

# 8-year long Sea Surface Temperature data from Indian geostationary satellite INSAT-3R: Evaluation and study of inter-annual variability over the Indian Ocean Region

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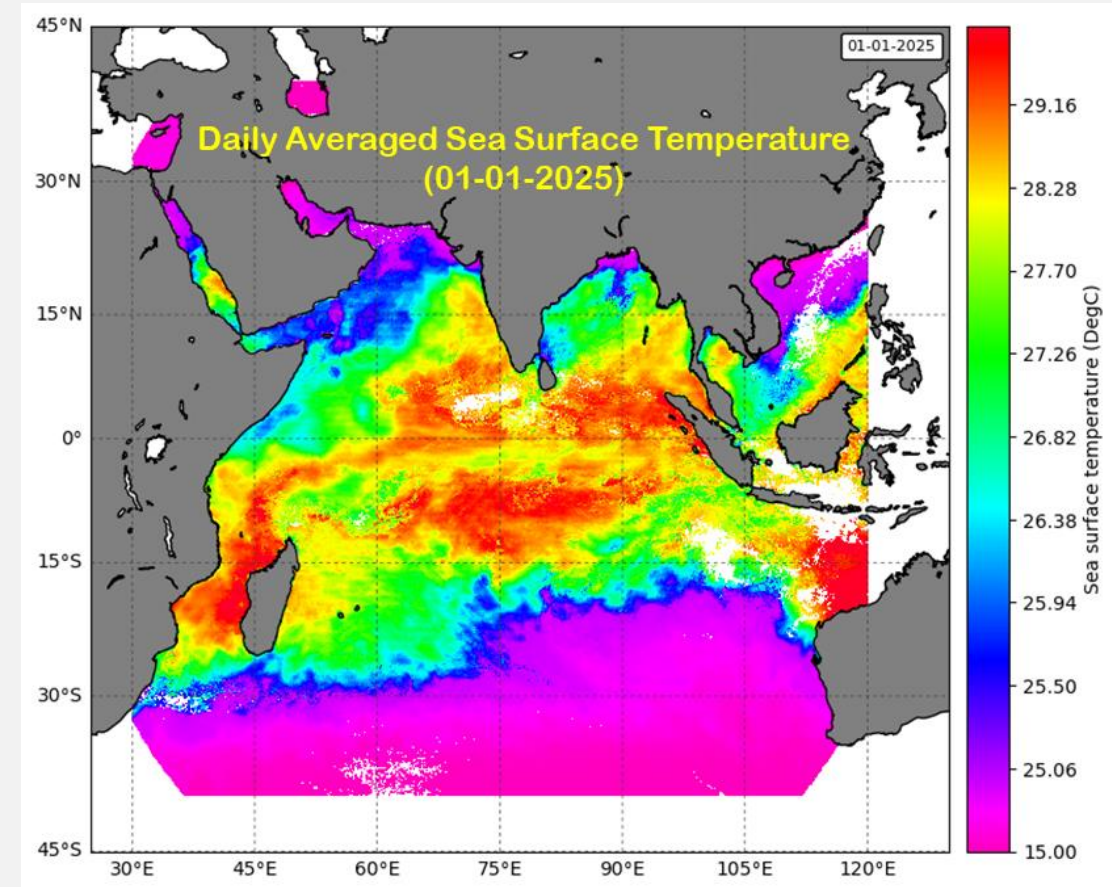
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# Outline

- Sensor Specifications
- Retrieval method and validation with in-situ
- Data used and study domain
- Intercomparison with standard products
- Inter-annual Variability
- Summary & Way forward

- Launched on 8 September 2016
- Channels: 6 channels in Imager
- Temporal resolution: 30min
- Split bands (TIR1 and TIR2) are used for the SST retrieval at 4km
- Both 30min and Daily products are available

	Name	Wavelength	Resolution
1	VIS	0.55-0.75 $\mu\text{m}$	1 km
2	SWIR	1.55-1.70 $\mu\text{m}$	1 km
3	MIR	3.8-4.0 $\mu\text{m}$	4 km
4	WVR	6.5-7.1 $\mu\text{m}$	8 km
5	TIR-1	10.2-11.3 $\mu\text{m}$	4 km
6	TIR-2	11.5-12.5 $\mu\text{m}$	4 km



Products available at [www.mosdac.gov.in](http://www.mosdac.gov.in)

The relationship between geophysical parameter and satellite measurements can be written in a generalized form as:

$$y = F(x) + e \quad (1)$$

By inverting above equation, the most likely geophysical parameters (x) can be retrieved that can reproduce the top-of-the atmosphere brightness temperatures, y.

