Intense Rainfall Events in the West Coast of India

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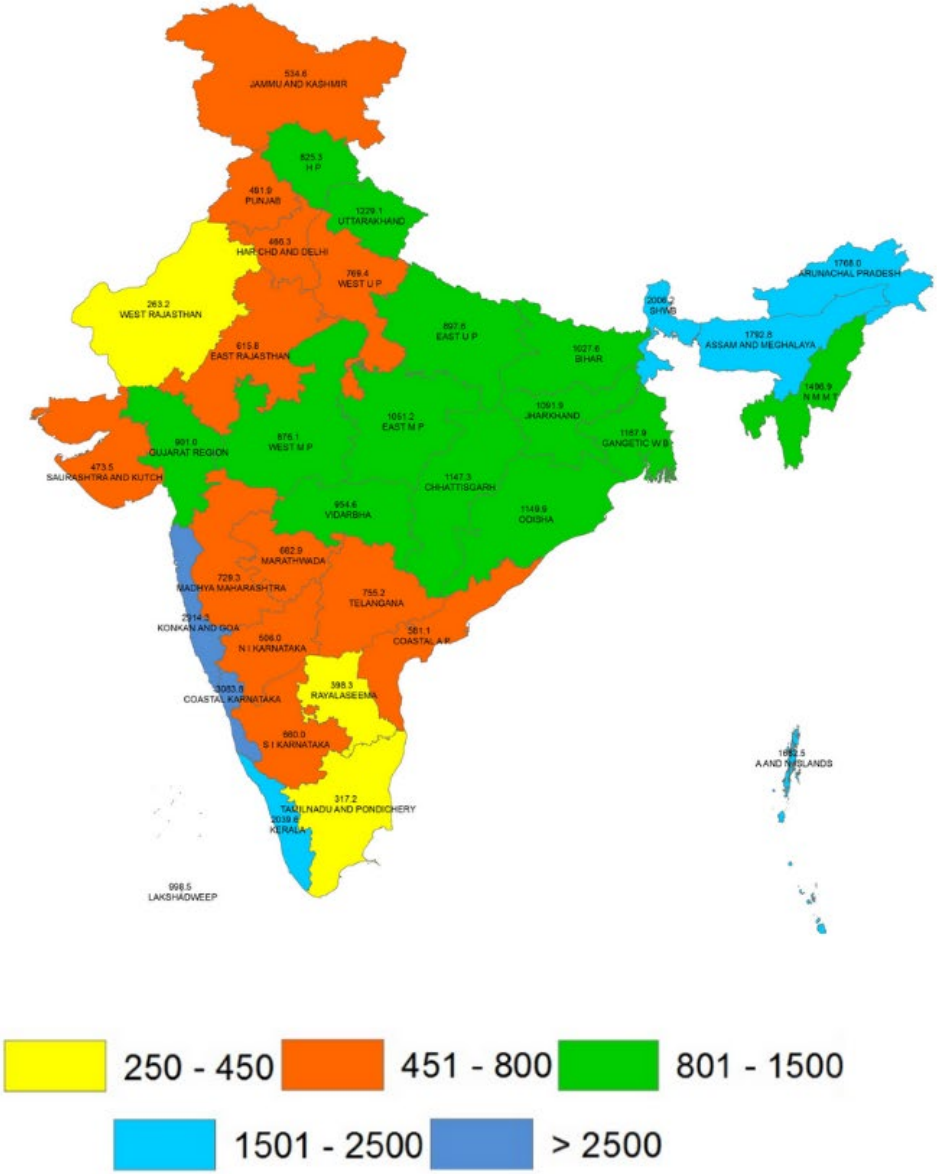
25-28 November 2019

Climatology of subdivisional rainfall (June to September)



All India extreme rainfall statistics (2019)

At least 1 station in a subdivision reported

≥ 20 cm/day: 213 cases

≥ 35 cm/day: 29 cases

≥ 40 cm/day: 19 cases

≥ 45 cm/day: 8 cases

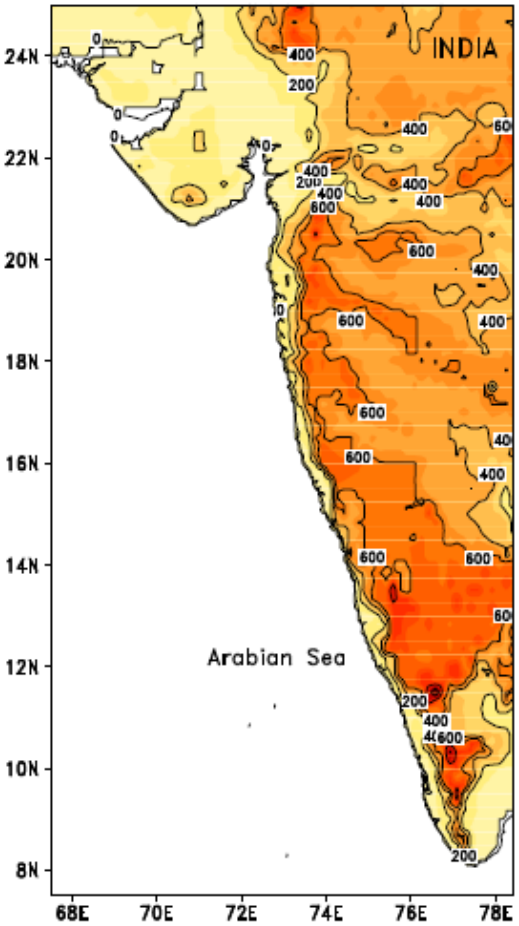
≥ 50 cm/day: 4 cases

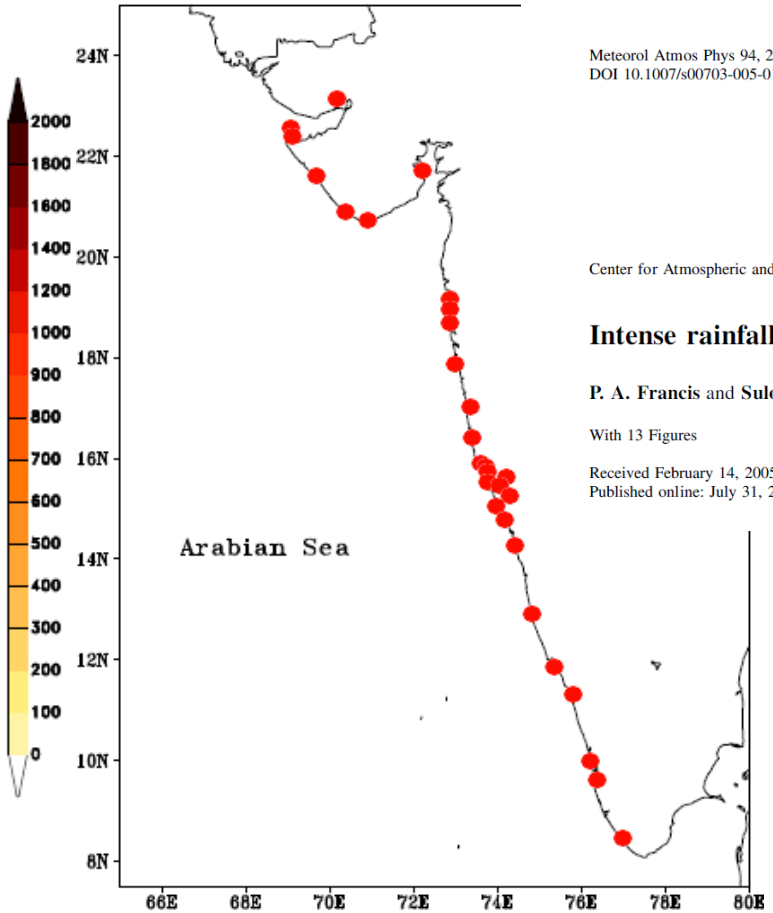
Cases happened in the three subdivisions along the west coast viz., Kerala, Coastal Karnataka and Konkan and Goa

≥ 20 cm/day	: 41 cases
≥ 35 cm/day	: 7 cases
≥ 40 cm/day	: 5 cases
≥ 45 cm/day	: 3 cases
≥ 50 cm/day	: 0 cases

Outline

- Intense rainfall events over the west coast of India: Space-time variation
- Systems associated with intense rainfall events
- Intense rainfall events in the recent years
- Equatorial Indian Ocean Oscillation
- Intense rainfall events and links to convection over the western equatorial Indian Ocean
- Concluding remarks





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Intense rainfall events over the west coast of India

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With 13 Figures

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Daily rainfall data from 30 stations along the west coast, obtained from IMD were used in this sudy

Study was done for the period 1951-1987 (37 years) where data from these stations are available with major data gaps.

