ASSESSMENT OF EXTREME EVENTS OVER THE CARIBBEAN REGION

Regional and Teleconnection Analysis

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INTRODUCTION

- Heat wave events were identified in the United Stated with disastrous effects. In the year 1980, more than 1,250 people died due to a strong heat wave. Although the high health risk, the heat wave events were no widely studied over the Caribbean region.

- The drought event could reduce the rate of economic growth or increase the rate of economic contraction. This event can intensify the water stress in countries, regions and local communities in the Caribbean.

Extreme Events	**Variables**	**Possible Driving Variables**
Heat wave	HI (Air Temperature, Relative Humidity)	SST, High Pressure System
Drought	Rainfall	Vertical wind shear, SOI

CARIBBEAN CLIMATOLOGY

- During the dry season, SST is well below the convection threshold ($26^{o}C$) in almost the entire North Tropical Atlantic. Only the western Caribbean is able to support convective activity. The warm pool in the NTA spreads gradually eastward in the ERS toward the Windward Greater Antilles with SSTs between 27.5 and 28 °C.

- At late rainfall season, the SSTs > $26^{o}C$ develop deep convection and encompasses the entire Caribbean basin.

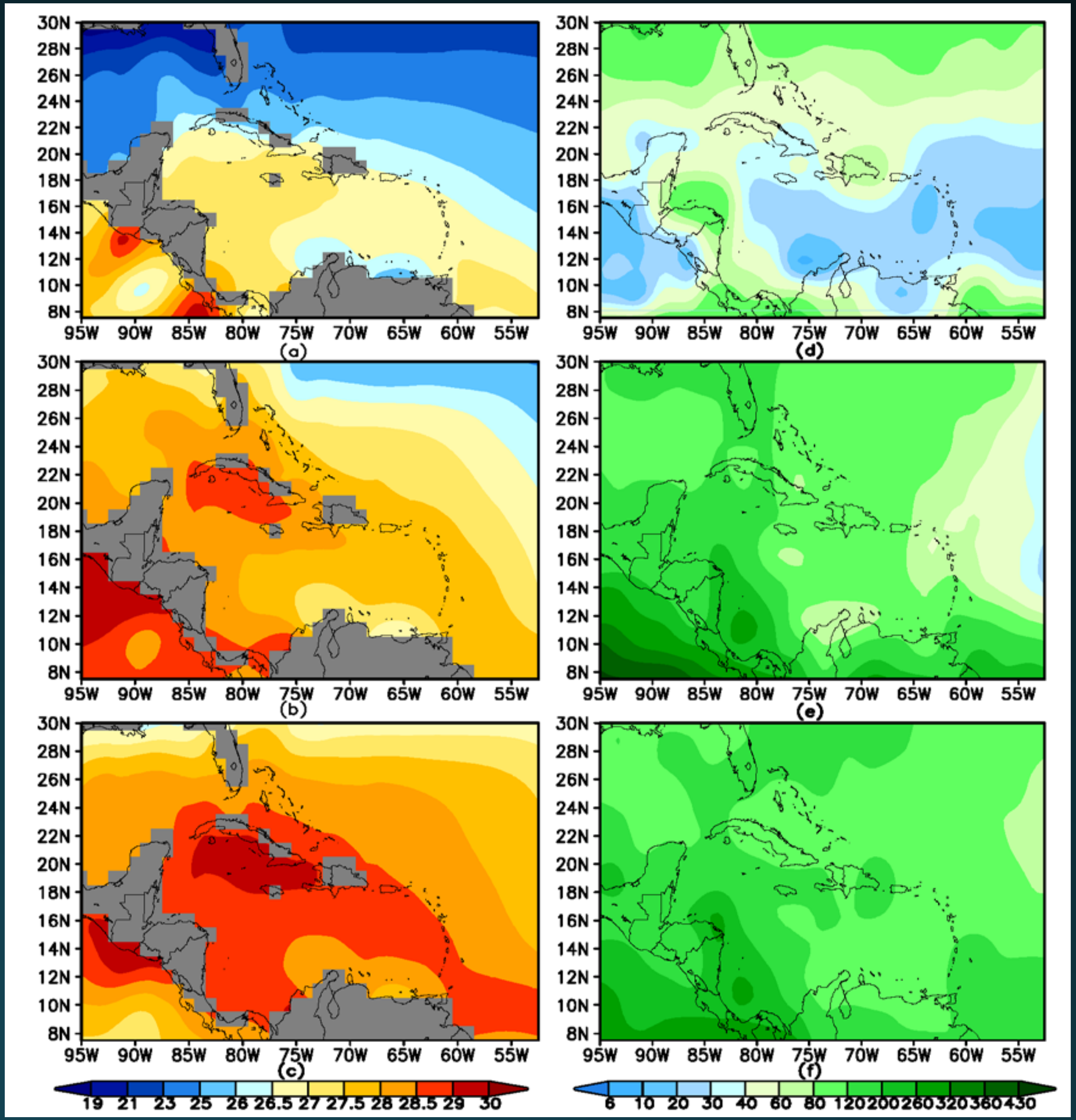
- The rainfall increases noticeably in the ERS generating intense precipitation in the western Caribbean Sea (between 120 and 200 mm). The intense precipitation area spreads up to the Leeward Greater Antilles in the late rainfall season, following the spread of the SST.

