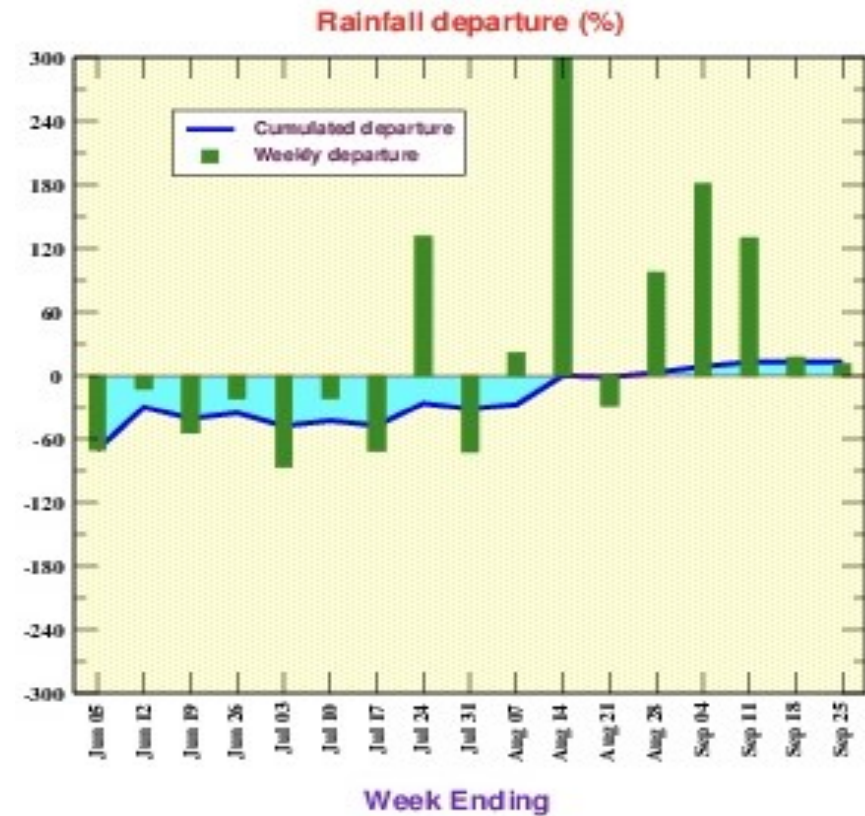
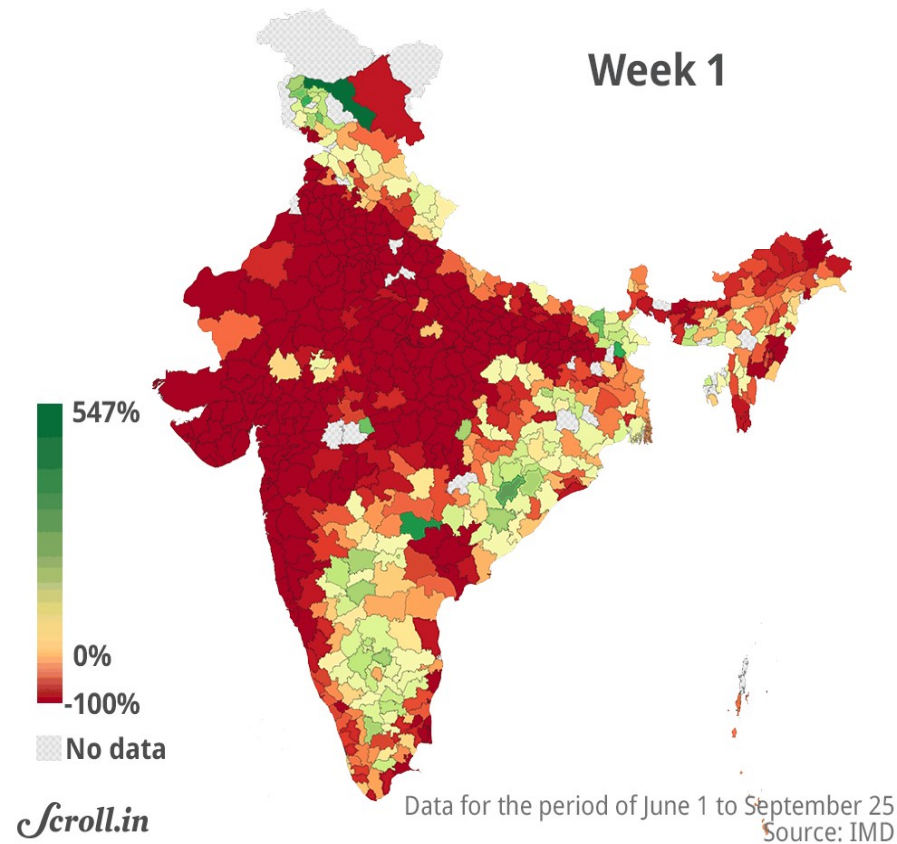
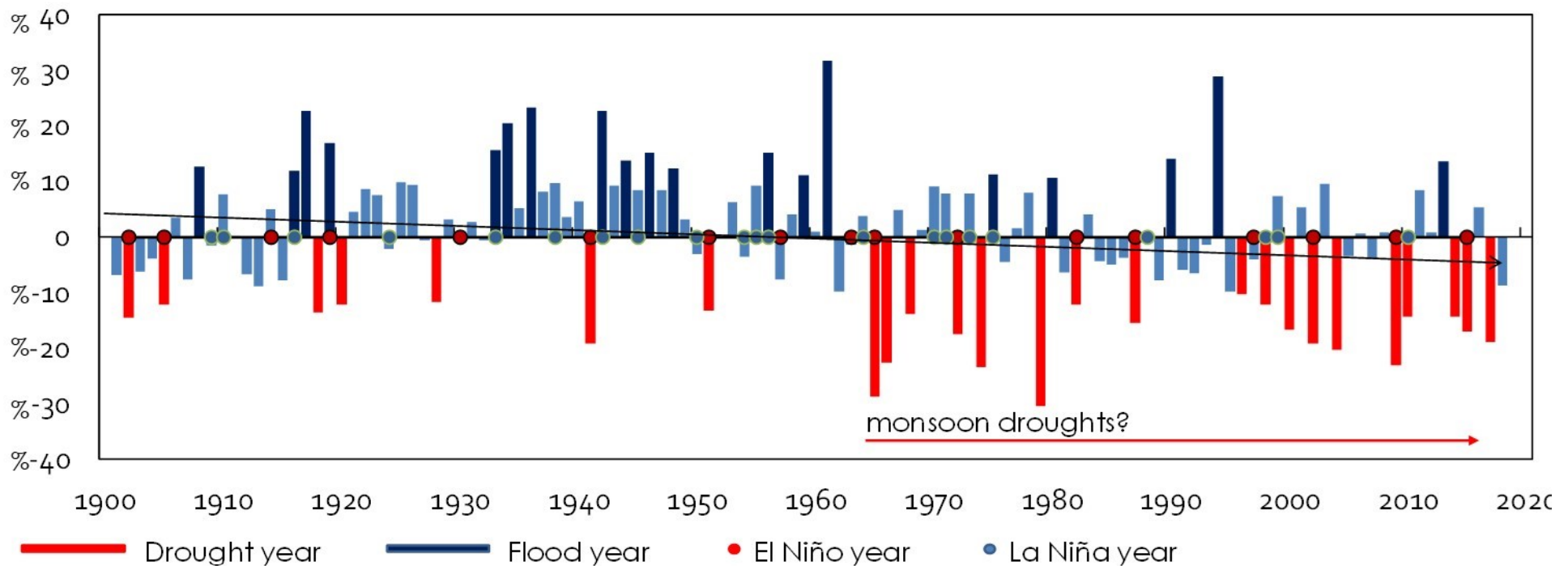


