

# Shifting Pattern of Streamflow Droughts across Global Tropics in the Recent Decades

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# Research Gaps

- Onset of Drought & its shifting pattern has not been investigated
- Very few studies on analyses of concurrent trend in drought onset & severity

Similar studies were found for floods ([Chen et al. 2012](#); [Wasko et al. 2020](#))

[State of Global Water Resources 2022](#),  
[WMO](#)



Large areas of the globe recorded **drier than normal** conditions in both 2021 and 2022

IPCC AR 6

Sixth Assessment Report

Medium confidence in assessing global drought 'hotspots'



Trend towards persistent and more severe droughts since the 1950s

**Why?**

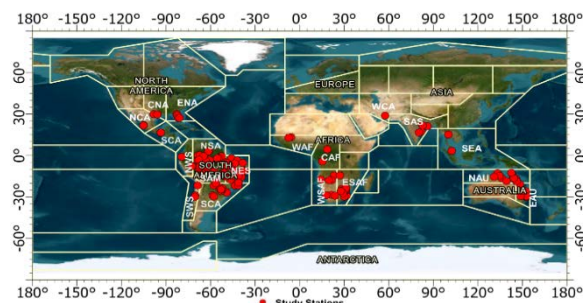
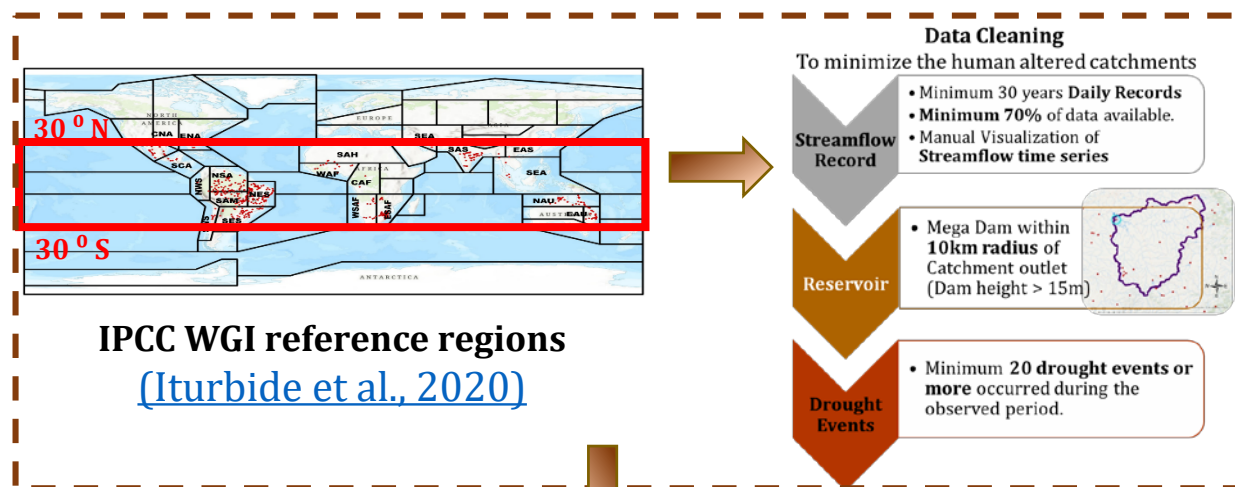
To develop

**Seasonality-Informed  
drought forecast  
model**

❑ Is there any **regional shift** in drought onset vs deficit volume over two **climate normal periods 1991-2020 vs 1961-1990**?

# Streamflow Drought Identification

Shifting Pattern of Streamflow Droughts across Global Tropics in the Recent Decades



- **135 sites**
- **19 IPCC WGI region**
- **1961 -2020**

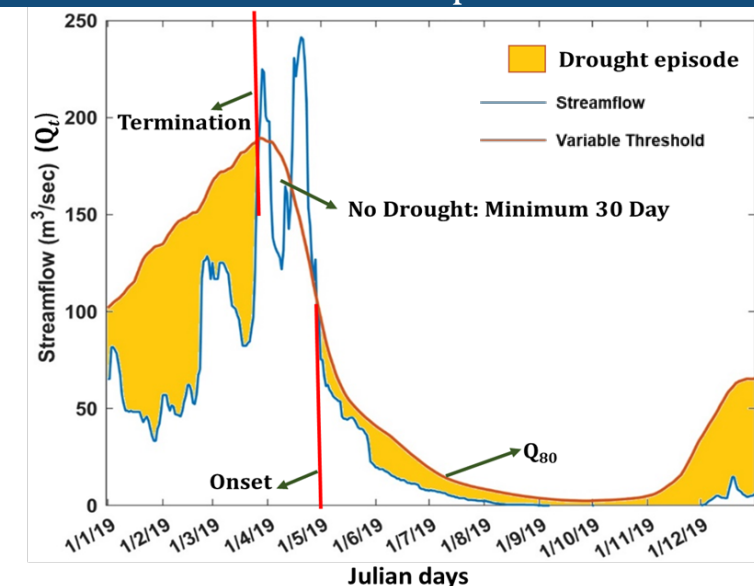
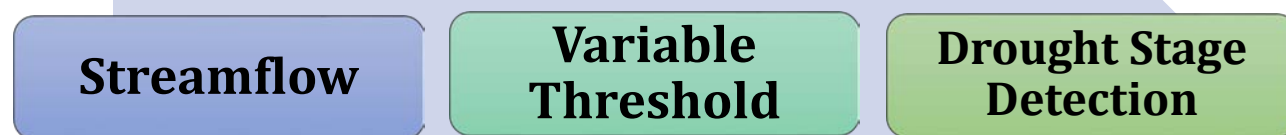