Climatology 1979 - 2005

DS

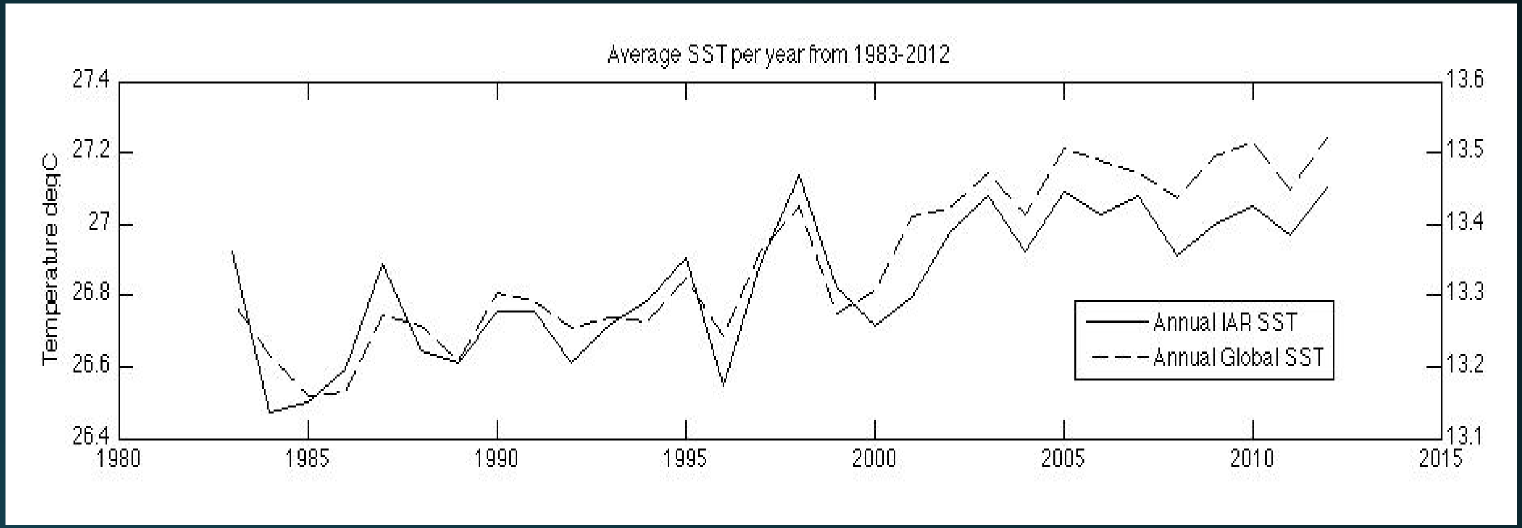
ERS

LRS



Observed climatological SSTs from Reynolds-Smith for (a) DS, (b) ERS and (c) LRS. The blue color depicts SST<$26.5^{0}C$, while the red color SST>$26.5^{0}C$. Observed climatological accumulated precipitation from CPC-Merged analysis for (d) DS, (e) ERS and (f) LRS.

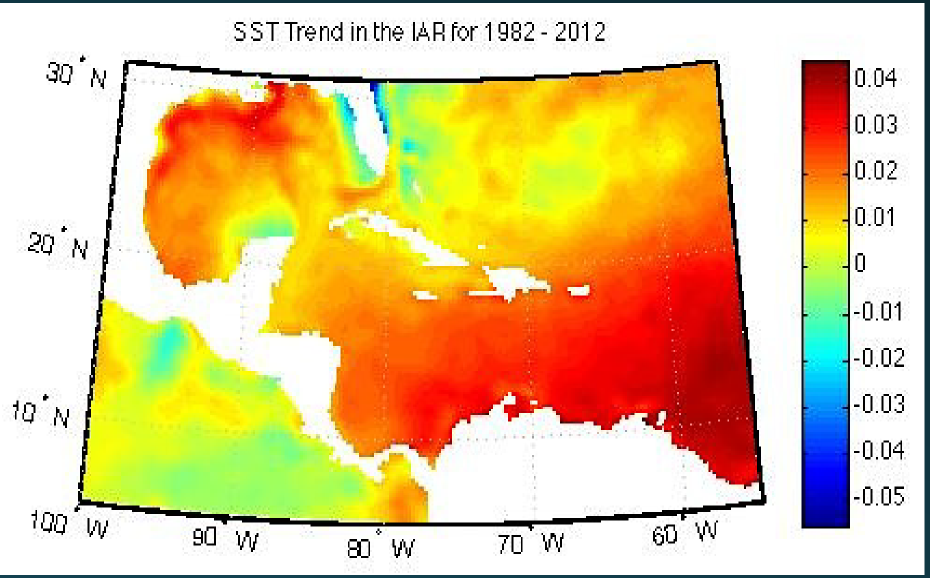
CARIBBEAN CLIMATOLOGY



Caribbean SSTs warming

Larger SST → stronger vertical convection → more intense rainfall

0.015°C per year

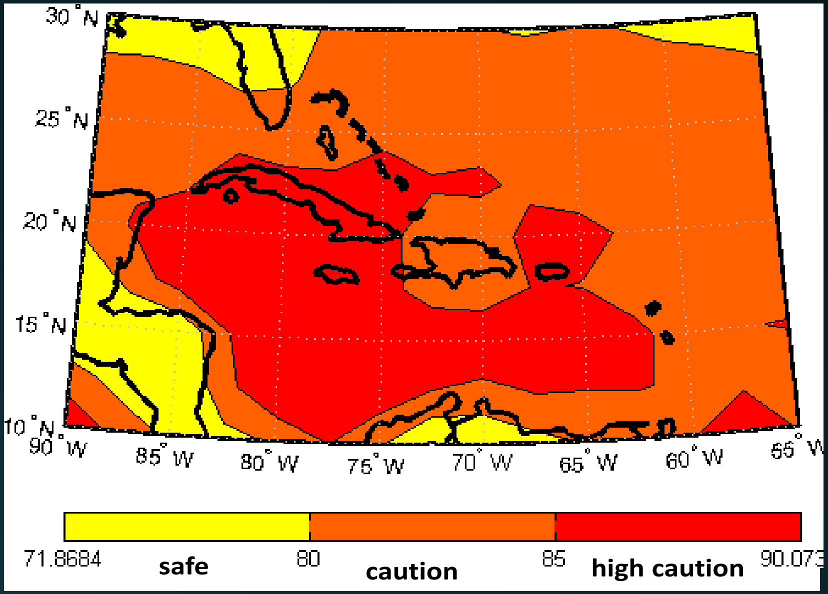


Glenn et al. 2015; JGR-Letters

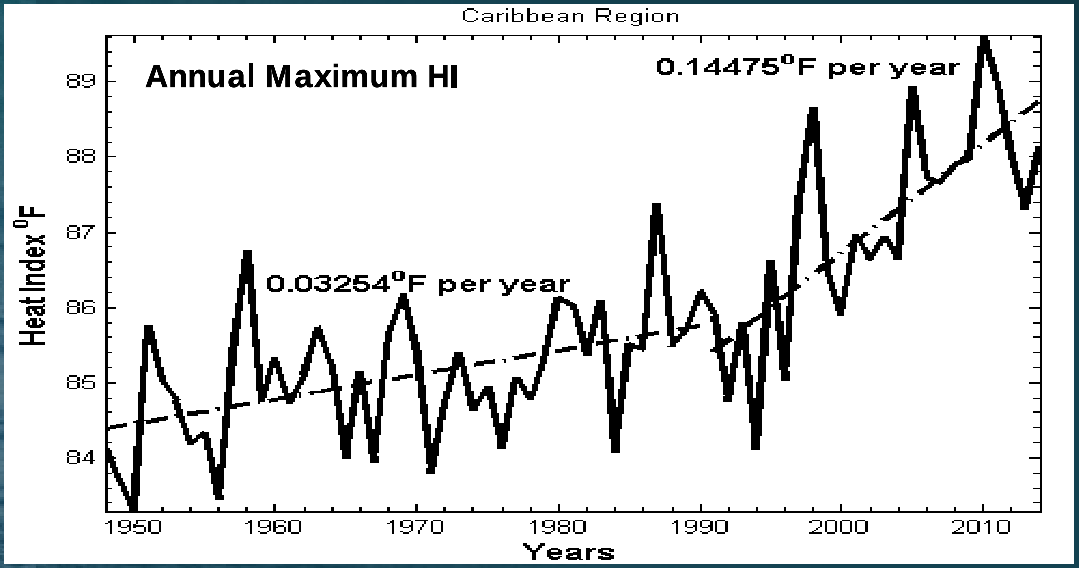
IS THE REGIONAL WARMING DRIVING EXTREME EVENTS OVER THE CARIBBEAN REGION?

