

3rd Summer School on Theory, Mechanisms and Hierarchical Modeling of Climate Dynamics: Tropical Oceans, ENSO and their teleconnections

Introduction to Week 2

David M. Straus

ENSO teleconnections continue to be an area of very active research. They include not only effects on the circulation over the mid-latitudes (Europe, Asia, North America, South America), but also a strong influence on the Asian Monsoon. The Monsoon also has its own set of teleconnections not all of which are related to ENSO. It will be very helpful for researchers and students alike to learn the latest advances in the understanding of ENSO dynamics and its broad range of teleconnections. One emphasis of this workshop will be the Asian Monsoon, which is a complex phenomenon of great importance to the regional agriculture and hence to the well-being of a very significant population. In recent years there has been an advance in understanding of how the Monsoon is affected by, and interacts with, the tropical ocean basins, the adjoining land masses, mid-latitudes and the stratosphere.

THE LECTURES (part 1)

- **An Overview of pathways of ENSO influence on the extra-tropics** (In-Sik Kang)
- **A Review of Three-Ocean Interactions and Climate Variability** (Chunzai Wang)

- **High-Frequency ENSO during the AMOC slowdown in the North Atlantic freshwater hosing experiment using atmosphere-ocean coupled general circulation model CCSM** (Siswanto Siswanto)
- **Impact of tropical SSTs on the predictable components of the late-winter atmospheric circulation in the North Atlantic-European region** (Sara Ivasic)

- **Monsoons, ITCZs and the concept of the global monsoon** (Simona Bordoni)
- **A review of the influence of the Indian Ocean Dipole on the Indian summer monsoon and ENSO** (Annalisa Cherchi)

- **Modelling-robustness of the past and future forced changes of the ENSO-Indian summer monsoon teleconnection** (Aneesh Sundaresan)
- **A web of Teleconnections: Methods for Isolating Climate-Driver Signals and Understanding Their Societal Impacts** (Anne Laurel Disera)
- **Teleconnection of ENSO in South Asian monsoon and relative influence of the Indian Ocean** (V. Krishnamurthy and J. Shukla)

THE LECTURES (part 2)

- **Results of ENSO & Indian Ocean influence on South Asian Monsoon from 50 years of simulations with a large ensemble** (Erik Swenson)
- **Nonstationarity and Potential Multi-Decadal Variability in Indian Summer Monsoon Rainfall and Southern Annular Mode Teleconnection** (Pushpa Pandey)
- **Information Entropy as Quantifier of Potential Predictability in the Tropical Indo-Pacific Basin** (James Olawale Ikuyajolu)
- **Dominant controls of Cold-season precipitation variability over the high mountains of Asia** (Moatesim Ashfaq)
- **Impact of Monsoon on the atmospheric composition** (Narendra Ojha)

- **Atlantic Zonal Mode: An Emerging Source of Indian Summer Monsoon Predictability in a Warming World** (Ajaya Mohan Ravindran)
- **ENSO teleconnections and Predictability of the Euro-Atlantic region during winter in the inter-basin framework** (Mohammed Adnan Abid)
- **On the characteristic tilt of boreal summer intraseasonal oscillation** (Sambrita Ghatak)
- **An observational study of the variability of East African rainfall with respect to sea surface temperature and soil moisture** (Claudine Wenhaji Ndomeni)
- **Indo-western Pacific ocean capacitor: ENSO forcing, coupled feedback and impact** (Shang-Ping Xie)

THE LECTURES (part 3)

- **Early- and late-winter ENSO teleconnections to the Euro-Atlantic region in state-of-the-art seasonal forecasting systems** (Franco Molteni)
- **Connections between Subtropical High Pressure, the Hadley Circulation and Baroclinic Instability** (Weiteng Qiu)
- **The MSE seasonal cycle and the Horn of Africa long and short rains** (Kevin Schwarzwald)
- **Near-inertial wave amplitude in the tropics as a diagnostic for validating mixed layer dynamics in general circulation models** (Marta Mrozowska)



A Review of Three-Ocean Interactions and Climate Variability

Chunzai Wang

**State Key Laboratory of Tropical Oceanography
SCSIO/Chinese Academy of Sciences
Guangzhou, China**

Outline

- **Why three-ocean interactions?**
- **Influence of the Pacific Ocean on other oceans**
- **Influence of the Indian Ocean on other oceans**
- **Influence of the Atlantic Ocean on other oceans**
- **Summary and future work**

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A review of the influence of the Indian Ocean Dipole on the Indian summer monsoon and ENSO