Percentage of days in which rainfall occurred above the given threshold at one or more stations

Threshold cm day^{-1}	Percentage of days with rain above threshold	
0.01	99.37	
5	58.15	**2620 days**
10	28.64	**1300 days**
15	11.89	**540 days**
20	05.00	**225 days**
25	01.79	**80 days**
30	00.08	

Total no. of days considered: 4514

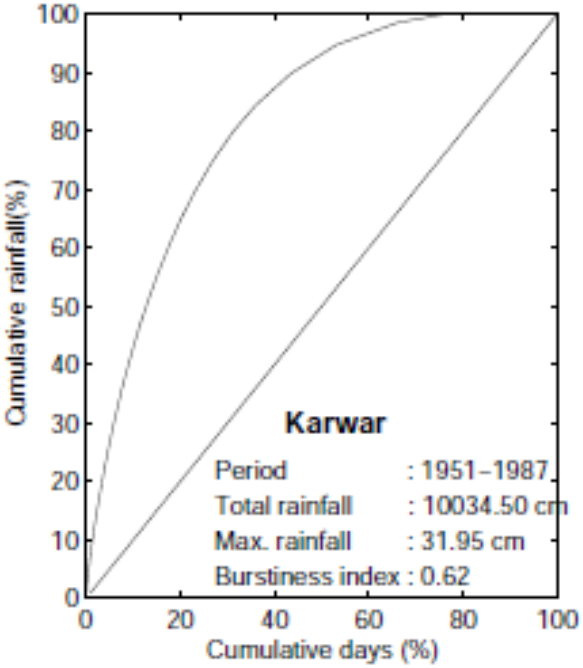
Rainfall statistics for individual stations

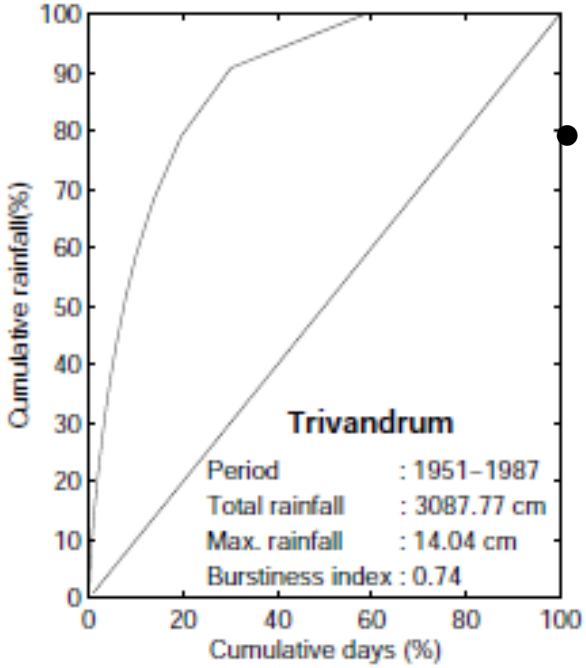
- If we consider individual stations, on an average, rainfall above 20 cm/day, which occur only in about 0.5-1% of days in the season account for about 5-10% of total rainfall!

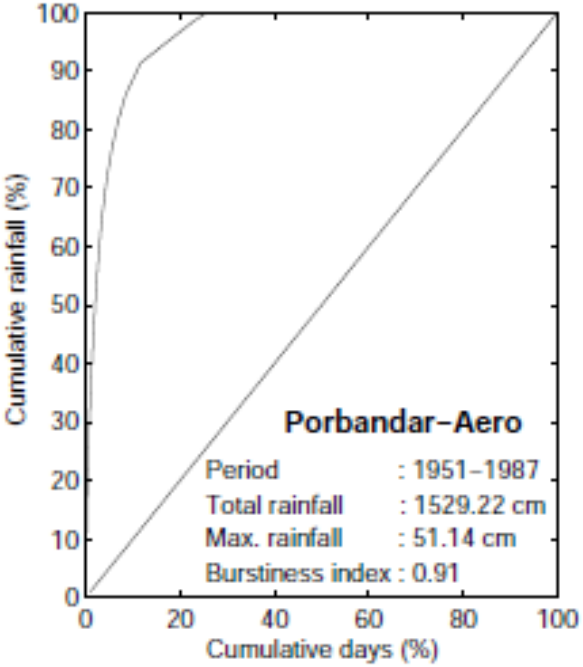
- In some stations, contribution of rainfall above 20 cm/day to seasonal rainfall upto 17%

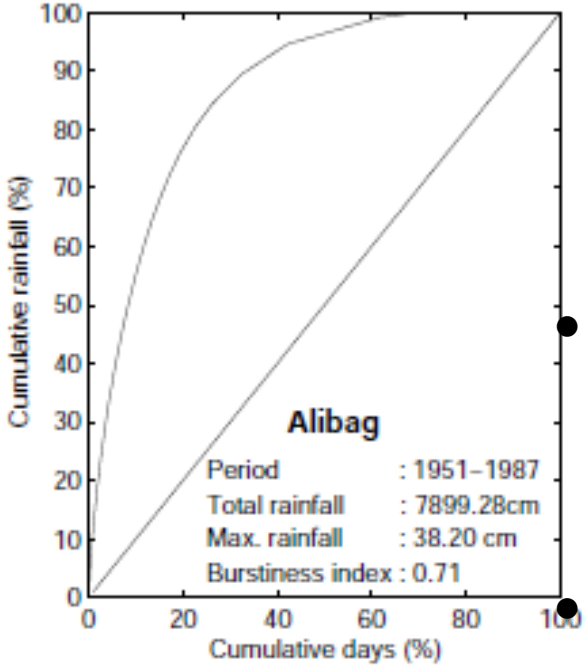
- Low intensity rainfall events (less than 5 cm/day), which occur in about 80-90% days in the season accounts for only about 40-50% total rainfall!

Burstiness index









- If the rainfall in each intensity class contributed equally to the total rainfall, we expect the cumulative rainfall (calculated from intensity class in descending order) to be linearly related to the cumulative days. This is represented as the diagonal line in the graph.
- However, in most stations, rainfall events with large intensity contribute to a large fraction of cumulative rainfall as seen from the curve in the graph which represents the actual distribution of rainfall.
- The ratio between the area under the actual curve to that under the diagonal line is called the ‘burstiness index’
- In Porbandar, extreme events make up most of the rainfall.

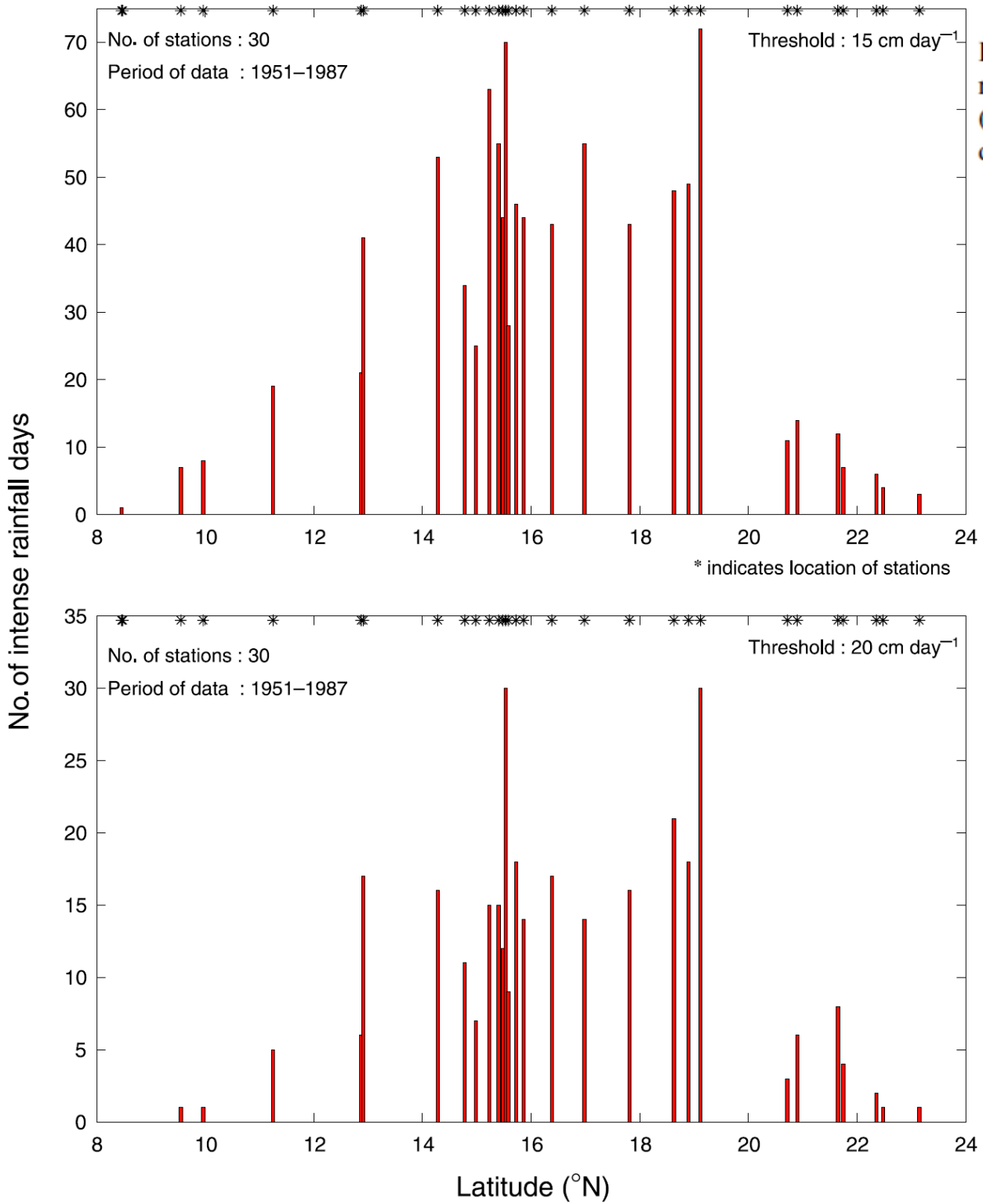
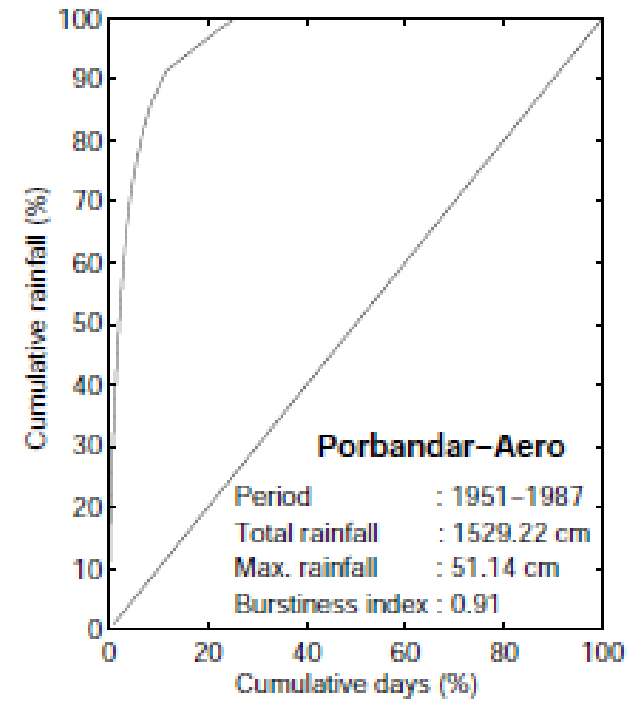


