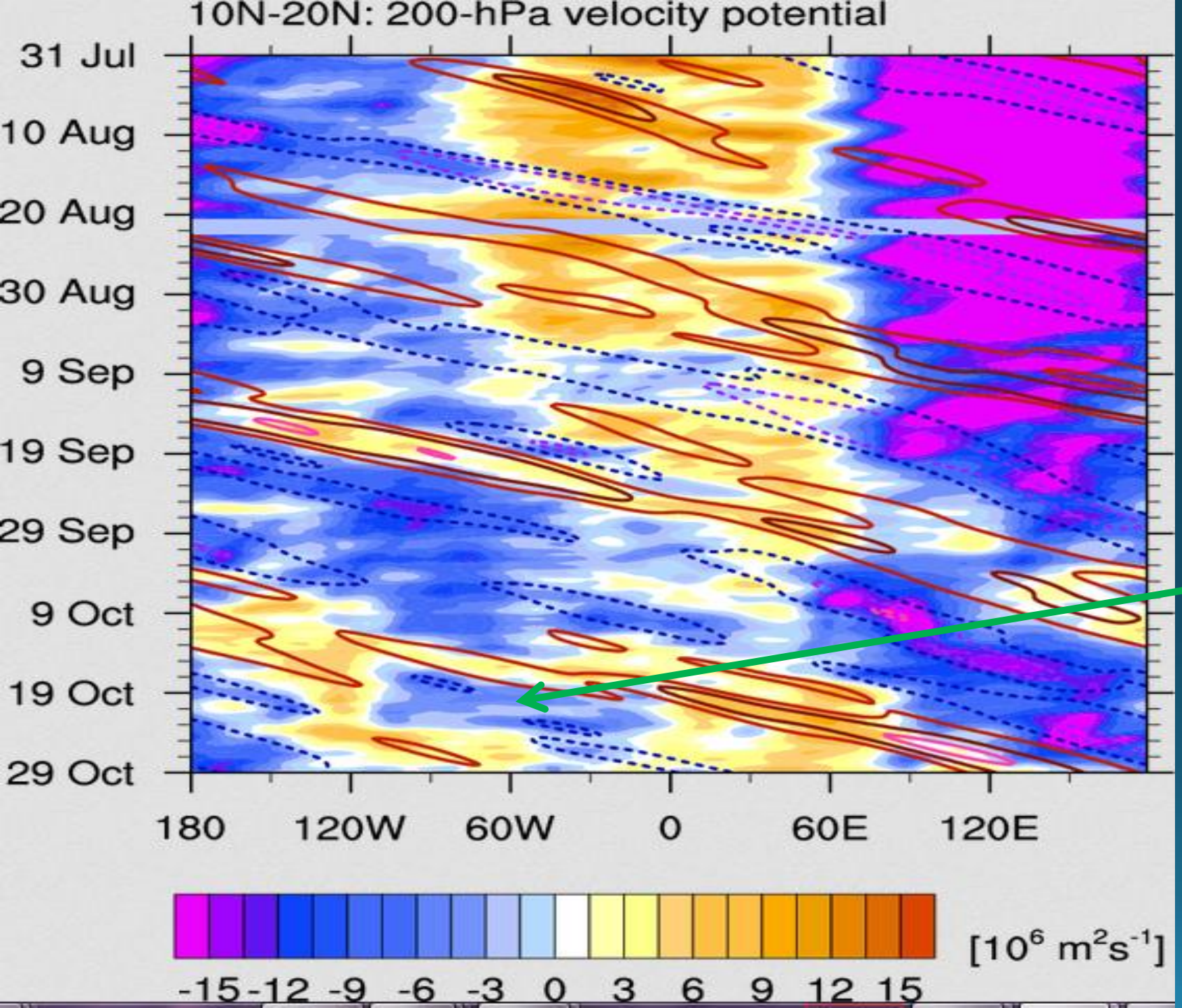


Negative Velocity Potential = Divergence

Trinidad & Tobago
10-11 North Latitude 60-61 West Longitude

Positive VP:
Convergent lower troposphere, from 16-20 October 2018

Source: http://mikeventrice.weebly.com/tropical-waves.html



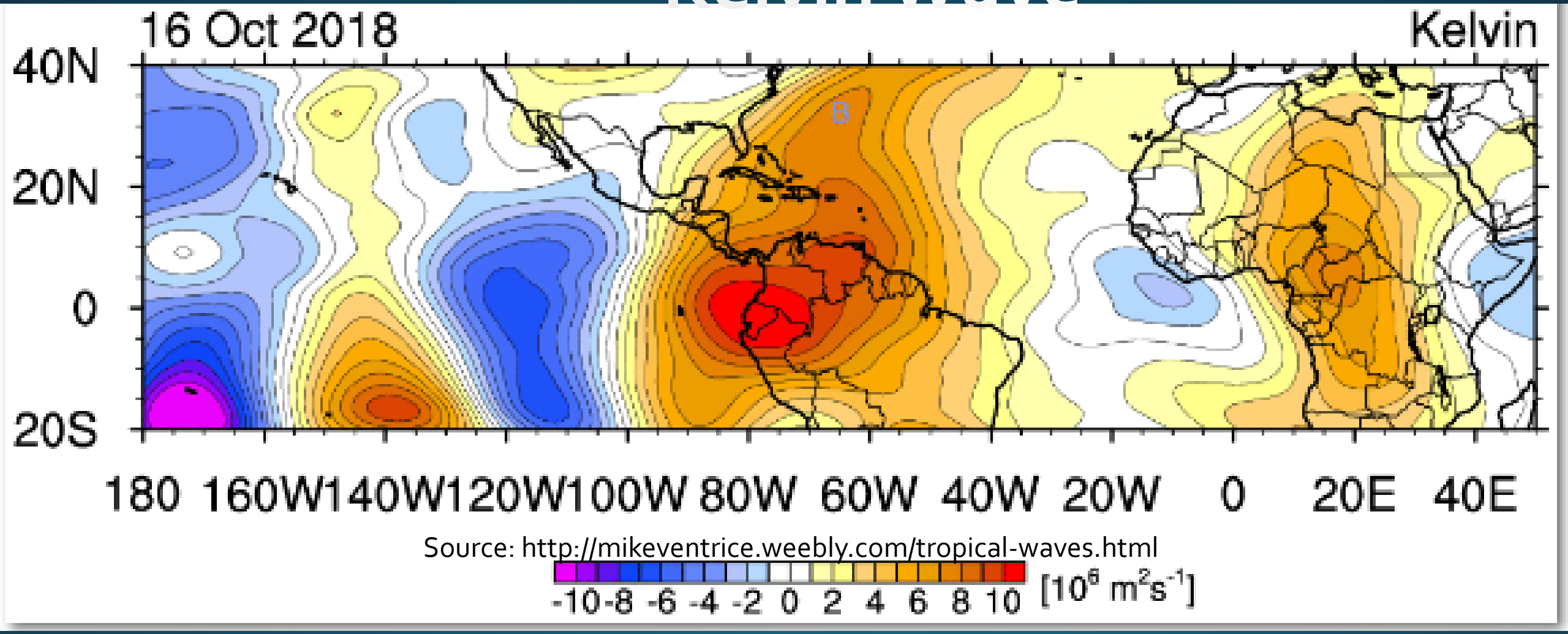
Negative Velocity Potential = Divergence

