Some Caribbean Drought Research at CSGM, Mona

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About the CSGM

- Founded in 1994
- Located in the Department of Physics, UWI
- Research Group:
  - Faculty members, research fellows, postgraduate students (Ph.D. and M.Phil) & research associates
- History of collaborations with various regional and international organizations: IAI, AIACC, CIMH, INSMET, 5 C's, NCDC
- Numerous publications in peer reviewed journals, technical reports, book chapters.

About the CSGM

Mandate: Climate Science Research for the Caribbean

- To investigate and understand the mechanisms responsible for a) the mean climate and b) extremes in climate in the Caribbean
- To investigate climate change and it's historical, current and future manifestations in the Caribbean.
- To promote climate data capture and sound data management principles.
- To investigate and promote the advantageous uses of climate information for the development of the Caribbean region.
- To build capacity (data, human and technical) to do climate science within the Caribbean region and respond to climate science demands within the region

Drought Research

Drought: - *a prolonged and abnormal moisture deficiency*

3 pronged approach to research

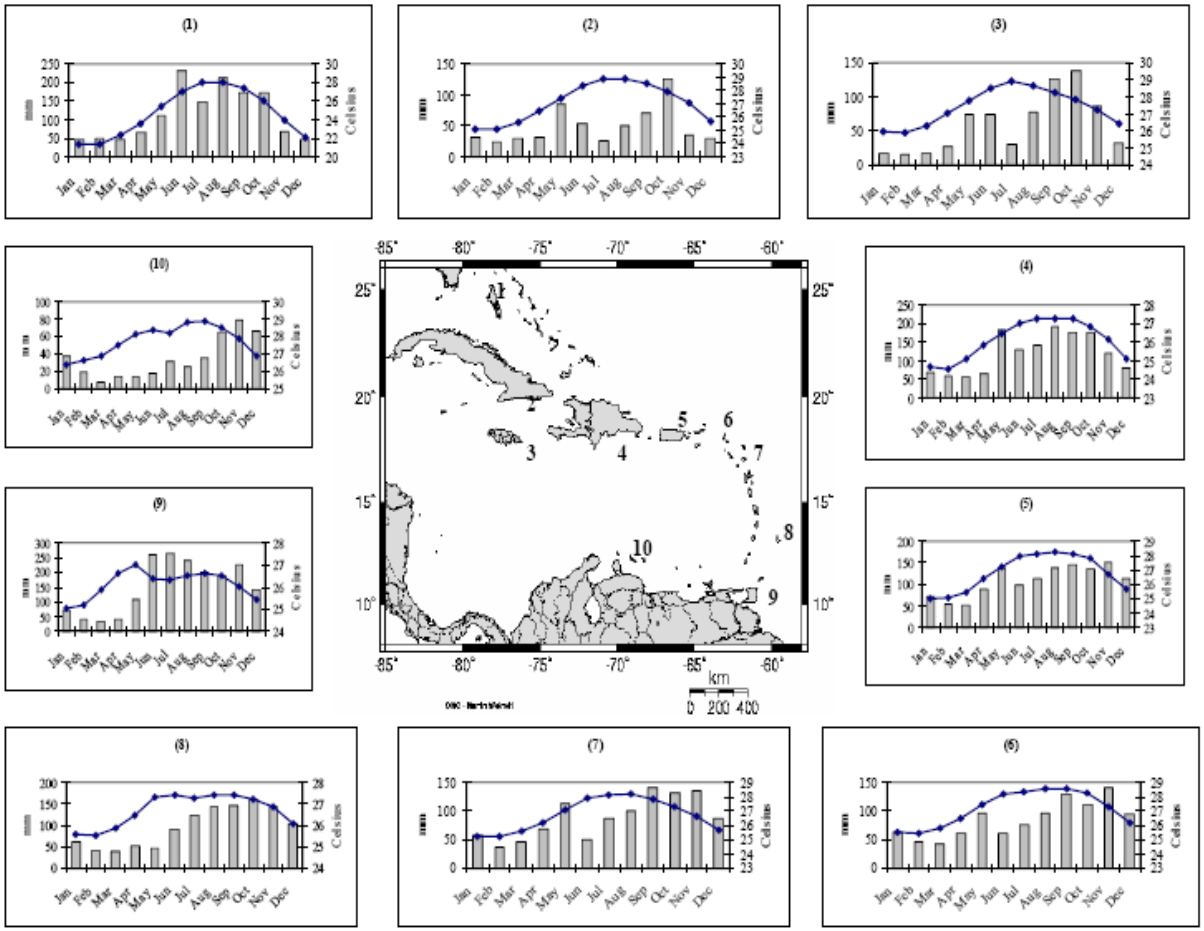
Drivers

SPIs

C Change

- Drivers of Caribbean rainfall and lack of it
- Determining periods of drought from indices (SPIs) and drivers
- Long term Climate Change

Drivers of Rain



Drivers

SPIs

C Change

Drivers of Rain

1. Dry Season

December - April

2. Rainfall Season

May - November
Peaks in September/October

3. Bimodal - MSD

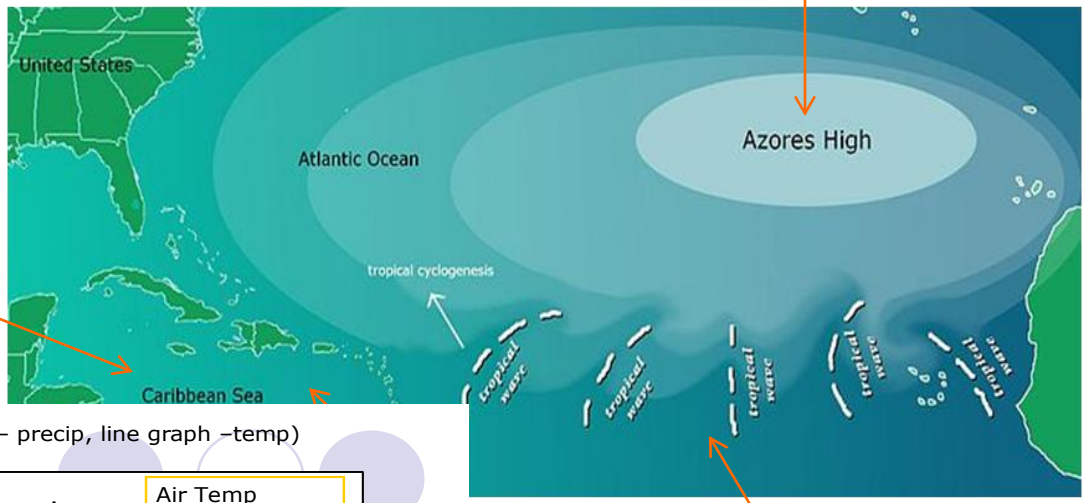
Early season - May-July
Late Season - Aug –Nov

Interests:

What sets up this pattern…
What causes deviations from this pattern…
Drought measured against this pattern…

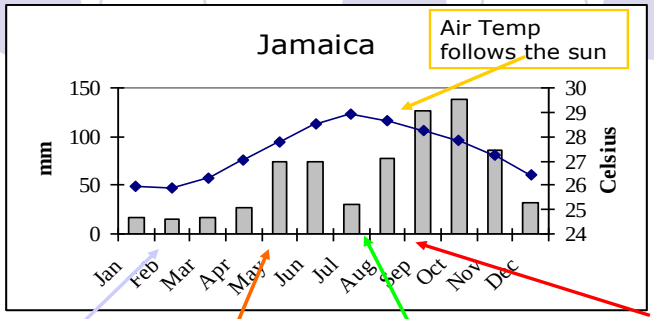
Drivers of Rain

High Pressure



SSTs

Climatology (Bar graph – precip, line graph –temp)



Easterly Waves

NAH moves closer to equator

Stronger trades

Low SST

Mid-lat fronts

NAH starts Northward migration

Weaker trades

SST begins to increase

NAH temporarily retreats Southward

'Mid-Summer Drought'

NAH return Northward

High SST

Easterly waves

ITCZ North

Trade Wind Strength + vertical shear

Drivers

SPIs

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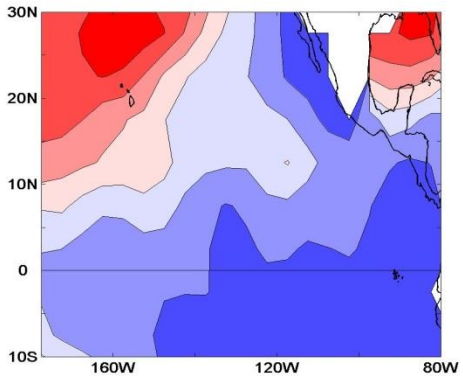
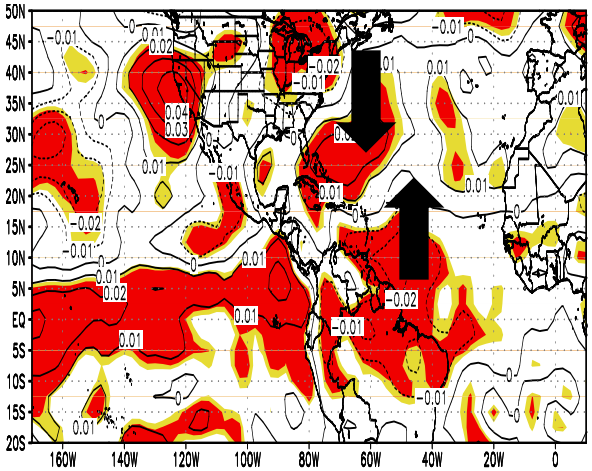
Drivers of Rain – DJFMA



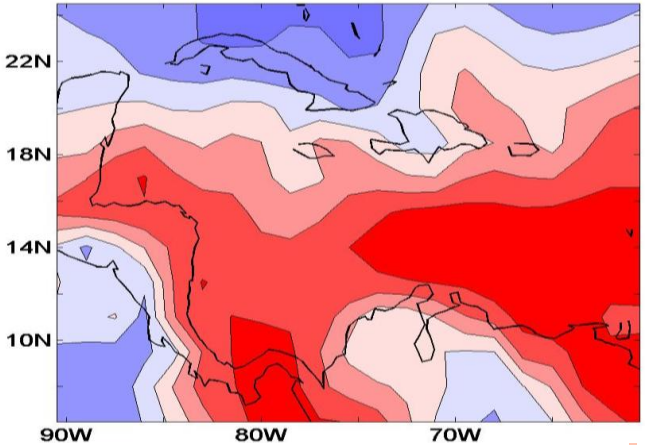
Strong La Niña

Ascent over Amazon and eastern Caribbean => Descent over tropical - subtropical Atlantic: Hadley cell



