Latent and Sensible heat flux variations in north Indian Ocean during ENSO and Indian Ocean dipole years

D. Swain* and S. K. Ghose
IIT Bhubaneswar, INDIA

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Introduction

- El-Nino Southern Oscillation (ENSO): variation of magnitude or position of sea surface temperature (SST) in the Pacific Ocean [1]

- ENSO influences the global climate system in many ways through ocean-atmospheric interaction

  (Teleconnection between ENSO & Indian Ocean cannot be ignored)

- Indian Ocean dipole (IOD): characterised by anomalous warm SSTs in the western Indian Ocean and cooler SST anomaly in the south eastern equatorial Indian Ocean [2, 3]

- Study of variation of latent heat flux (LHF) and sensible heat flux (SHF) during El-Nino, La-Nina, and IOD events is essential

(These fluxes control the SST and hence contribute to the oceanic heat budget [4, 5])

Data

- Daily gridded objectively analyzed LHF and SHF (OA Flux) data [6]
- Sea level anomaly (SLA) from archiving, Validation, and Interpretation of Satellite Oceanographic (AVISO) [7]
- Information on El-Nino, La-Nina, and positive & negative IOD years

Analysis Period: 1986-2015

El-Nino				La-Nina		
Weak	Moderate	Strong	Very strong	Weak	Moderate	Strong
2004-05	1986-87	1987-88	1997-98	2000-01	1995-96	1988-89
2006-07	1994-95	1991-92	2015-16	2005-06	2011-12	1998-99
2014-15	2002-03			2008-09		1999-00
2018-19	2009-10					2007-08
						2010-11

Positive IOD years: 1994, 1997, 2006, 2012, and 2015
Negative IOD years: 1989,1992, 1996, 1998, 2010, and 2014.

Methodology

- LHF and SHF considered for all the El-Nino and La-Nina years from the 30 years of OA Flux data (1986 to 2015).
- Mean LHF & SHF computed taking all El-Nino and all La-Nina years followed by their differences ($LHF_{ElNino} – LHF_{LaNina}$).
- Similar analysis for positive and negative IOD years.
- Hovmoller (Time-Longitude) diagrams plotted for SLA during each year from (1986 to 2015) at 5 ^{o}N latitude.
- Heat fluxes for El-Nino, La-Nina, positive & negative IOD, and co-occurrence of IOD and El-Nino years analyzed separately.

The plots were analyzed and inferences drawn.

