

Influence of Tropical Ocean Basins on the Interannual Variability of Indian Summer Monsoon Rainfall during three recent epochs

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1. Introduction

- The Indian summer monsoon rainfall (ISMR: June to September) plays a significant role, due to its direct impact on agriculture and the economy (Gadgil and Gadgil, 2006).
- El Niño-Southern Oscillation (ENSO); an ocean-atmosphere coupled system, is one of the drivers that strongly modulates the variability of ISMR (Kirtman & Shukla, 2000).
- Apart from the influence of the Pacific Ocean, the influence of the Indian and Atlantic Ocean on ISMR is also important to understand (Gadgil, Vinayachandran and Francis, 2003).

2. Objective

- To understand the epochal variations in the interannual relationship between ENSO and ISMR.
- To understand the contribution of India Ocean and Atlantic Ocean in modifying the ENSO-ISMR interannual relationship over the four homogenous regions of India (North-west, North-East, Central and South peninsular India).

3. Data

Sr. No.	DATA SET
1.	Extended reconstructed Monthly SST (ERSSTv5) ($2^{\circ} \times 2^{\circ}$), (https://psl.noaa.gov/data/gridded/data.noaa.ersst.v5.html) National Oceanic and Atmospheric Administration (NOAA) (Huang et al., 2017)
2.	Monthly rainfall ($0.25^{\circ} \times 0.25^{\circ}$) for Indian region by India Meteorological Department (Pai et al., 2014).

4. Methodology

- To understand the epochal variations of the ENSO-ISMR relationship and the role of other tropical oceans (Indian Ocean and Atlantic Ocean) this study considered three different periods (P-I: 1961-1980; P-II: 1981-2000; P-III: 2001-2023).

4. Methodology (Contd.)

- We have considered four SST Indices from three tropical Oceans to see their lead-lag correlation with ISMR.

List of SST indices from the three Tropical (Pacific, Atlantic and Indian) Oceans			
Sr. No.	Tropical Pacific Ocean	Region	Reference
1.1	Nino3.4 Index	(5°N-5°S, 170°W-120°W)	
1.2	Central Pacific (CP) ENSO	1.7 (Nino4) - 0.1 (Nino1+2)	Takahashi et al, 2011
1.3	Eastern Pacific (EP) ENSO	(Nino1+2) - 0.5 (Nino4)	Nino4 Index (5°N-5°S, 160°E-150°W) Nino1+2 Index (0-10°S, 90°W-80°W)
1.4	Trans Nino Index (TNI)	(Nino1+2) - (Nino4)	Trenberth and Stepaniak, 2001
Tropical Indian Ocean			
2.1	North Indian Ocean (NIO) Index	(5°N-30°N and 50°E-70°E)	Sharma et al, 2024
2.2	Western Equatorial Indian Ocean (WEIO) Index	(10°S-10°N and 50°E-70°E)	
2.3	Eastern Equatorial Indian Ocean (EEIO) Index	(10°S-0° and 90°E-110°E)	
2.4	Dipole Mode Index (DMI)	(WEIO)ano - (EEIO)ano	
Tropical Atlantic Ocean			
3.1	North Tropical Atlantic (NTA) Index	(55°W - 15°W, 5°N - 25°N)	Enfield et al. (JGR, 1998)
3.2	South Tropical Atlantic (STA) Index	(30°W - 10°E, 20°S - 0°)	Enfield et al. (JGR, 1998)
3.3	Atlantic Nino (ATL3) Index	(20°W-0°, 3°S-3°N)	Bi et al, 2022
3.4	Atlantic Zonal Mode (AZM) Index	(5°S to 3°N, 20°W to 10°E)	Sabeerali et al, 2019