Negative rainfall anomalies over northern Caribbean

Positive rainfall anomalies over south-eastern Caribbean



Rain – 2011 & (El Nino) Drought 2010

Drivers

SPIs

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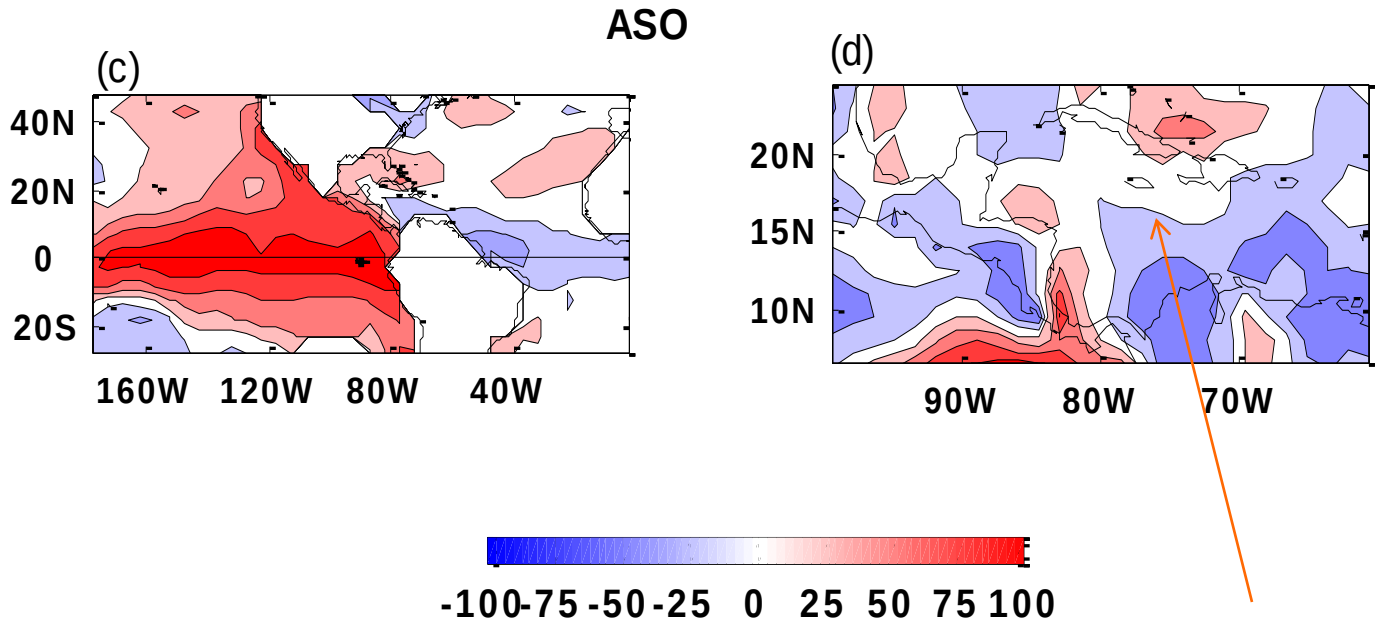
Drivers of Rain – MJ & SON

Gradients in SSTs between Equatorial Pacific and Tropical Atlantic



Dry Caribbean basin

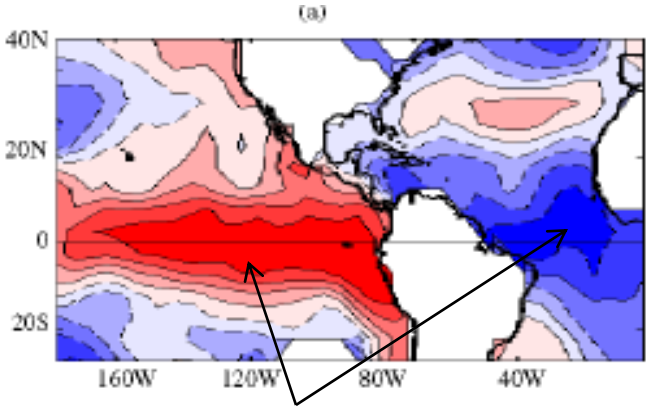
Drought 1997-1998

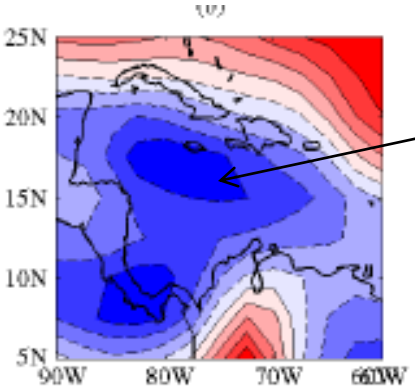
Drivers

SPIs

C Change

Drivers of Rain – JA

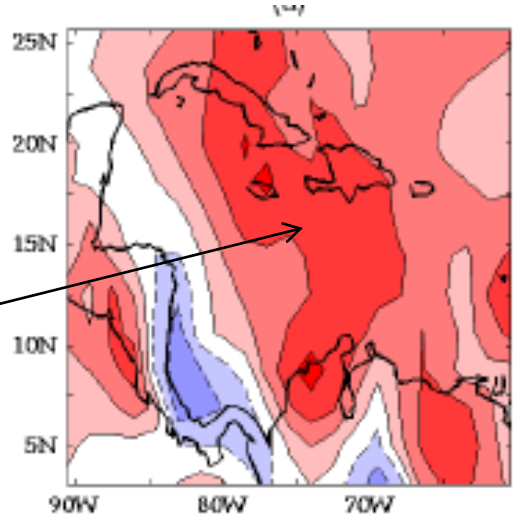




Low level wind strengths (CLLJ)

Gradients in SSTs between Equatorial Pacific and Tropical Atlantic

Drier than normal Caribbean basin during midsummer drought



Drought 1997

Drivers

SPIs

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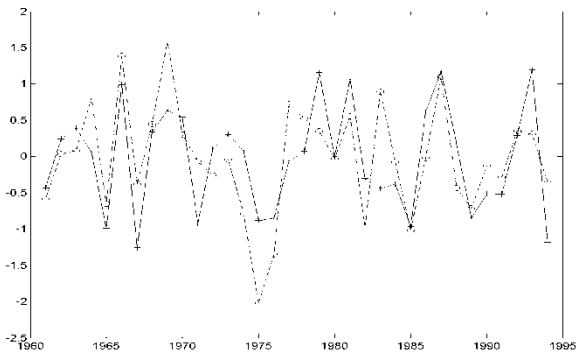
Drivers of Rain – Predicting drought?

The Caribbean Model

MJJ RAIN =

- **– 0.0610 + 0.3111 NINO3(FMA)**
- **– 0.0675 SLP2(FMA)**
- **– 0.0299 SLP4(FMA)**
- **+ 0.1187 VSH4(FMA)**

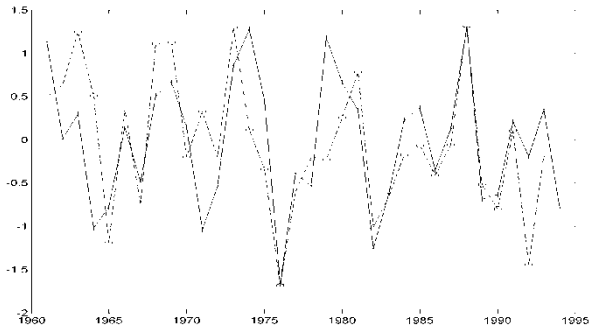
$R^2 = 0.76$



ASON RAIN =

- **– 0.0280 + 1.5822 CSST(MJJ)**
- **– 0.7227 PACEq(MJJ)**
- **– 0.5739 PACTNA(MJJ)**

$R^2 = 0.70$



Determining drought

- We are studying rainfall indices including the SPI, Standardized Precipitation Index
- We use it to determine trends in drought <u>but on longer timescales</u>

Determining drought

- SPI is:
  - A time-series
  - Created from precipitation data
  - Statistical reference to show which periods are dry relative to previous similar periods.
  - Multiple timescales analysis – 1 month, 3 month, 6 month, 12 month, etc.

SPI	Category
<2.0	Extremely Humid
1.5 to 1.99	Severely Humid
1.0 to 1.49	Moderately Humid
0.5 to 0.99	Humid
0.0 to 0.49	Normal to Slightly Humid
-0.49 to 0.0	Slightly Dry to Normal
-0.99 to -0.5	Dry
-1.49 to -1.0	Moderately Dry
-2.0 to -1.5	Severely Dry
>-2	Extremely Dry

Determining drought

- Doing analysis at country and regional scale (data allowing).
- We use precipitation data: rainfall in Jamaica and the Caribbean
- 3 datasets:
  - All-island rainfall for Jamaica – 1881-2009 (Source: Jamaican Met Service)
  - Station data for Jamaica – 1971-2010 (Source: Jamaican Met Service)
  - CMAP Caribbean data – 1979-2010 (Source: Xie et al, 1997)

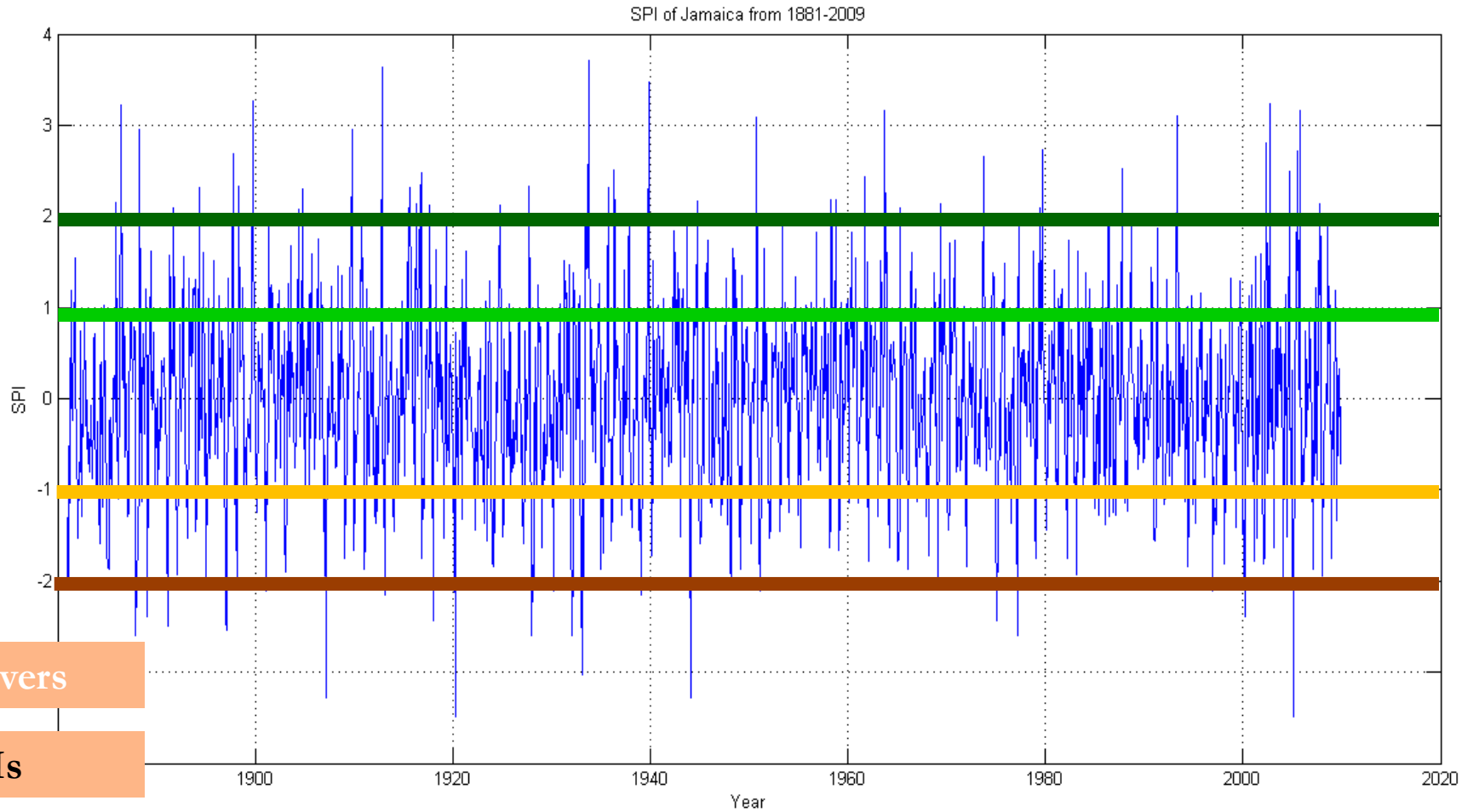
What does an SPI look like?