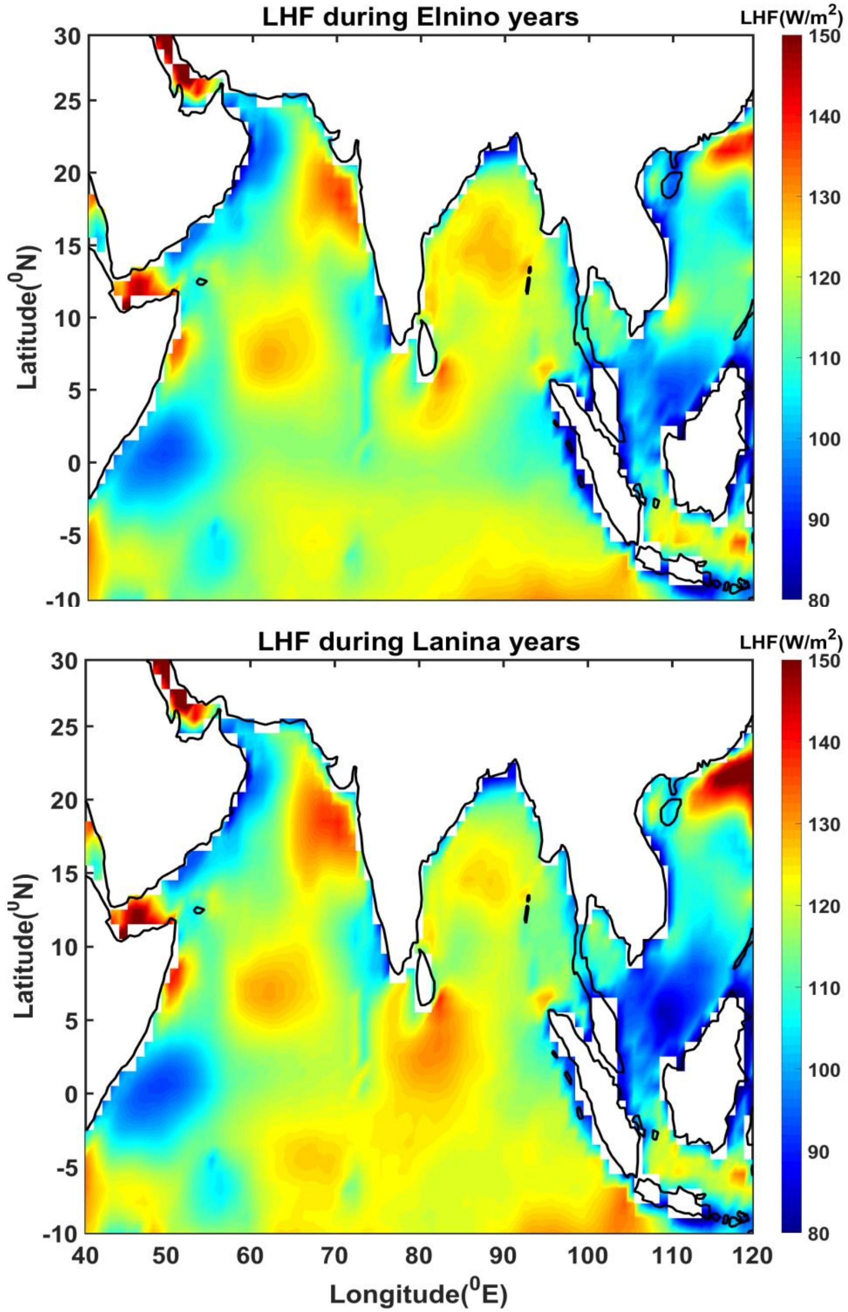


Fig 1. Mean LHF over the study region for El-Nino & La-Nina periods

Observations & Discussions

During El-Nino years LHF is higher in:

- Bay of Bengal
- Somali coast
- Western Arabian Sea
- South equatorial Indian Ocean

During El-Nino years, SHF is:

- higher in Somali coast
- nearly same in BoB

Causes

- ➢ Warming (cooling) in the western Indian Ocean (Eastern Indian Ocean) during IOD
- ➢ Basin-wide cooling during winter in the Indian Ocean during La-Nina years, due to propagation of upwelling Rossby wave [8].