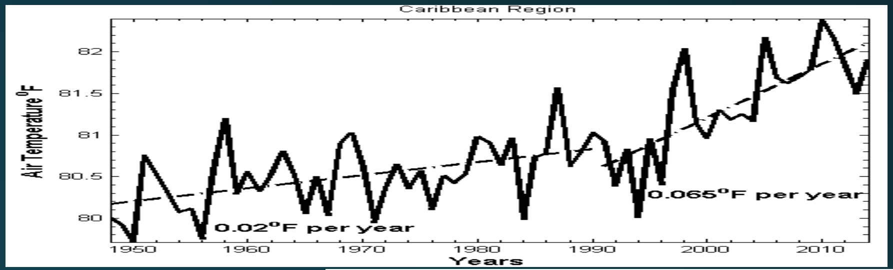
HEAT INDEX IN THE CARIBBEAN REGION

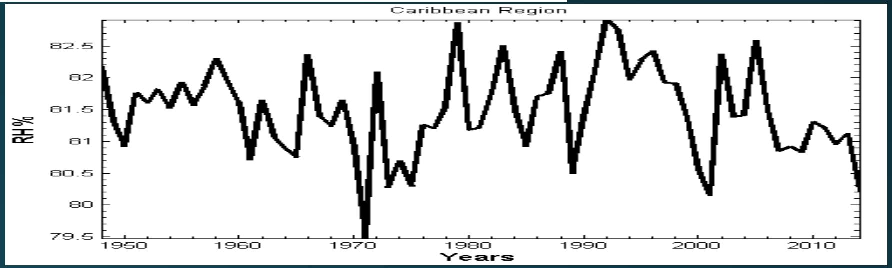
- The heat index is a measure of heat-stress danger.
- NWS uses the Rothfusz's regression equation to calculate heat index.
- Climatologically, the Greater Antilles can be defined as a region of "caution" for heat stress.
- Long term HI trend shows a HI increasing tendency. Since the nineties a fast HI increase is observed with a rate of 0.14^{o}F per year.
- ***SST → Air temperature → main driver of the HI.***



Classification using the NWS Heat Index chart.