Drivers

SPIs

C Change

SPI – 1 for Jamaica

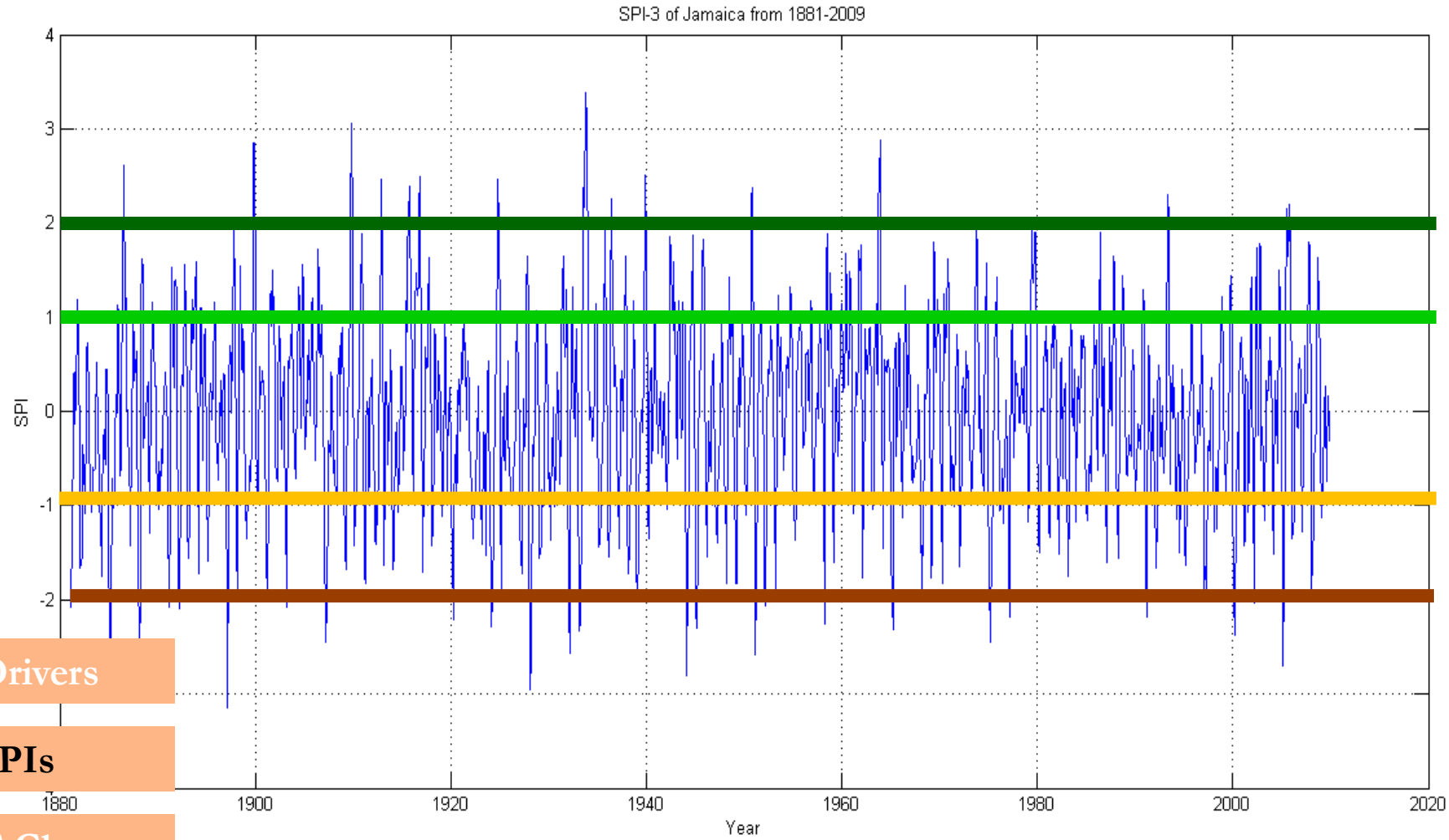


Drivers

SPIs

C Change

SPI – 3 for Jamaica

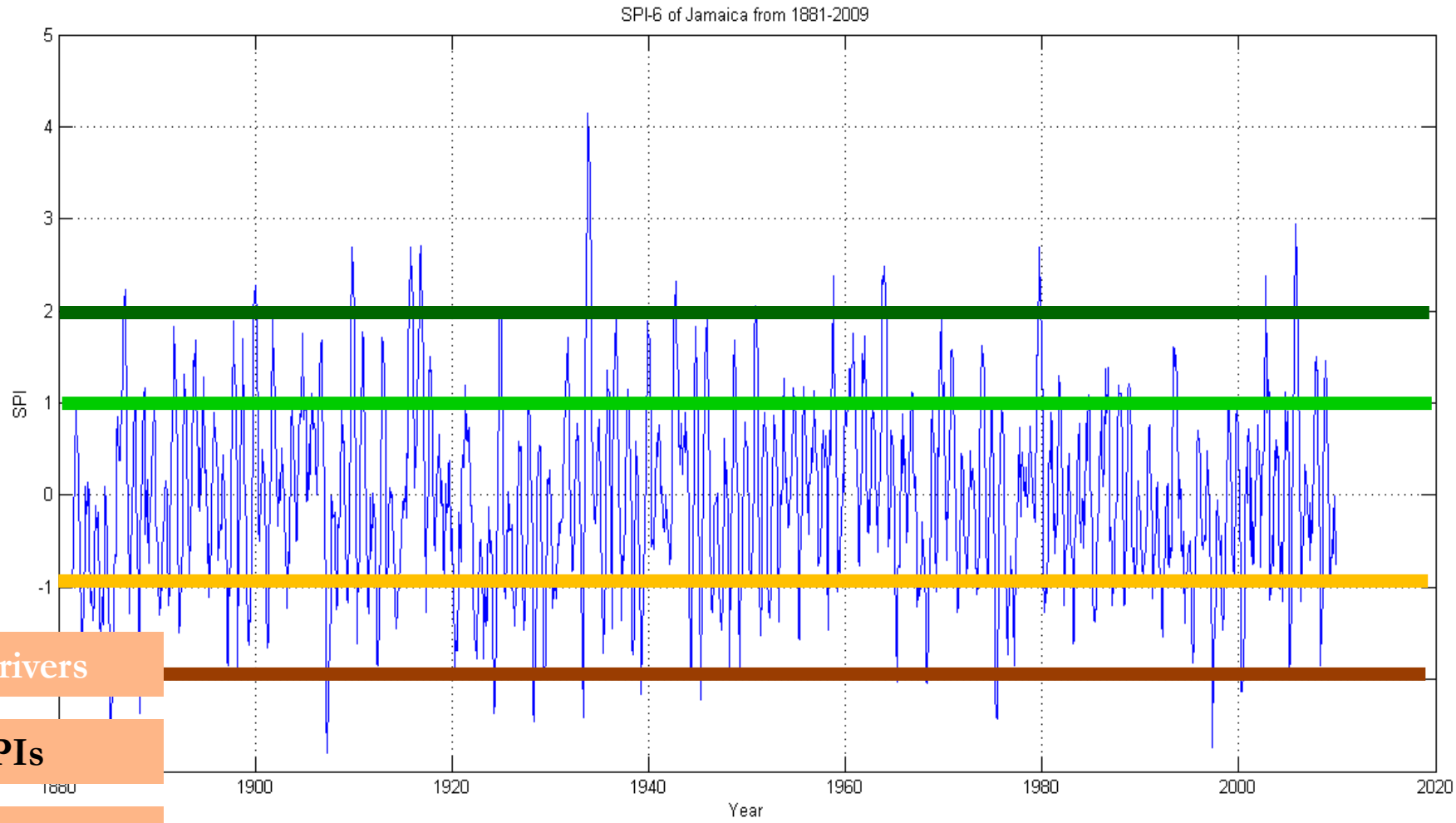


Drivers

SPIs

C Change

SPI – 6 for Jamaica

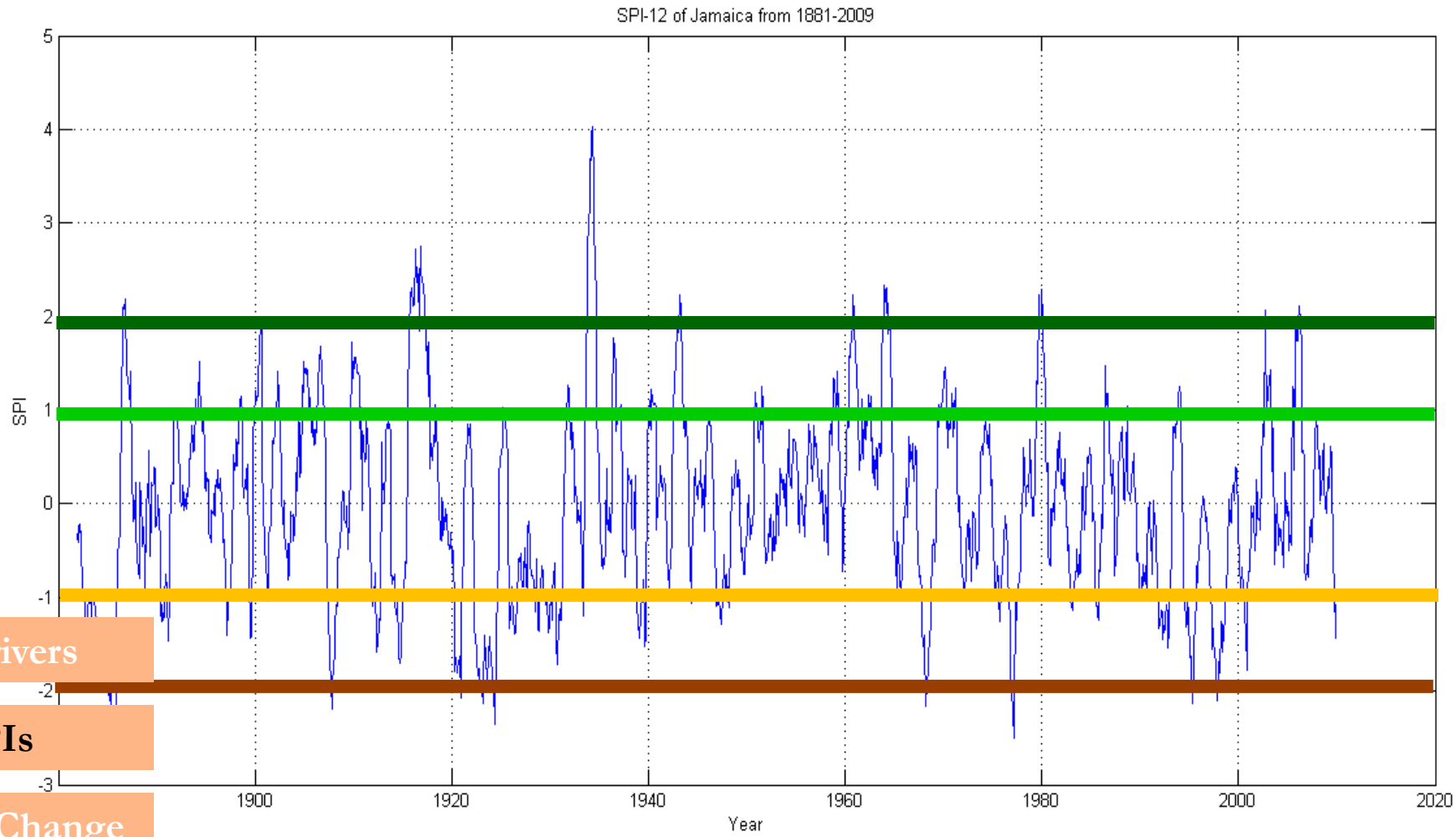


Drivers

SPIs

C Change

SPI – 12 for Jamaica