Trinidad & Tobago
10-11 North Latitude 60-61 West Longitude

Blue: Divergence associated with Kelvin Wave between Oct 16-19, 2018

Source: http://mikeventrice.weebly.com/tropical-waves.html

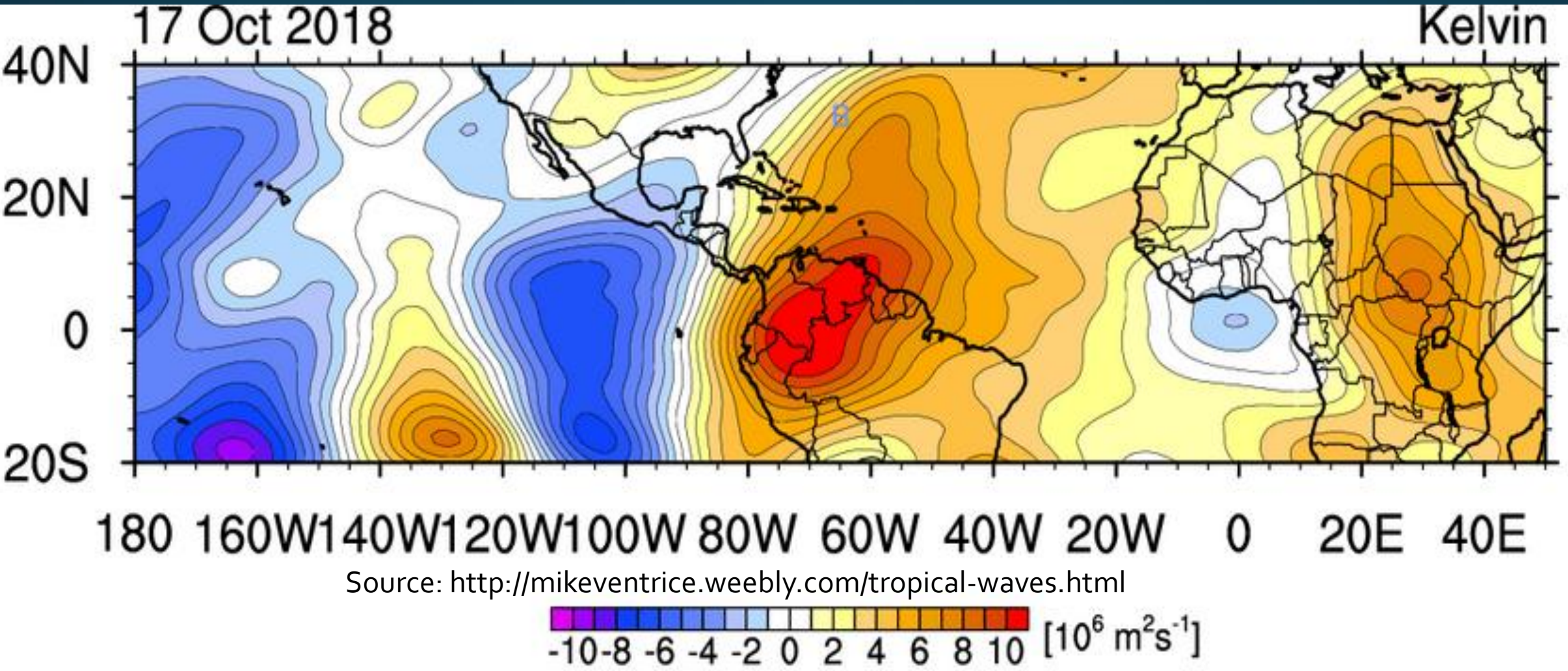
Kelvin Wave



Source: http://mikeventrice.weebly.com/tropical-waves.html

- Kelvin Wave influenced the weather at the local scale through its velocity potential plot
- Centre of low level convergence over northern South America with a tongue over Trinidad and Tobago on the 16th
- Keep in mind shape and direction of movement