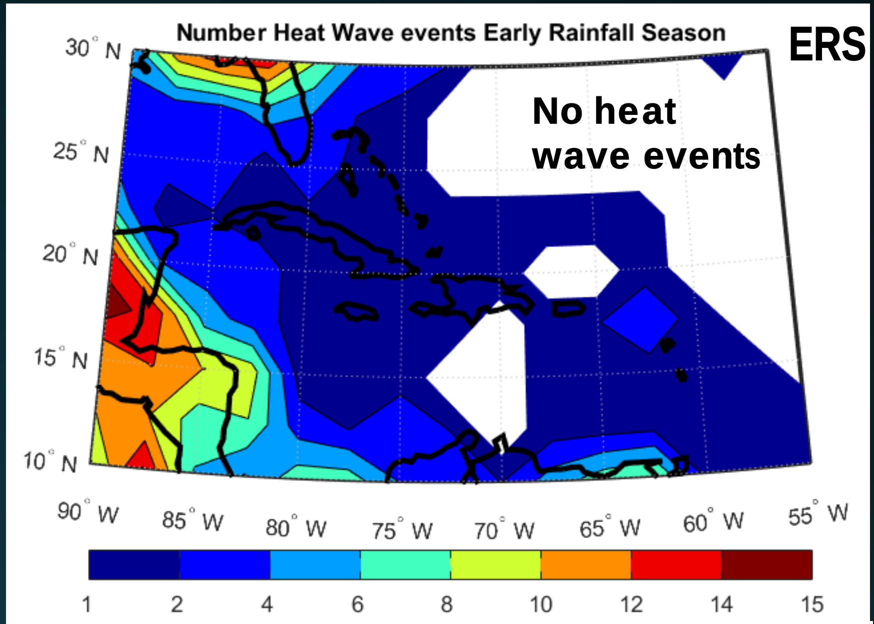


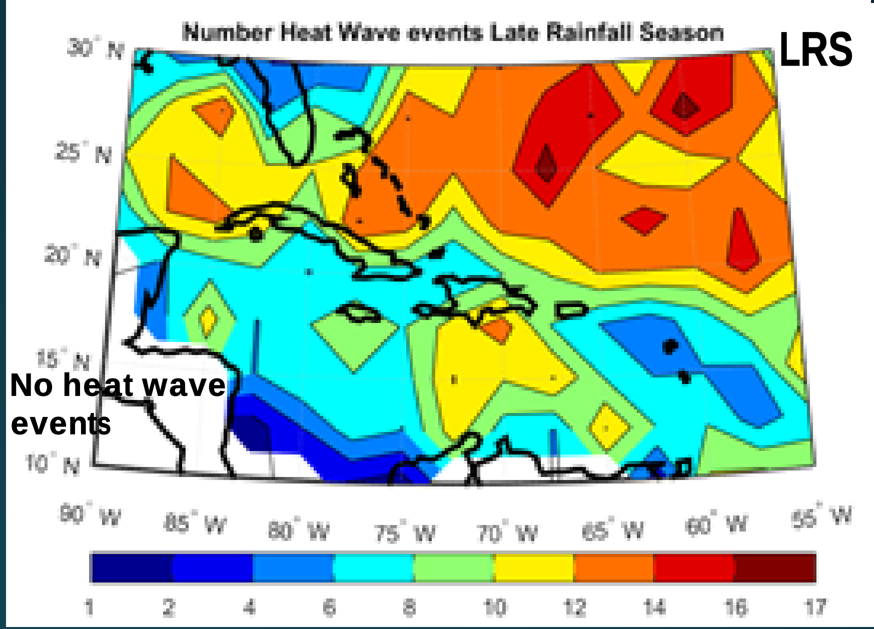


Long term Trend 1948 - 2014

HEAT WAVE EVENTS IN THE CARIBBEAN REGION

- ***A heat wave is defined as an extreme hot event with a heat index exceeding the 99.5 percentile, at least three consecutive days.***
- ***ERS*** was characterized by a low number of heat wave events from 1948 to 2014.
- The Greater Antilles shows one to two events, while the Central America have the largest one, ranging between 10 and 15 heat wave events.
- The Southwest North Atlantic and tropical North Atlantic are identified as a region without heat waves development.
- During the ***LRS***, for the same years, largest heat wave events are observed in the Southwest North Atlantic, which correspond with the seasonal variation of the Bermuda-Azores High.
- Regions far away from the Bermuda-Azores High show lower heat waves. Greater Antilles are affected with five to eight heat waves with highest impact at Eastern Cuba, southern Dominican Republic and Puerto Rico.

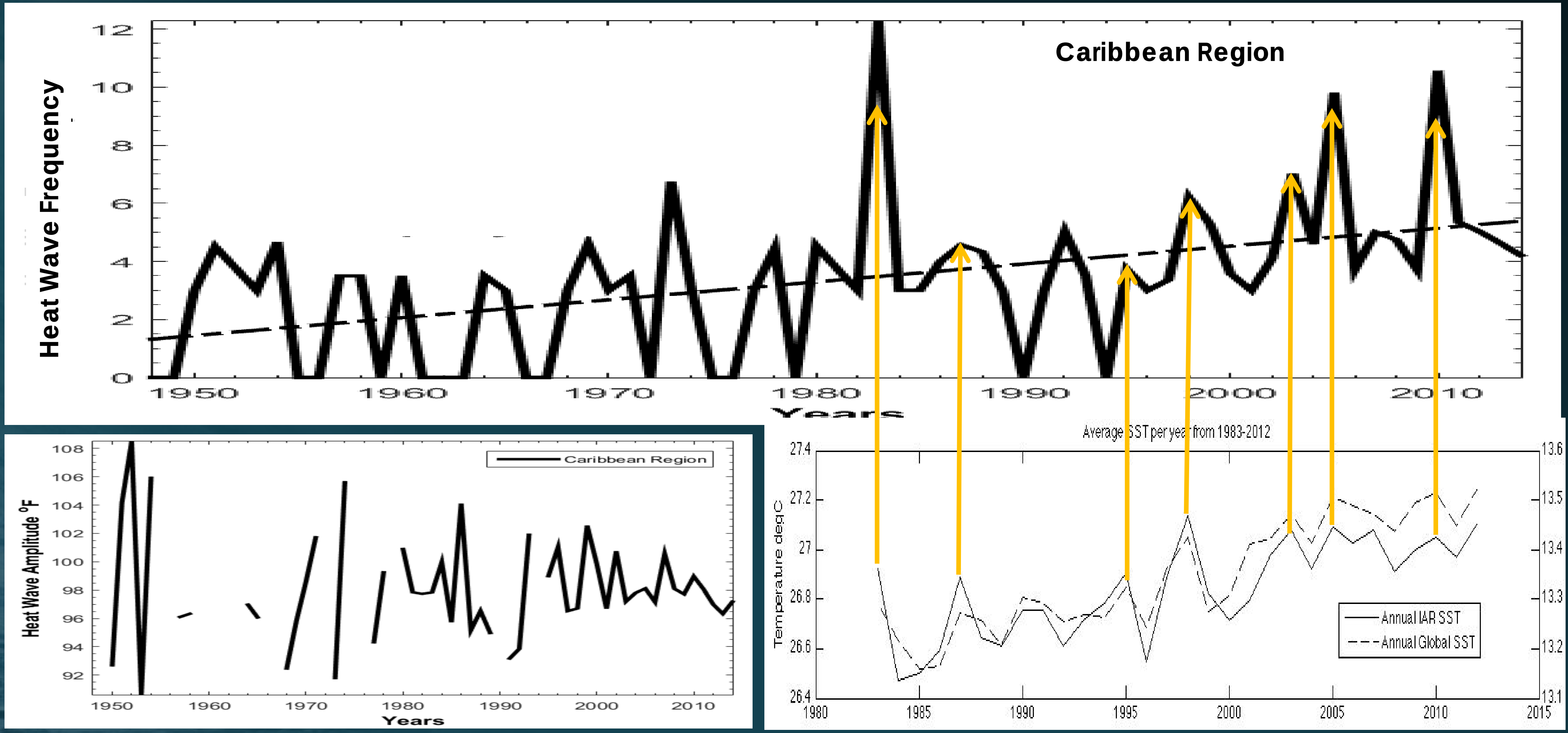




Long term 1948 - 2014

HEAT WAVE EVENTS IN THE CARIBBEAN REGION

- Heat wave event frequency is increasing with time, specially since late nineties where every years show heat wave events. In this period heat wave amplitude is decreasing.
- SST and heat wave show a direct relationship, following an increasing trend.