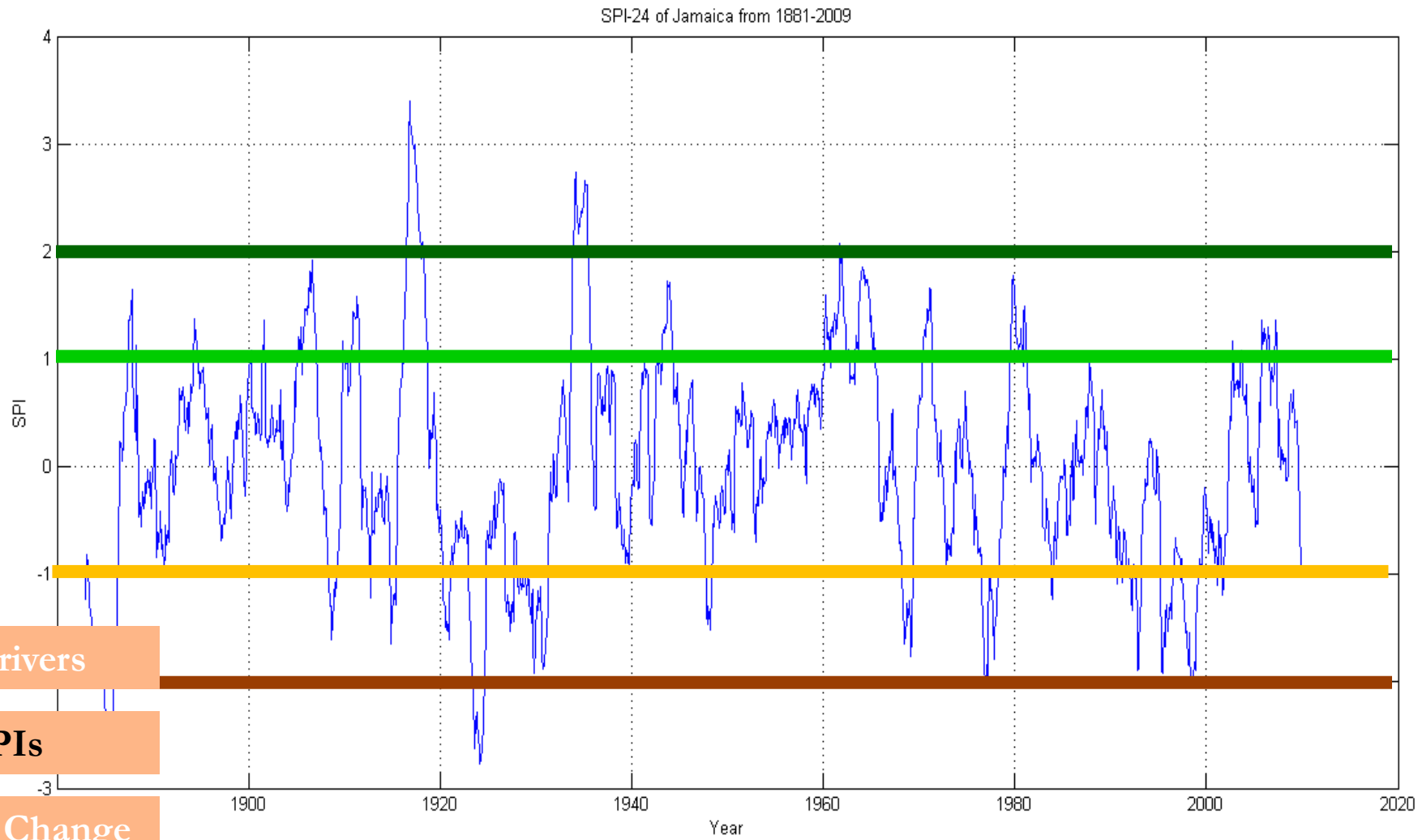


Drivers

SPIs

C Change

SPI – 24 for Jamaica

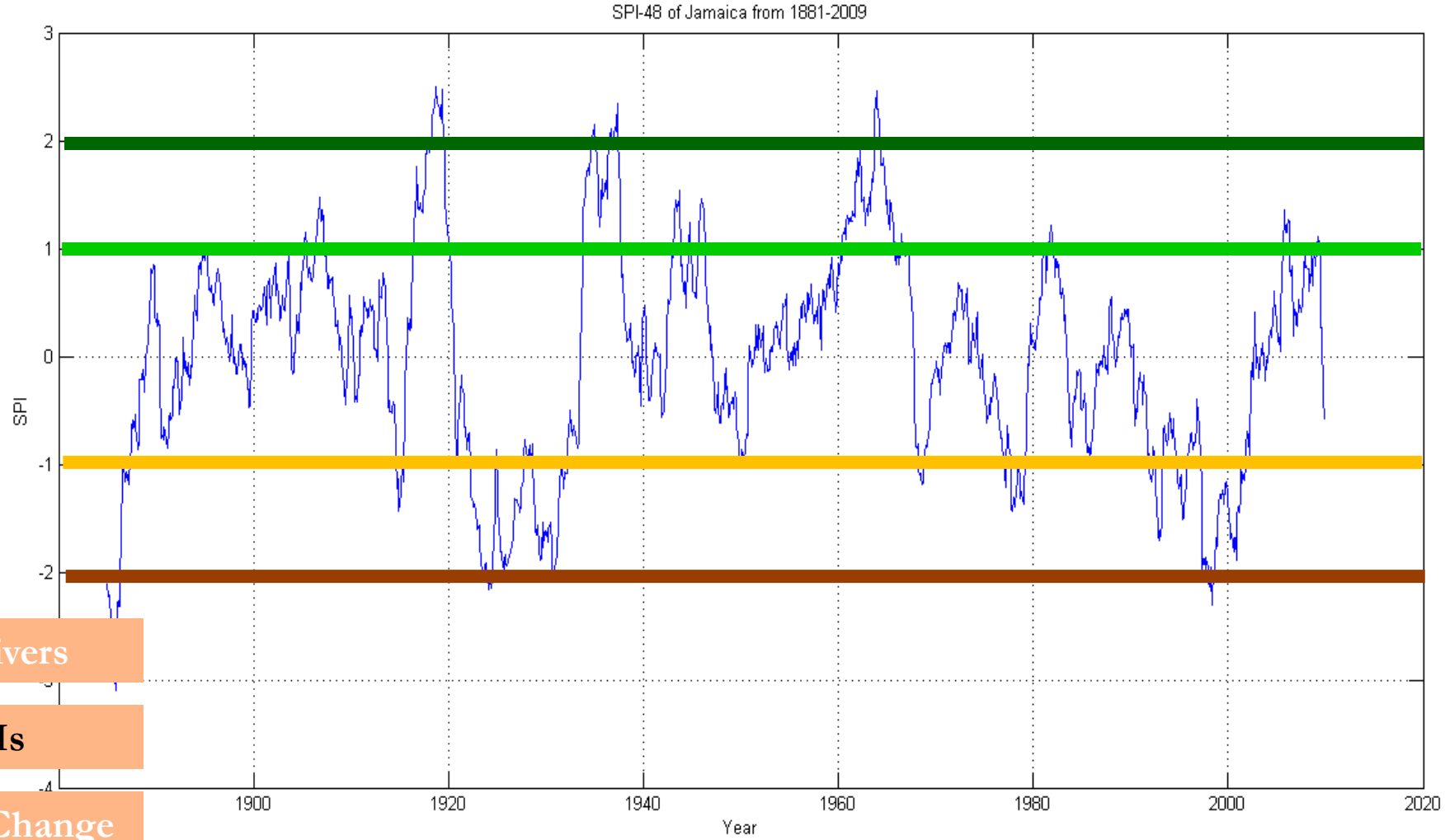


Drivers

SPIs

C Change

SPI – 48 for Jamaica



Drivers

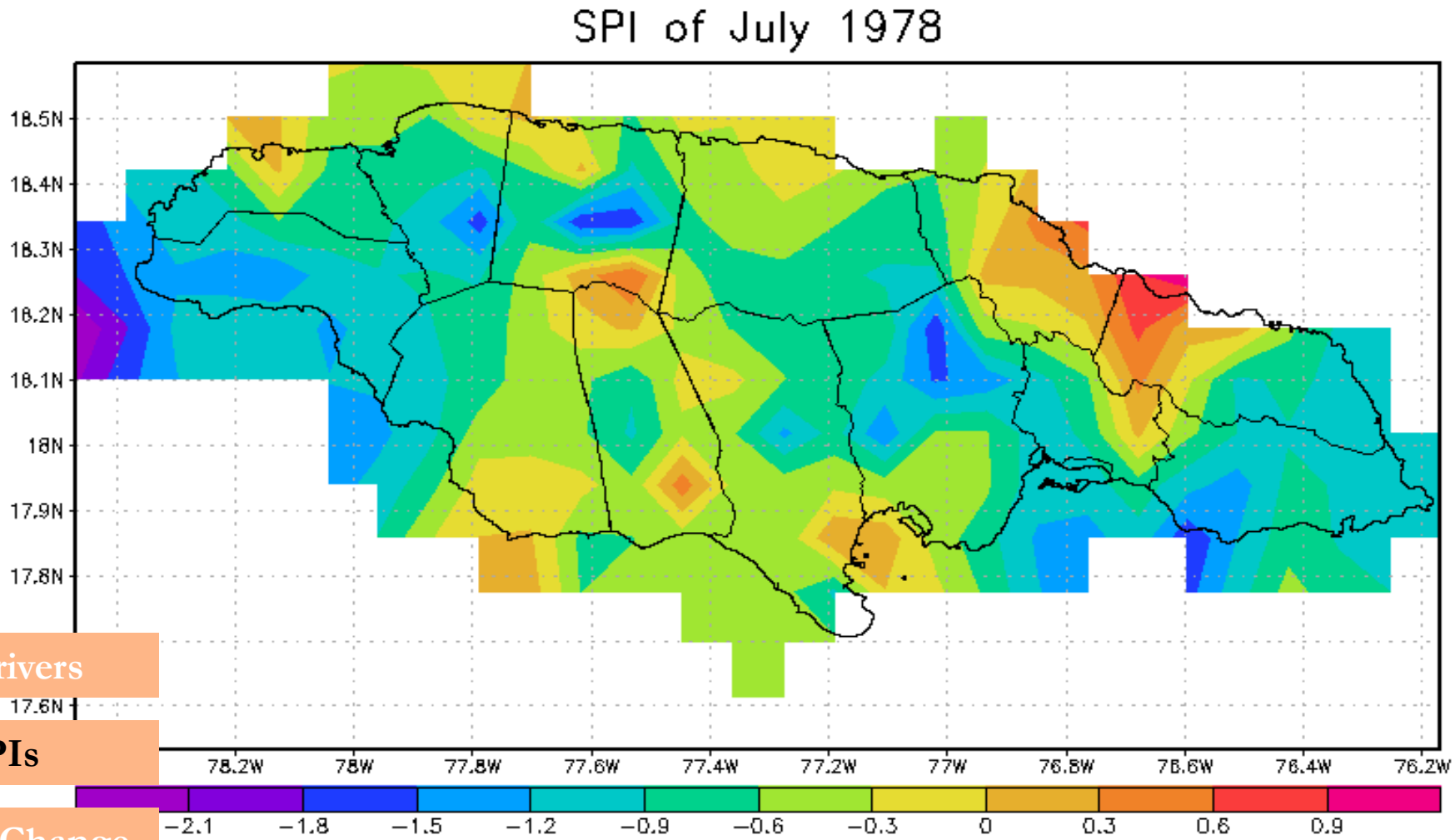
SPIs

C Change

Station Data - Jamaica

- Each map is for one month of SPI-12