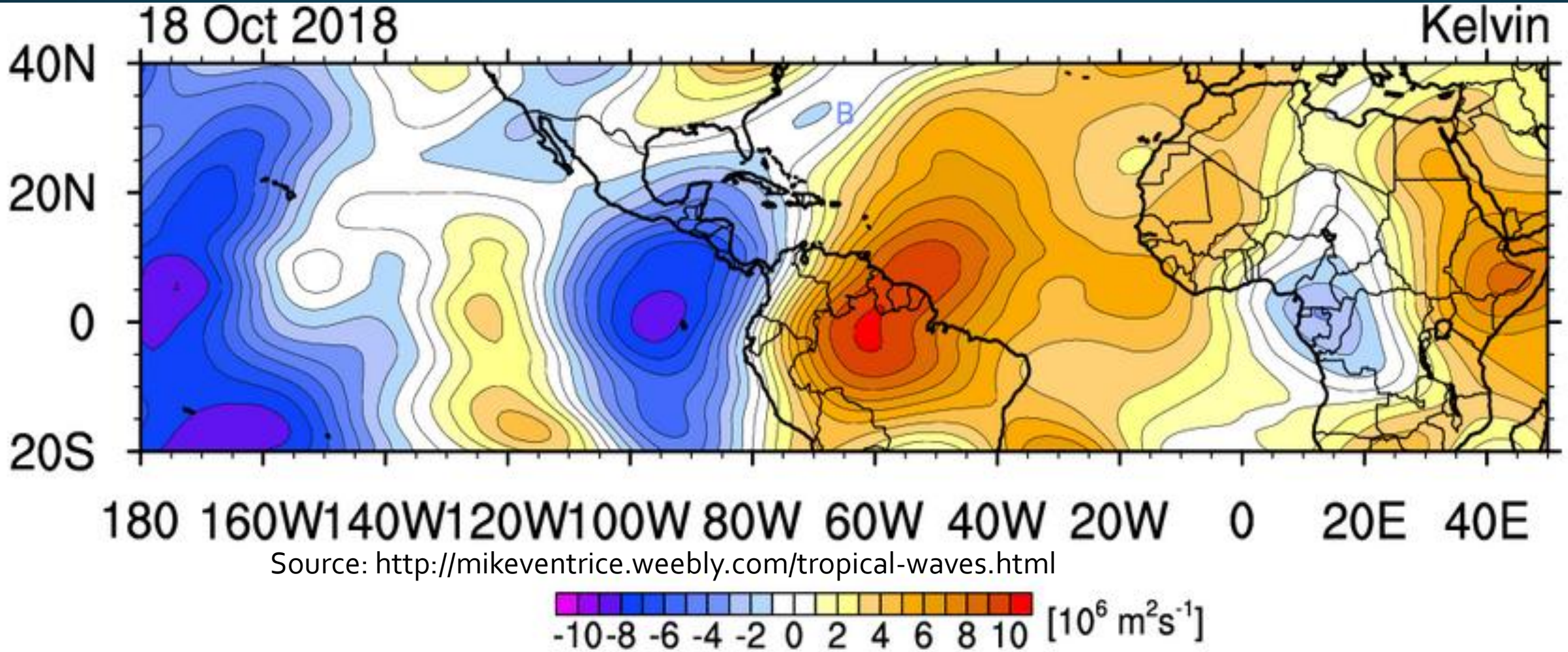
Kelvin Wave



Source: http://mikeventrice.weebly.com/tropical-waves.html

Wednesday, Kelvin Wave extends reach and influence with core extended over Trinidad and Tobago