Illustration for drought detection at Jacinto, Brazil  
GRDC ID: 3649211

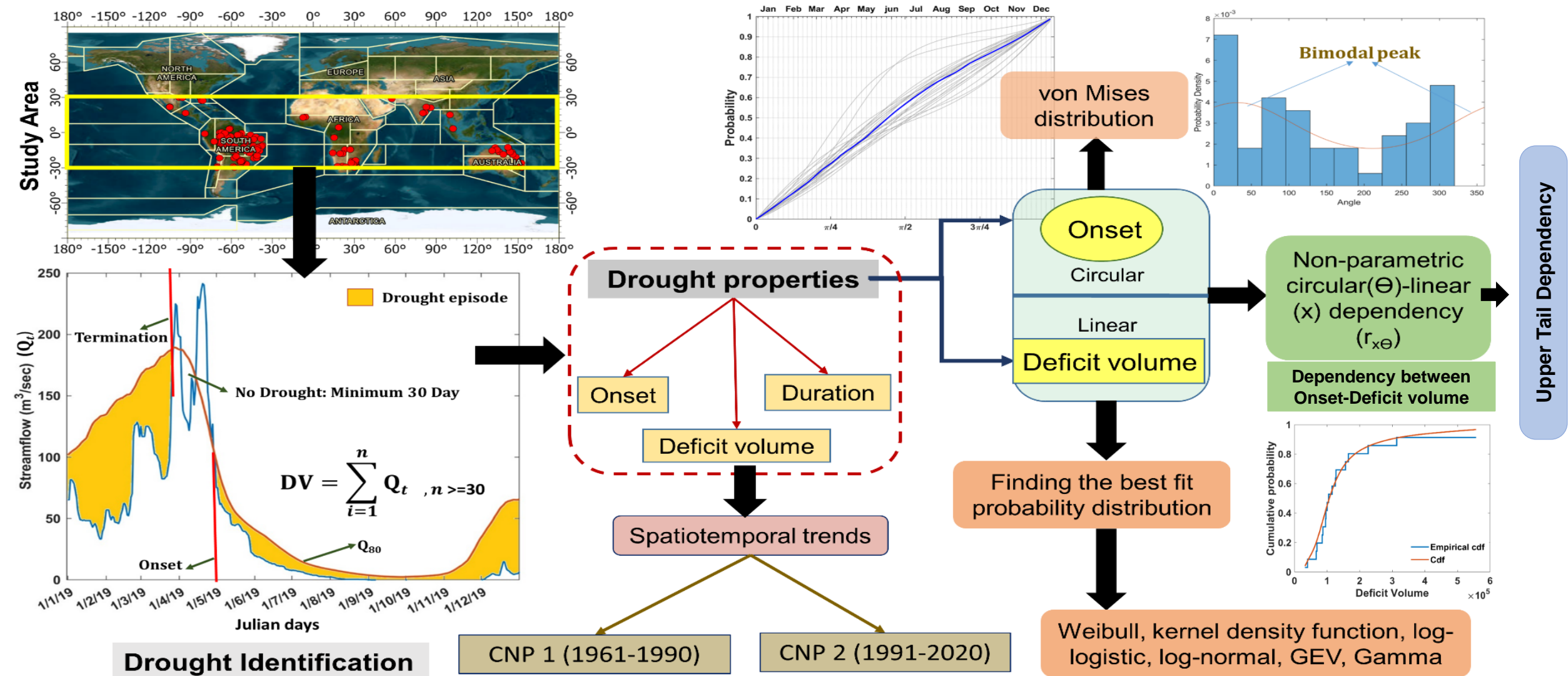
**Daily Variable Threshold**

Threshold **80%** exceedance probability

Centered moving average: **31-day ( $\pm 15$  days)**  
smoothing filter

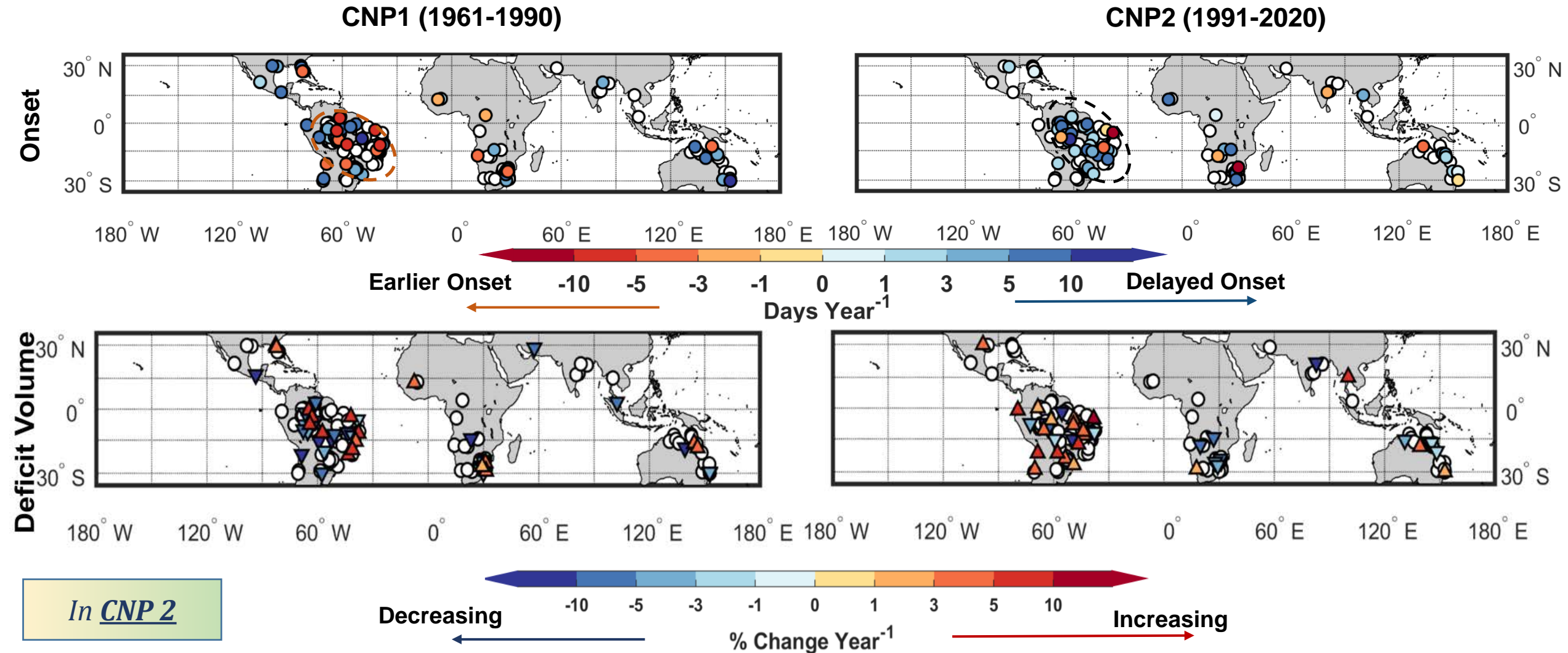
# Shifting Pattern Identification

Shifting Pattern of Streamflow Droughts across  