Fig. 4. Variation of the number of days with rainfall above the thresholds of 15 cm day^{-1} (top) and 20 cm day^{-1} (bottom) with latitude during the period 1951–1987

Intense rainfall events are more frequent in Konkan and Goa and Coastal Karnataka compared to other parts of the west coast.



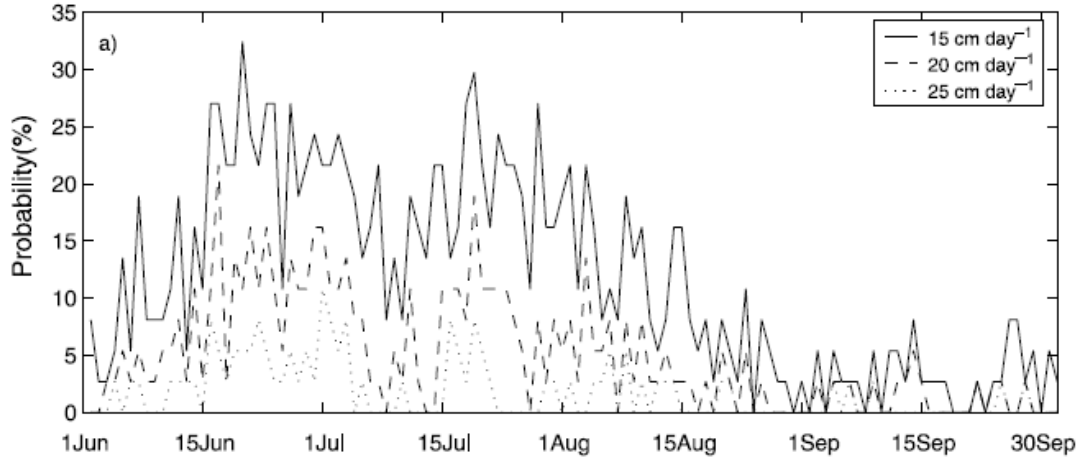
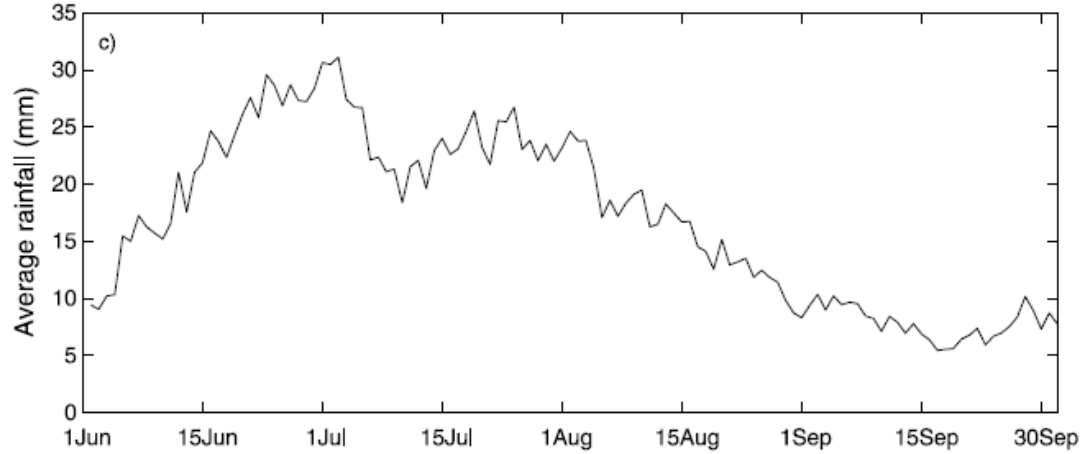


Fig. 3. Daily variation of the fraction of years (expressed as percentage) in which (**a**) one or more stations over the west coast reported rainfall above the specified threshold, (**b**) one or more stations, two or more stations and three or more stations reported rainfall above 15 cm day^{-1}, and (**c**) daily long term mean (1951–1987) rainfall (mm) over the west coast (average for all the stations in Fig. 2)



Probability for intense rainfall events to occur is more in the second half of June and second half of July.

This is consistent with the distribution of mean seasonal rainfall also.

In the period 1975-1987, 100 intense rainfall events occured in the west coast.

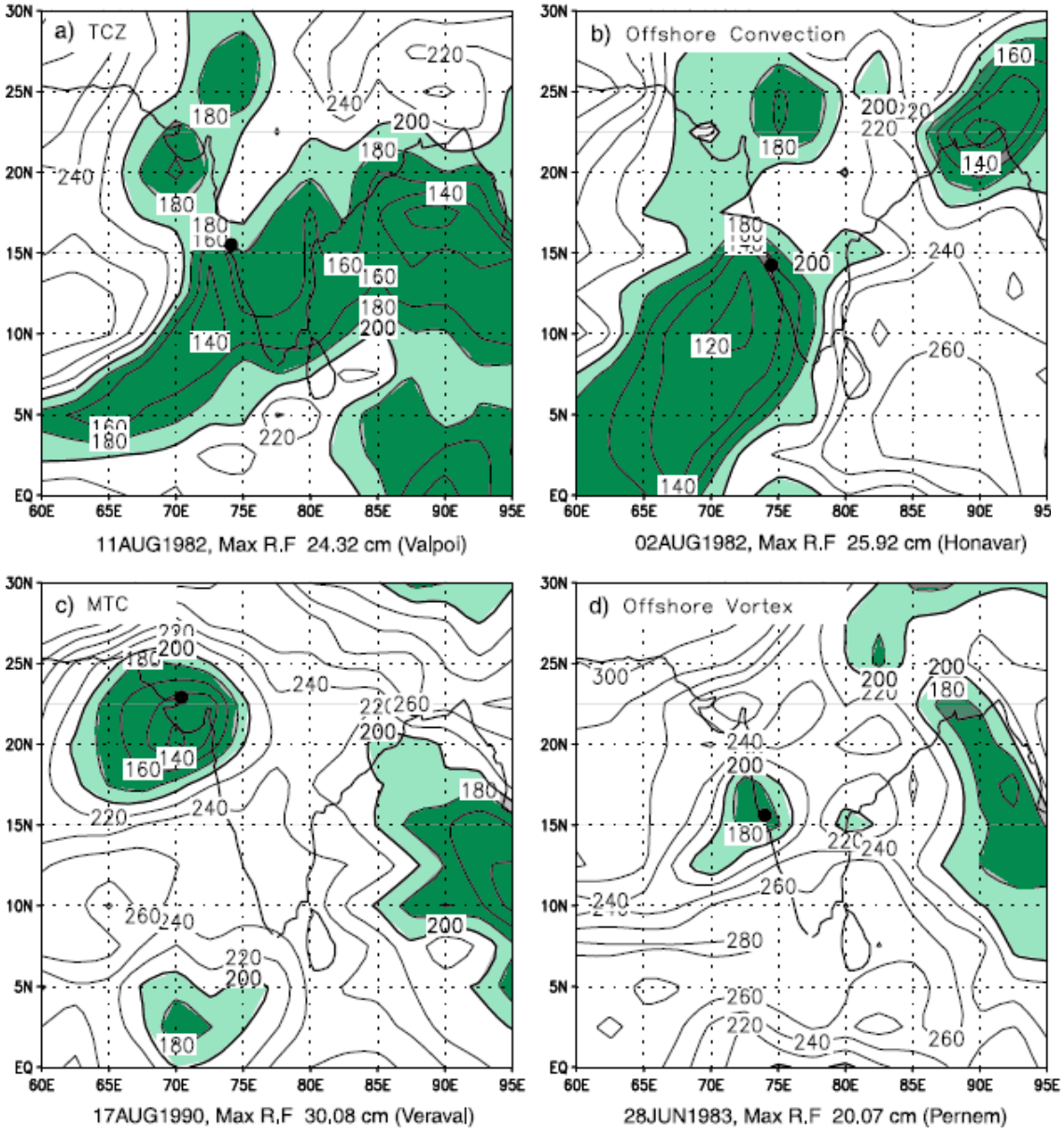


Table 3. Number of intense rainfall events (with rainfall above 20 cm day^{-1}) associated with each class of convective systems

Type of convective system	No. of intense rainfall days associated
TCZ	63
Offshore convection	15
MTC	6
Offshore vortex	1
Offshore convection + TCZ	8
TCZ + MTC	5
Offshore convection + MTC	2

It may be noted that as most of the intense rainfall events are associated with large-scale convective systems, these intense events may not be isolated cases.