The inversion technique 1DVAR or optimal estimation is used to invert the equation.

Assuming the forward model is a general function of the state, the representative (measurement + model) error has a Gaussian distribution, and there is a prior estimate with a Gaussian uncertainty distribution, the maximum probable state x can be found by minimizing the cost function, J:

$$J(x) = (x - x_0)^T B^{-1} (x - x_0) + (y - y(x))^T R^{-1} (y - y(x)) \quad (2)$$

where, y is the observations with error covariance R;  $x_0$  being the prior atmospheric state having error covariance B and y(x) is the observations simulated through forward model using atmospheric state x.

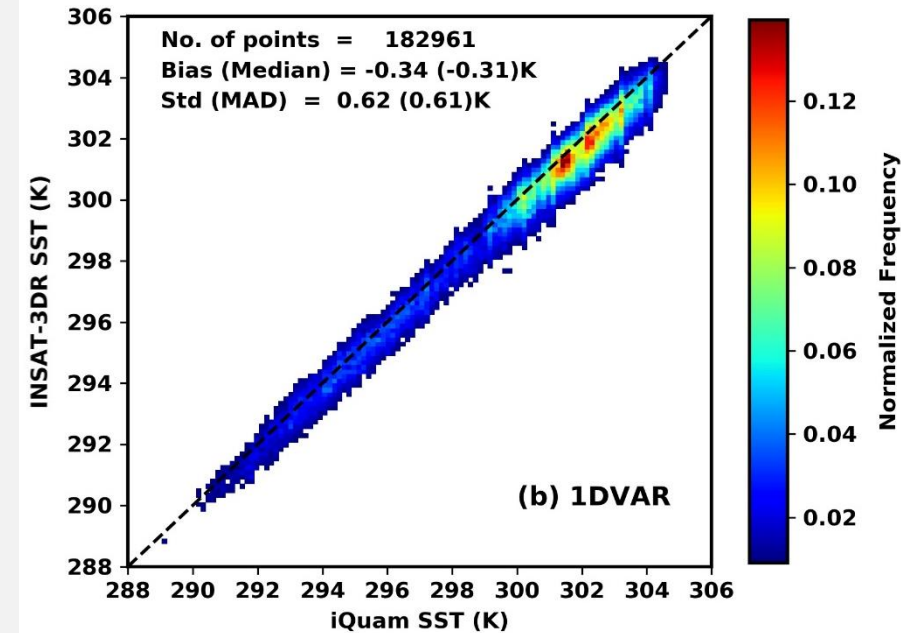
Rodgers (1976) gives the following iterative solution to the minimization of J(x):

$$x_{n+1} = x_0 + B H_n^T (H_n B H_n^T + R)^{-1} [y - y(x_n) - H_n (x_0 - x_n)] \quad (3)$$

$H_n$  is the sensitivity of the simulated observations with respect to state variables also known as Jacobian matrix.

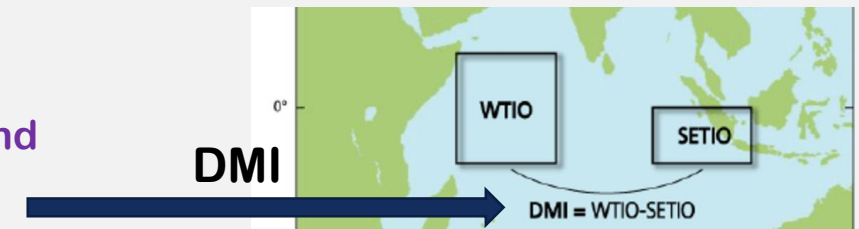
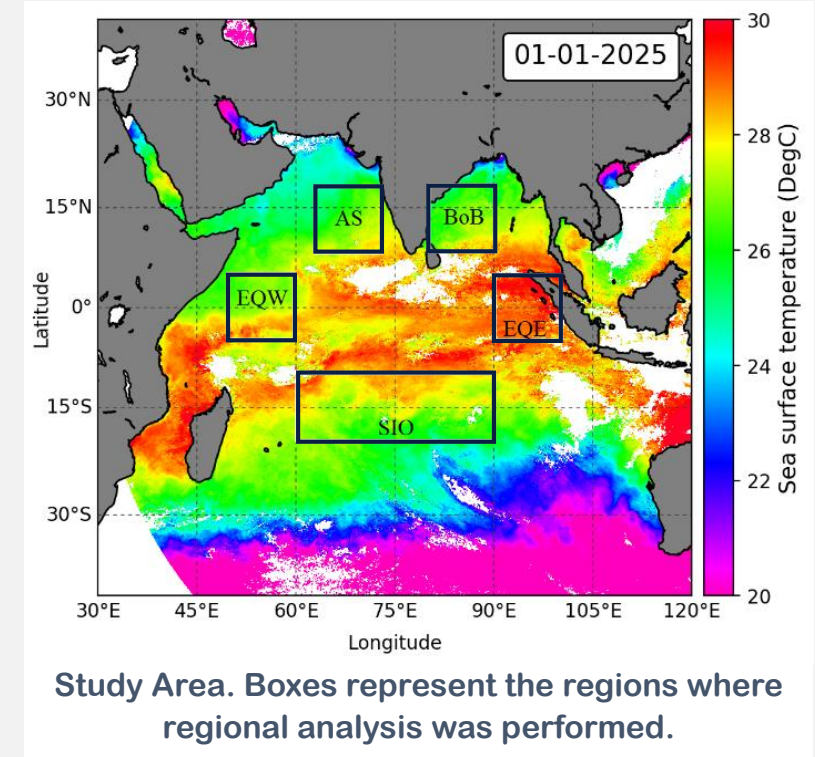
**Gangwar and Thapliyal 2020**