- In each map, we can determine which areas were in drought or getting more rain than normal

Station Data - Jamaica

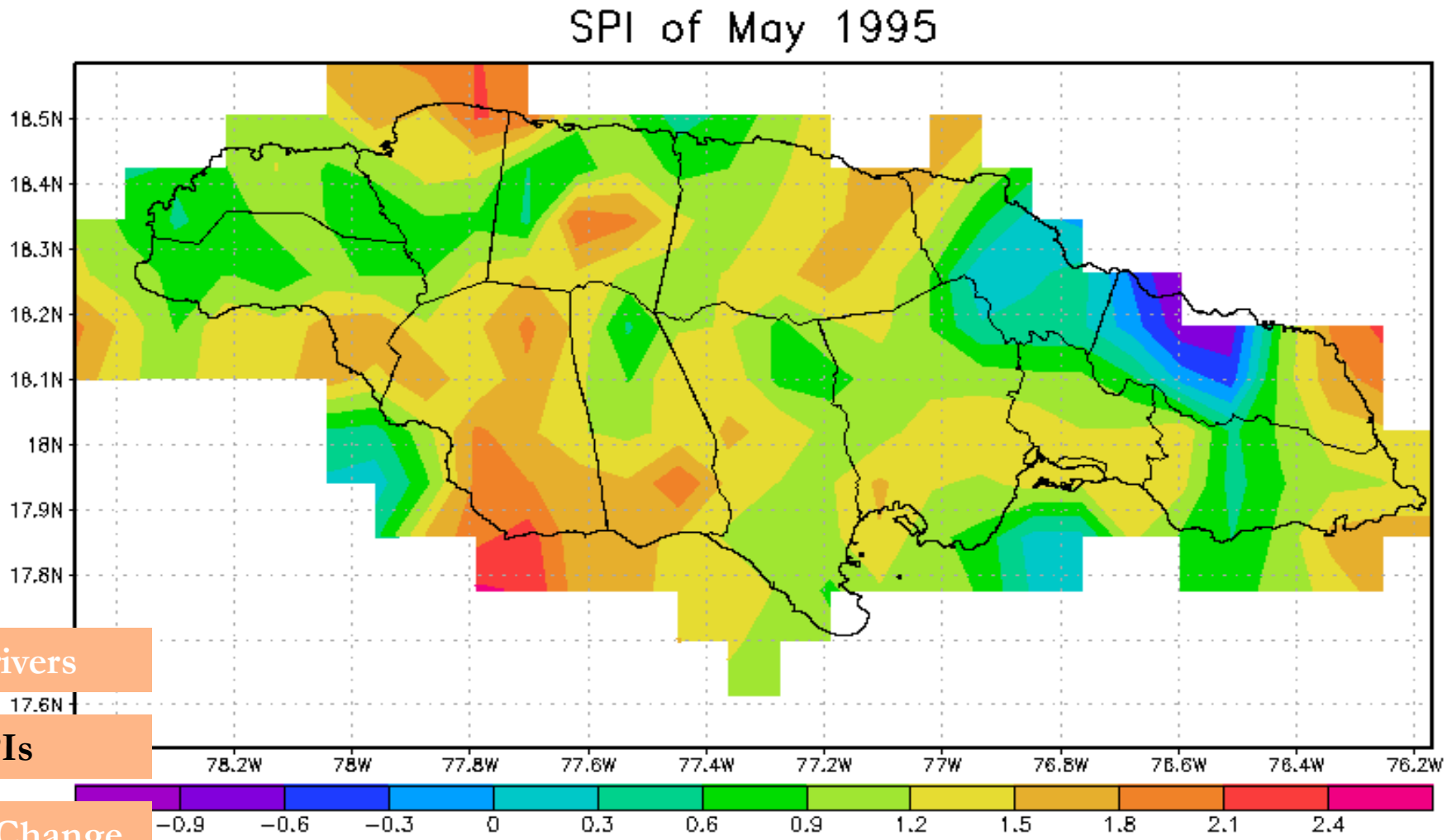


Drivers

SPIs

C Change

Station Data - Jamaica



Drivers

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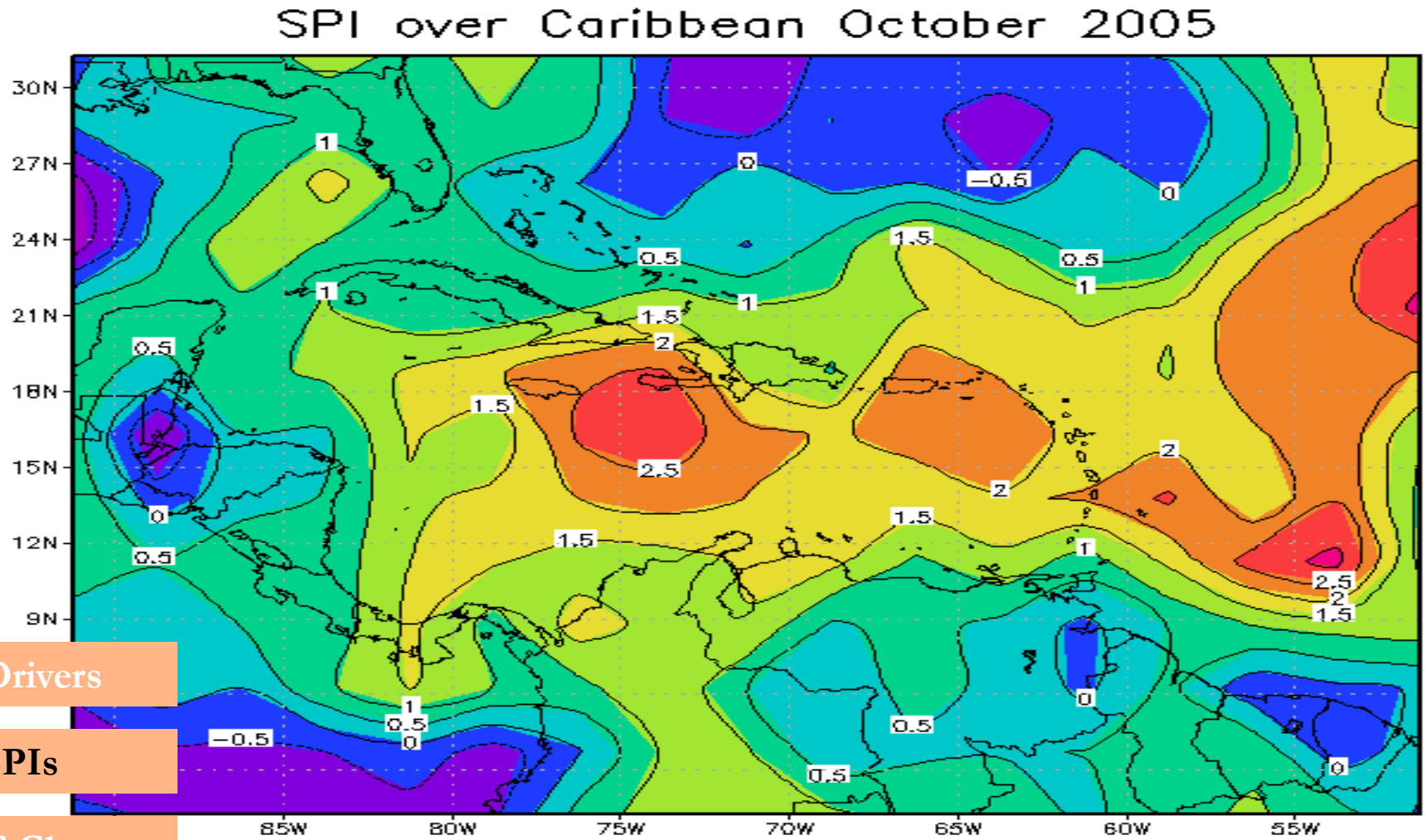
C Change