Annalisa Cherchi

National Research Council of Italy, Institute of the Atmospheric Sciences and Climate (CNR-ISAC), Bologna, Italy

Talking about the Indian Ocean Dipole (IOD) and how it is related with the El Nino Southern Oscillation (ENSO), the Indian summer monsoon (ISM) and their connection



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IOD & ENSO:

IOD as forced by ENSO, IOD as free mode of variability, IOD as trigger of ENSO

IOD & ISM:

direct influence or biennial oscillation framework

IOD, ENSO & ISM:

complex interactions largely modulated by internal dynamical processes (2019 as interesting case)

Teleconnection of ENSO in South Asian Monsoon and Relative Influence of the Indian Ocean

V. Krishnamurthy and J. Shukla, *George Mason University, USA*

Tuesday, 26 July 2022, 4:15 pm – 5:00 pm

The seasonal mean monsoon rainfall over India is mainly determined by slowly varying boundary forcings such as SST.

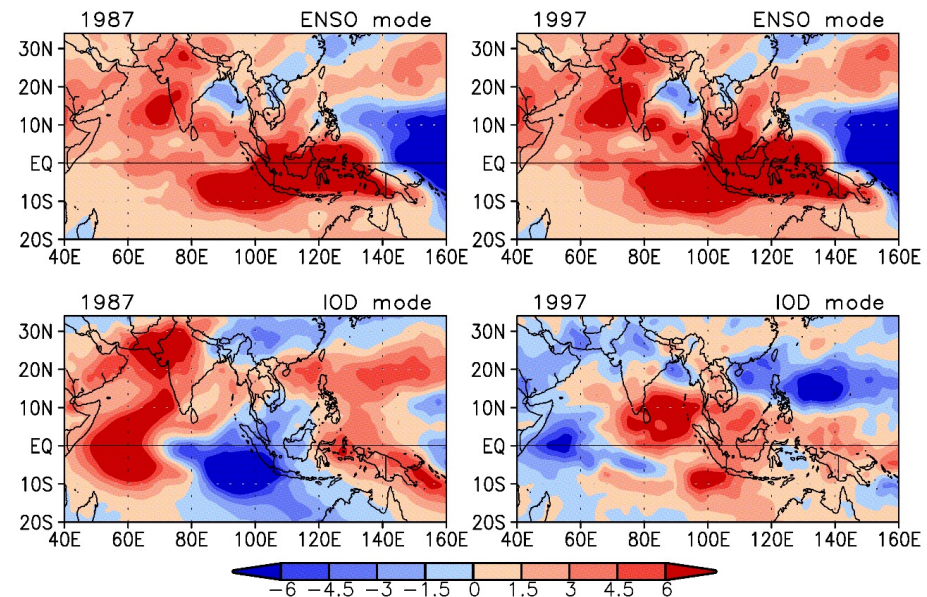
The leading seasonally persisting modes of the Indian monsoon consist of ENSO mode and IOD mode.

The relative influence of ENSO and IOD modes determine the seasonal mean rainfall.

For example,

In 1987, the ENSO mode and IOD mode interfered constructively, resulting in weak monsoon rainfall

In 1997, the ENSO mode and IOD mode interfered destructively, resulting in normal monsoon rainfall.

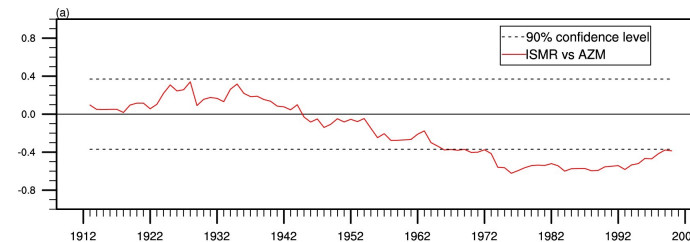


Seasonally persisting ENSO and IOD modes obtained by applying MSSA on daily OLR anomalies for the period 1979-2021: JJAS seasonal mean for 1987 and 1997

Atlantic Zonal Mode: An emerging source of ISMR variability in a warming world

Decadal Variability

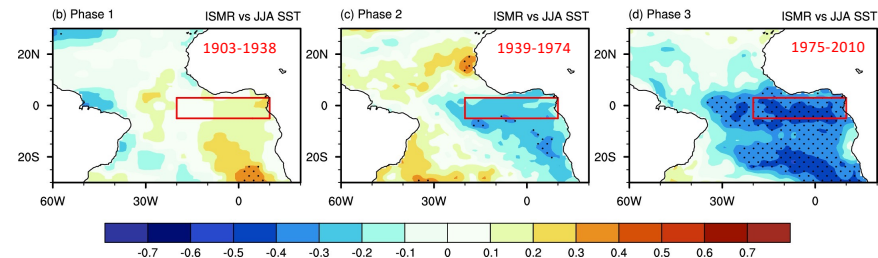
21 yr running correlation between
central Indian monsoon rainfall and
AZM index (1903-2010)