## Validation with in-situ (iQuam)



Slight under estimation of higher SST values

- INSAT-3DR L2B Data (2017 – 2024) [www.mosdac.gov.in](http://www.mosdac.gov.in)
  - Converted to Monthly average for long term analysis
- OISST Data (2017 – June 2023):  
<https://psl.noaa.gov/data/gridded/data.noaa.oisst.v2.highres.html>
  - Converted to Monthly averaged
- INSAT data mapped to 25km x 25km
- Study Area: 30 - 110 E , 30 S – 30N
- Regional Analysis: (Time series and Normalised histogram)
  - Arabian Sea (AS) : 60E – 70E, 8N – 18 N
  - Bay Of Bengal (BoB) : 80E – 90E , 8N – 18N
  - Western Equatorial Indian Ocean (EQW): 50 – 60 E, 5S – 5N
  - Eastern Equatorial Indian Ocean (EQE): 90E – 100E, 5S – 5N
  - Southern Indian Ocean (SIO): 60E – 90E, 20S – 10S
- Inter-annual Variability: Indian Ocean Dipole, Dipole Mode Index (DMI) =  
Difference in SST anomalies averaged in the Western (50E – 70E; 10S – 10N) and  
Eastern Equatorial Indian Ocean (90E – 110E; 10S – Equator)