5. Results

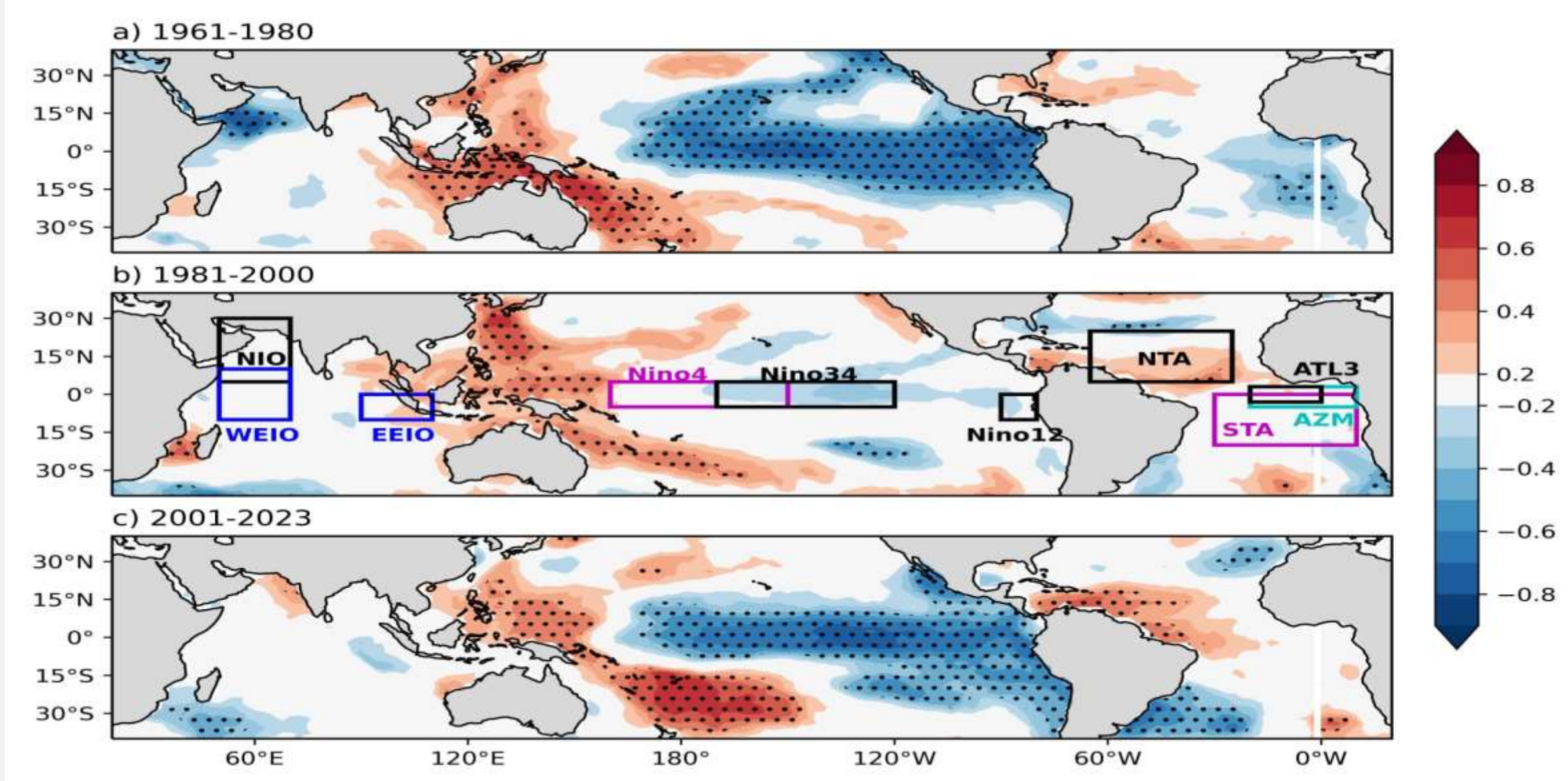


Fig.1: Simultaneous Pearson's correlation of ISMR with tropical Ocean SST anomaly during a) P-I, b) P-II and c) P-III. Rectangular boxes in b) represent various regions used to calculate the SST anomaly indices over the tropical Oceans.