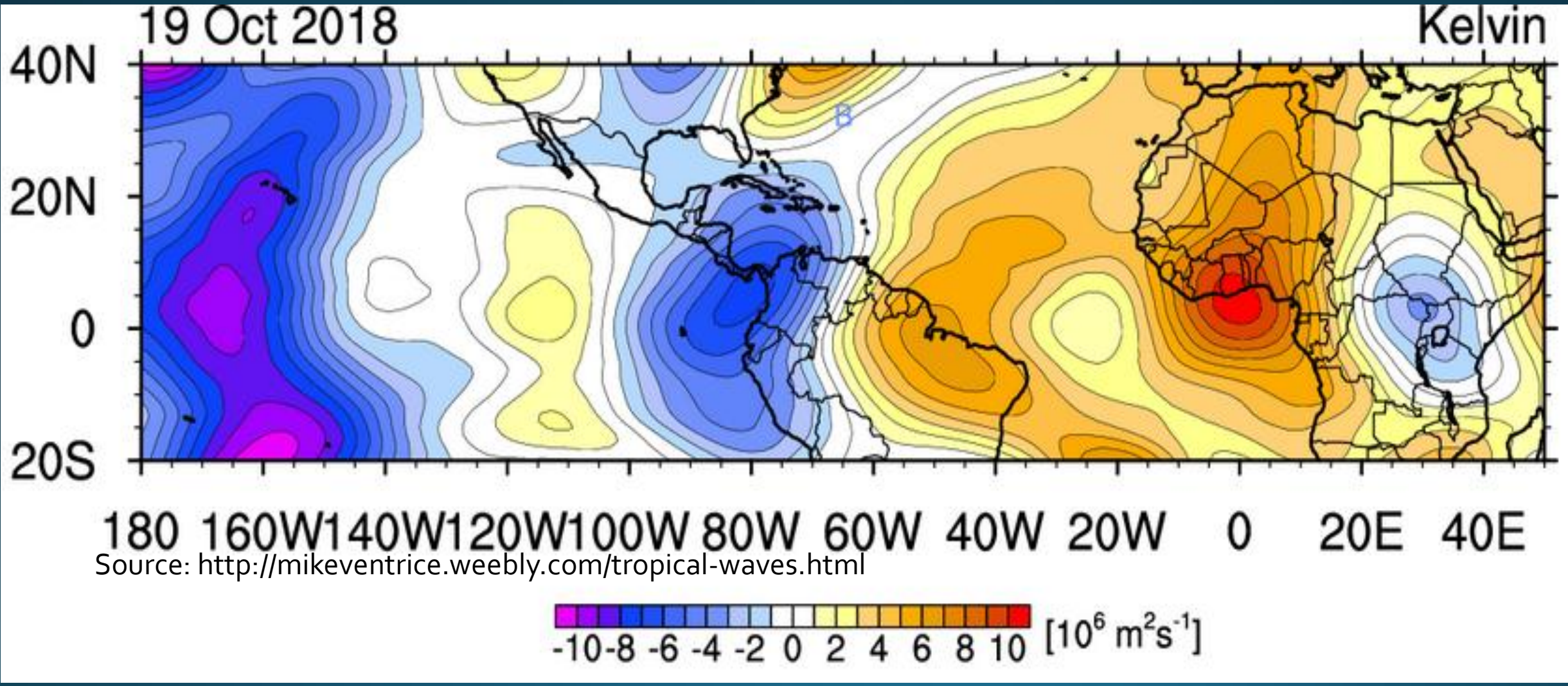
Kelvin Wave



Source: http://mikeventrice.weebly.com/tropical-waves.html

Thursday, Kelvin Wave Continues to Influence Local Rainfall

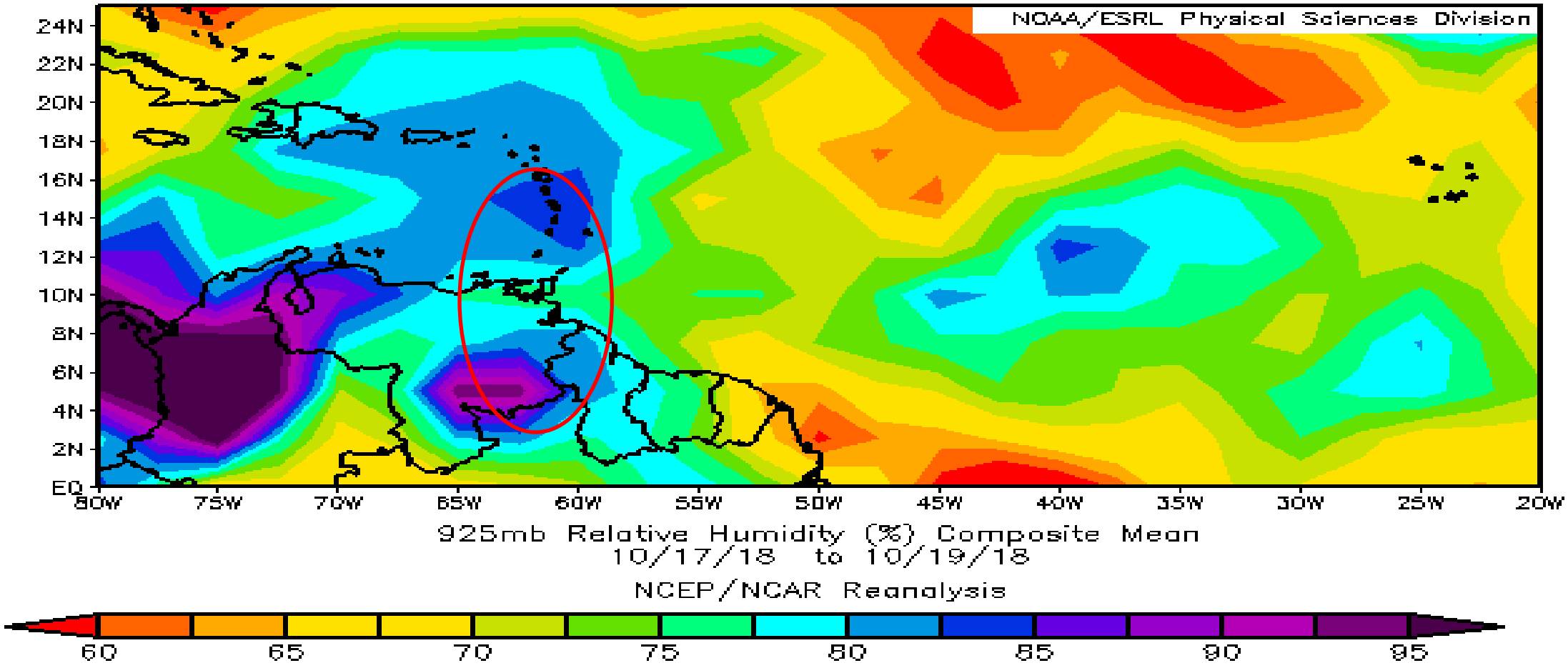
Kelvin Wave



Source: http://mikeventrice.weebly.com/tropical-waves.html

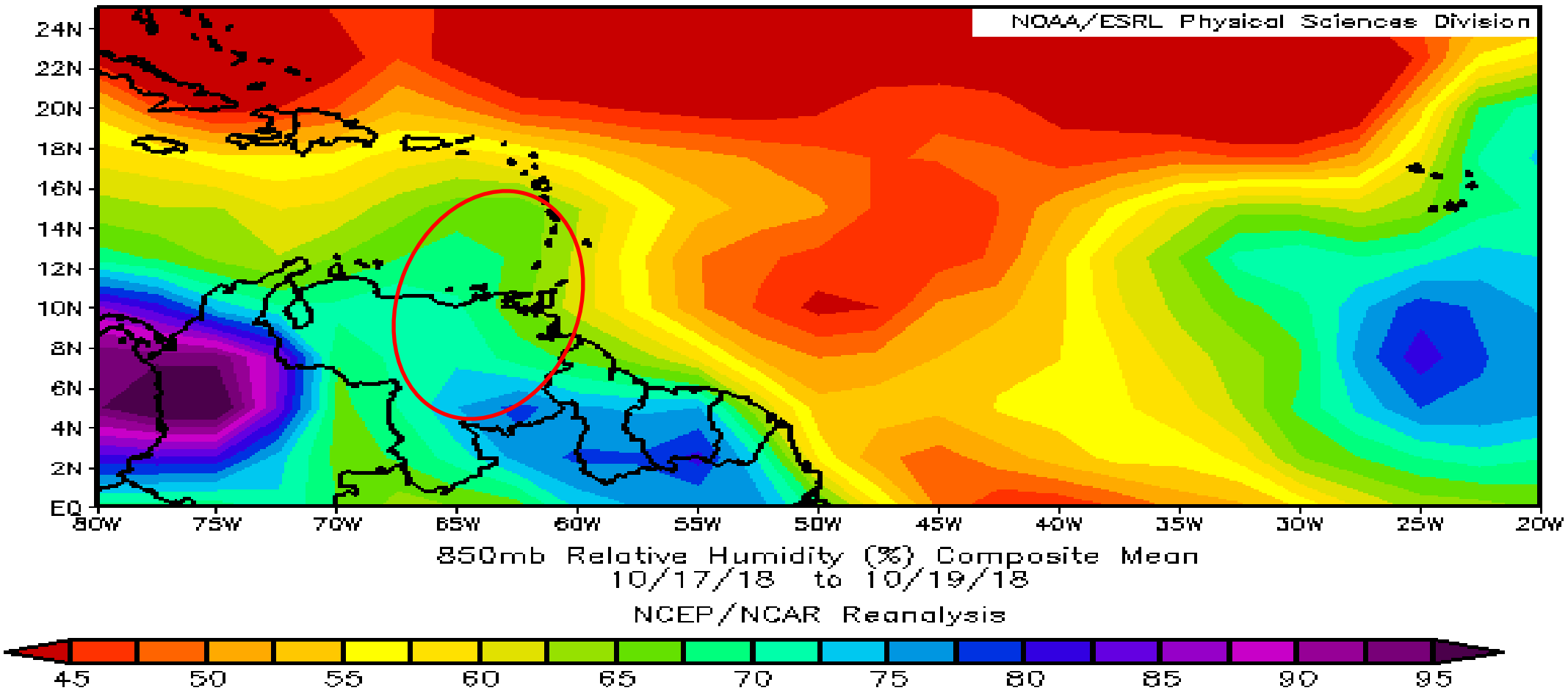
Friday, Kelvin Wave progressed eastward providing a lagged effect on the local rainfall, as they tend to do