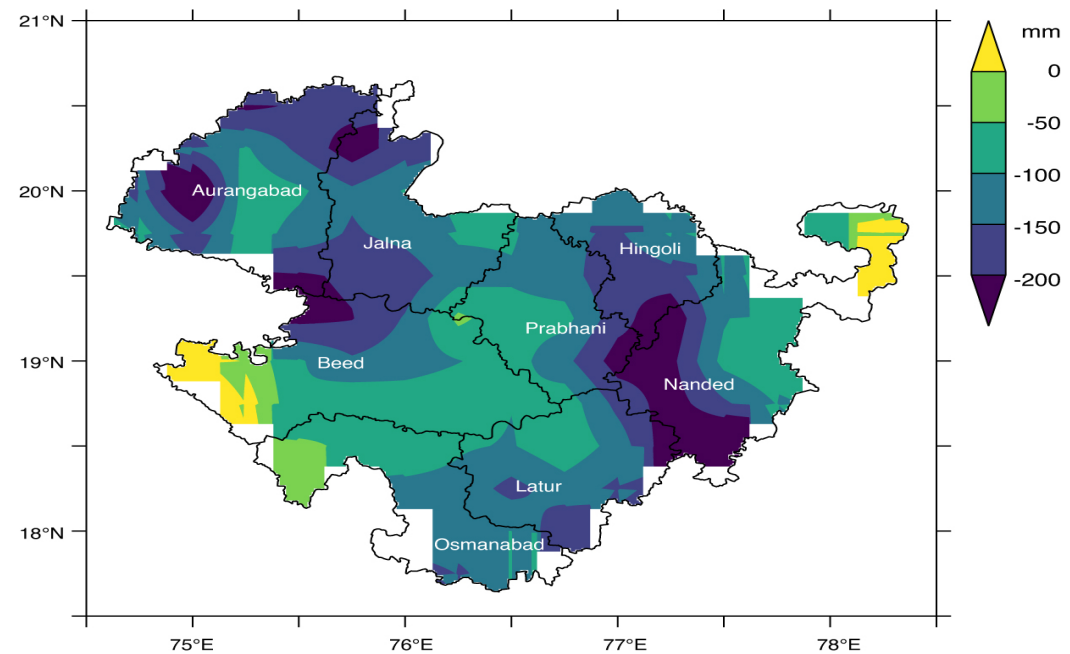
# Key Drivers of Monsoon Crazyiness

Cumulative rainfall departure from normal, for each week of the monsoons

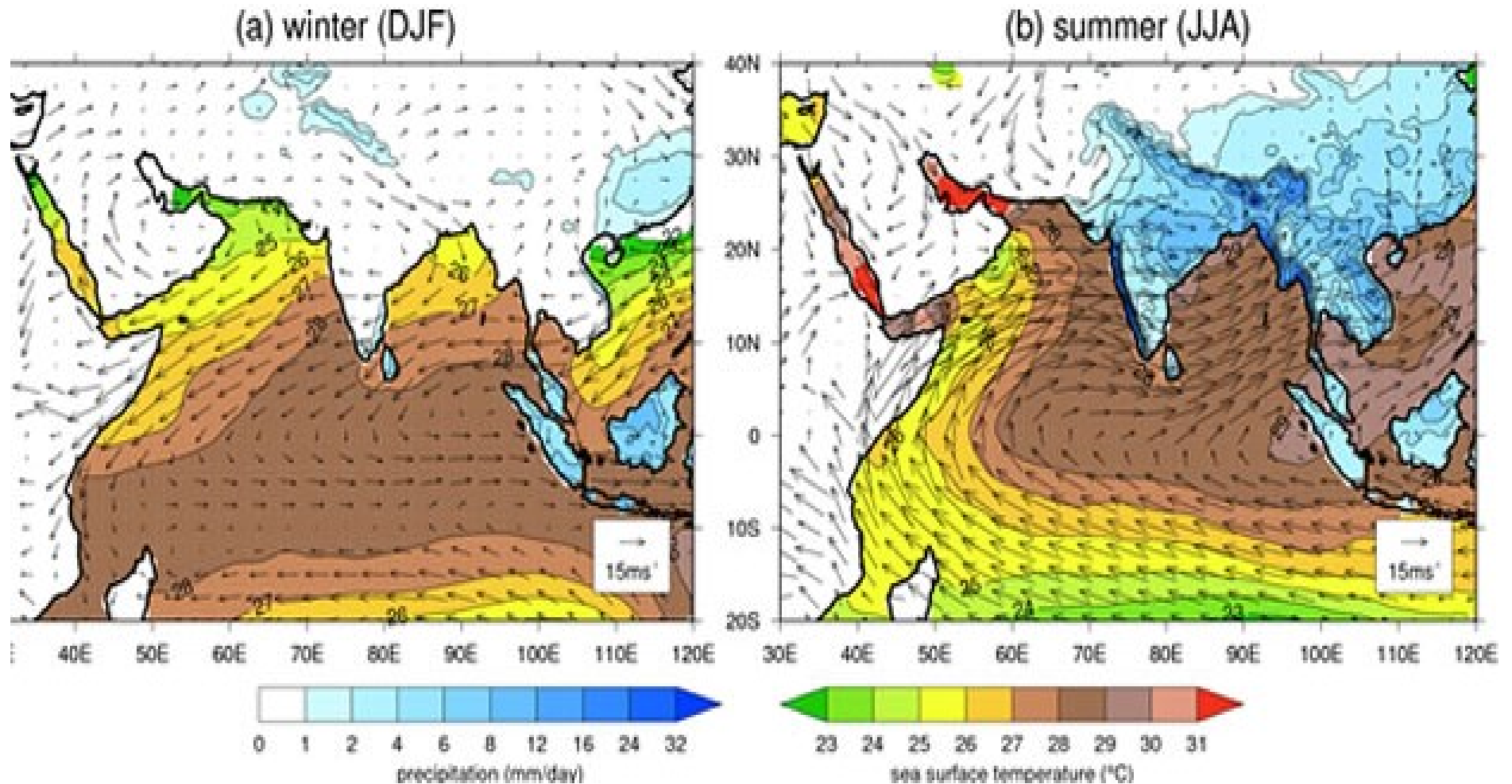




**Where is all the  
Moisture Coming  
from? Are some  
Regions of India  
Donating their Share of  
the Monsoon to the  
Floods?**