It is possible that the nearby stations also recorded high rainfall.

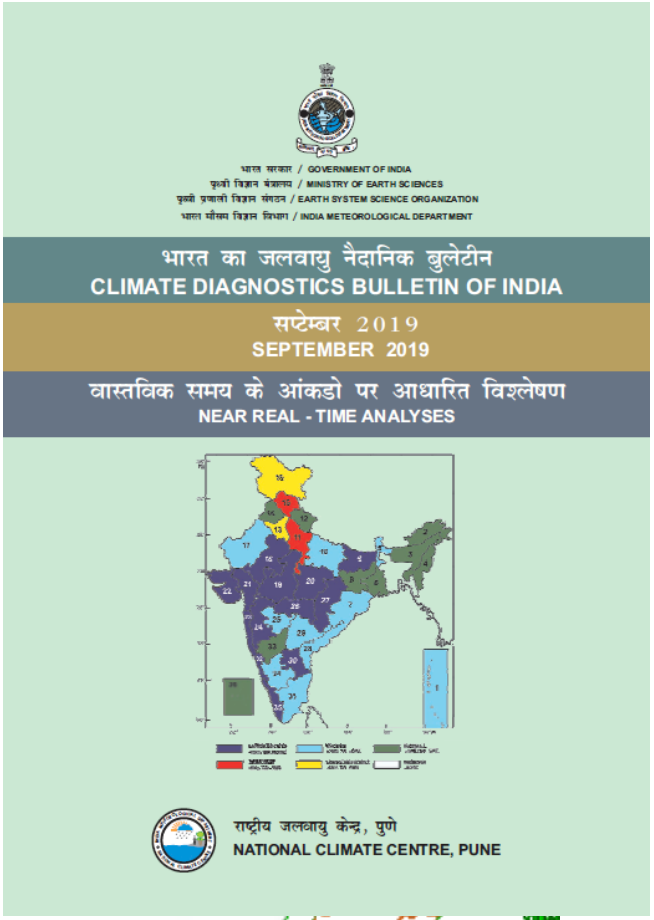
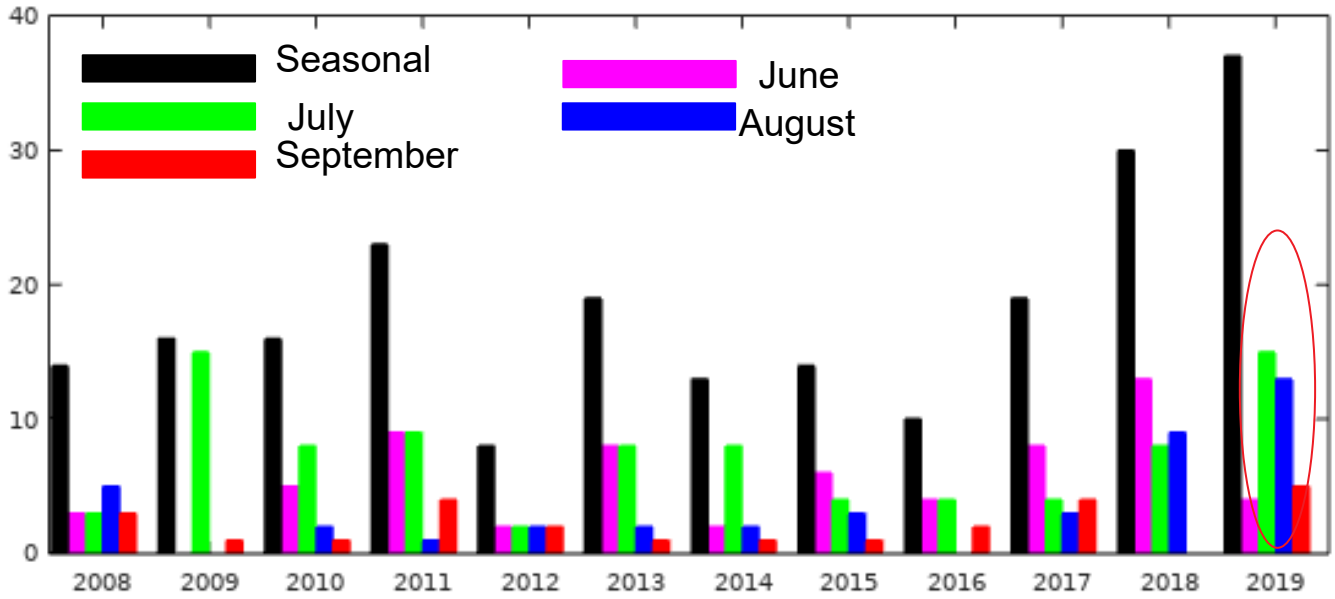


TABLE 2

STATIONS WHICH RECEIVED VERY HEAVY (g.e.12 cm) AND EXTREMELY HEAVY (g.e.21 cm) RAINFALL IN 24 HOURS DURING SEPTEMBER 2019

(Only the stations which received highest rainfall in the subdivision on the given date are mentioned in the table)

DATE	STATION NAME	NAME OF SUBDIVISION	RAINFALL (cm)
	BELPADA Arg	ORISSA	22

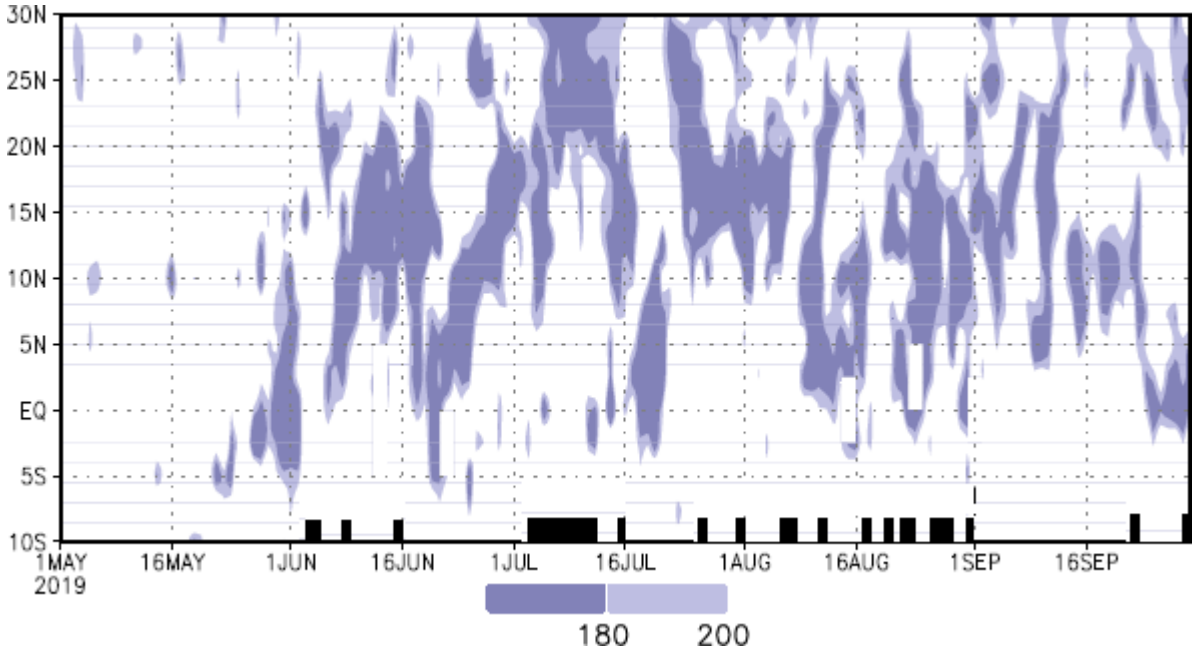


Number of intense rainfall events during 2008 to 2019*.

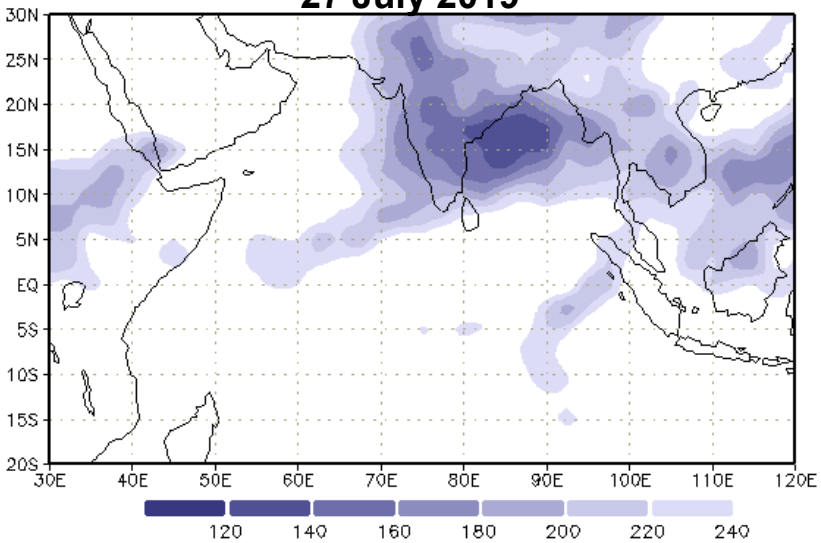
Note: If multiple stations recorded above 20 cm/day rain in a given day, only the station which received highest rain is counted.