925 hpa Relative Humidity

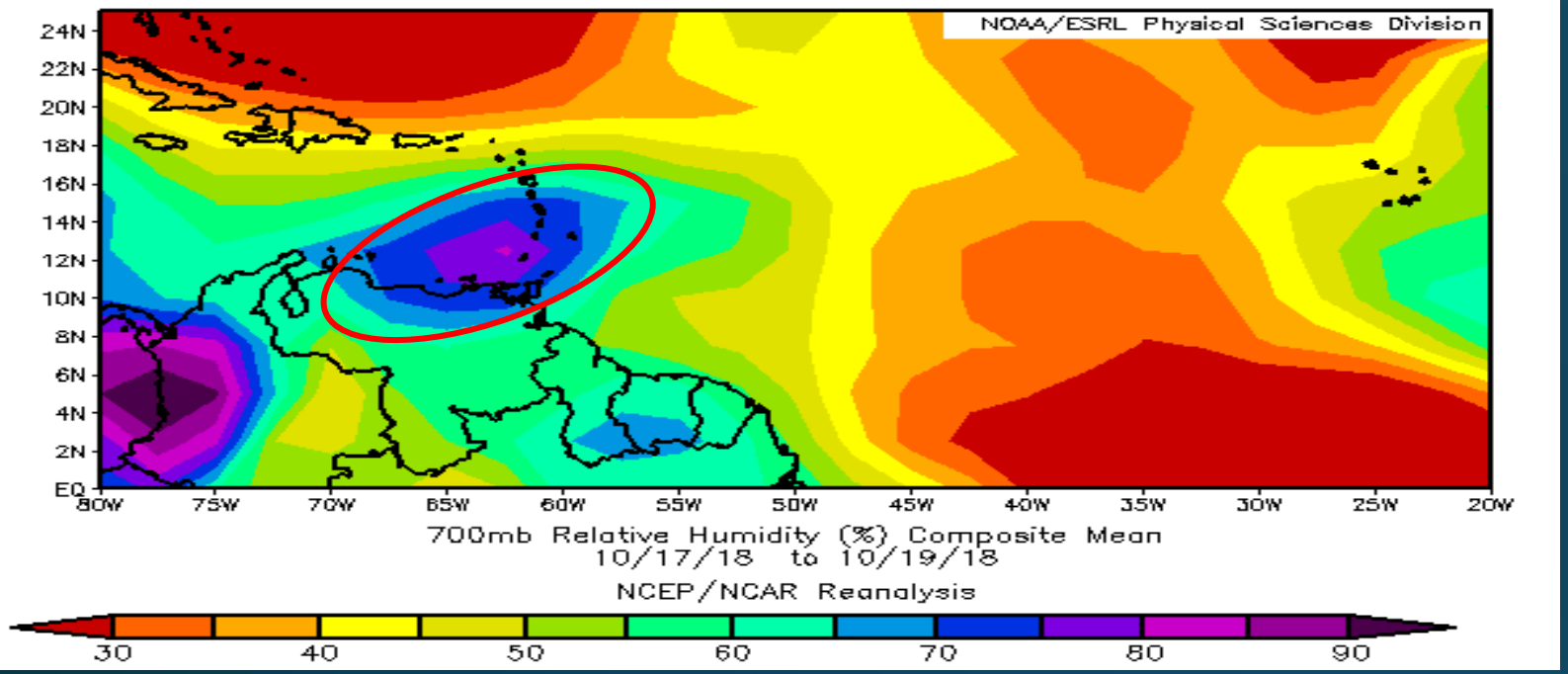


925 mb RH in sync with Kelvin Wave orientation

850 hpa Relative Humidity

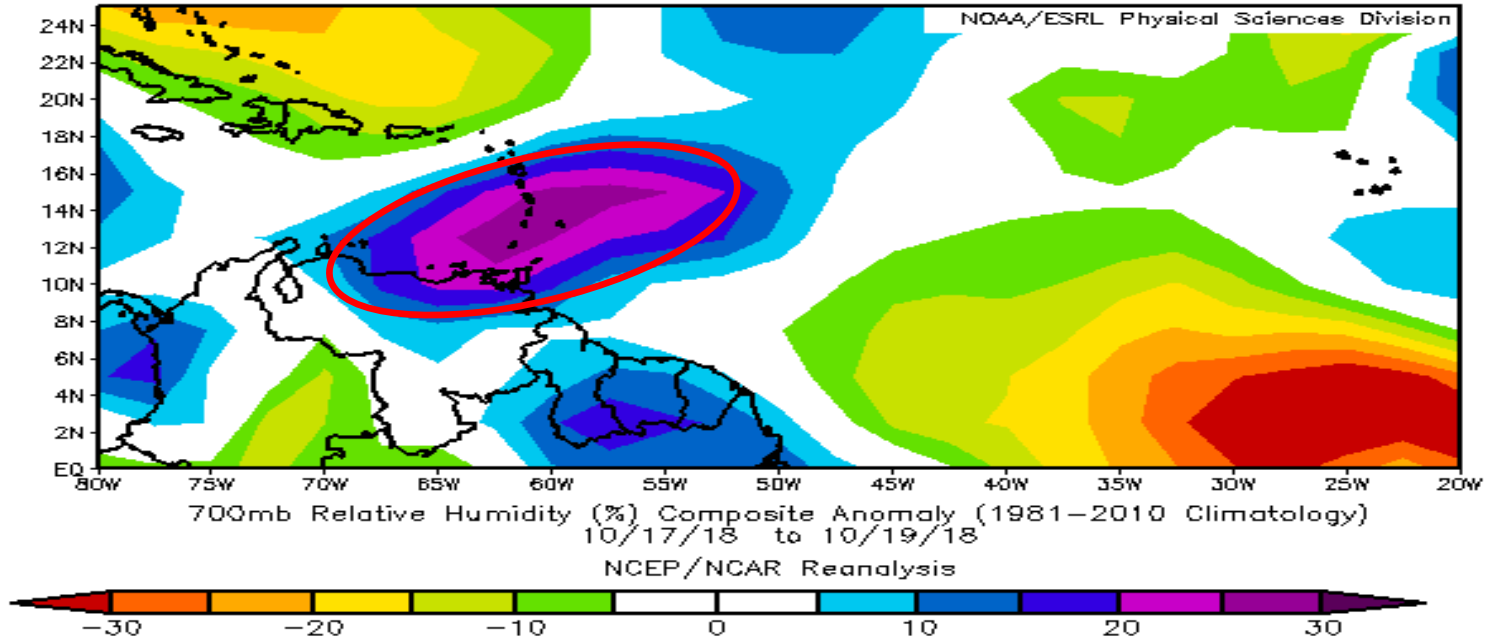


850 mb RH pronounced northeast/southwest, adding credence to the influence and impact of the kelvin wave