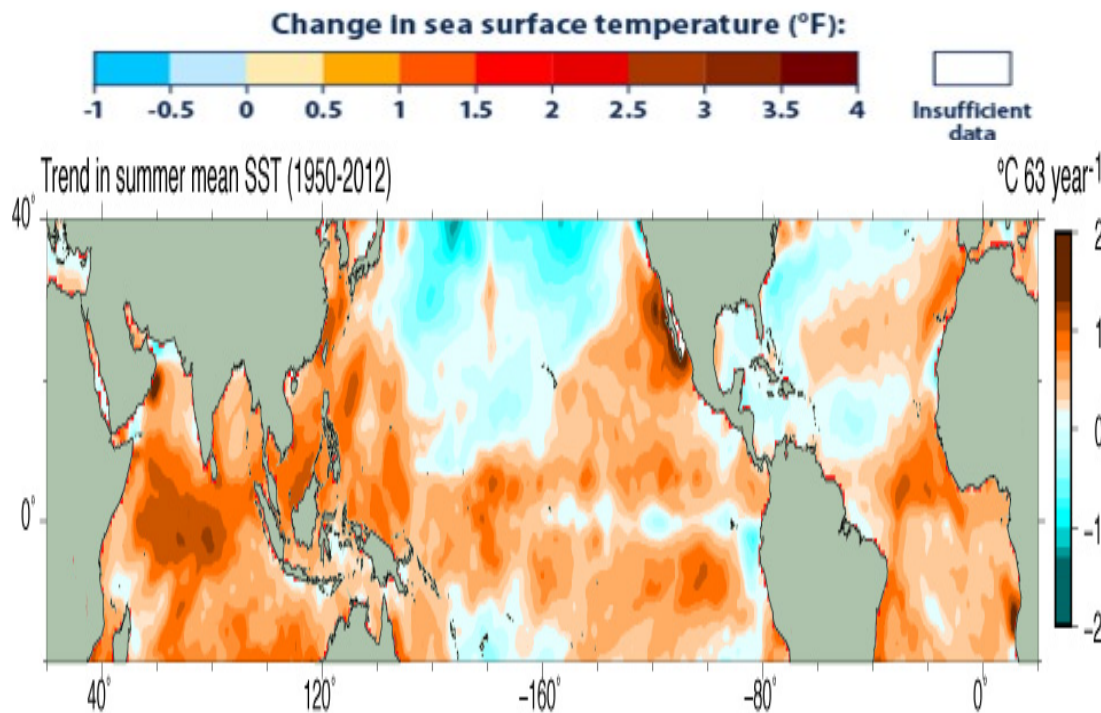
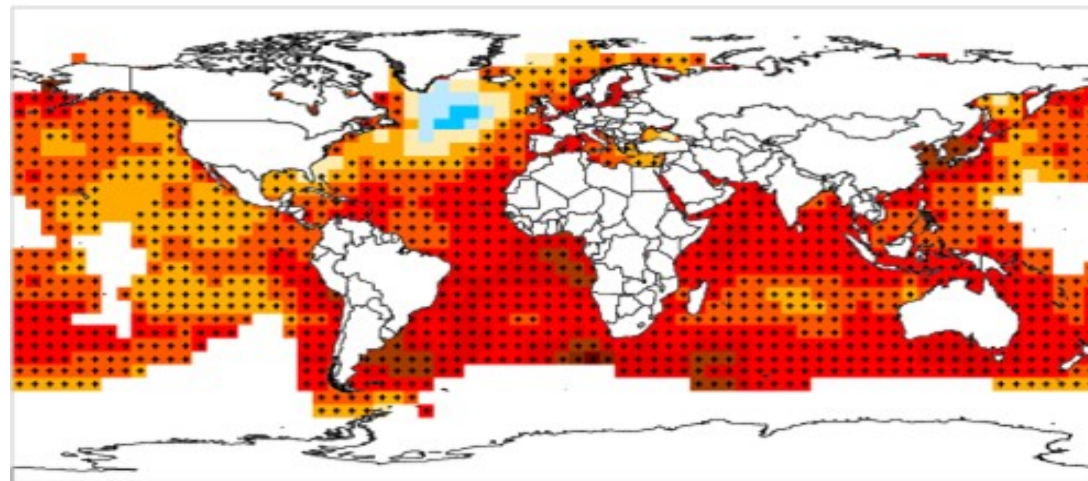
## Warm Ocean: Drives the Split Personality of the ITCZ



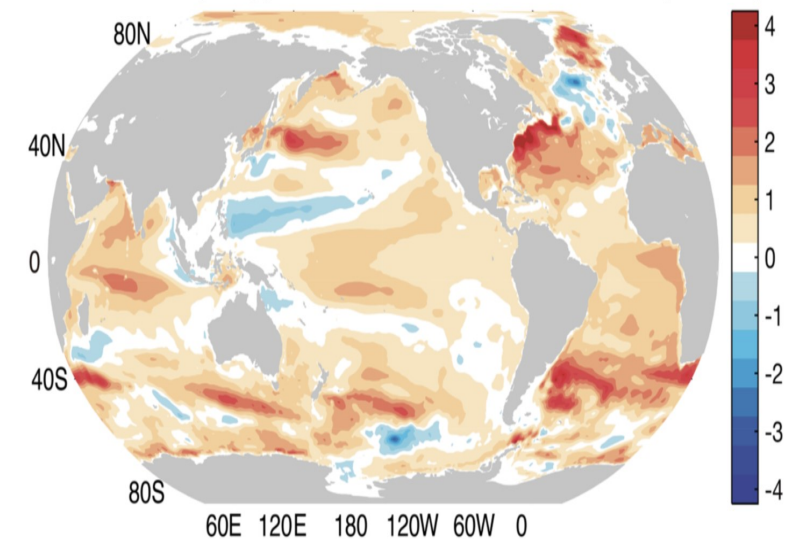
**200 lakh crore buckets of water is dropped on India!!**

# Seasonality of Warming and Pattern Selection:

Role of ITF? Role of MOC? Arabian Sea MOC vs. Bay of Bengal MOC?