Global Tropics in the Recent Decades





# Shifts in Onset Time & Deficit Volume

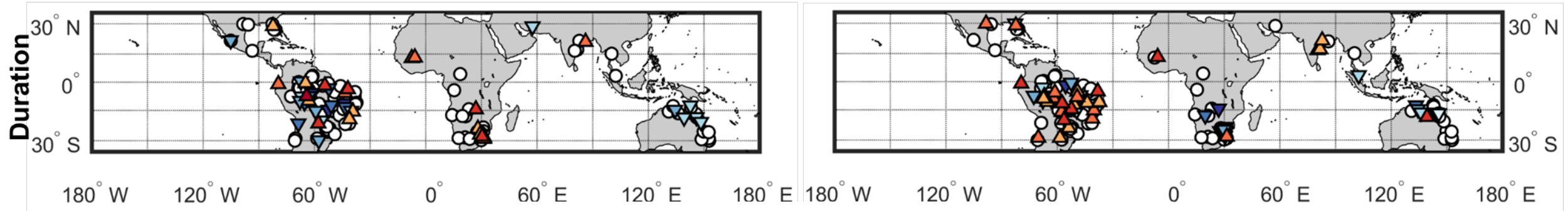


- 68% (92 out of 135) of sites show a delayed onset
- 43% (58 out of 135) of catchments show increasing trends in deficit volume
- Increase in deficit volume with delayed onset ~27%