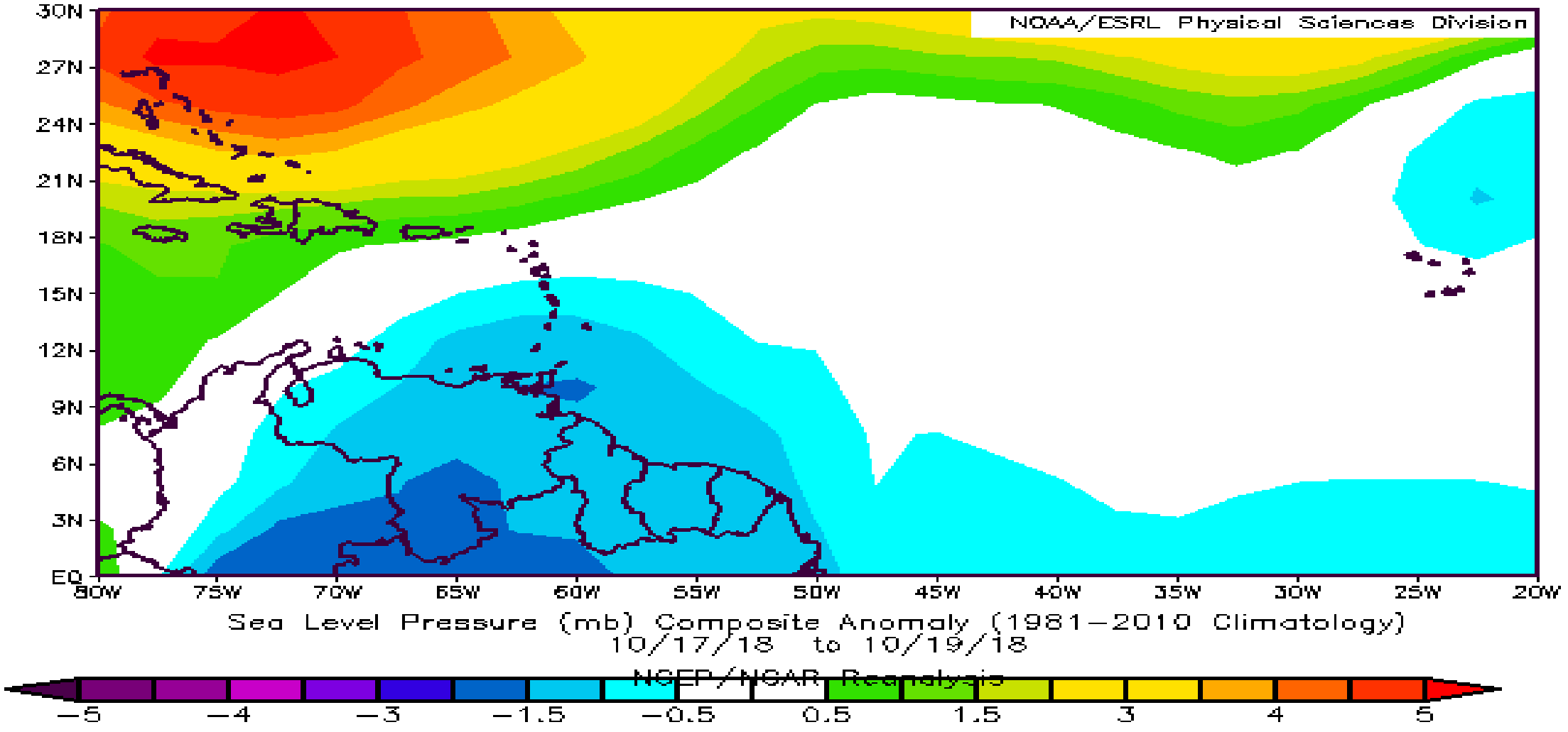


700 hpa major moisture oriented NE/SW

700 mb Relative Humidity Higher than normal & oriented in direction of trough

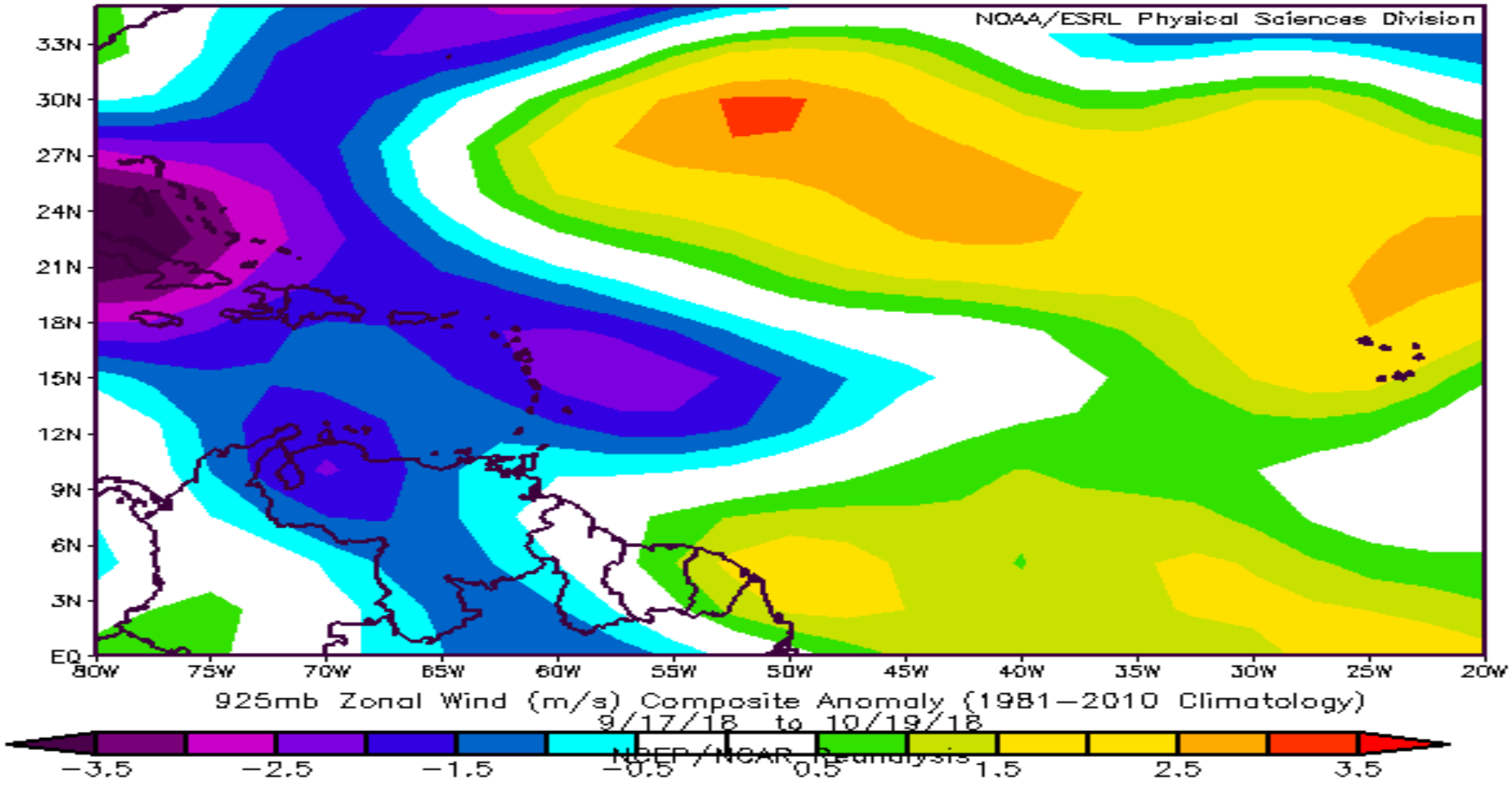


Mean Sea Level Anomaly



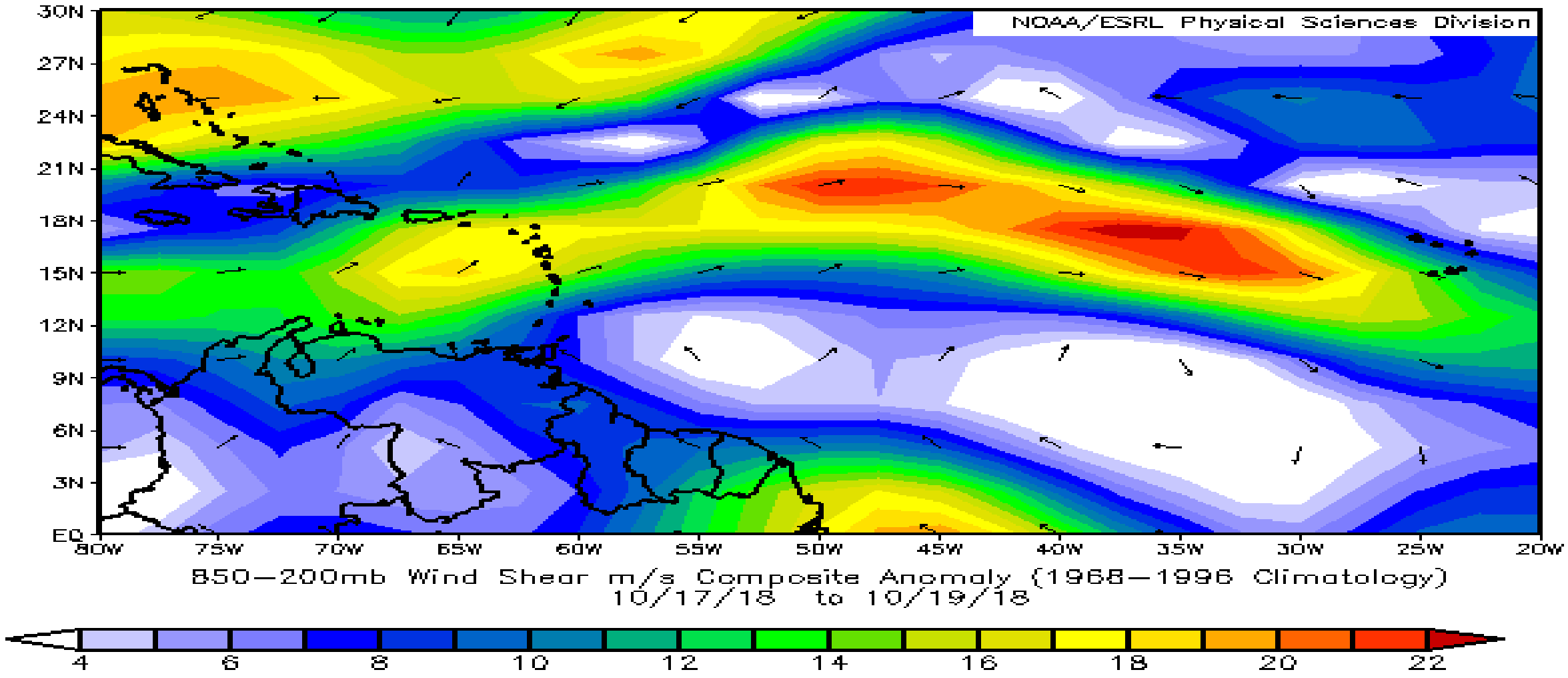