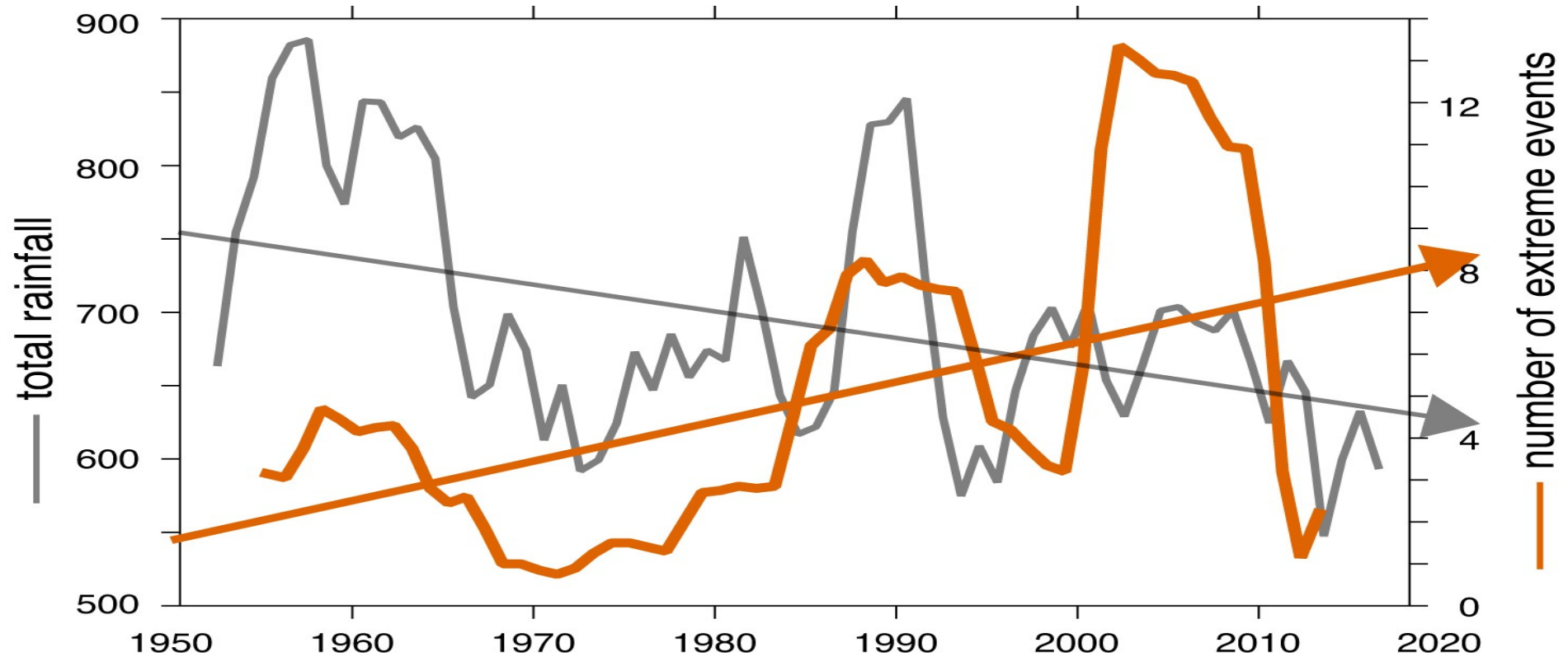


2019 OHC anomaly at upper 2000m relative to 1981-2010 baseline ( $10^9 \text{ J m}^{-2}$ )





## In the Meantime: Threefold Increase in Widespread Extremes



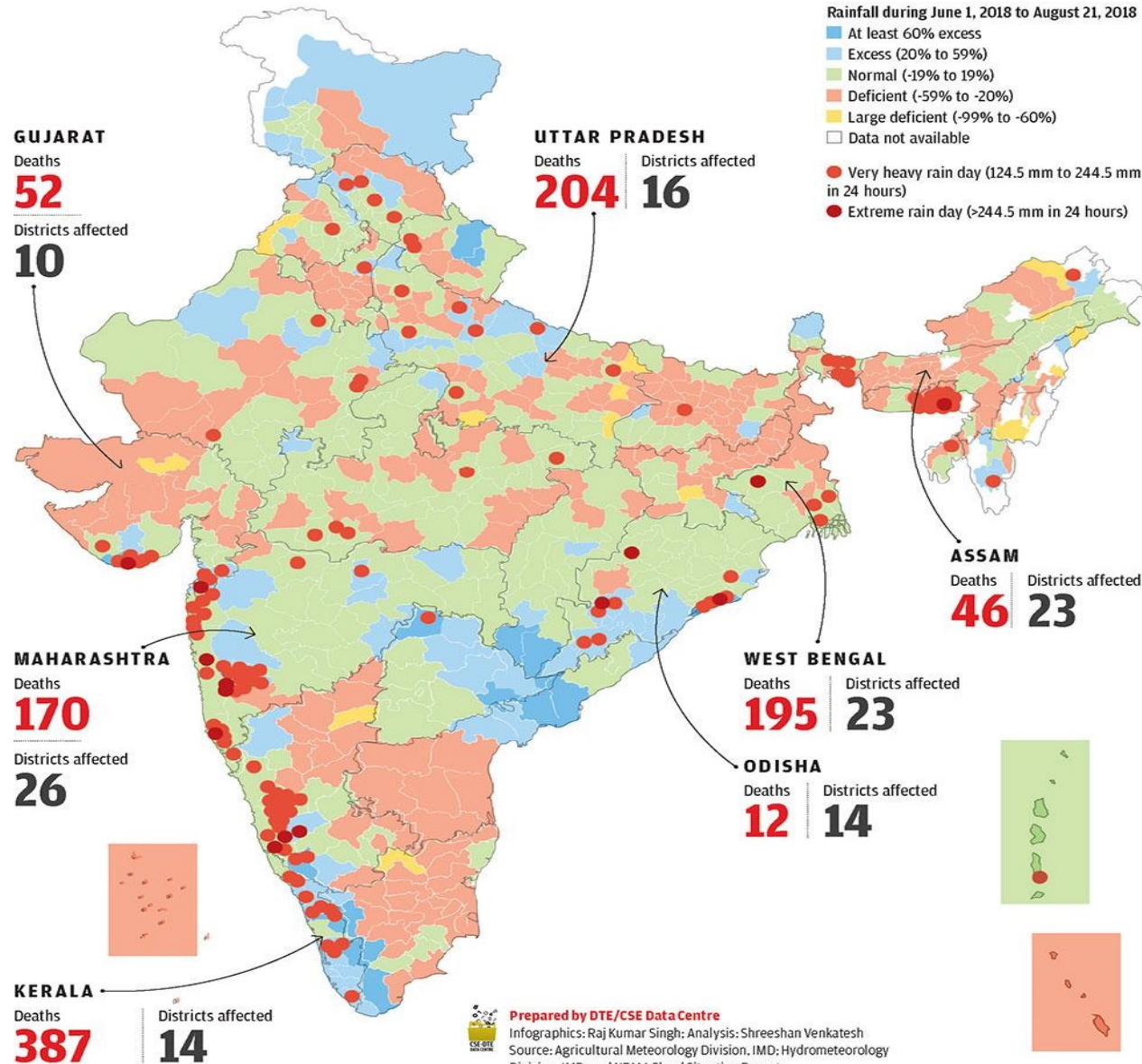
Widespread events have gone from ~2/year to 6/year

Roxy et al. 2017

MONSOON 2018

# Excess rains plague India

Rainfall during monsoon is becoming more extreme and frequent throughout the country. This is causing floods, claiming lives and damaging property



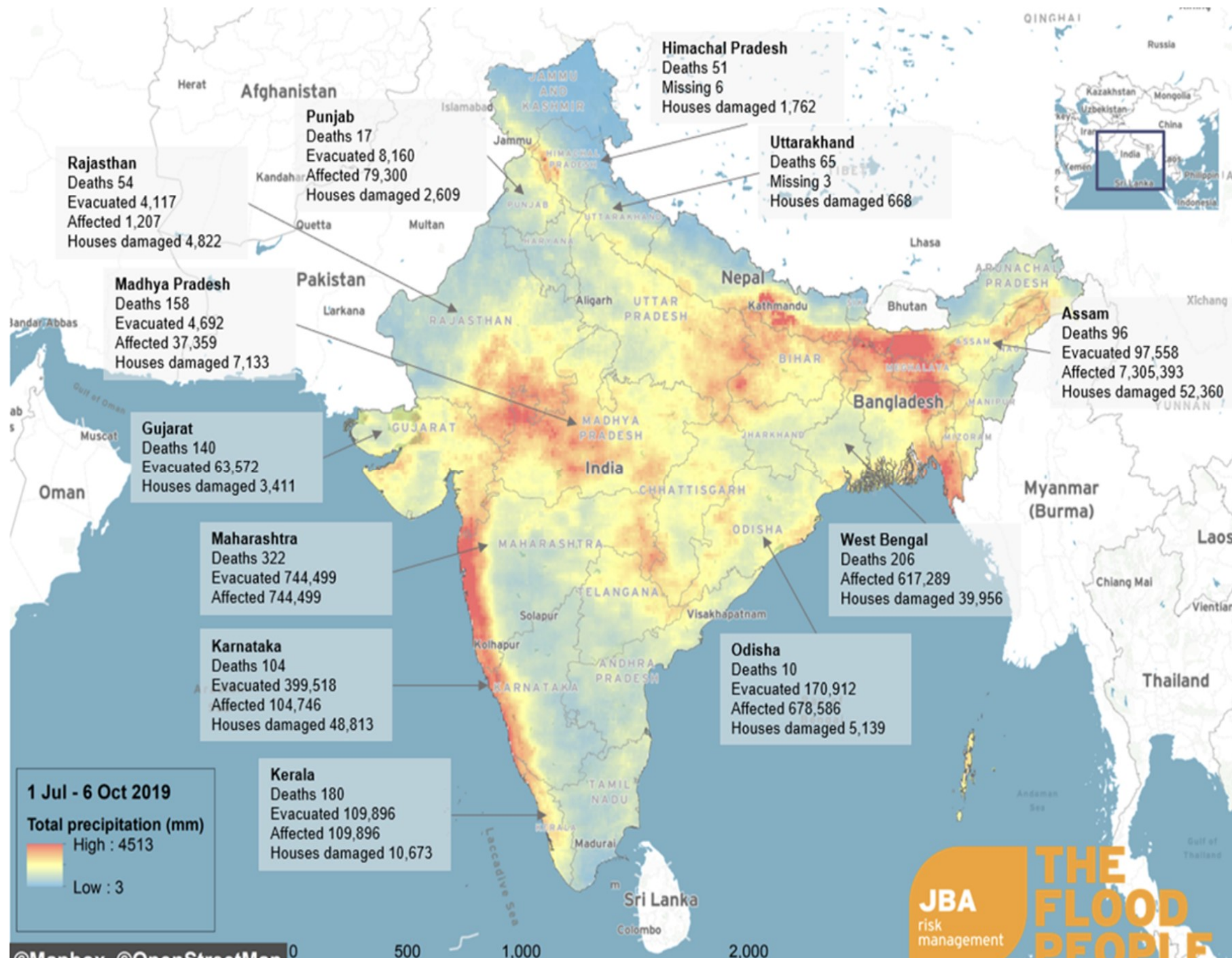
Prepared by DTE/CSE Data Centre

Infographics: Raj Kumar Singh; Analysis: Shreeshan Venkatesh

Source: Agricultural Meteorology Division, IMD; Hydrometeorology

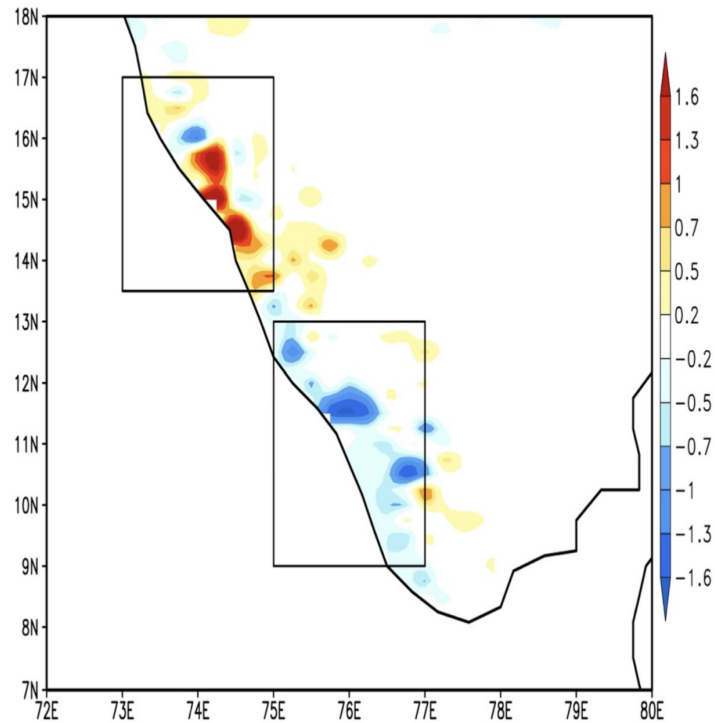
Division, IMD; and NDMA Flood Situation Reports