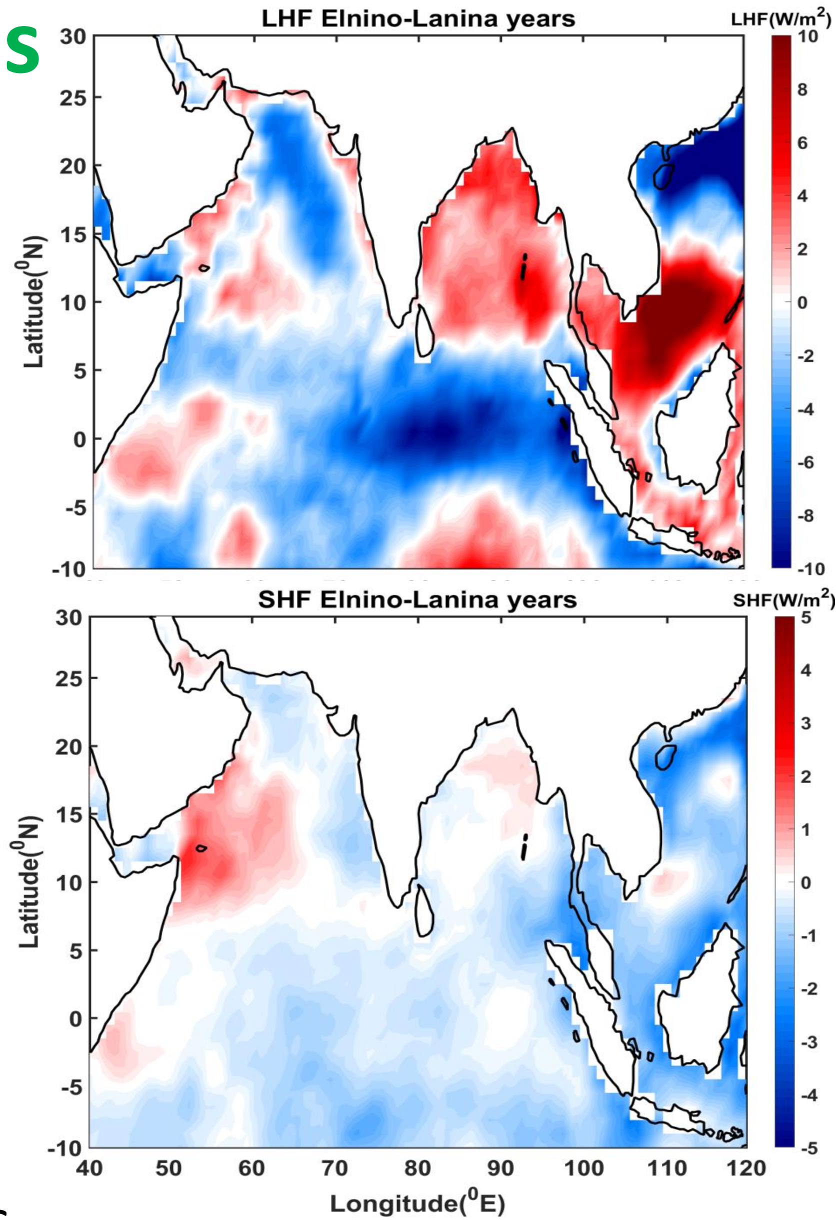


Fig 2. Distribution of Flux differences (LHF_{ElNino}–LHF_{LaNina}) & (SHF_{ElNino} – SHF_{LaNina}) over the study region

Positive and Negative IOD years

During positive IOD years, LHF:

- is higher in South equatorial Indian Ocean below the equator
- is higher in Somali cost
- is lower in Indian cost
- I s lower in equatorial region

During positive IOD years, SHF:

- is lower in BoB
- is lower in Central AS
- is higher in south west Indian Ocean

Near the Somali coast, easterly wind over the equatorial Indian Ocean causes upwelling during monsoons [2, 3]. Upwelling brings the cooler water to the surface, reducing LHF.

Reverse phenomena occurs in the eastern equatorial Indian Ocean; hence higher LHF and lower SHF during positive IOD years