CARIBBEAN DATA - CMAP



Drivers

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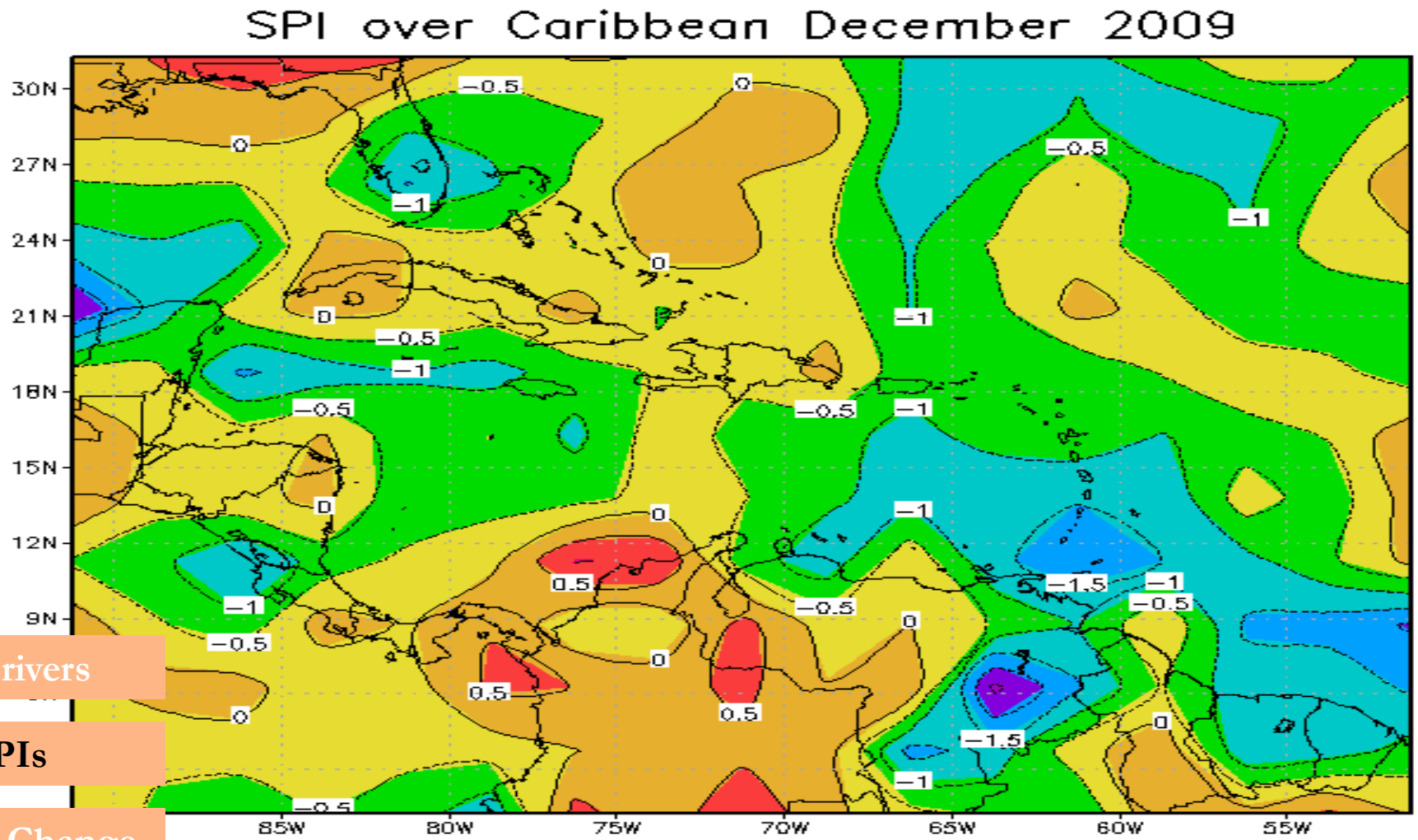
CARIBBEAN DATA - CMAP



Drivers

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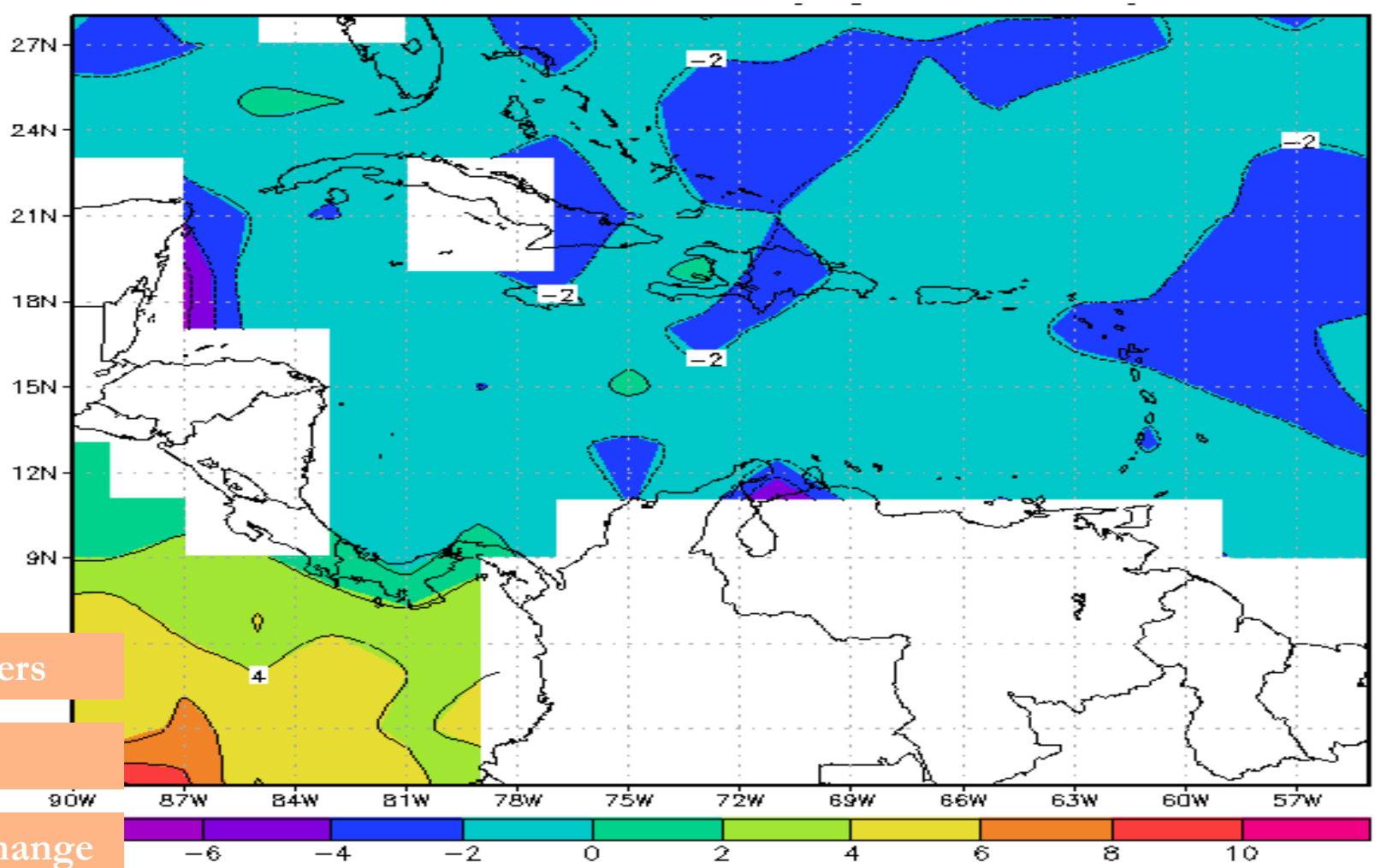
C Change

What all that Means

- We can look at each map and eyeball a variability potential of any region.
  - For example, when Portland is relatively wet, Kingston and St. Andrew are uncharacteristically dry
- We can also use the maps to determine point by point time-series, and correlate the points to see if certain regions really do vary with each other
- We can also look at the different regions and see what we are being influenced by

DRIVERS:
SEA-SURFACE TEMPERATURES (MJJ) (DRY – WET)

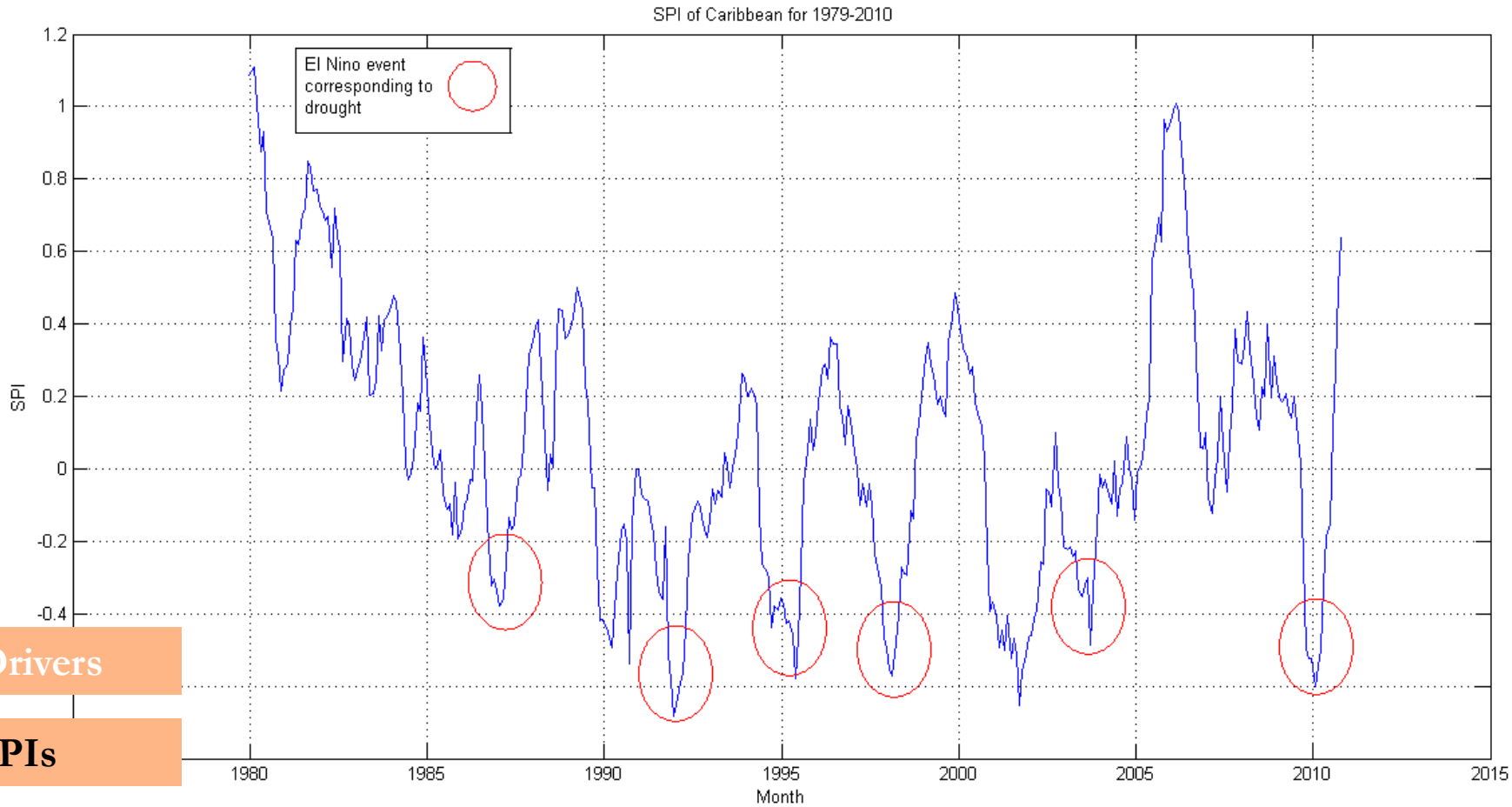


Drivers

SPIs

C Change

DRIVERS: EL NINO?