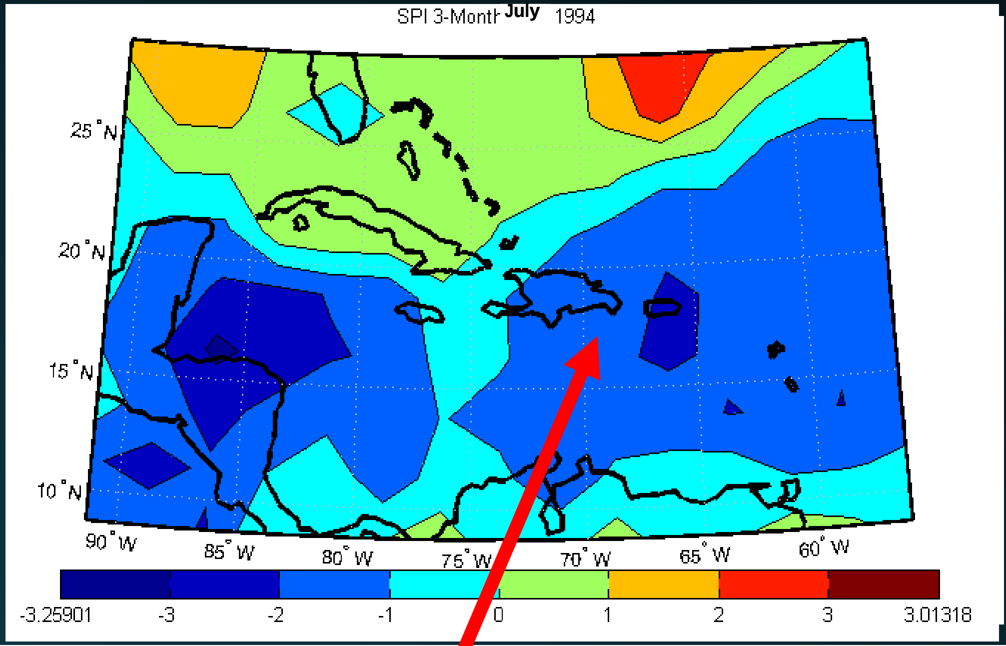
DROUGHT INDEX IN THE CARIBBEAN REGION

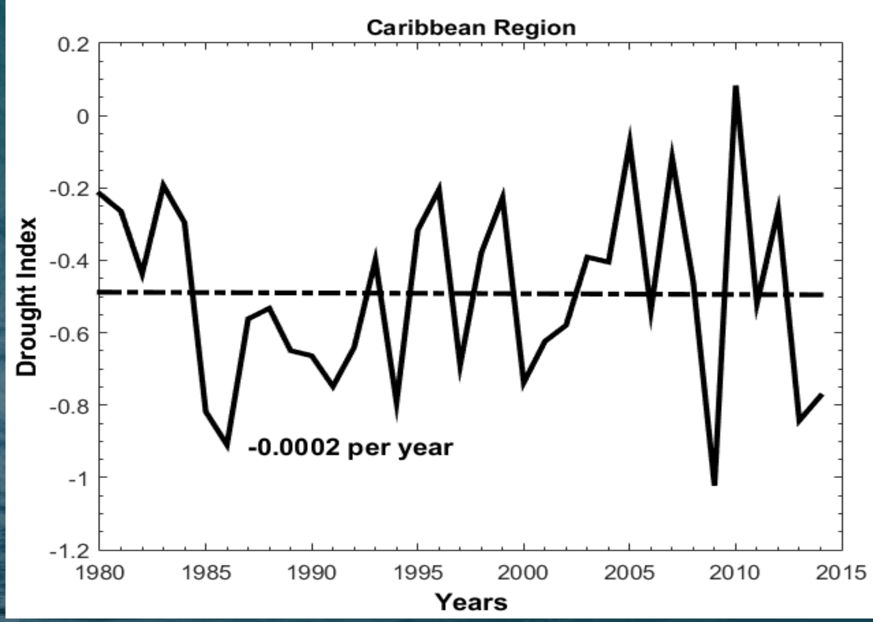
- **Standardized Precipitation Index (SPI)**
- 3-month SPI: reflects short/medium moisture condition. In agriculture gives an indication of Soil Moisture condition at the growing season.
- Data process: use a sliding windows technique.
  - Accumulate rainfall for the selected time scale (e.g. 3 months). The accumulated rainfall correspond to the last month in the time scale.
  - Move the sliding windows to the next months and repeat the process. Continue sliding the windows for all months.
  - A gamma distribution is fitted to the monthly values and the CDF is transformed to the standardized normal distribution. The z-scores is the SPI.

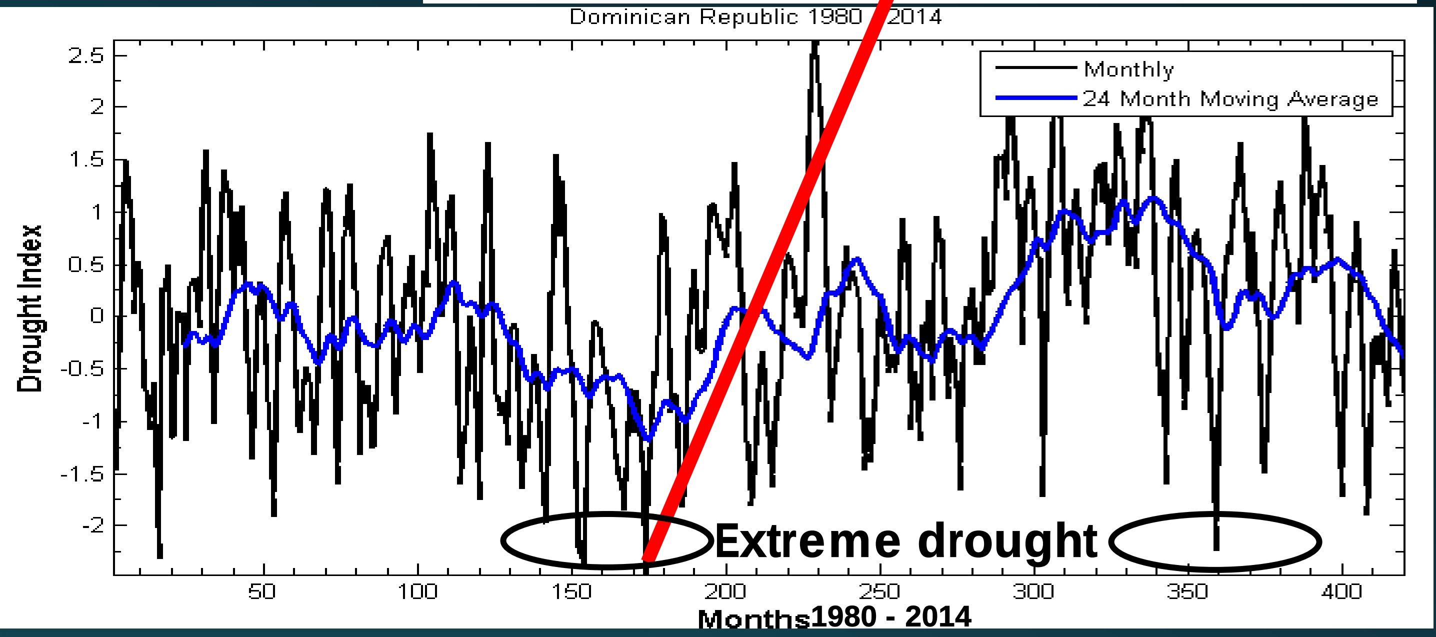
SPI	Classification
> 2.0	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
0 to 0.99	Mildly wet
0 to -0.99	Mild drought
-1 to -1.49	Moderate drought
-1.5 to -1.99	Severe drought
< -2.0	Extreme drought

DROUGHT INDEX IN THE CARIBBEAN REGION

- Long term annual minimum SPI 3 month sliding window shows an decreasing trend, which means slight drought intensification.
- SPI 3 month sliding window for June 1994 shows severe to extreme drought in Dominican Republic and Puerto Rico.
- Central America also have extreme drought, while the northern Caribbean region is mildly to moderate wet.
- Long term monthly drought index in Dominican Republic show periods of severe and extreme drought events.