If multiple subdivisions have recorded more than 20 cm/day rainfall, they are considered as a single event

Latitude-time section of Outgoing Longwave Radiation (2019)



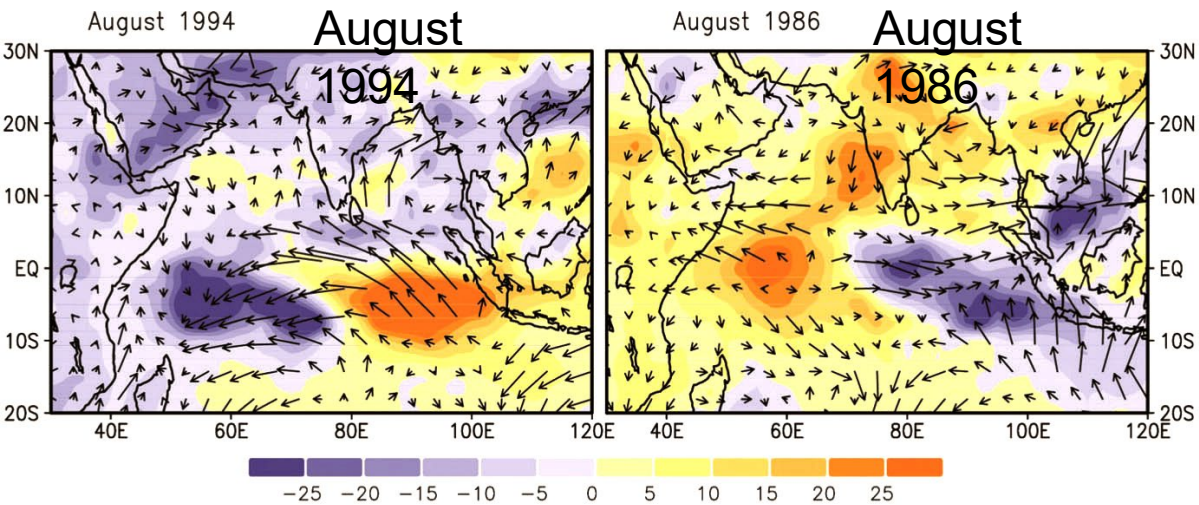
27 July 2019

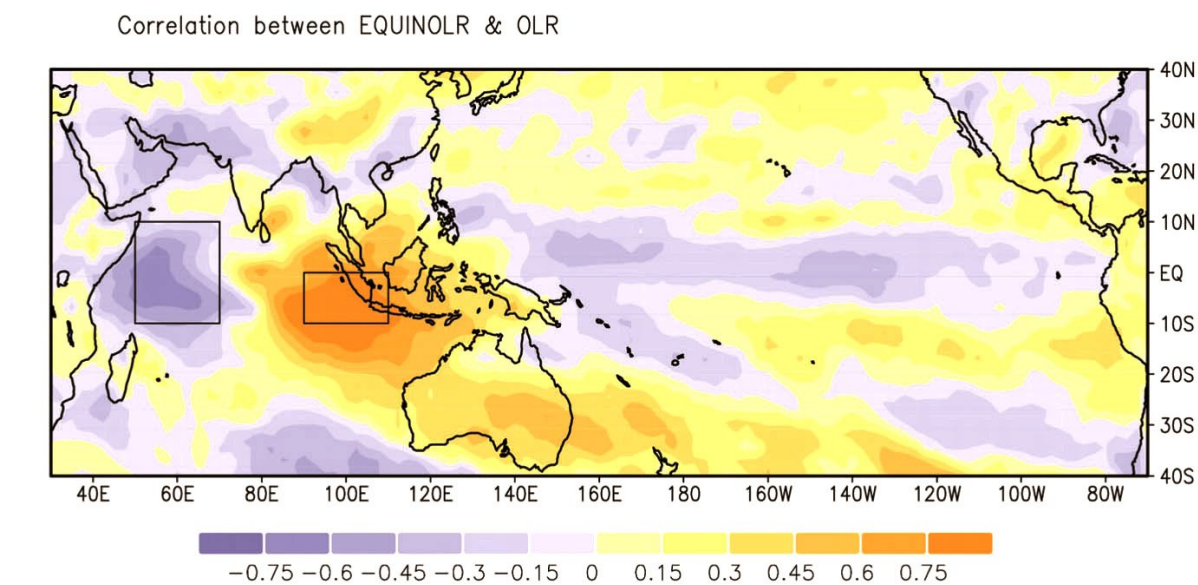


- **The intense rainfall events in the west coast in 2019 are linked to large-scale convective patterns and on most of the occasions, convection over the Bay is high on these days.**

- **On many occasions, the intense rainfall events over the west coast are linked to convection over the western equatorial Indian Ocean.**

The Equatorial Indian Ocean Oscillation (EQUINOO)



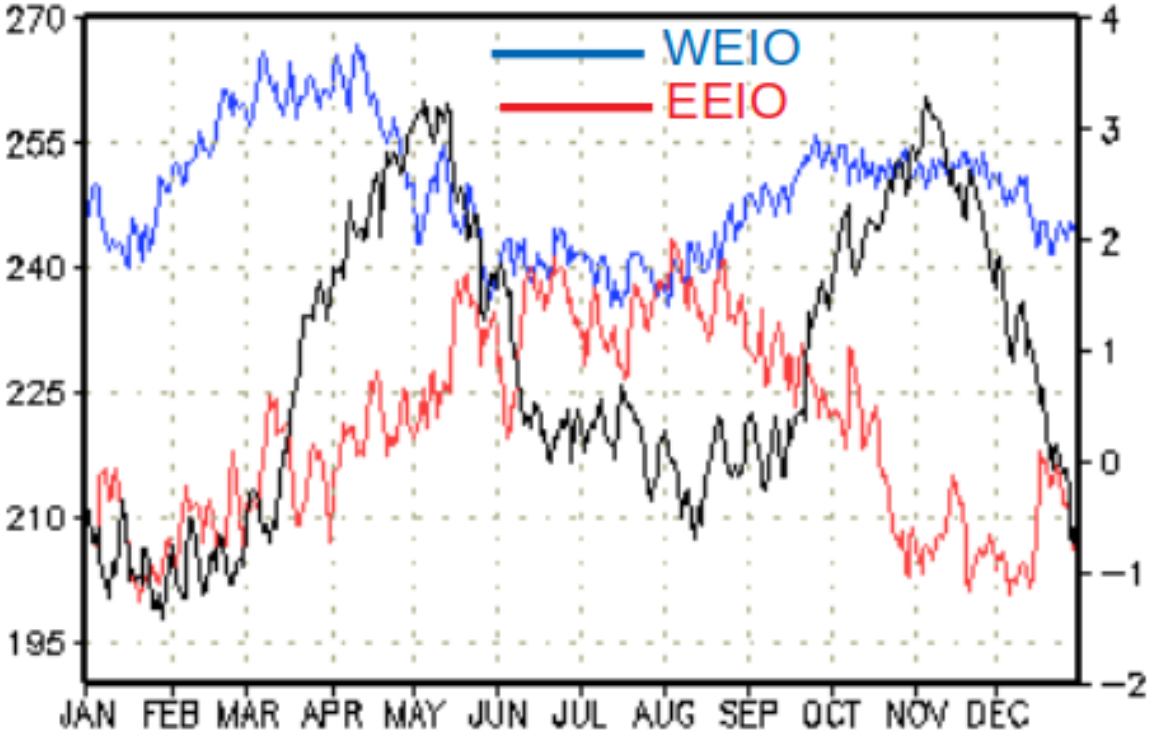


Pattern of correlation between OLR over the EEIO and OLR everywhere.

- **EQUINOO involves an oscillation between a phase in which convection over the west equatorial Indian Ocean (WEIO) is enhanced and that over the east equatorial Indian Ocean (EEIO) is suppressed in the positive phase and with OLR anomalies of the opposite sign over WEIO and EEIO in the negative phase.**

- **Associated with the convection anomalies, anomaly of the zonal component of surface winds over the central equatorial Indian Ocean is easterly in the positive phase and westerly in the negative phase of the EQUINOO**