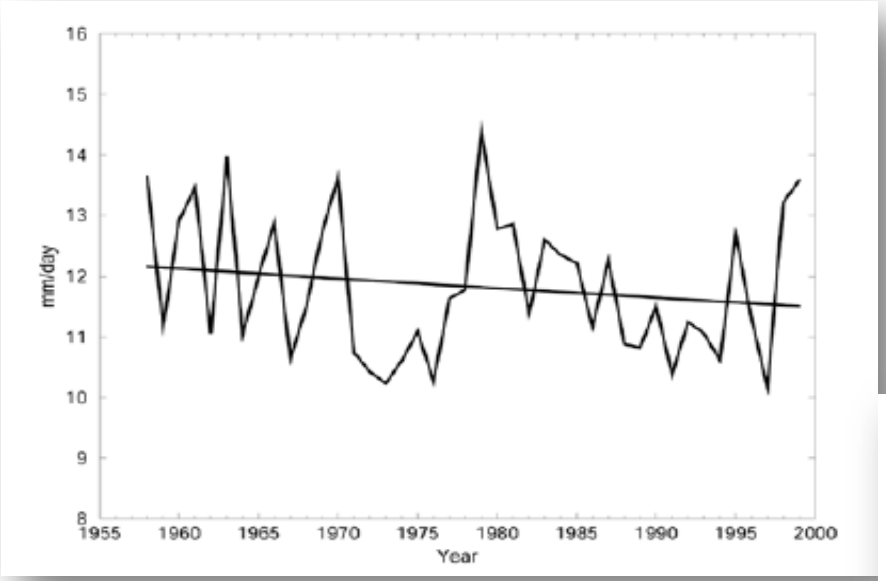


Drivers

SPIs

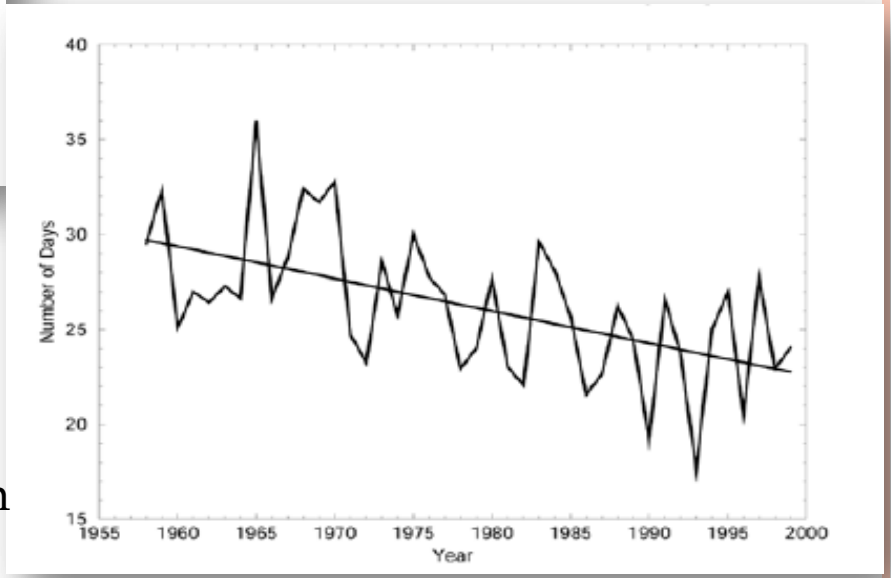
C Change

Other Indices



RAINFALL

- Caribbean daily rainfall intensity decreasing



- Maximum number of consecutive dry days decreasing for Caribbean

Climate Change - Drought

"Under global warming the Caribbean is projected to be significantly drier by century's end during its primary rainy season from May through November. "

Drivers

SPIs

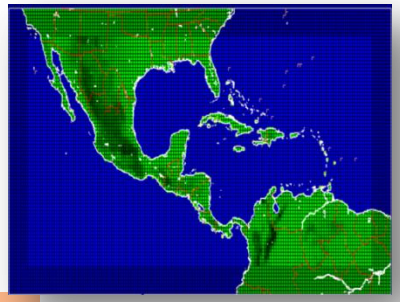
C Change

Climate Change - Drought

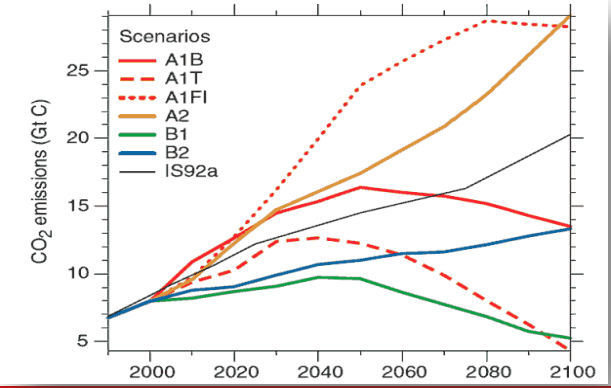
Models	+	Scenarios	=	Future Climate

Regional Climate Model

- **PRECIS, UK**
- Caribbean
- Scale ~50 km



- IPCC Special Report on Emissions Scenarios i.e. SRES scenarios.
- Storylines associated with CO_2 concentrations
- A2 (high emissions) A1B (medium emissions) and B2 (low emissions)



Drivers

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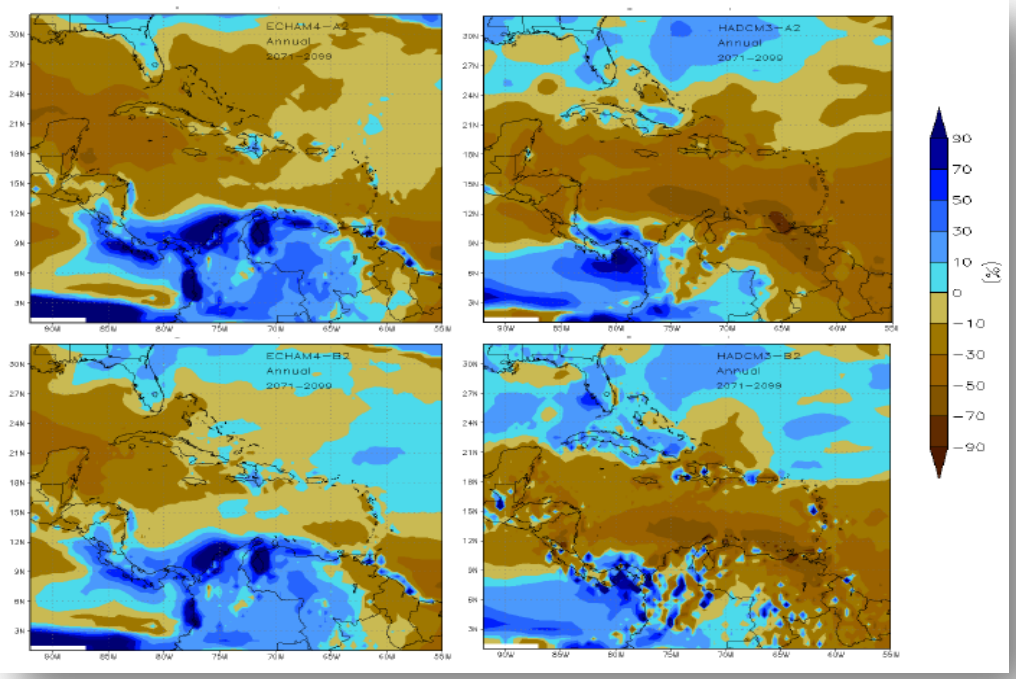
Climate Change - Drought



General tendency for drying (main Caribbean basin) by end of the century.

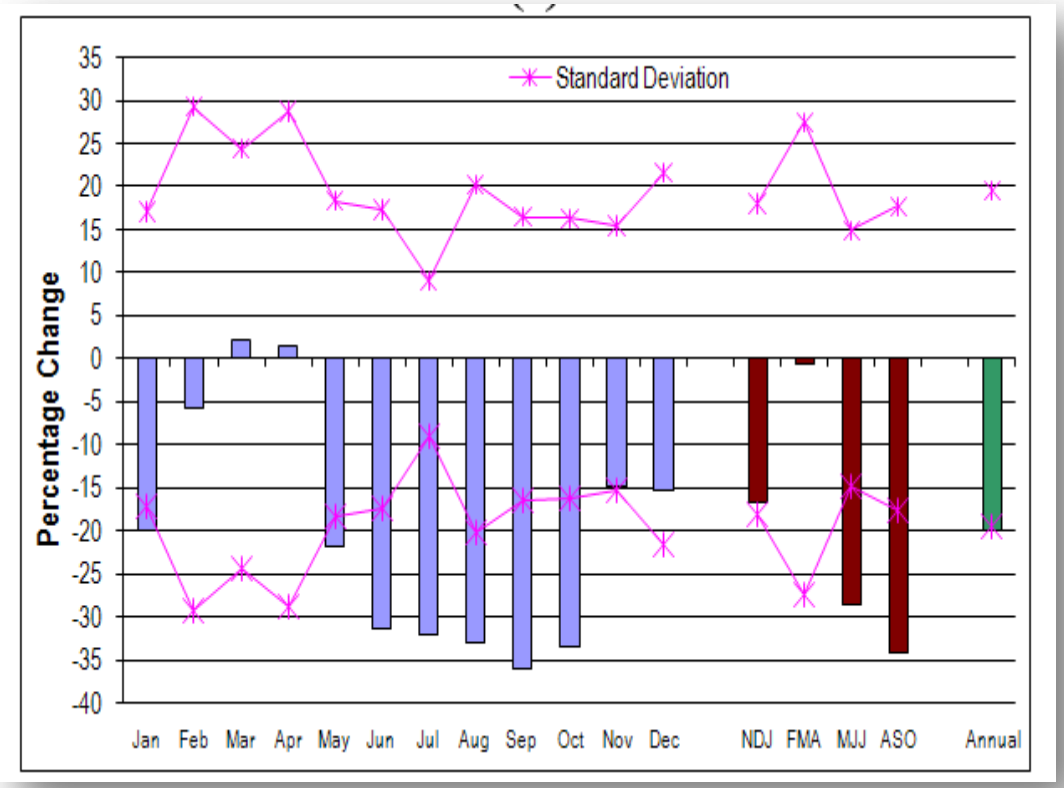
Drying between 25% and 30%

Possibly wetter far north Caribbean NDJ and FMA.