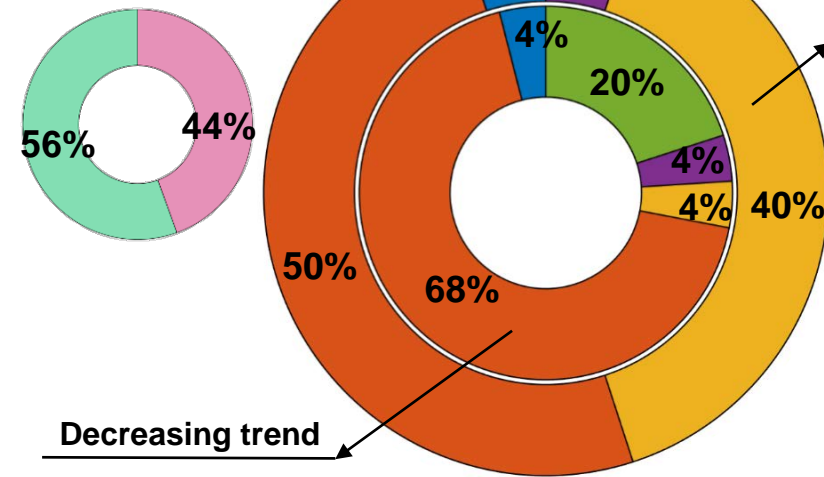
# Increasing trends in Drought Duration

1961-1990

1991-2020



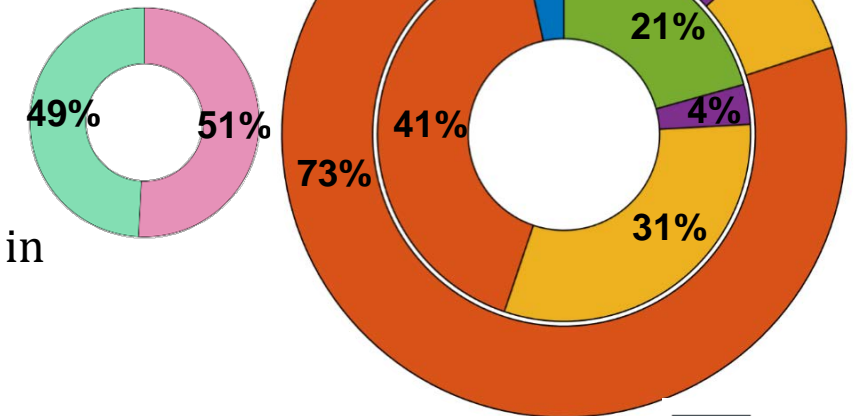
Decreasing -10 -5 -3 -1 0 1 3 5 10 Increasing  
% Change Year<sup>-1</sup>



Decreasing trend Increasing trend

Duration

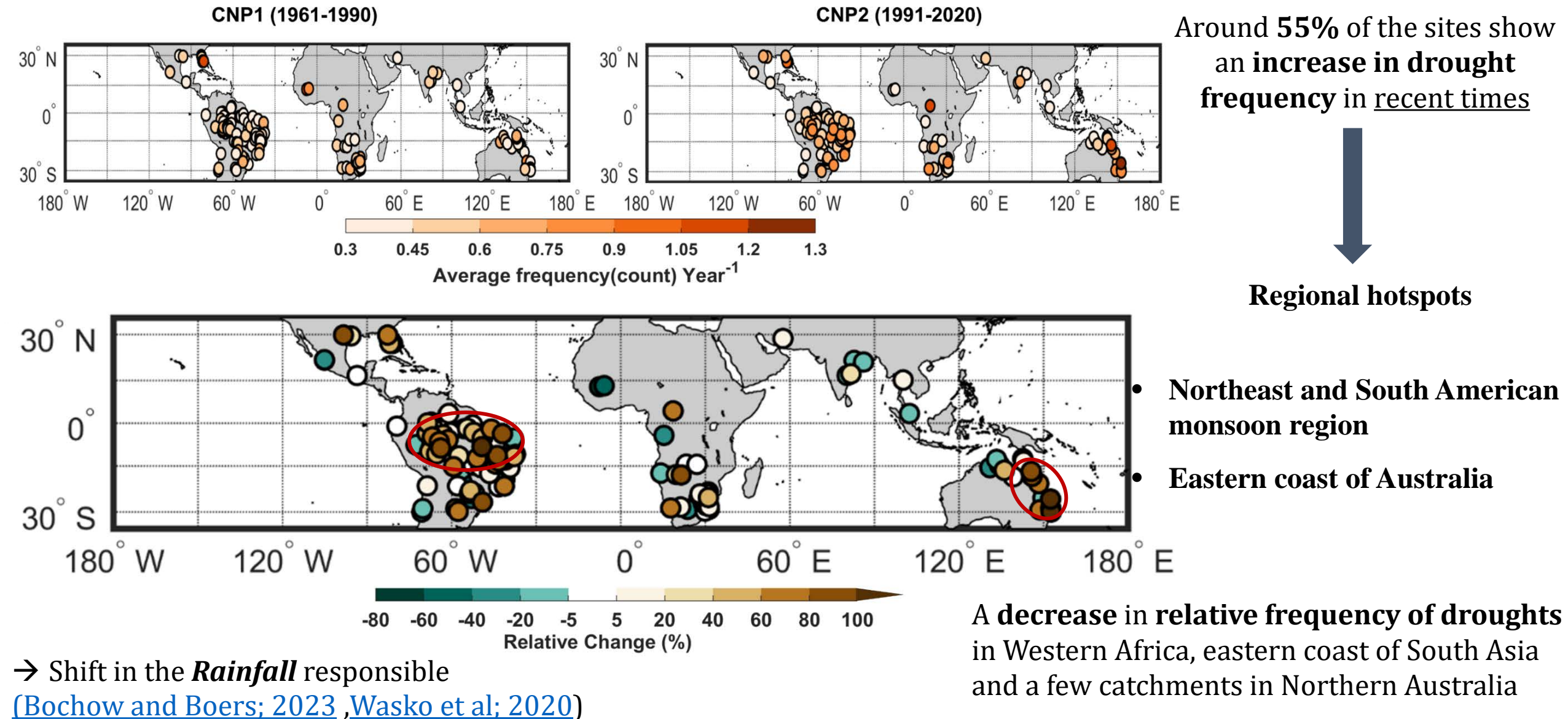
- More number of sites show significant ( $p\text{-value} > 0.9$ ) increasing trend in duration in the recent time window



- Nearly 21 % of station show **Increase in drought deficit volume and duration with delayed onset**