Climatologically, below normal sea level pressures were established over Trinidad and Tobago during the period

Zonal Wind Anomaly



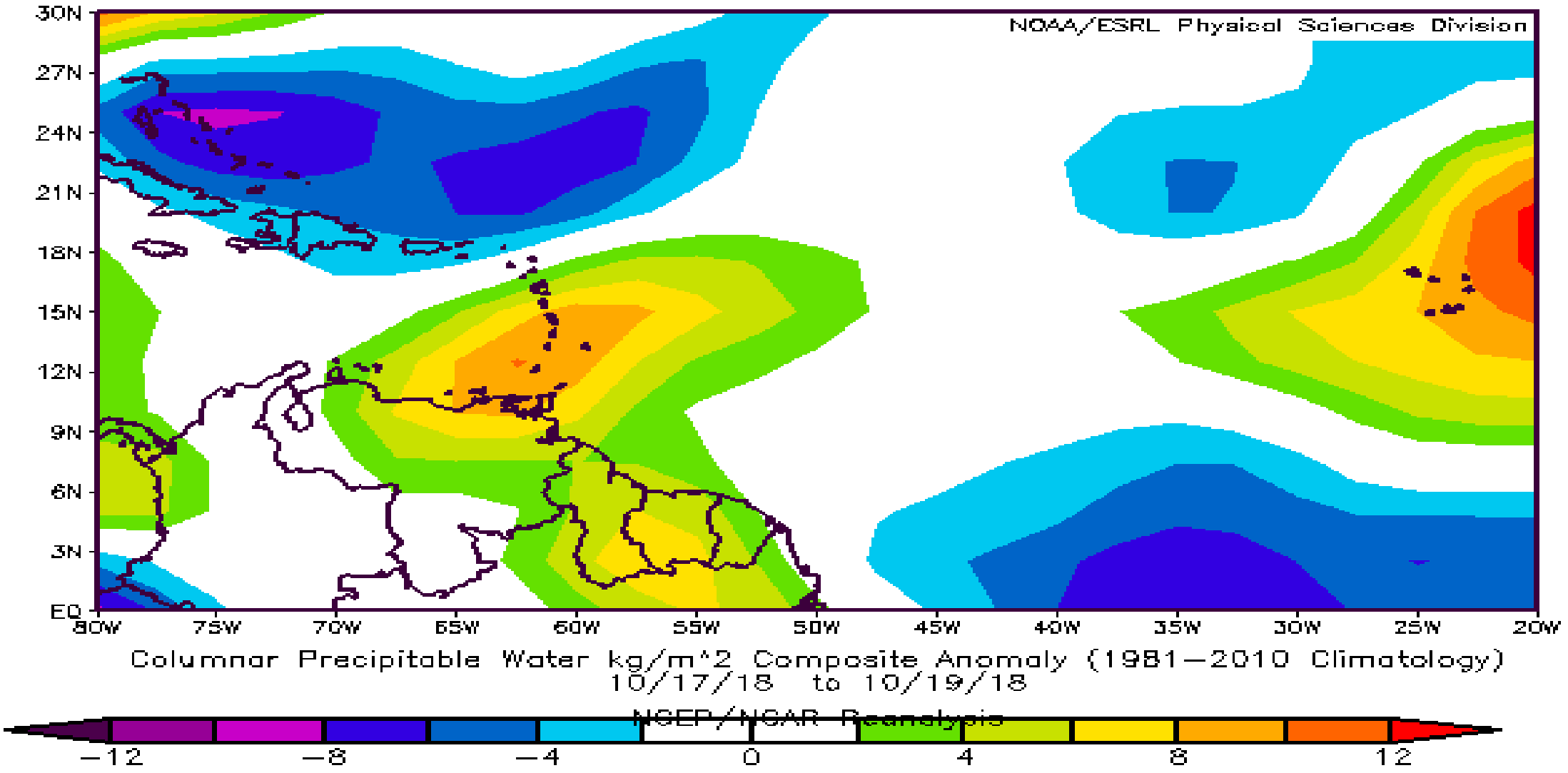
Corresponding shifts occurred in wind speeds. Zonal winds much lighter than usual