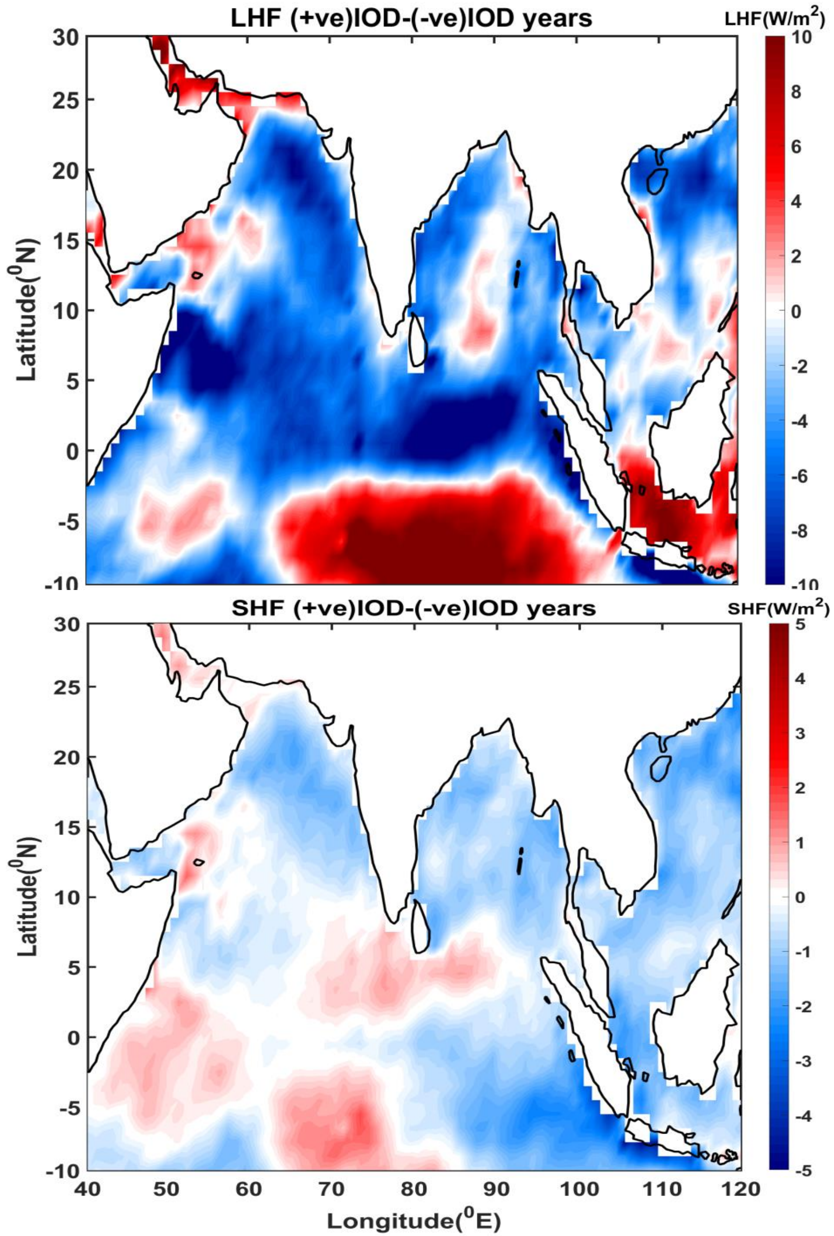


Fig 3. Distribution of Flux differences ($LHF_{+ve\ IOD}$ – LHF_{-veIOD}) & (SHF_{+veIOD} – SHF_{-veIOD}) over the study region

West ward propagating Rossby Waves during +ve IOD and El-Nino years (Time 150 to 300 nearly refers summer Monsoon months-JJAS)