5. Results (Contd.)

Based on the lead-lag correlation, we analyzed the role of North Indian Ocean (NIO) and South Tropical Atlantic Ocean (STAO) SST on ISMR.

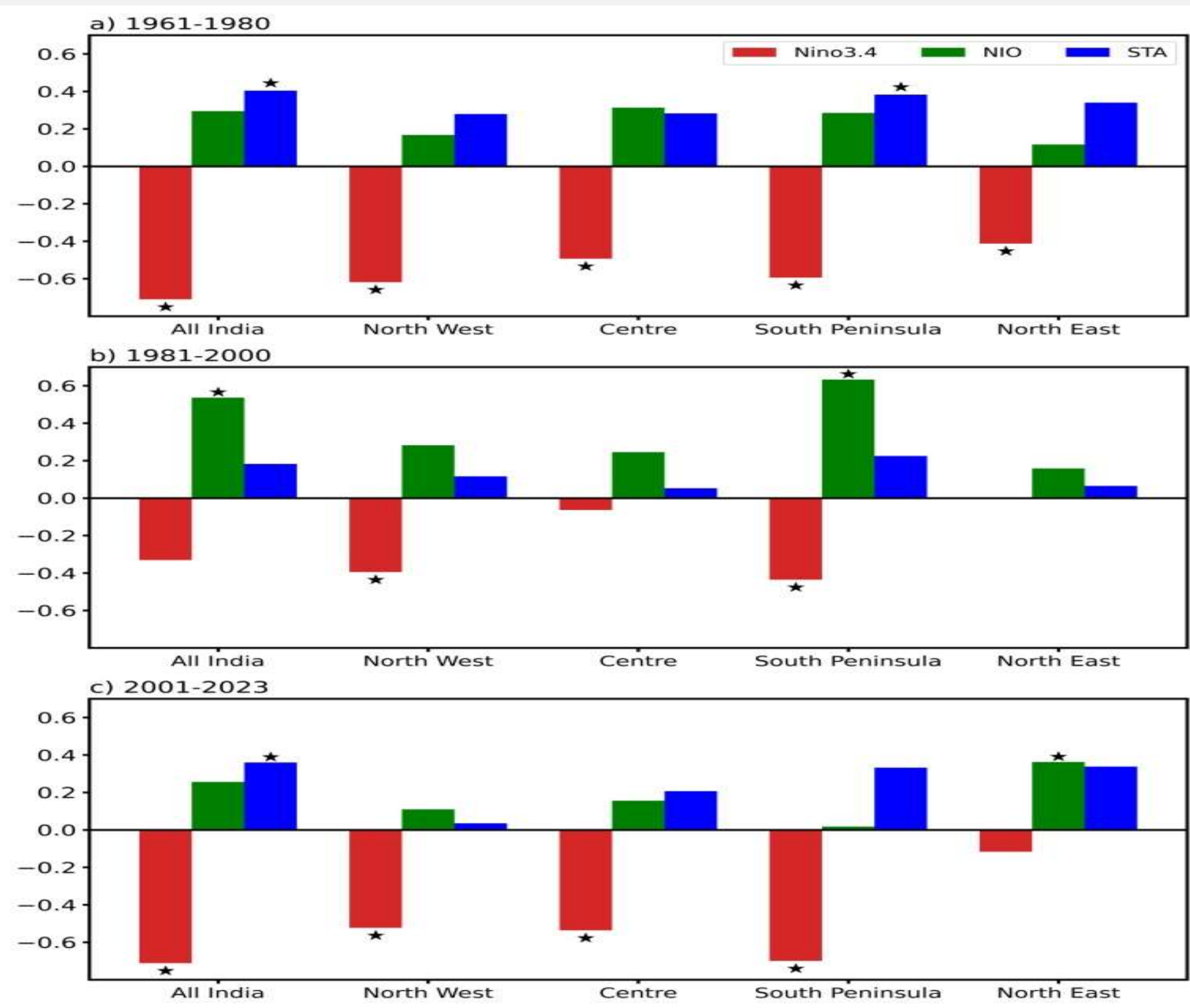


Fig.3: Pearson's correlation between tropical SST indices (Nino3.4: June to September season, NIO: Preceding October to January season, STA: preceding October to January season) and ISMR (June to September season) during a) P-I, b) P-II and c) P-III. Stars represent statistically significant correlation with 90% confidence level, based on Student's t-test.