Drying exceeds natural variability June-October – wet season dryer!

Mean changes in the annual rainfall for 2071-2099 with respect to 1961-1989, as simulated by PRECIS_ECH and PRECIS_Had for SRESA2 and SRESB2.

Climate Change - Drought



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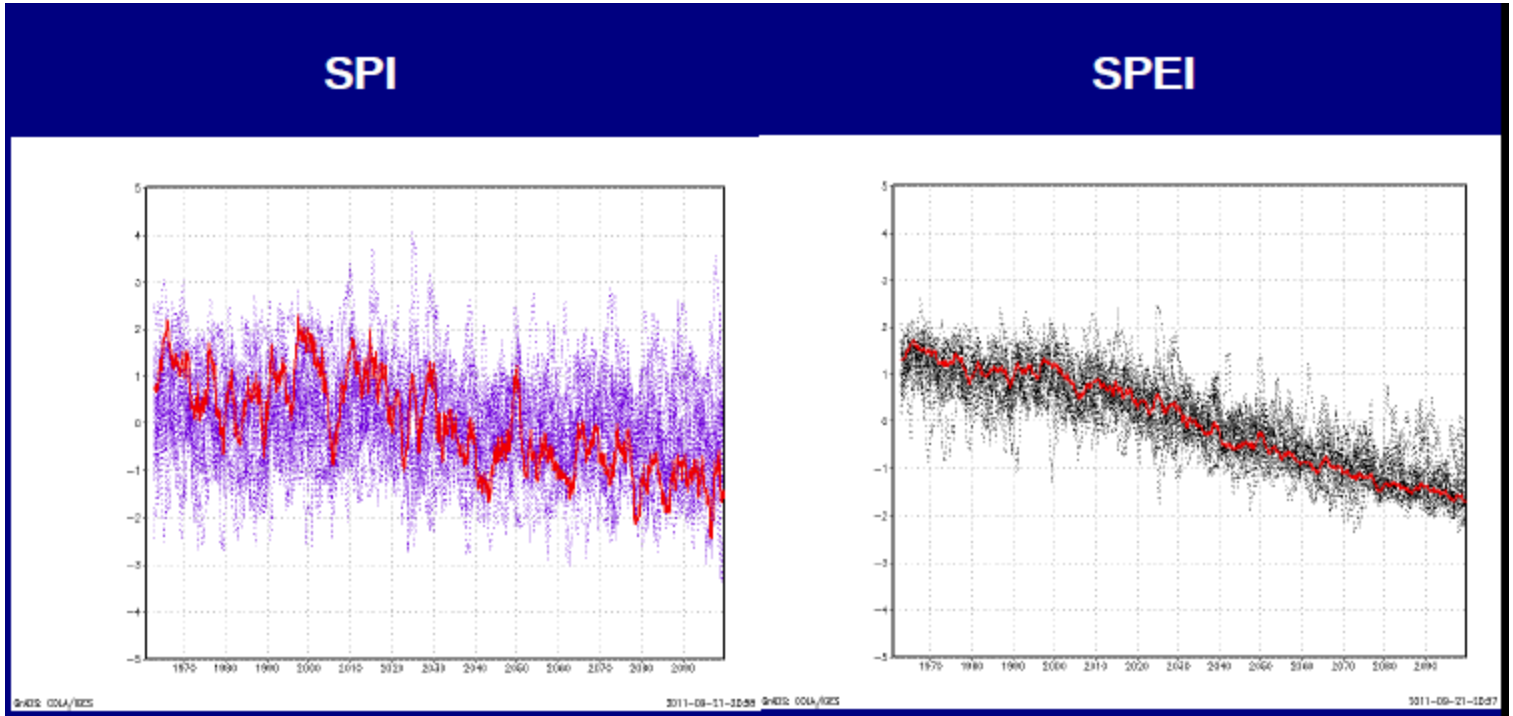
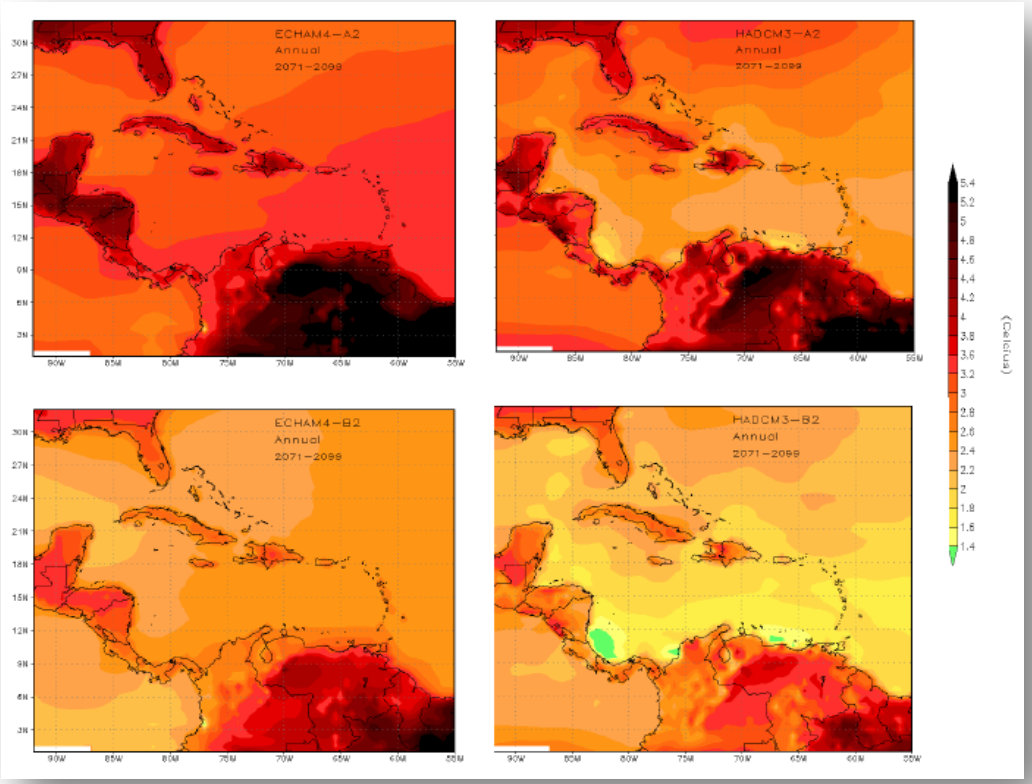


1961-2099 SPI and SPEI estimates from 17 AR4 GCMs (dot lines). Multimodel mean (black line) is included.

INSMET (2011)

Climate Change - Drought



Irrespective of scenario the Caribbean expected to warm.

Warming between 1 and 5ºC

Warming greater under A2 scenario.

Warming consistent with projections for other parts of globe.

Warming far exceeds natural variability

Mean changes in the annual mean surface temperature for 2071-2099 with respect to 1961-1989, as simulated by PRECIS_ECH and PRECIS_Had for SRESA2 and SRESB2.

CLIMATE CHANGE - DROUGHT

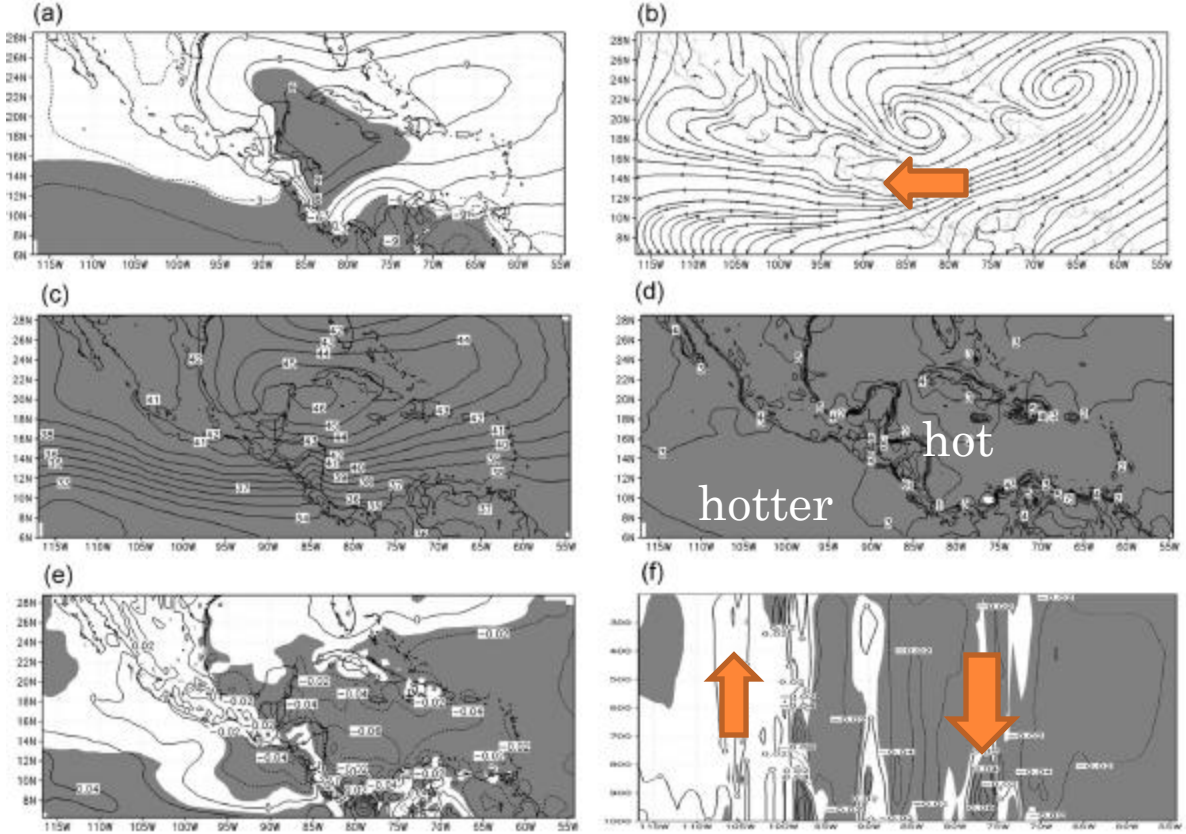


Figure 7. Climatological maps for the mean Caribbean wet season (May–November) for 2071–2100 relative to 1961–1990. (a) Geopotential (gpm) at 1000 hPa. (b) Streamlines at 925 hPa. (c) Geopotential (gpm) at 700 hPa. (d) Surface temperature (°C). (e) Vertical velocity (Pa/s) at 500 hPa. Signs are reversed so positive indicates ascent. Shading in Figures 7a, 7e, and 7f indicates differences statistically significant at the 90% level. In Figures 7c and 7d the entire domain is significantly different.

Taylor et al. (2011)

Summary Drought Research

Drought: - *a prolonged and abnormal moisture deficiency*

3 pronged approach to examining

Drivers

SPIs

C Change

- Drivers of Caribbean rainfall and lack of it
- Determining periods of drought (SPIs and other indices)
- Long term Climate Change

Summary Drought Research

THANKS