For more such infographics visit: [www.downtoearth.org.in/infographics](http://www.downtoearth.org.in/infographics)



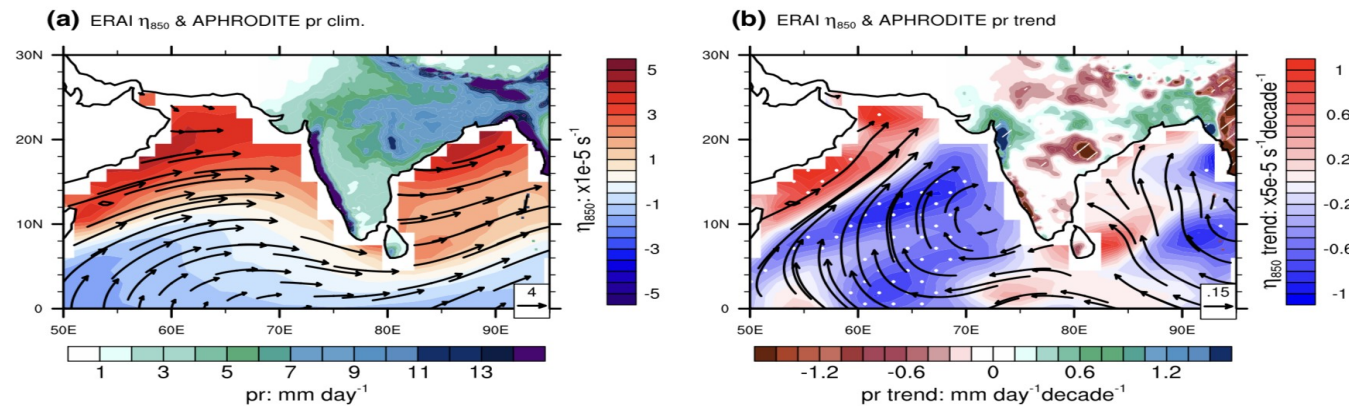


**Fig. 2** The trends in rainfall ( $\text{mm day}^{-1} \text{decade}^{-1}$ ) in the Western Ghats during the south-west monsoon period for the period 1931–2015. The boxes marked in the figure are the areas considered for the study



**Causality is not Entirely Clear. Local vs. Remote**

**Will Kerala monsoon continue to Decline?**

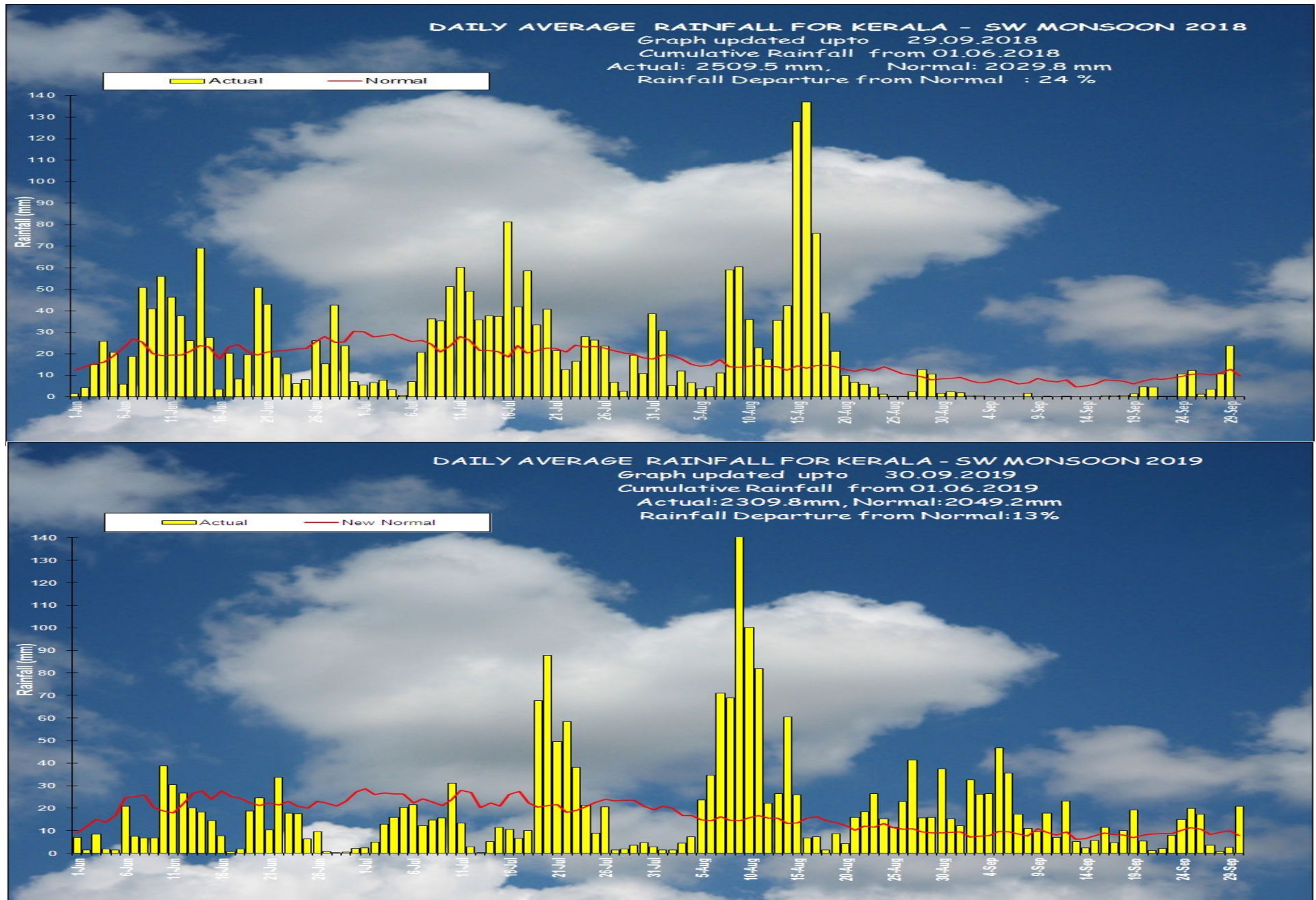


**Fig. 1** **a** Climatological JJAS mean (1981–2000) oceanic winds at 850 hPa, (vectors;  $\text{m s}^{-1}$ ), absolute vorticity (shading over oceans;  $1 \times e-5 \text{ s}^{-1}$ ) and land precipitation ( $\text{mm day}^{-1}$ ) and **b** linear trends (1979–2007) in JJAS mean winds (vectors,  $\text{m s}^{-1} \text{decade}^{-1}$ ), absolute vorticity (shading over oceans;  $5 \times e-5 \text{ s}^{-1} \text{decade}^{-1}$ ) and land