Wind Shear Anomaly



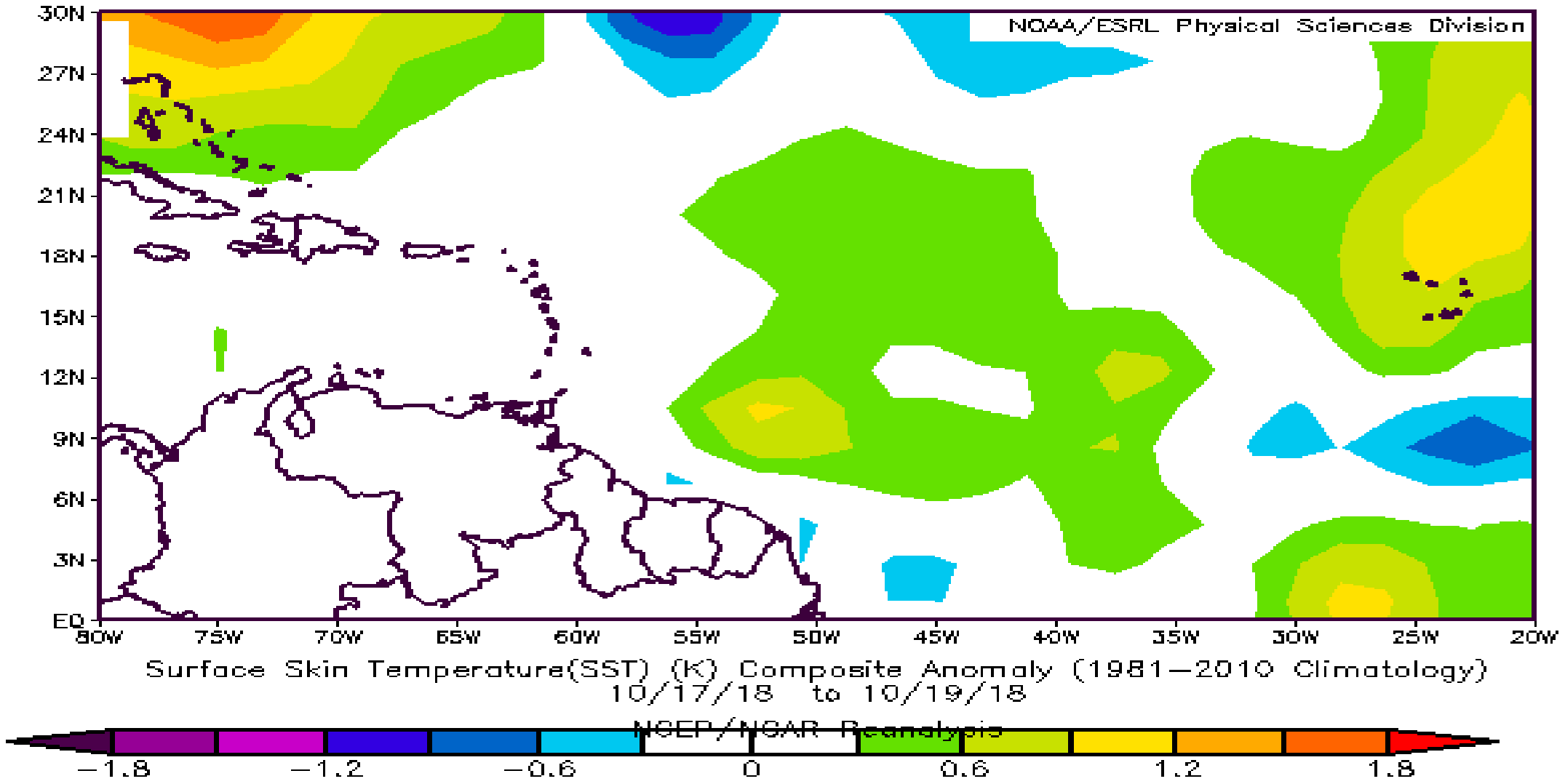
Much lower than usual wind shear also existed between 850 and 200 mb

Precipitable Water Anomaly



Much greater than average volume of precipitable water was available in column above T&T

Sea Surface Temperature Anomaly



Sea surface temperatures were near average but on the warm side during the 3 days

Review of the Major Flooding

1. Nearly saturated soils late in the wet season became saturated
2. High incidence of near continuous nature rainfall events sustained daily development of rainfall with flash flood characteristics
3. Large areal coverage of high intensity and persistent almost semi-stationary rainfall producing system
4. Orientation of the rain areas along the major rivers and tributaries
5. A unique mix of traditional high rainfall producing systems collocated with major sub-seasonal climate driver in the form of a Kelvin Wave
6. A background state of below normal sea level pressure, low wind shear, above average available precipitable water

Lessons Learnt

1. Taught us about the kind of climate-related risks we now face and will face in the future

2. Demonstrated how prepared or un-prepared we are for these level of climate hazard.

3. Should serve as an alarm indicator that even though there is well developed early-warning system for severe weather events, meteorologist must consider the back ground climatic seasonal and sub-seasonal forcers.

4. It is not good enough to have a well developed working early warning system. It also requires knowledge of the background landscape, vulnerable and at risk areas.

5. Early warning information must cause a reaction down to the last mille

Trinidad & Tobago Meteorological Service

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