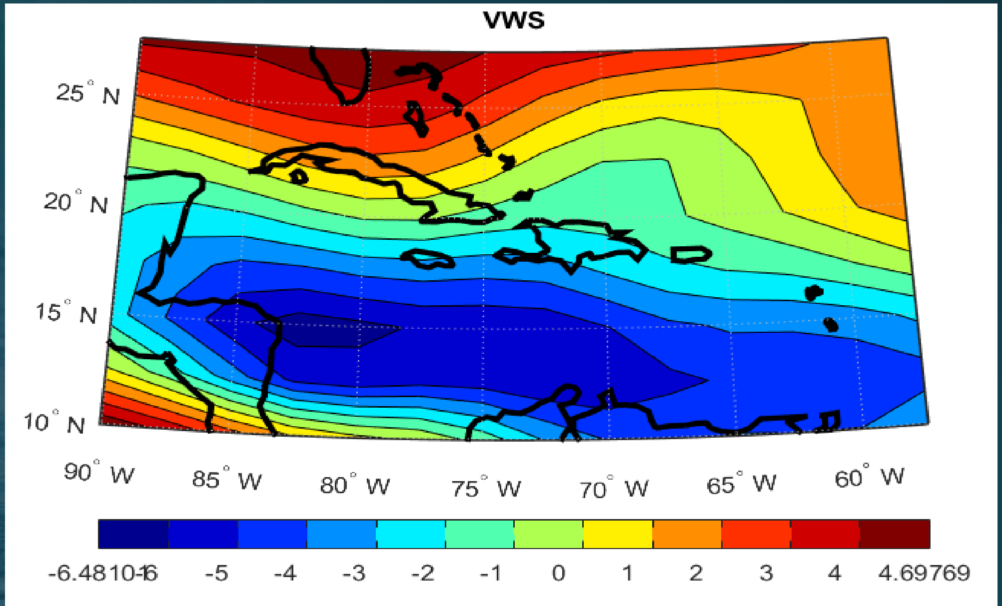


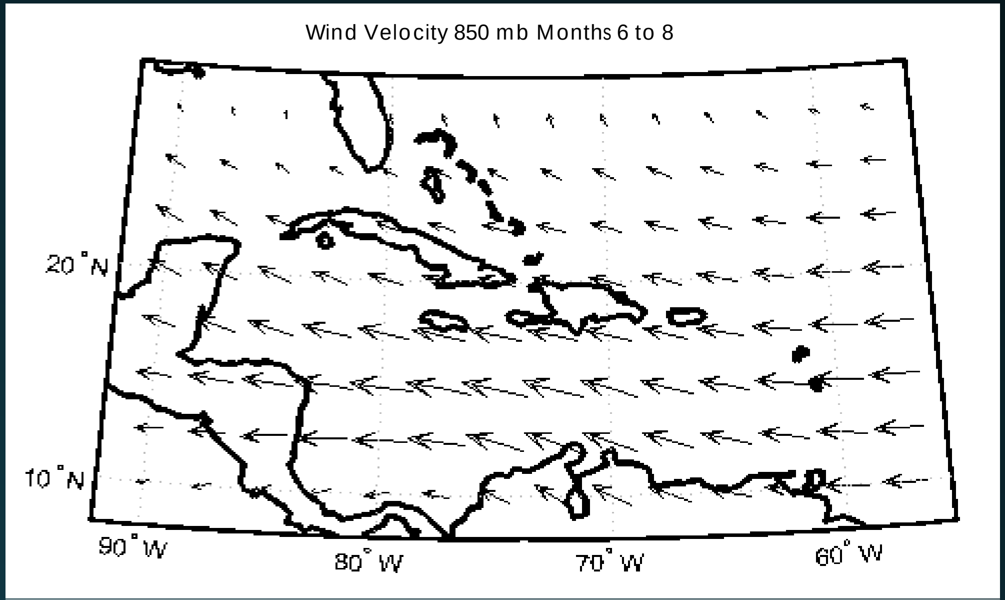
WHAT VARIABLES ARE DRIVING THE DROUGHT EVENTS OVER THE CARIBBEAN REGION?

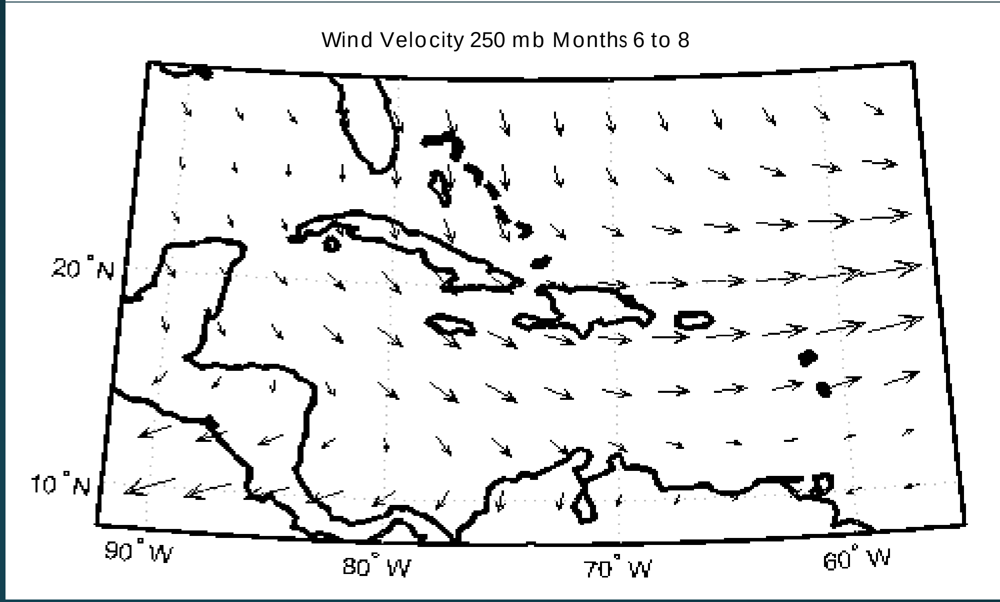
VERTICAL WIND SHEAR

- VWS is defined as the wind speed difference between 200mb and 850 mb.
- **VWS > 8m/s reduces vertical convection → less rainfall.**
- Over the Caribbean sea, high velocity at low atmospheric level cause negative VWS → high rainfall.
- At the Southwest North Atlantic positive VWS is observed → Lower rainfall.