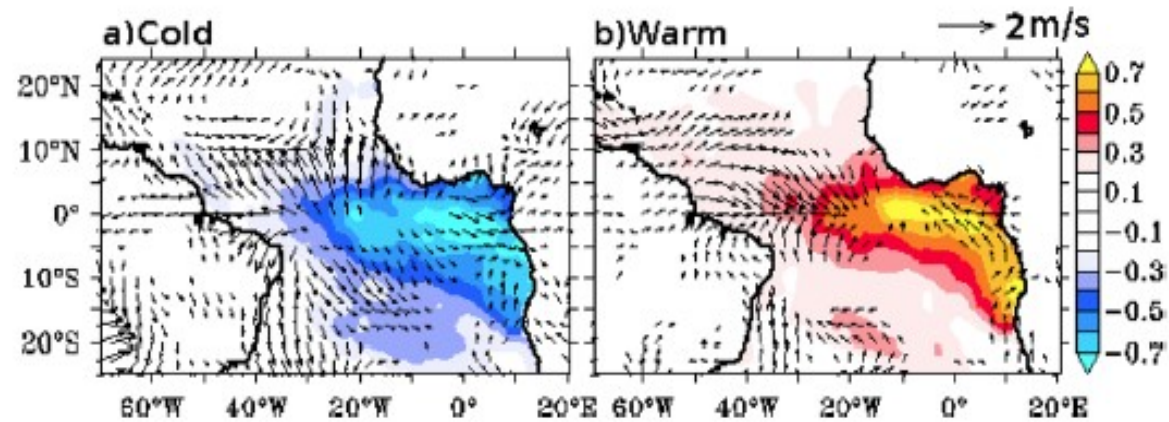
precipitation ( $\text{mm day}^{-1} \text{decade}^{-1}$ ). Winds are from ERA-Interim and precipitation from APHRODITE. Stippling (*dashes*) show regions with statistically significant ( $p < 0.05$ ) trends in zonal winds (precipitation)



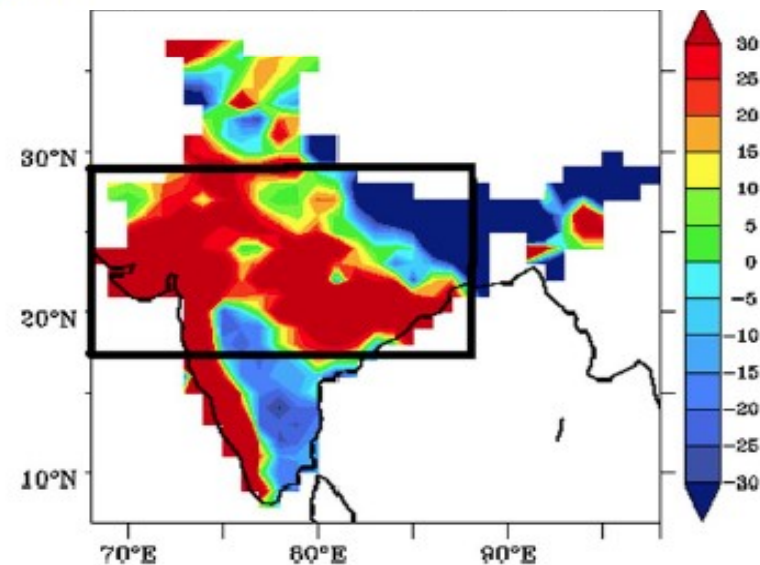
# What happens After the Extreme Events? Moisture Sources?



# The Atlantic Niño Definitely Influences the Indian Monsoon



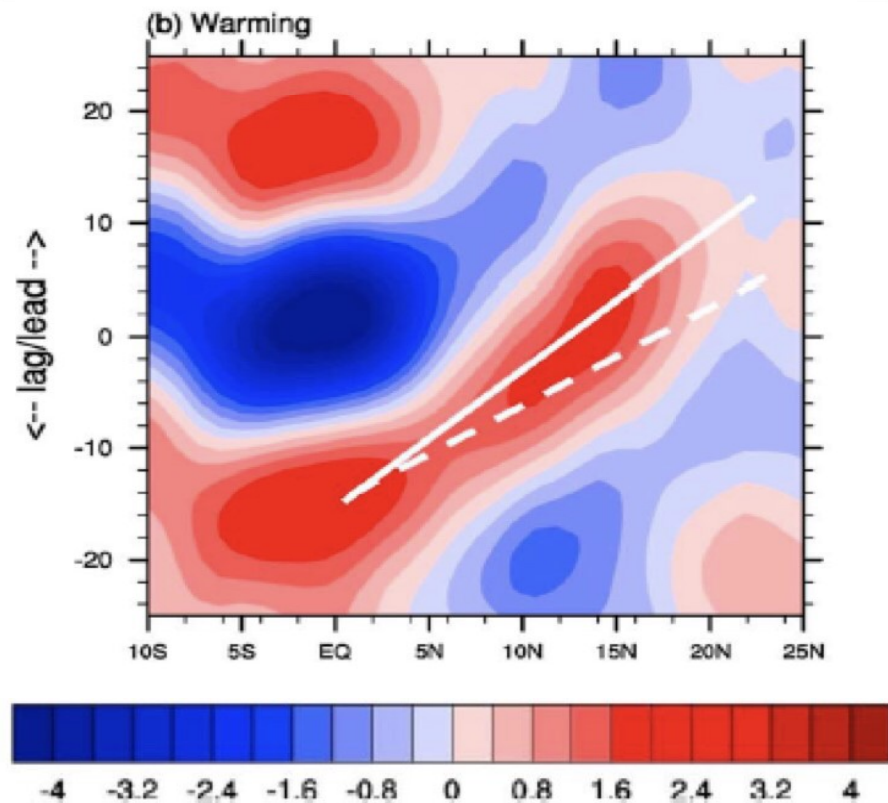
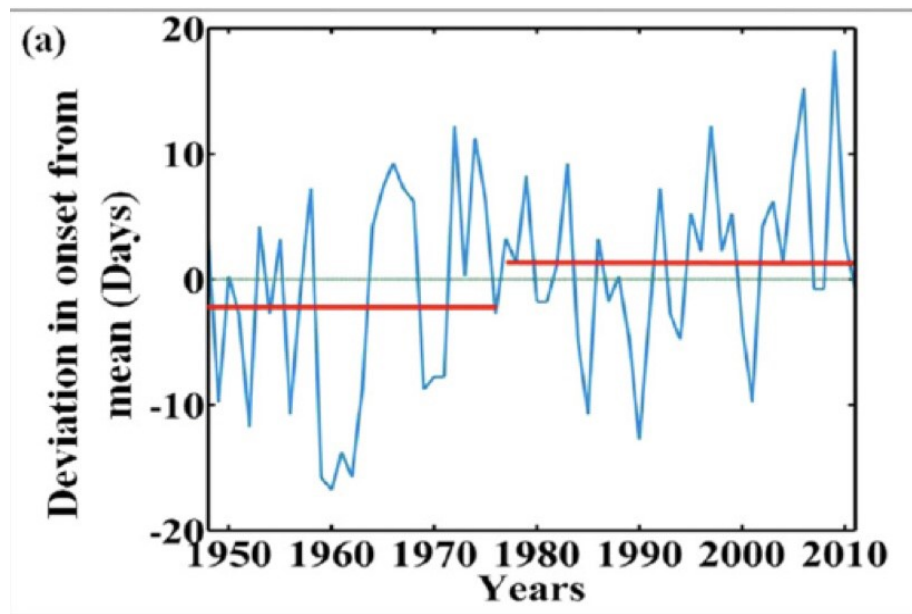
**Figure 1.** Seasonal composite (June–July–August) of SST anomalies overlaid by surface wind vector anomalies for the (a) cold and (b) warm AZM years.



**Figure 2.** The difference (cold-warm) in seasonal (June–August) composite of monsoon rainfall (mm month<sup>-1</sup>) during AZM years. The black box indicates the approximate area of core monsoon region (18°N–28°N and 65°E–88°E) defined by Rajeevan et al. [2010].