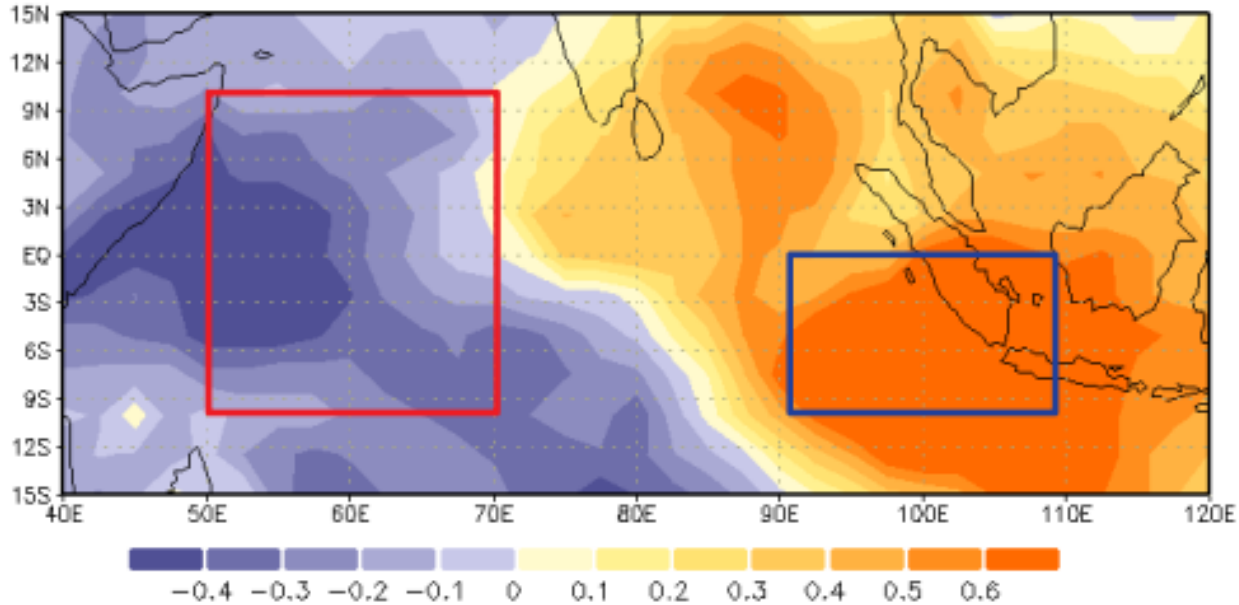
- **For analysis of the EQUINOO in the satellite era, we use an index, EQUINOLR, based on the difference of OLR averaged over the eastern and western equatorial Indian Ocean, so that positive values of EQUINOLR indicate a phase of the EQUINOO which is favourable for monsoon**



Climatologically, average OLR over the EEIO and WEIO are not very different.

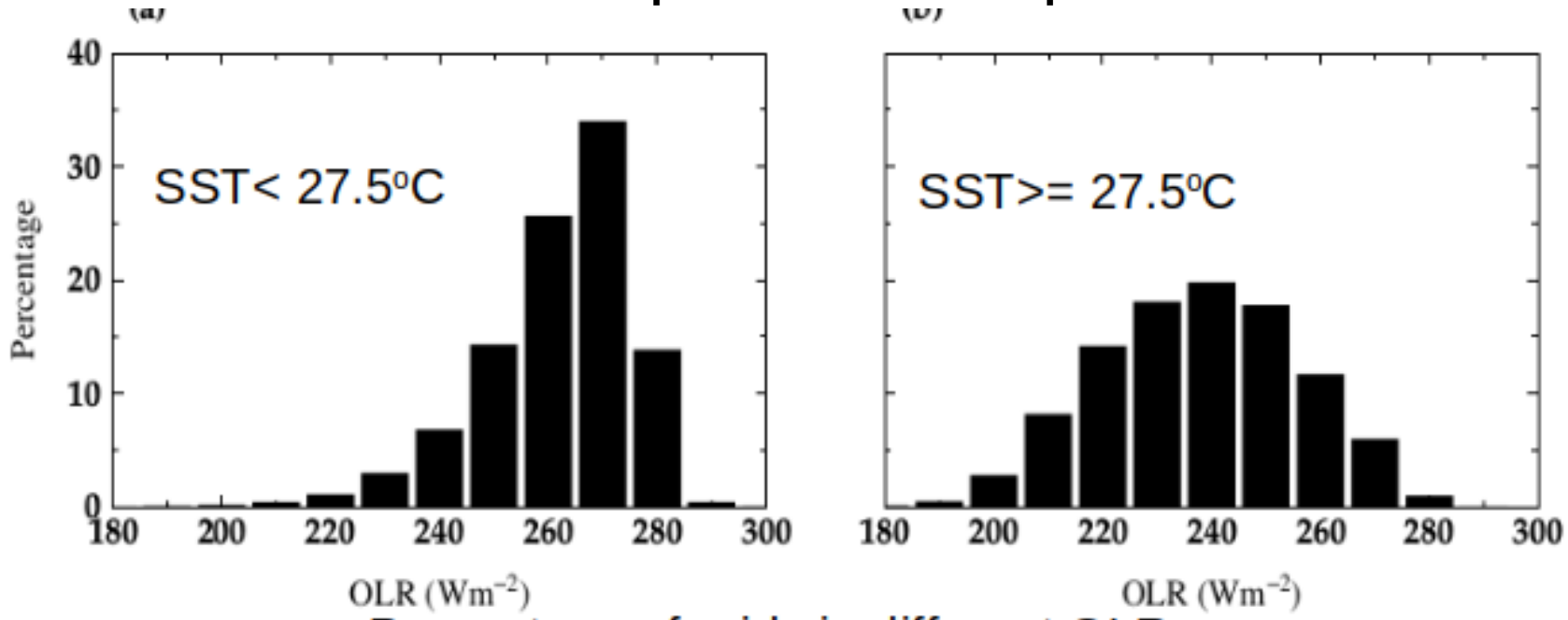
Convection over the WEIO is unfavourable for convection over the EEIO and vice-versa.

Climatologically, along with increased convection, the SST of WEIO decreases very fast.

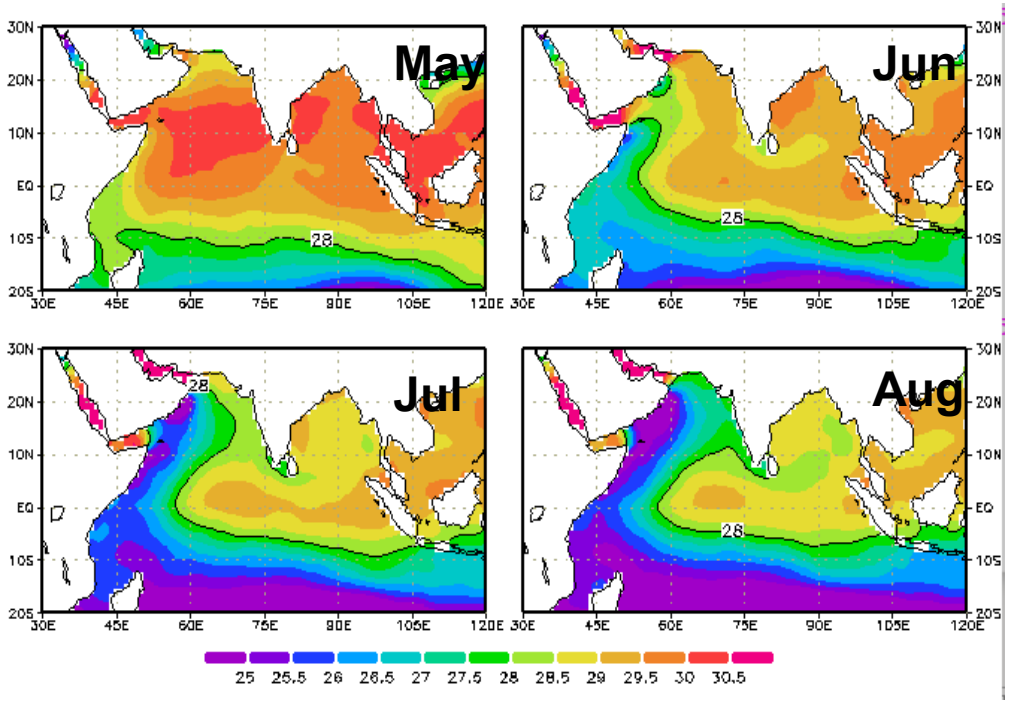


JJAS correlation between OLR over the EEIO and OLR everywhere

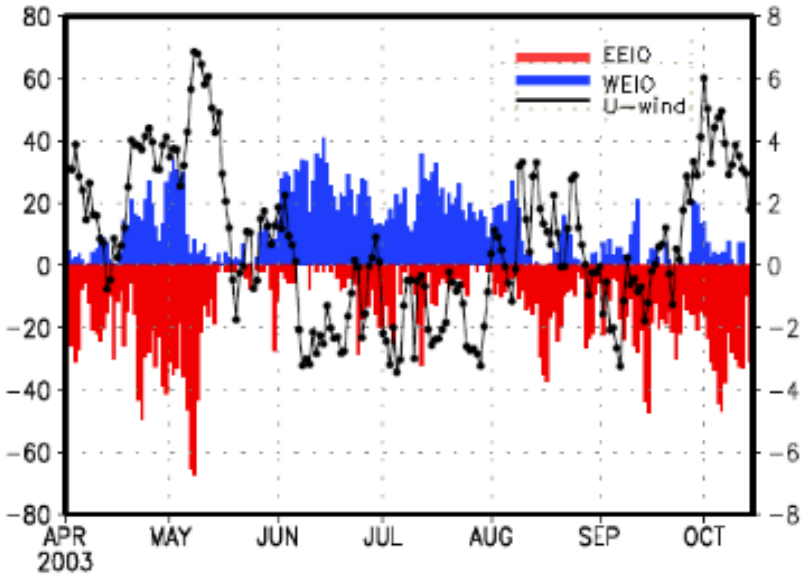
SST Convection relationship in the western equatorial Indian Ocean