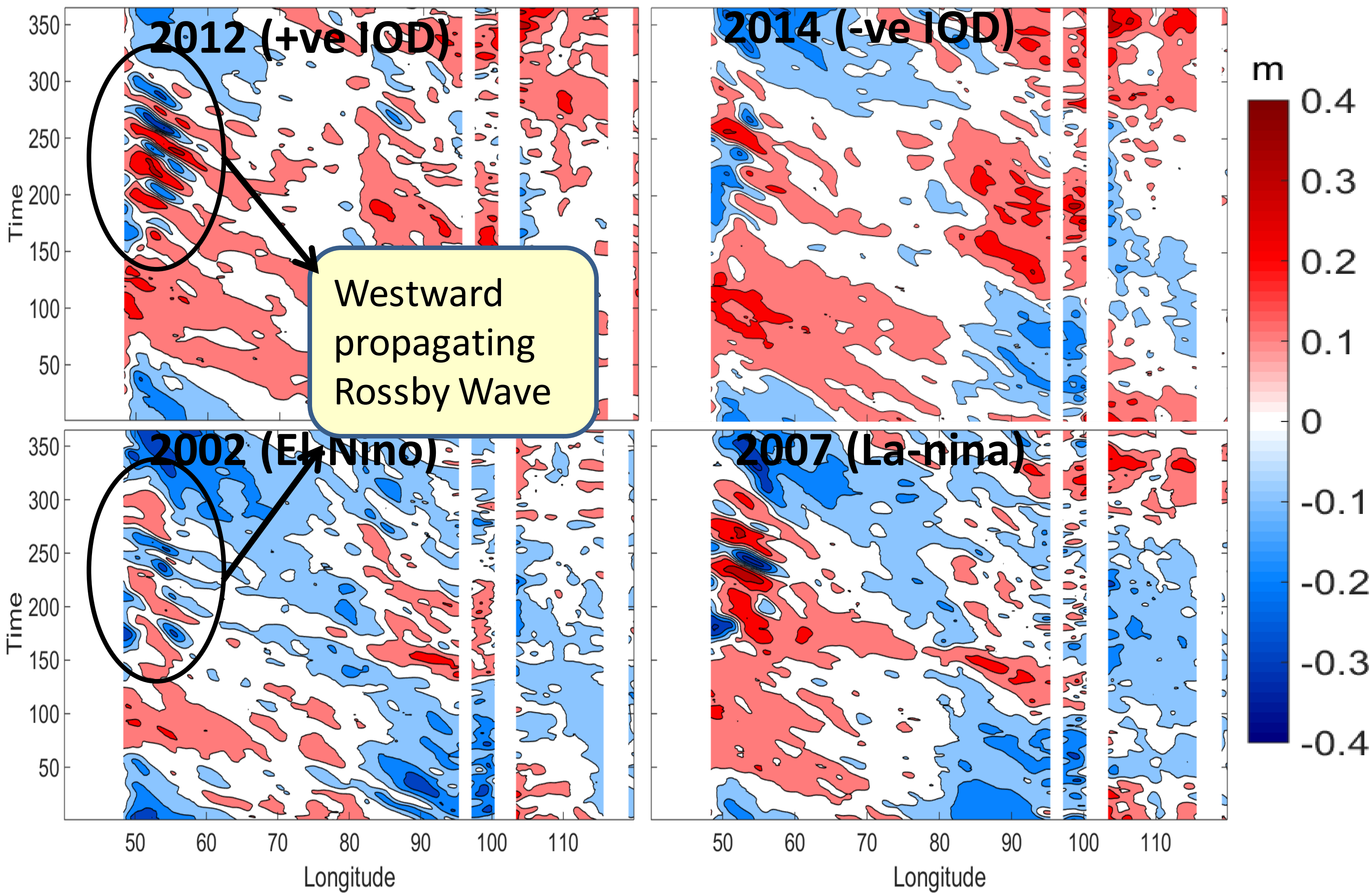
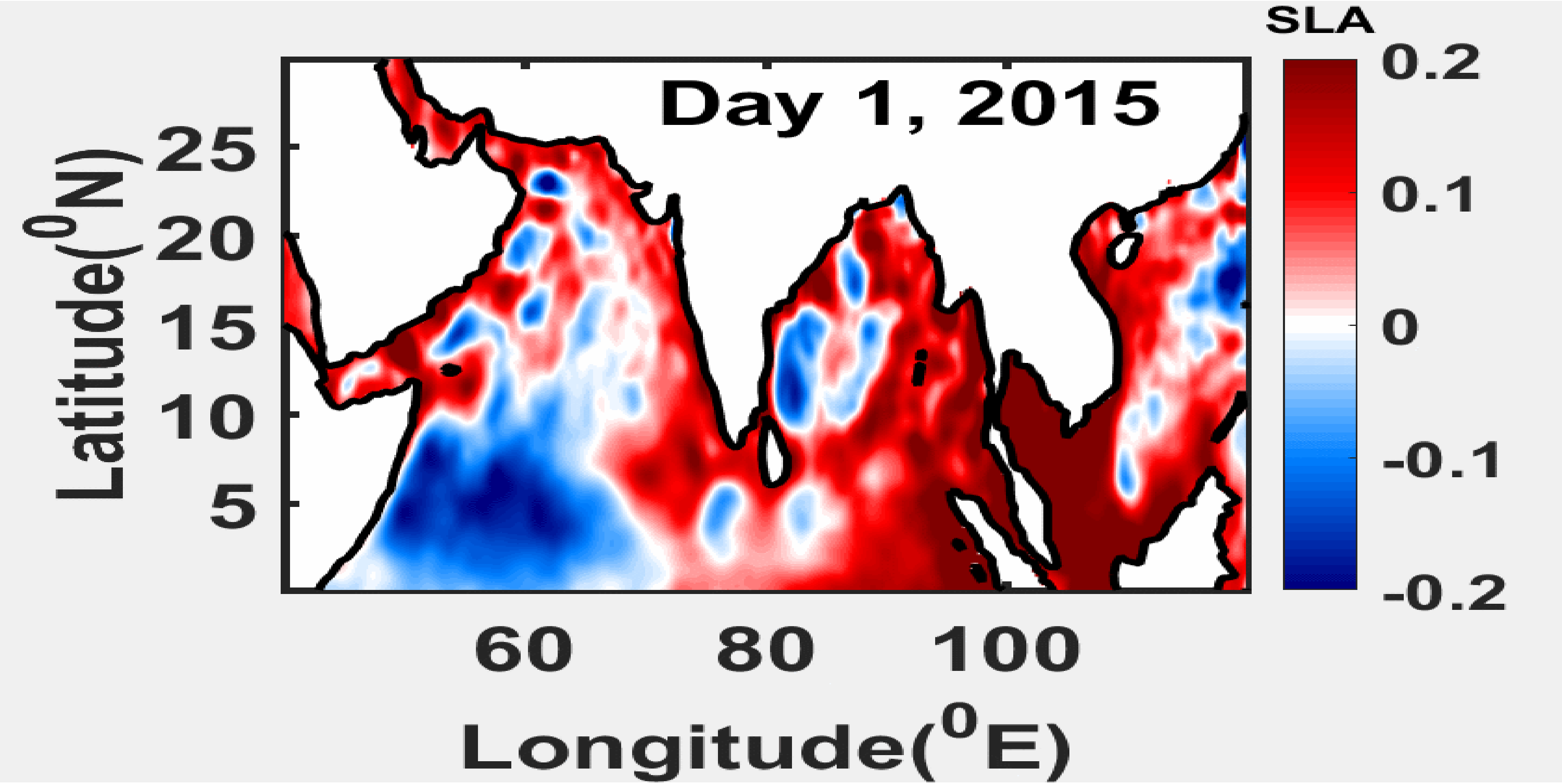


Fig 4. Hovmoller plots of Sea level Anomaly along 5 ^{0}N in the study region

Sea Level Anomaly for 2015 (+ve IOD)

- Continuous variation of SLA for the year 2015 (Day: 1 to 365)
- Westward propagating Rossby wave near the Somali coast (Day: 150 to 300)



Conclusions

- Strong westward propagation of Rossby waves during positive IOD and El-Nino years, resulting in upwelling near the Somali coast during monsoon months.

This results in cooler SST in this region, hence the LHF is less in this area during both positive IOD and El-Nino years.

The results are consistent with all positive IOD and El-Nino years except for the co-occurrence of IOD and El-Nino year.

- Stronger role of ocean dynamics and thermodynamics in modulating LHF and SHF variations during positive IOD and El-Nino years.

Negative IOD and La-Nina years behave like normal years considering heat flux variation.

- Rossby wave dynamics absent during normal years.
- Rossby wave propagation contributes to higher heat fluxes during El-Nino and positive IOD years compared to normal years.
- These fluxes contribute to the oceanic heat budget, controlling the upper ocean stratification
- Analysis of these mechanisms would aid in the understanding of El-Nino teleconnection and IOD effect in the Indian Ocean.

Thank you

References

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