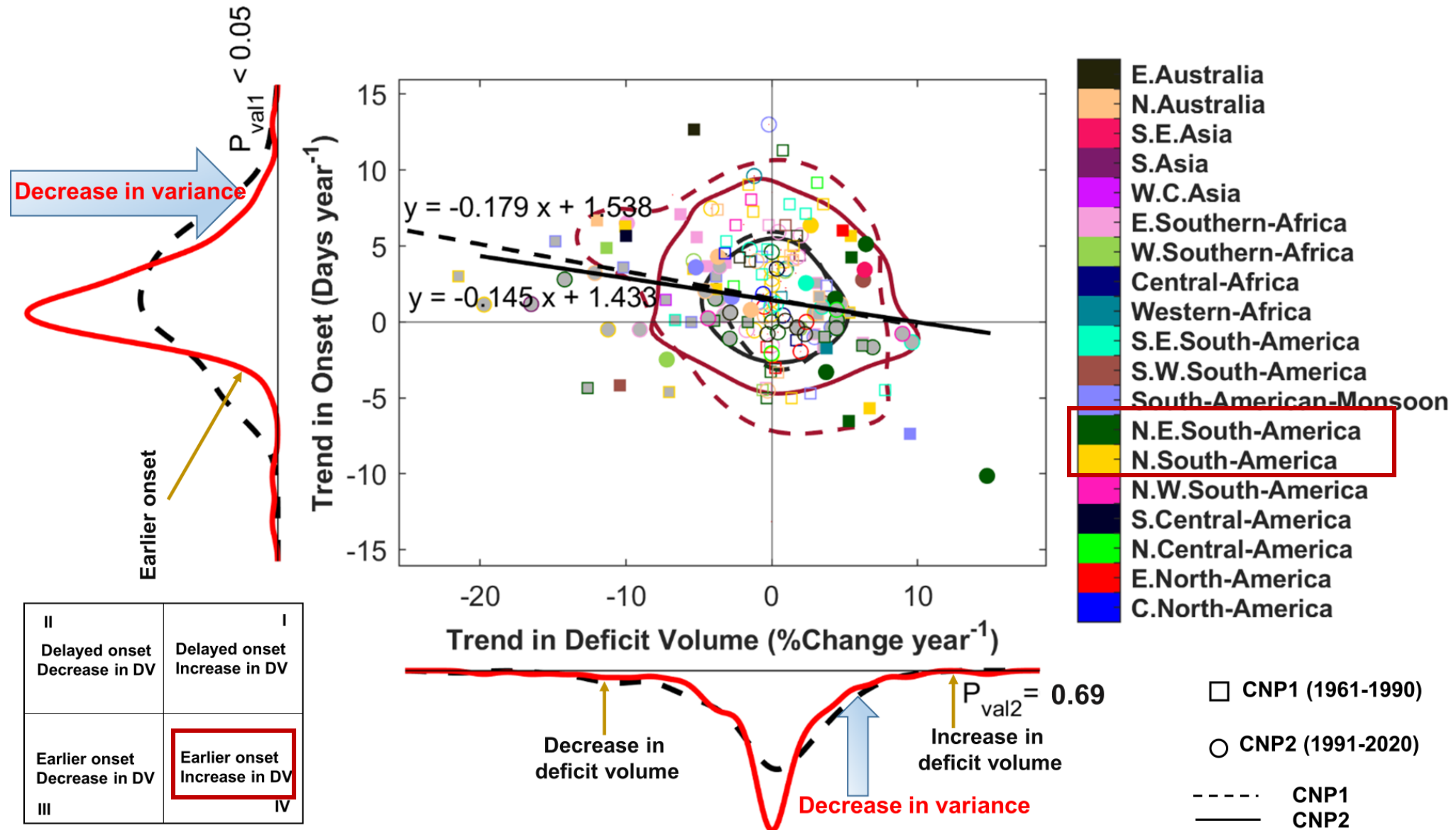
North America  
South America  
Africa  
Asia  
Australia