Climatology June – August 1979-2014

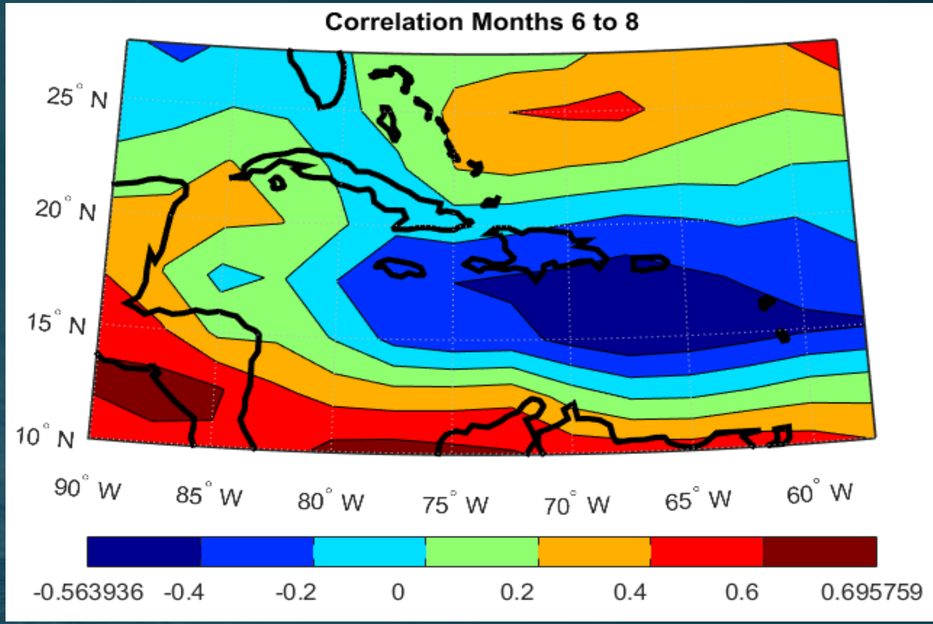


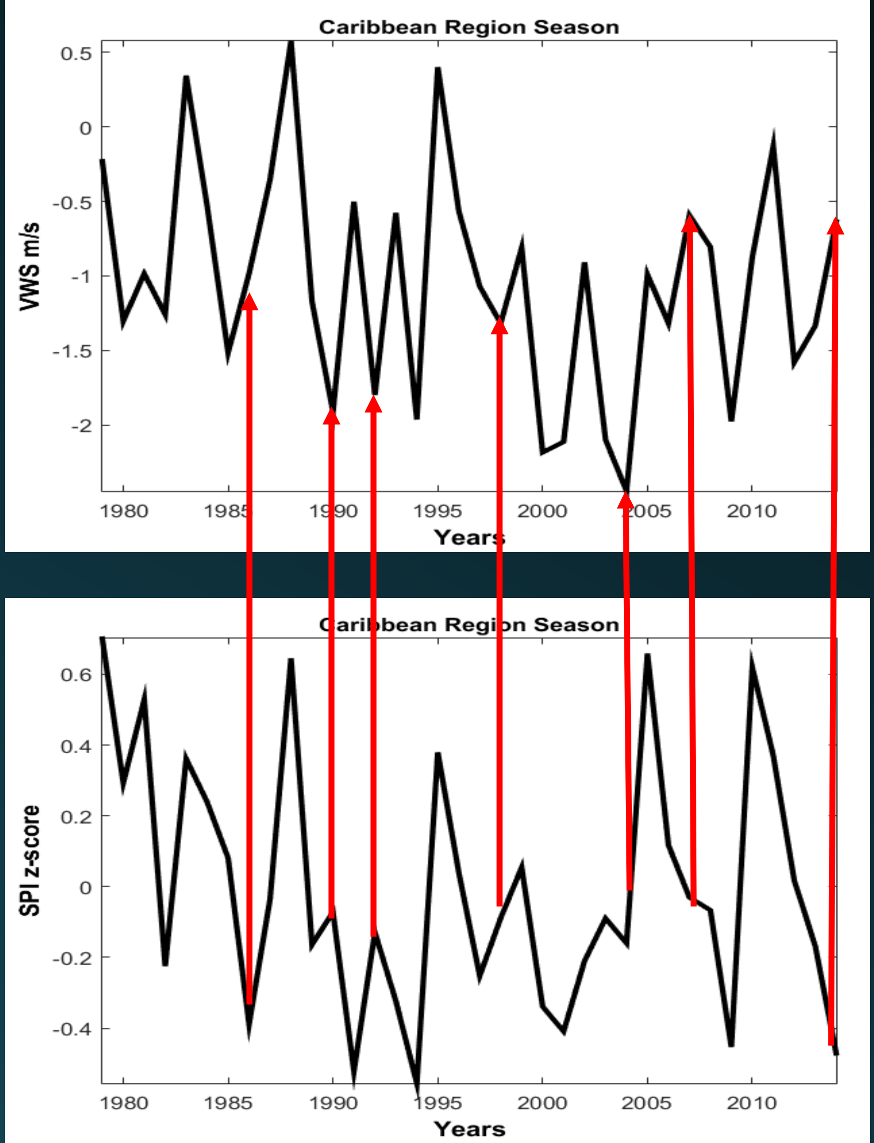




DROUGHT INDEX AND VERTICAL WIND SHEAR

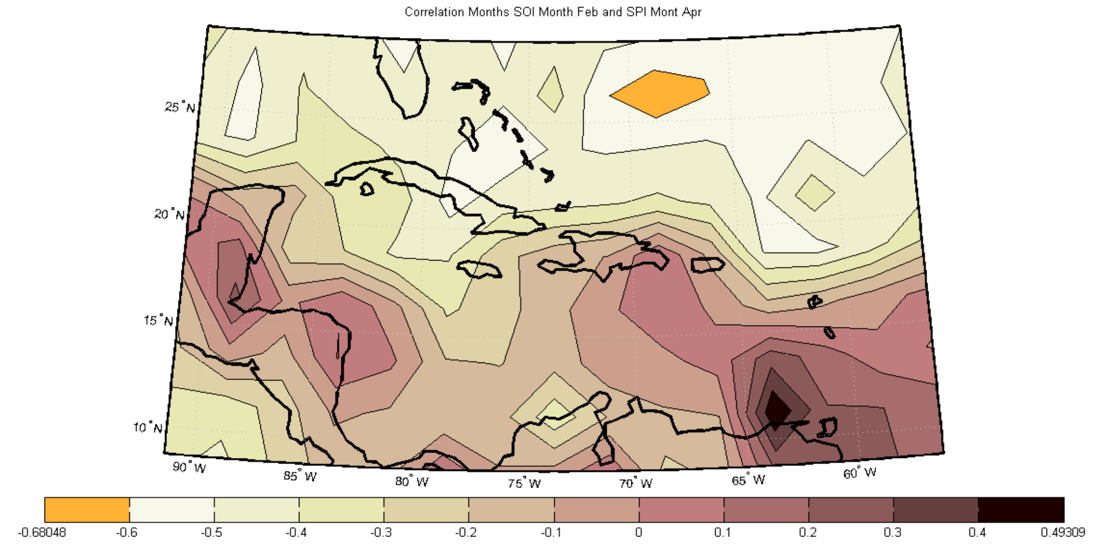
- Long term VWS and SPI 1 month sliding window shows a relationship but there are some periods where other events could explain the SPI variability.
- VWS and SPI 1 month sliding window show zero lag negative correlation from the end of the early rainfall season and the beginning of the late rainfall season (June to August).
- P-value less than 0.05 is located over the Caribbean Sea, indicating that there is enough statistical significance.

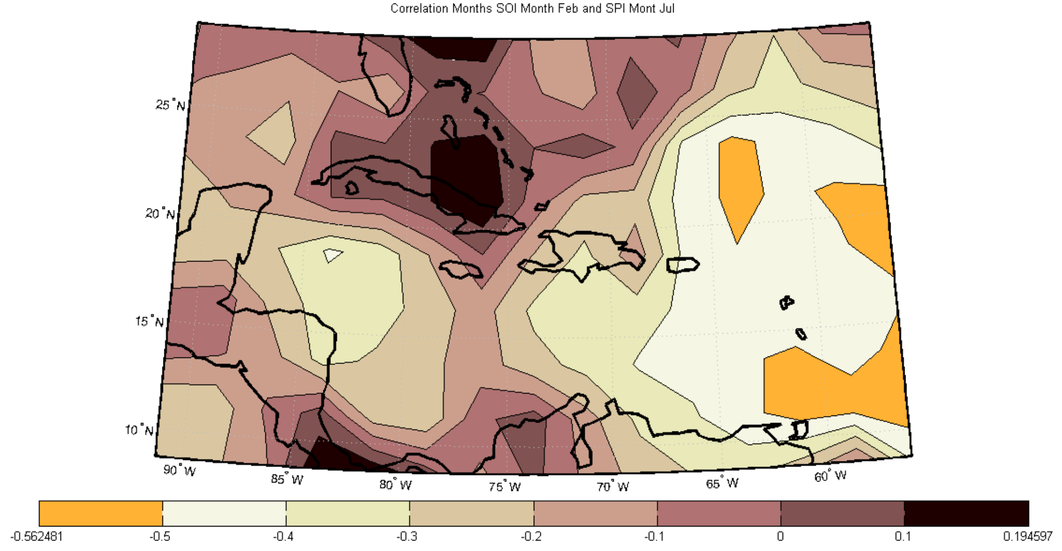


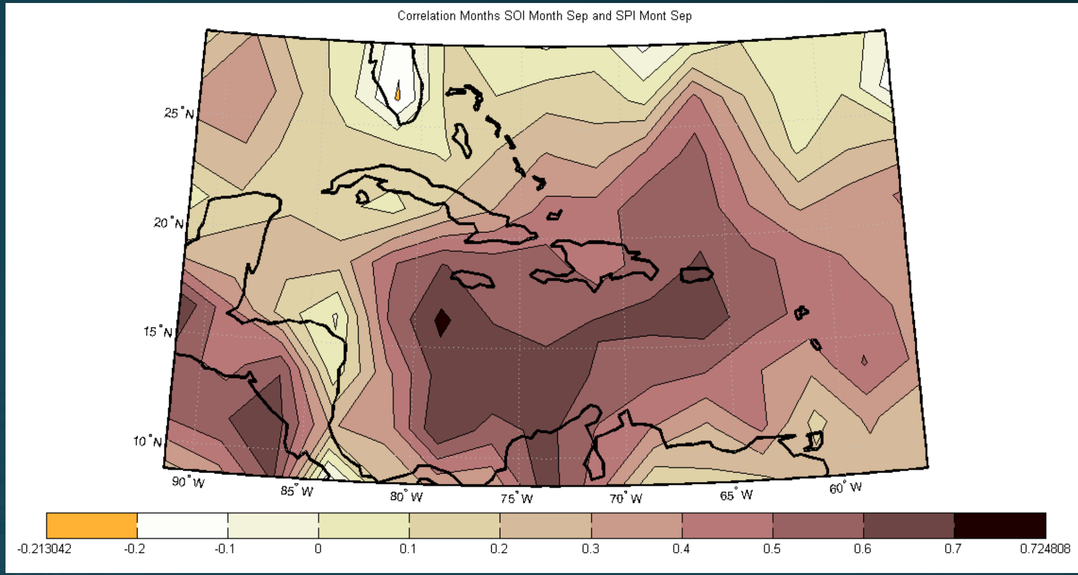


Pearson correlation coefficient

DROUGHT INDEX AND SOI







- Negative lag correlation zone during the ERS is moving from Southwest North Atlantic (April) to North Tropical Atlantic and Caribbean sea (July).

- Positive zero lag correlation is observed over the Caribbean sea during the LRS.

CONCLUSION AND FUTURE WORK

CONCLUSION	FUTURE WORK
• A warmer Caribbean region was observed over the past 30 years. • A fast HI increase was observed over the Caribbean region with a rate of 0.14oF per year. • LRS is the main season affected by heat wave events. • Heat wave frequency is increasing following the SST increasing trend. Also, Bermuda-Azores High could affect the heat wave.	Analyze the Bermuda-Azores high system anomalies and the relationship with: ▪ Heat wave events ▪ Drought events over the Caribbean region.
• SPI shows an drought intensification over the Caribbean region. • VWS and SPI have statistical significance between June and August, indicating that VWS drives partially the drought.	Analyze impact on the drought events: ▪ Caribbean low level jet. ▪ ITCZ seasonal.
• There is a significant relationship between SOI and SPI. • SPI at early rainfall season shows five - six month lag with respect to SOI. In the late rainfall season there is s zero month lag correlation.	Multilinear correlation to determine which atmospheric variables are driving the Caribbean drought events.