6. Conclusion

- The analysis showed a significant simultaneous correlation between ENSO and ISMR during P-I and P-III whereas insignificant correlation during P-II.
- During P-II, the role of NIO became important, particularly over the south peninsular India.
- During P-III, the influence from the NIO has reduced, at the same time the role of STAO became crucial.

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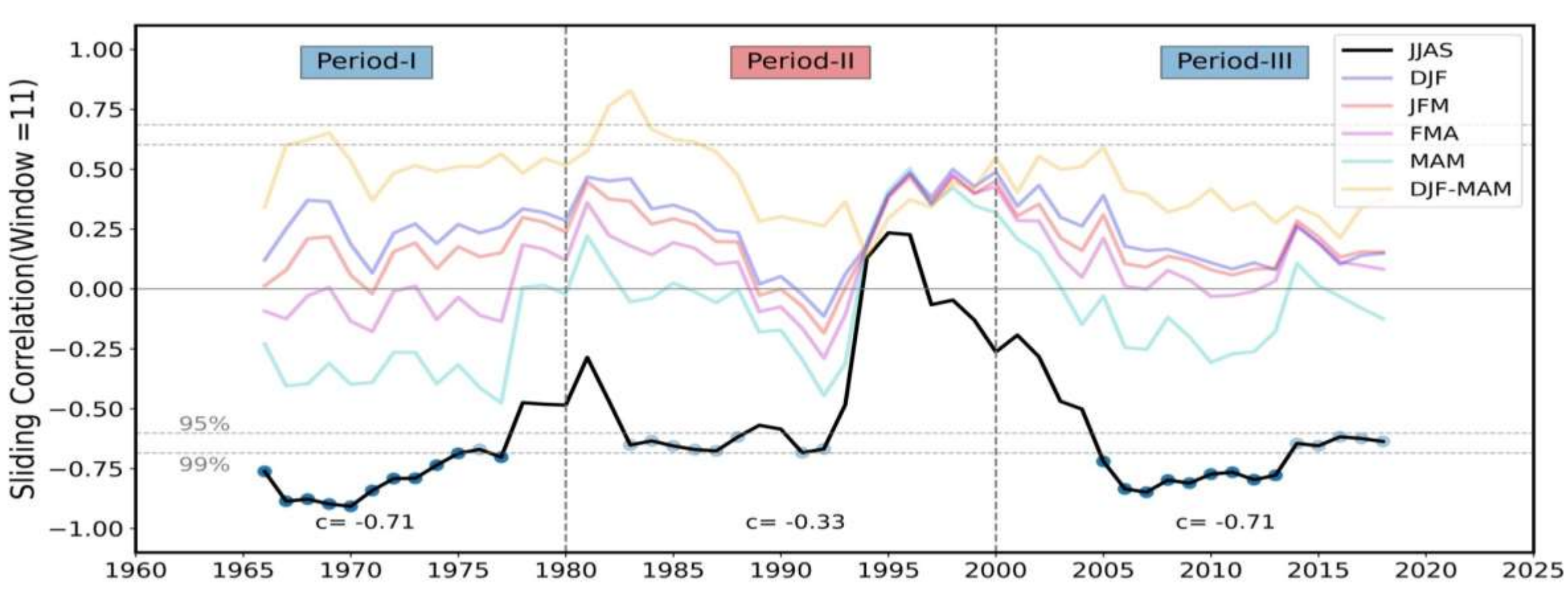


Fig.2: Lead-lag correlation of ISMR with tropical Ocean (Pacific, Indian and Atlantic Ocean) SST indices during periods P-I, P-II and P-III.