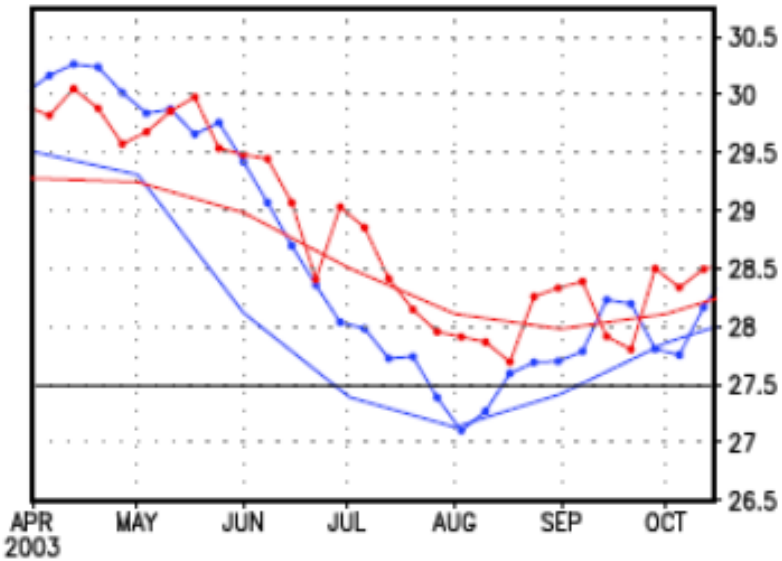
SST remaining above 27.5 ^{0}C is important for maintaining convection over the WEIO



- Climatologically, SST in the equatorial Indian Ocean is more or less uniform in May, but SST in the WEIO drops rapidly with progress of Monsoon.
- SST in the WEIO is mainly determined by the air-sea fluxes (Vinayachandran et al. 2002)



Convective Index of EEIO and WEIO and surface wind over CEIO



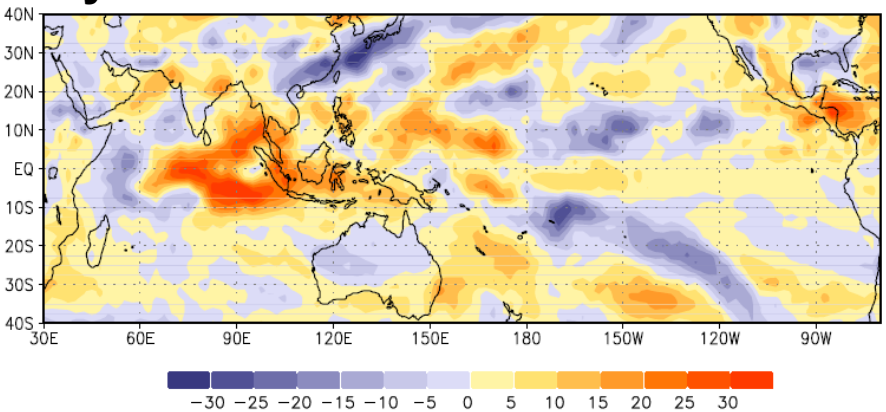
SST of EEIO and WEIO

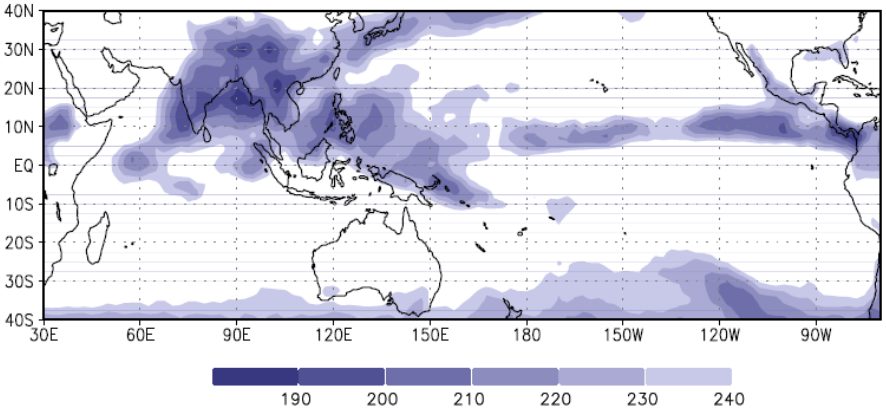
If the SST drop below 27.5°C in the WEIO, convection ceases rapidly.

Convective Index of a region: Sum of 200-OLR of every grid point where the OLR is below 200 Wm^{-2}

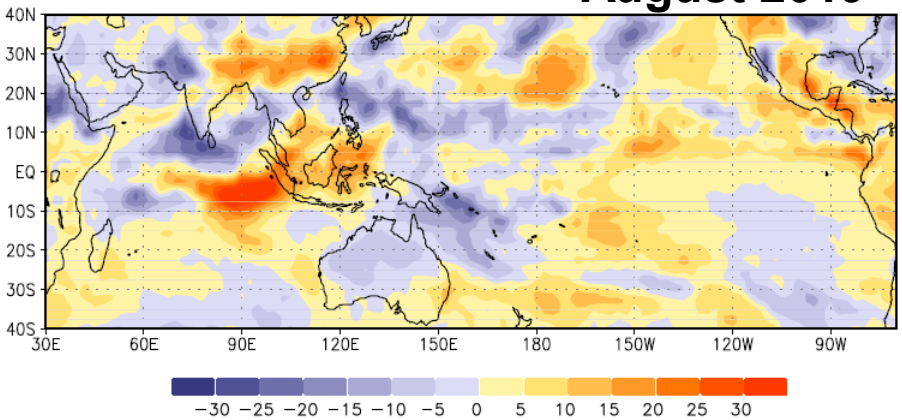
Latitude-time section of Outgoing Longwave Radiation

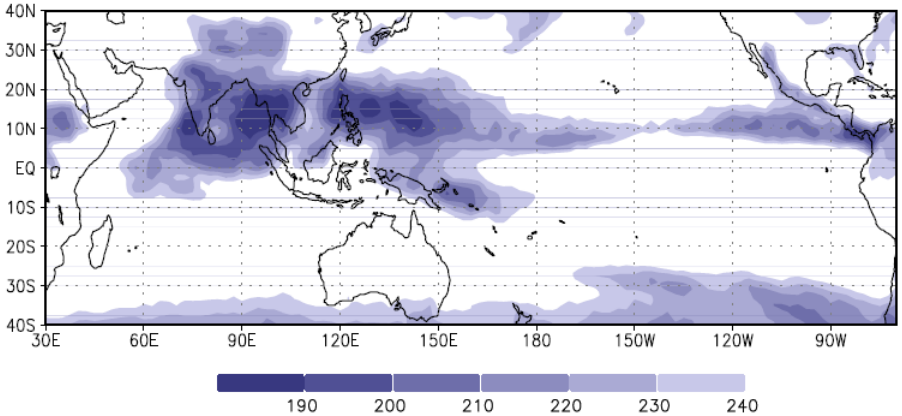
July 2019





August 2019





Summer monsoon of 2019: understanding the performance so far and speculating about the rest of the season

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[2]Indian National Centre for Ocean Information Services (Ministry of Earth Sciences, Government of India), Hyderabad 500 090, India