# Spatial Footprints of Frequent Droughts in Recent Period



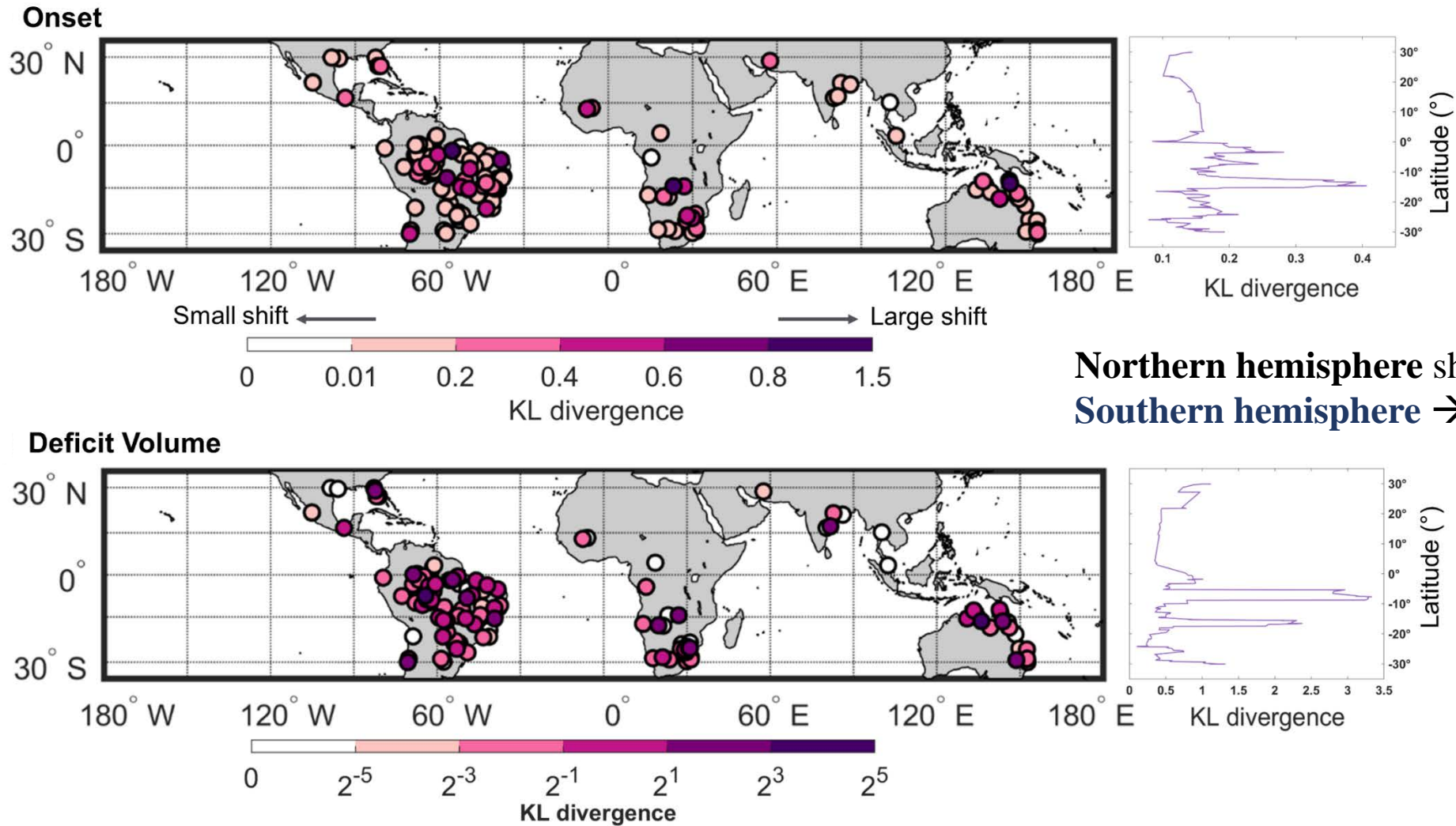


# Joint Trends in Drought Onset Time and Deficit Volume





# Quantifying Shifts in Drought Attributes

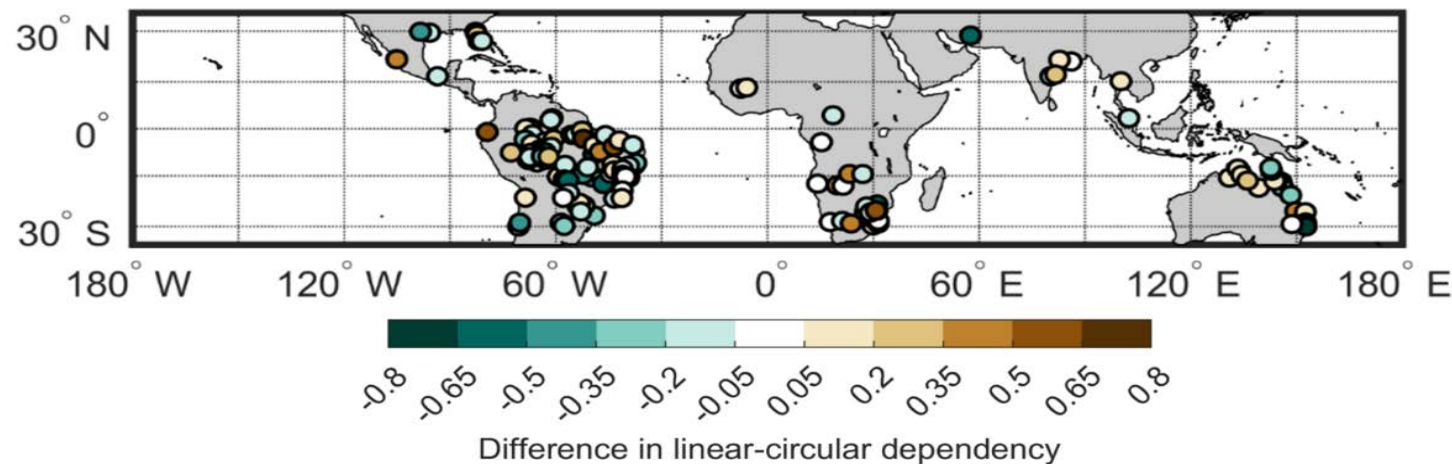


Northern hemisphere show a smaller shift than  
**Southern hemisphere** → KL divergence values

- ~ **one-third** of catchments show a **large shift** in the **deficit volume**
- ~ **8%** show a substantial change in the **onset timing**