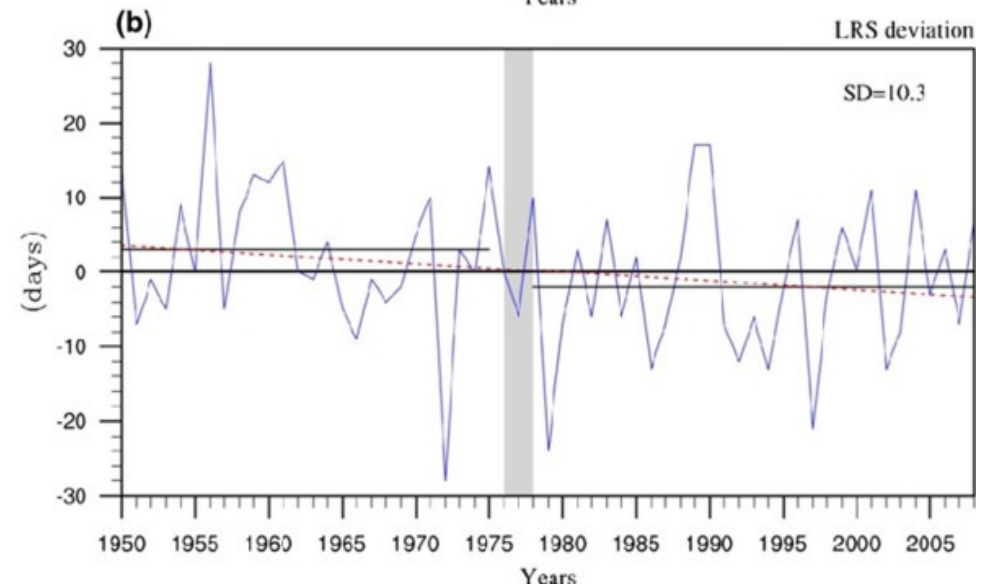
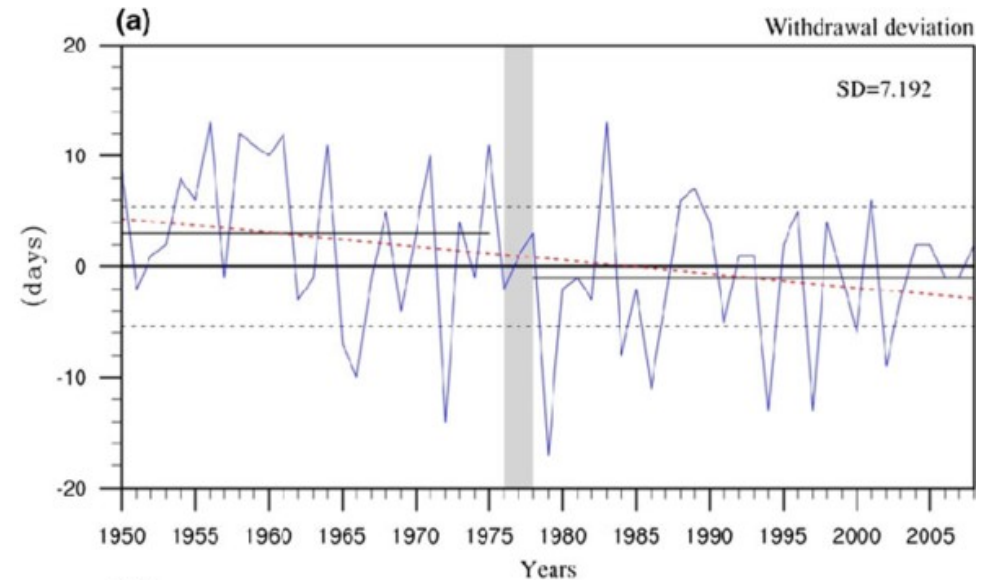
Pottapinjara et al.  
2014, 2016



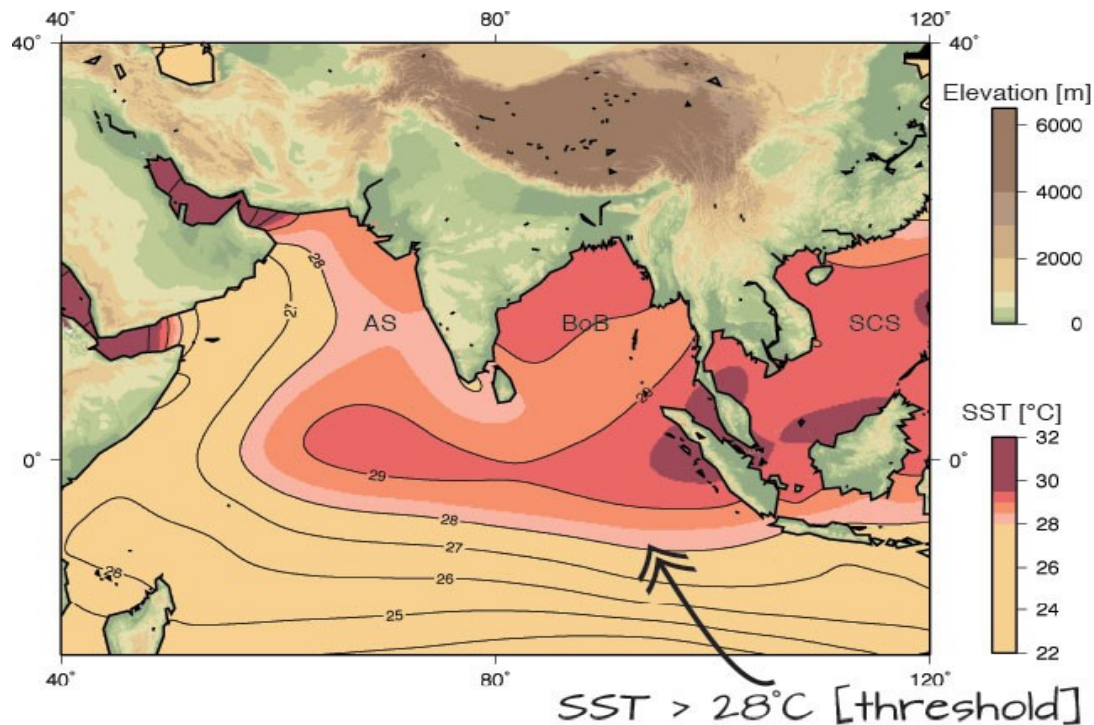


# Monsoon Onset/Withdrawal; Length of the Rainy Season

Sahana et al. 2015; Sabeerali et al. 2013





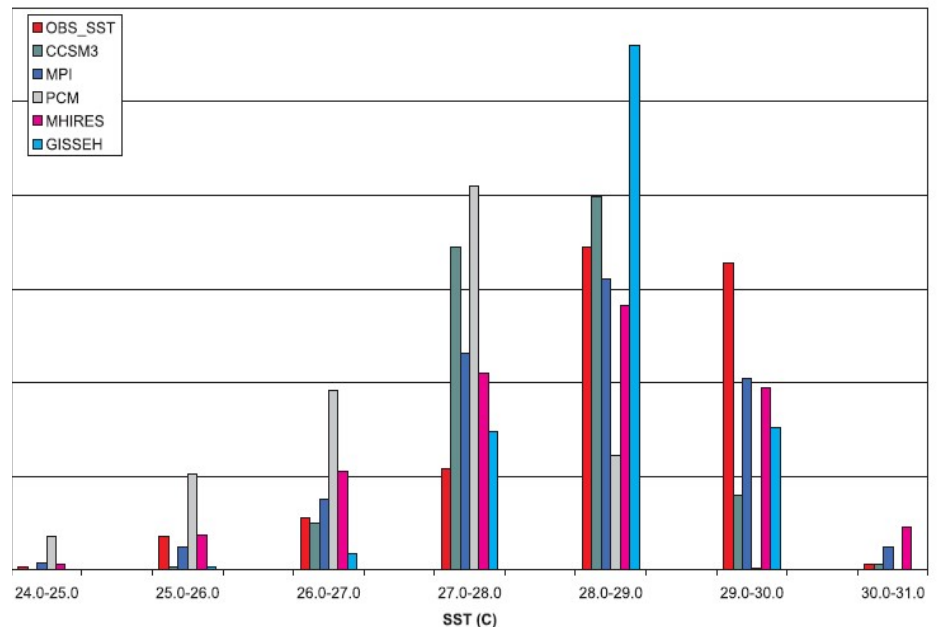
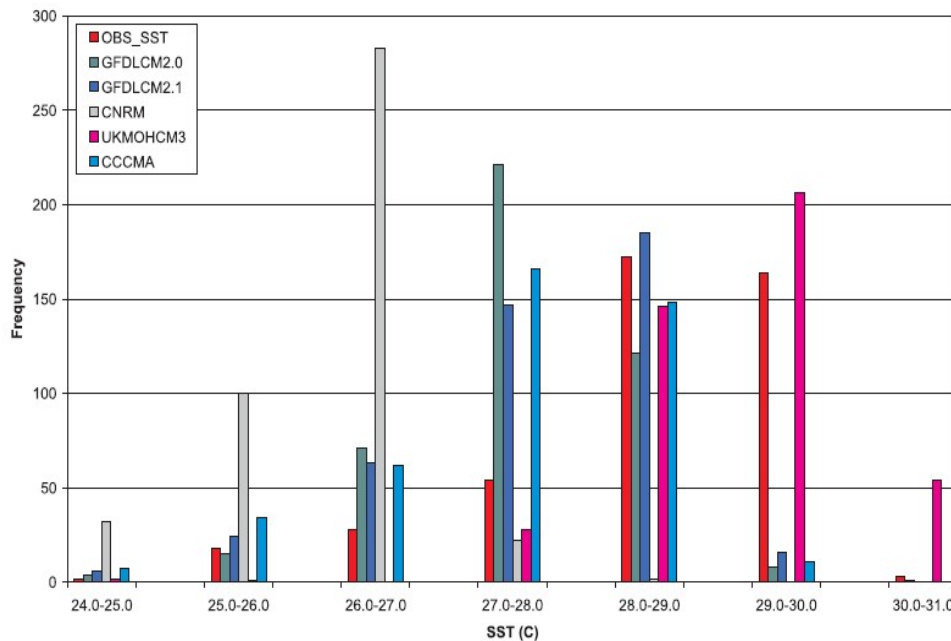