Monsoon and EQUINOO: validation of the educated guess for the season of 2019

Received

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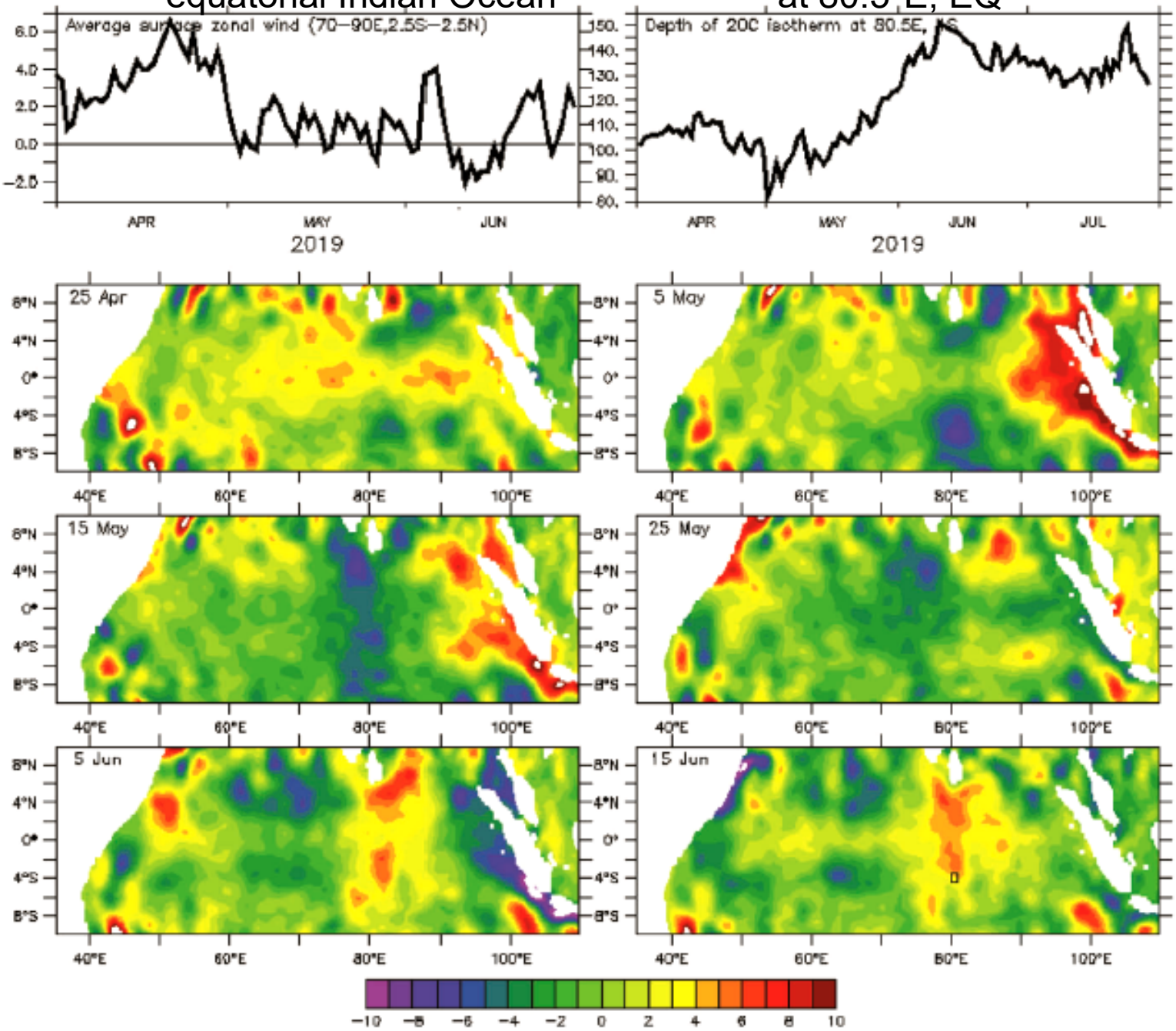
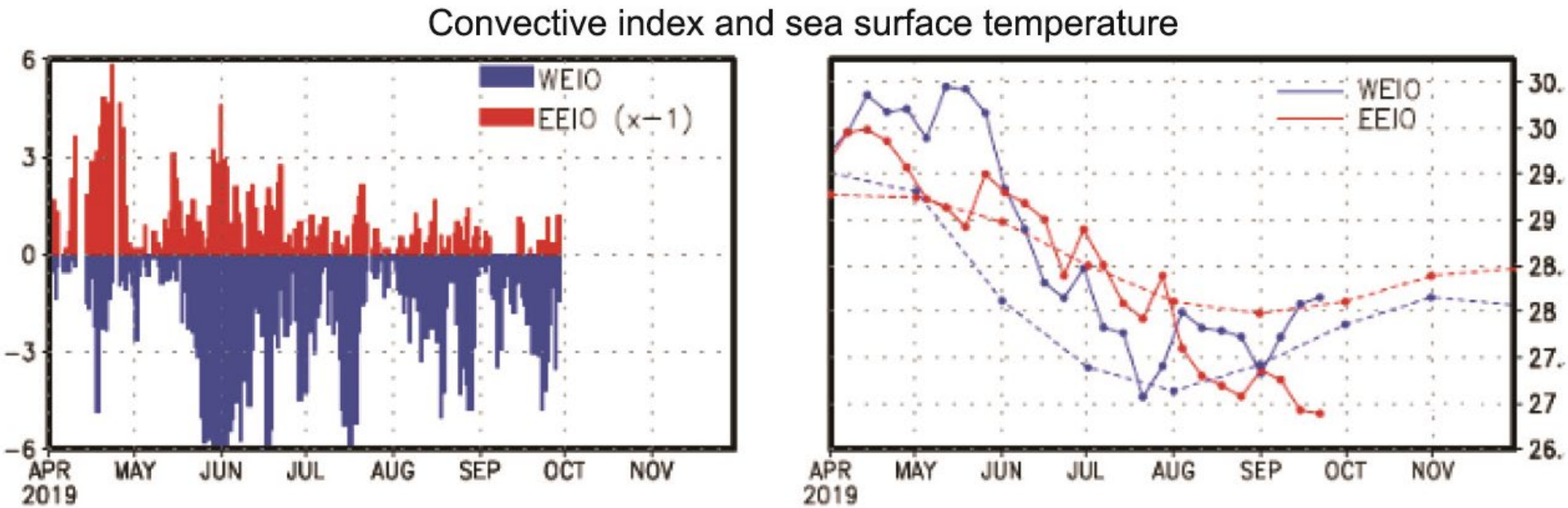
P. A. FRANCIS[2]
P. N. VINAYACHANDRAN[1]

Wind over the central equatorial Indian Ocean

Depth of 20 ^{0}C isotherm at 80.5^{0}E, EQ



Evolution of sea level anomaly in the equatorial Indian Ocean.

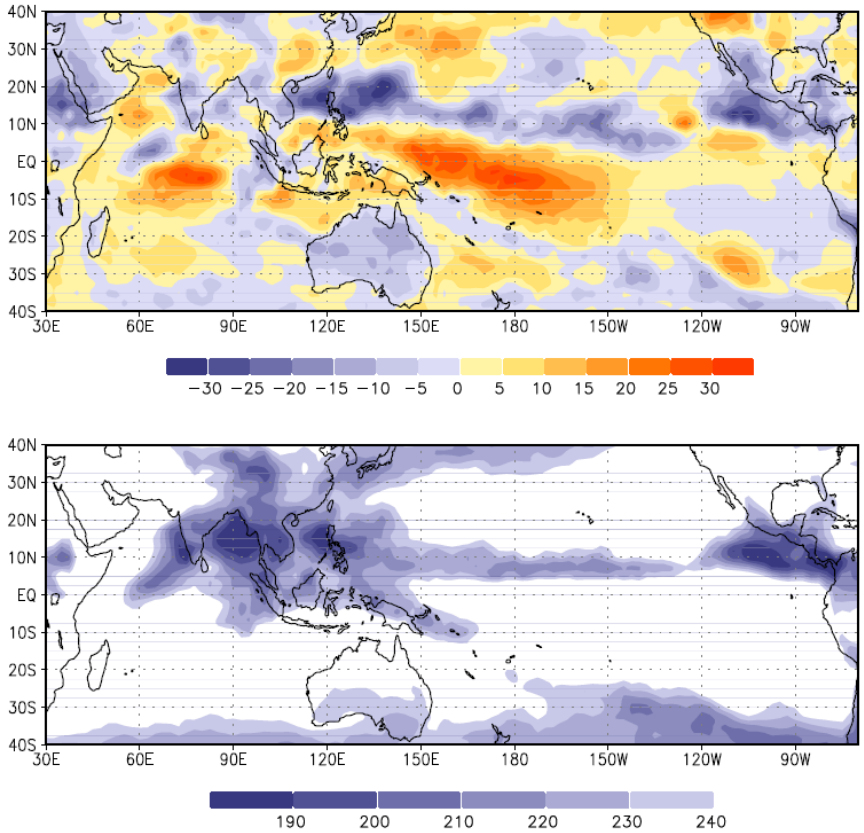


Evolution of convection and SST in the WEIO and EEIO

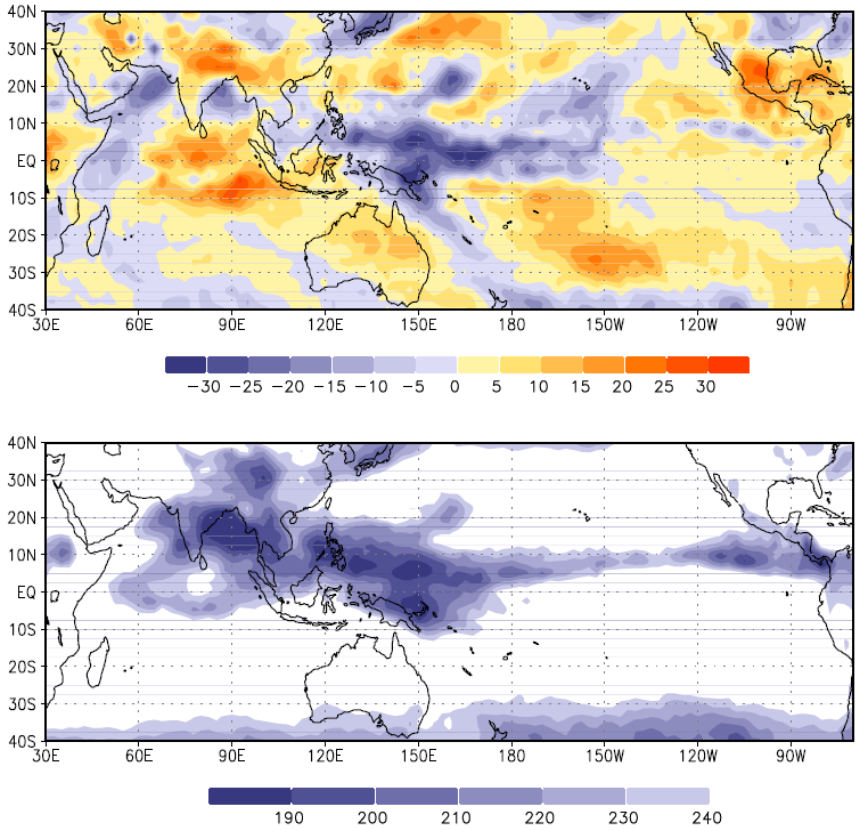
Convection over the WEIO sustained till the end of the season; SST remained above the threshold for deep convection, while the convection over the EEIO remained suppressed and SST remained below normal (and threshold for deep convection) in 2019.

Latitude-time section of Outgoing Longwave Radiation

June 2018



July 2009



Conclusions

- 20 cm day^{-1} can be considered as a reasonable threshold for intense rainfall events in the west coast of India.
- In many stations, intense rainfall events contribute significantly to the seasonal rainfall.
- Most of the intense rainfall events in the west coast are associated with large-scale convection patterns.
- A strong link between the convection over the west coast and that over the WEIO is seen during the months with several intense rainfall events in the west coast.
- Hence, it is important to understand and predict the ocean-atmosphere processes leading to enhanced convection over the WEIO.

Thank you

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