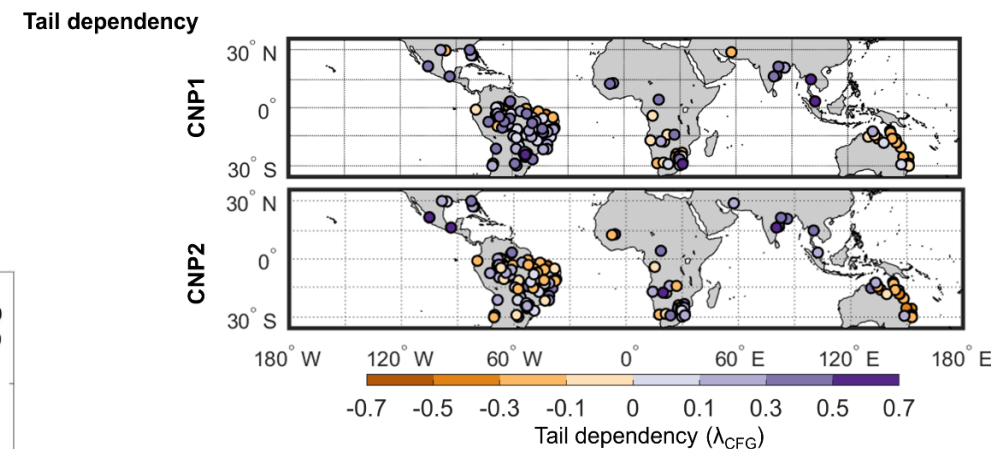
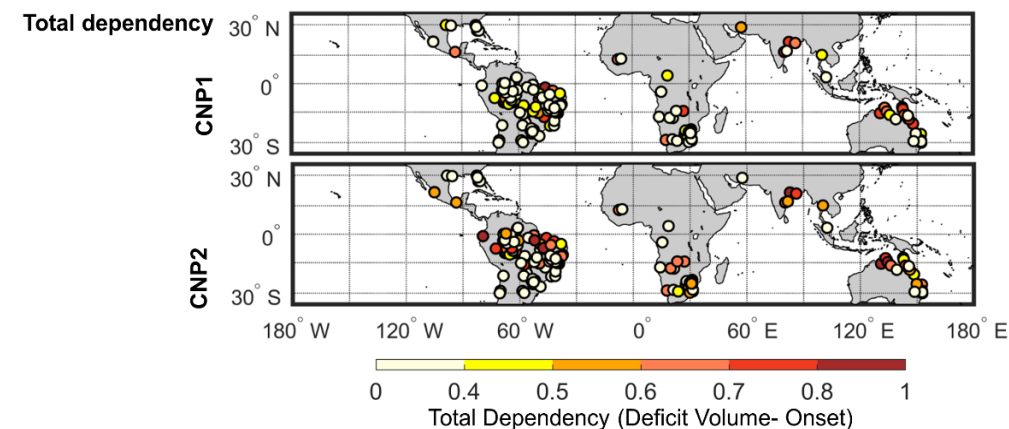
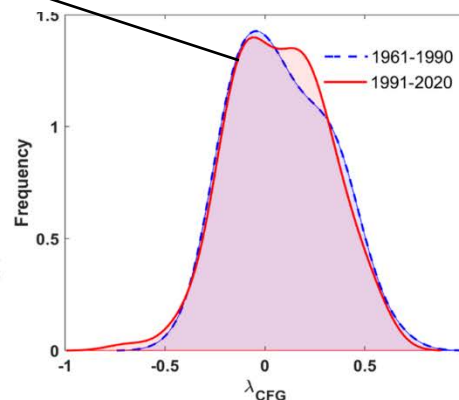
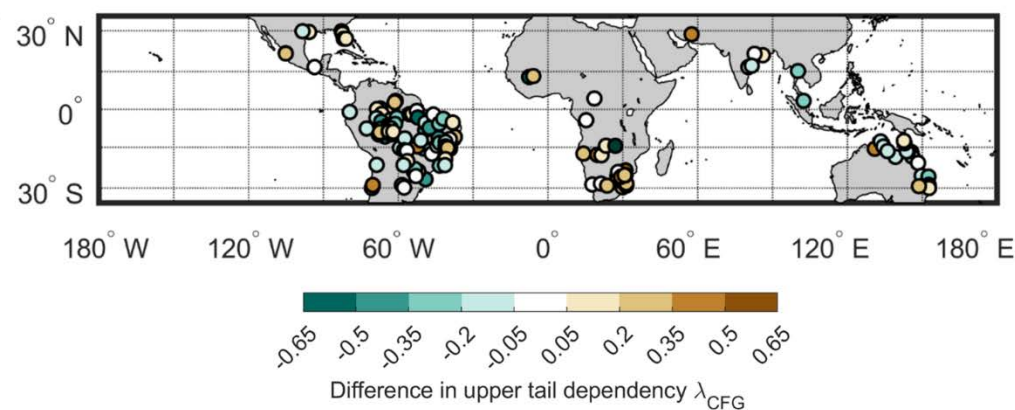
**13%** of sites show minimal shift  
(KL divergence ~ 0)

# Changes in Dependency Metrics



**23% more sites show the dependence strengths of  $> 0.5$  in CNP2 compared to CNP1**

Bimodal nature of distribution for CNP2



***Upper Tail Dependency Metrics***  
 **$> 50\%$  sites show a decrease in dependence strengths in CNP2**

# Summary

## Shifting Pattern of Streamflow Droughts across Global Tropics in the Recent Decades

Distribution of onset time and deficit volume show ***substantially shifts*** towards larger values in the recent (1991-2020) period



Northeastern and South American Monsoon, Western Africa, East Southern-Africa, South Asia and North Australia