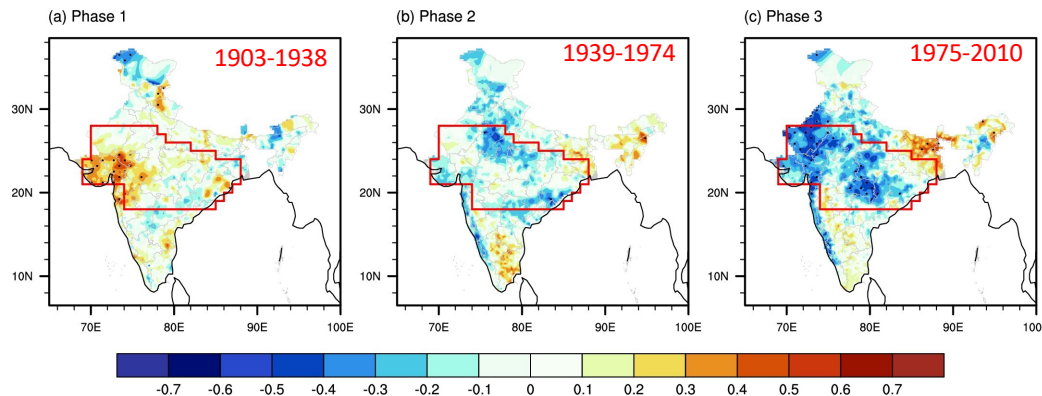
Sabeerali, Ajayamohan, Hamza, Chen, *Geophys. Res. Lett.*, 2019

Central India Rain vs SST

Inverse relation between ISMR
and AZM has strengthened in
recent decades

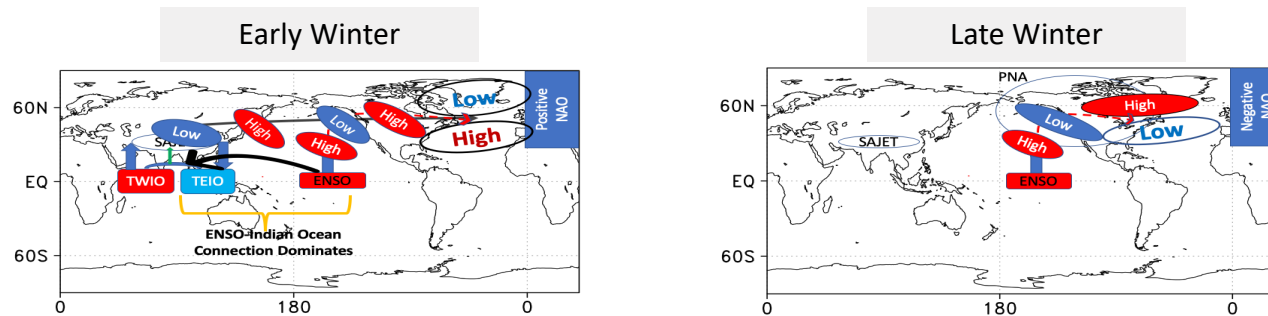


AZM index vs Rainfall



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Contrasting Early to Late winter ENSO teleconnections to the Euro Atlantic Region



Source: Abid et al. 2021, *J. Climate* (<https://doi.org/10.1175/JCLI-D-20-0075.1>)

- ✓ Separating ENSO teleconnections from early to late winter, the Indian Ocean (IO) heating anomalies mediates the in-phase ENSO teleconnections to the North Atlantic European (NAE) circulation anomalies during early winter.
- ✓ Modeling and observational analysis show that the Indian Ocean (IO) forcing dominates the NAE circulation anomalies variability during early winter.
- ✓ The IO heating anomalies variability during early winter, independent of ENSO, is mainly modulated by the pre-conditioning of the boreal Autumn Indian Ocean Dipole (IOD).
- ✓ Therefore, IOD can independently or along with ENSO can trigger IO heating anomalies, that dominates the variability and predictability of the NAE circulation anomalies during early winter.

Early- and late-winter ENSO teleconnections to the Euro-Atlantic region in state-of-the-art seasonal forecasts from the C3S database

Franco Molteni and
Anca Brookshaw
ECMWF, Reading, U.K.

Nov-Dec

500-hPa height
composites in
ENSO years: ERA-5

Jan-Feb