**BAD NEWS:** Even small SST Anomalies matter. Models have a Consistent Cold Bias. Historic trends wrong and Projections Unreliable in CMIP5 models.

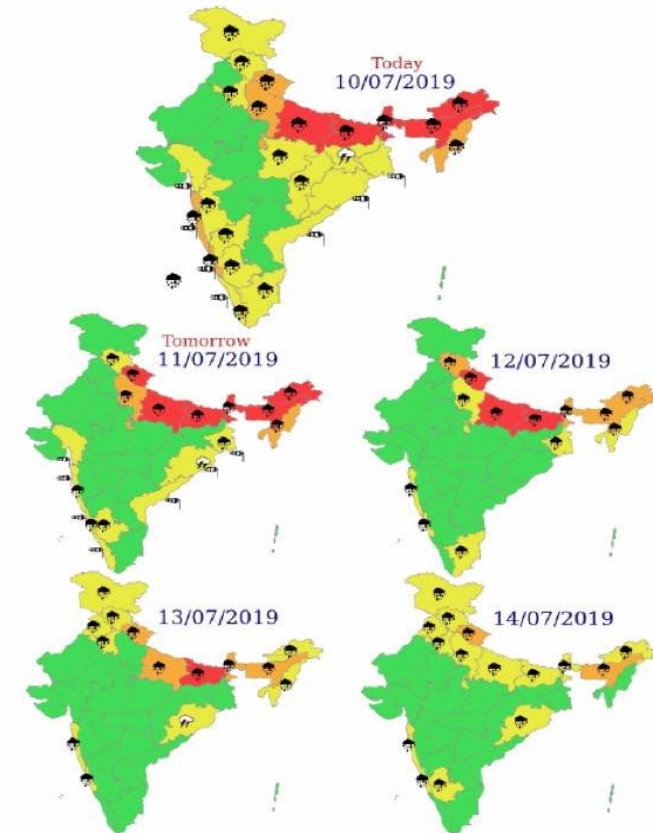
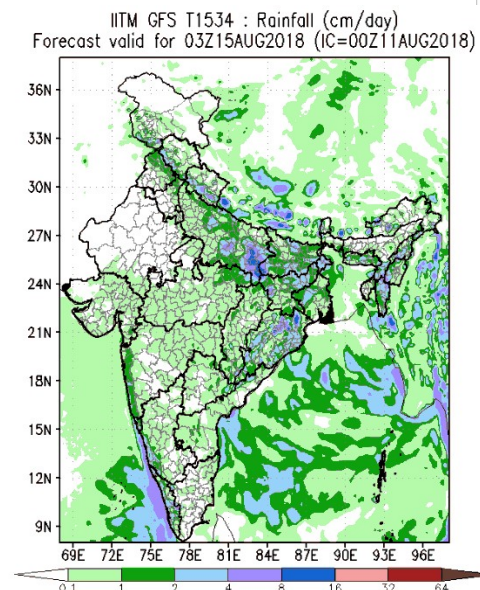
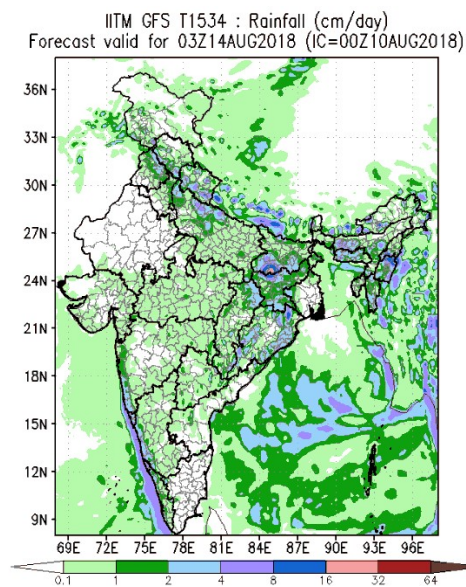
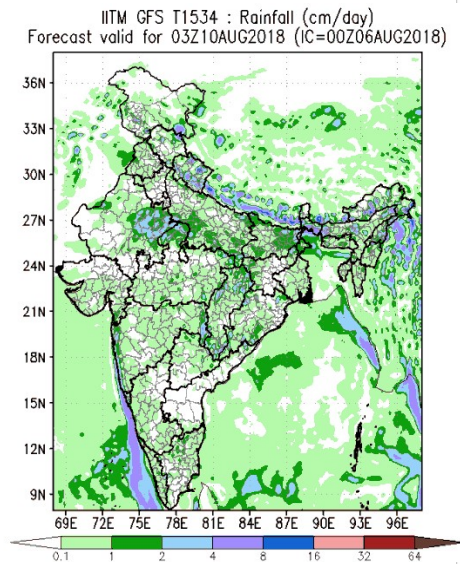
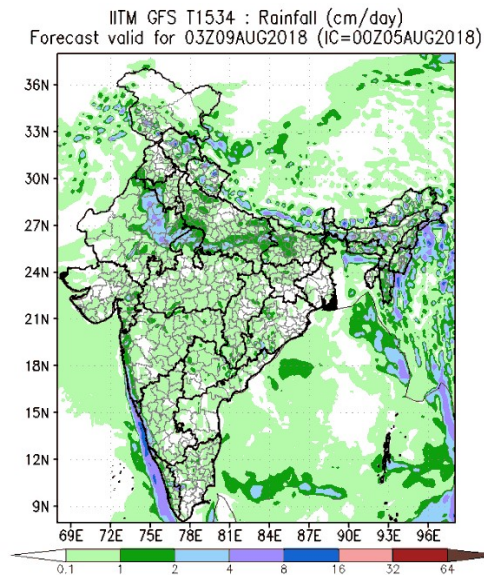
Roxy et al. 2012; Rajeevan & Nanjundiah 2009

SST Bias over the Indian Ocean (5S-10N, 50-100E)

SST Bias over the Indian Ocean (5S-10N, 50E-100E)



# Definitely Good News: Accurate Predictions of Extremes 4-7 Days Ahead!



**Clearly, there is a Long Way to go from Forecasts to Decisions.**

Shreyas Dhavale, Vineet Singh



- **Nonlocal Factors Complicate the Drivers for Adaptation and Mitigation**
- **Improving Predictions and Projections is an Absolute Imperative. S2S – Ready, Set, Go framework must be implemented**