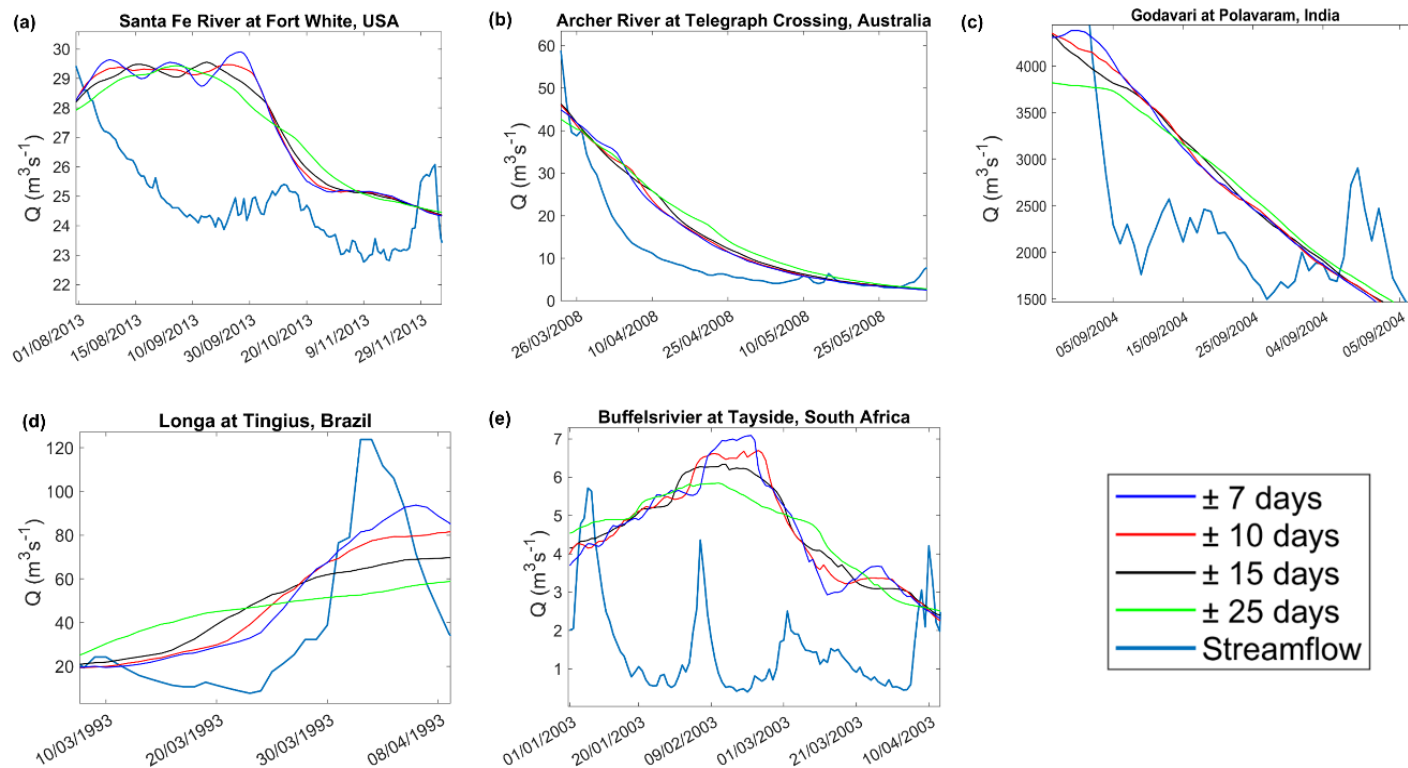
Dependence strengths of onset time-deficit volume may play a crucial role in ***bivariate risk quantification*** in areas with **strong seasonality** in streamflow

- ❖ Raut, A. & Ganguli, P.,(2023). **Observed Trends in Timing and Severity of Streamflow Droughts across Global Tropics** (*Communication in ERL, #ERL-116885.R1* )

***Any Questions?***



# Sensitivity of streamflow drought characteristics at different smoothing windows



We implemented a ***Centered Moving Average of 31 days*** to smooth the variable threshold time series



Smoothing window excludes several short-term deficits ([Ahmadi and Moradkhani, 2019](#))

GRDC / GSIM Id	Regions	Smoothing time window	Number of drought events (1961-2020)
1160850	ESAF	15 days ( $\pm 7$ days)	26
		21 days ( $\pm 10$ days)	26
		31 days ( $\pm 15$ days)	26
		51 days ( $\pm 51$ days)	27
3650477	NES	15 days ( $\pm 7$ days)	33
		21 days ( $\pm 10$ days)	21
		31 days ( $\pm 15$ days)	21
		51 days ( $\pm 51$ days)	36
4149810	ENA	15 days ( $\pm 7$ days)	34
		21 days ( $\pm 10$ days)	34
		31 days ( $\pm 15$ days)	34
		51 days ( $\pm 51$ days)	34
5109240	NAU	15 days ( $\pm 7$ days)	28
		21 days ( $\pm 10$ days)	25
		31 days ( $\pm 15$ days)	25
		51 days ( $\pm 51$ days)	30
in_0000098	SAS	15 days ( $\pm 7$ days)	35
		21 days ( $\pm 10$ days)	34
		31 days ( $\pm 15$ days)	35
		51 days ( $\pm 51$ days)	35

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