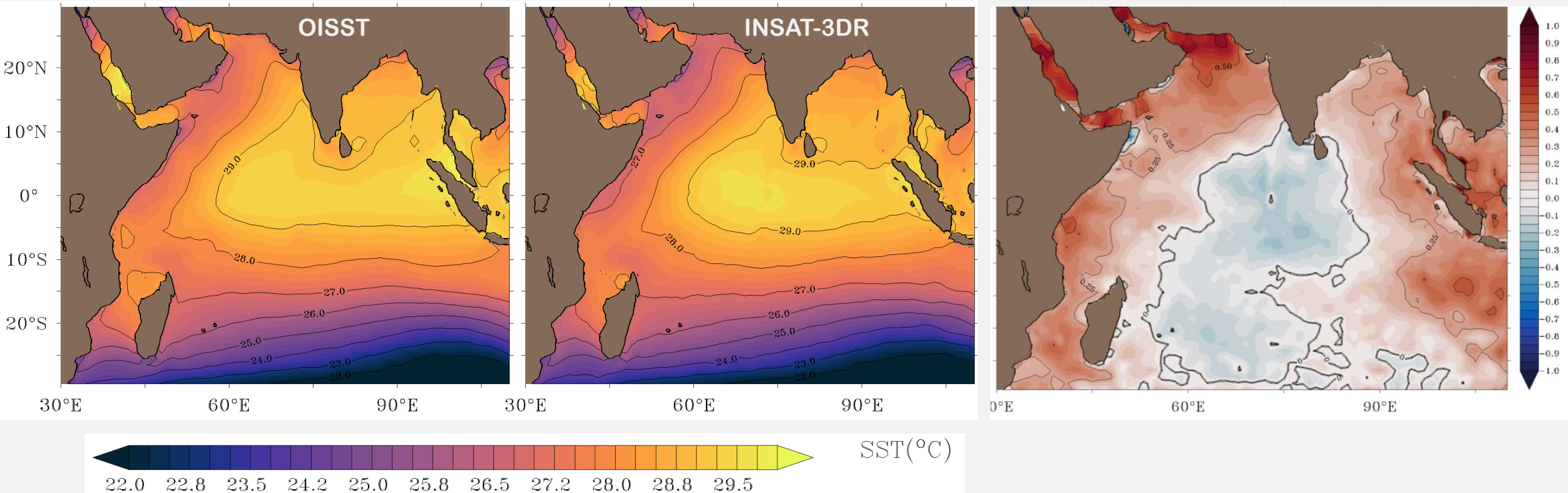




# Comparison with OISST

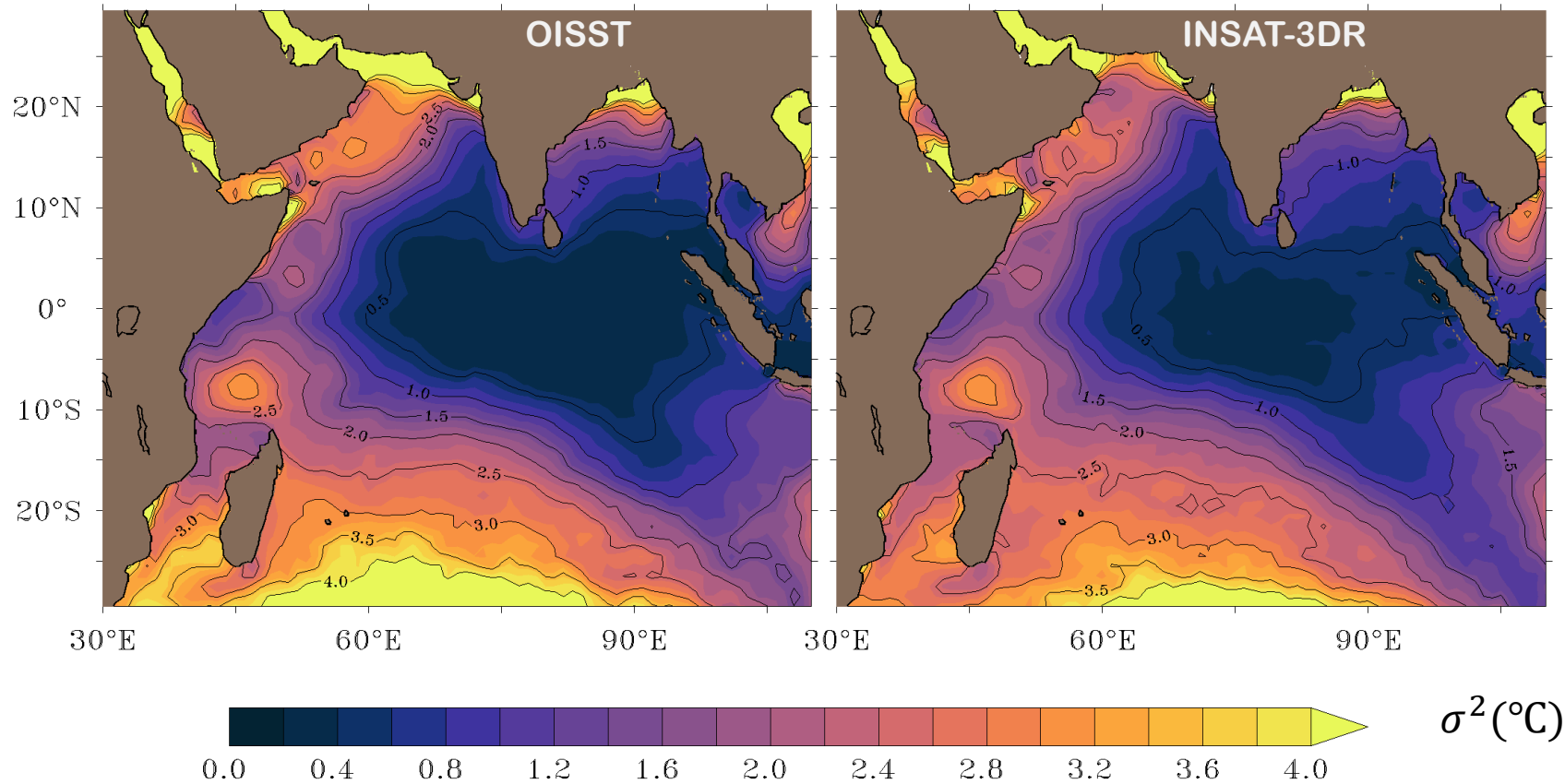
## Mean SST (Jan 2017 – June 2023)

## Bias

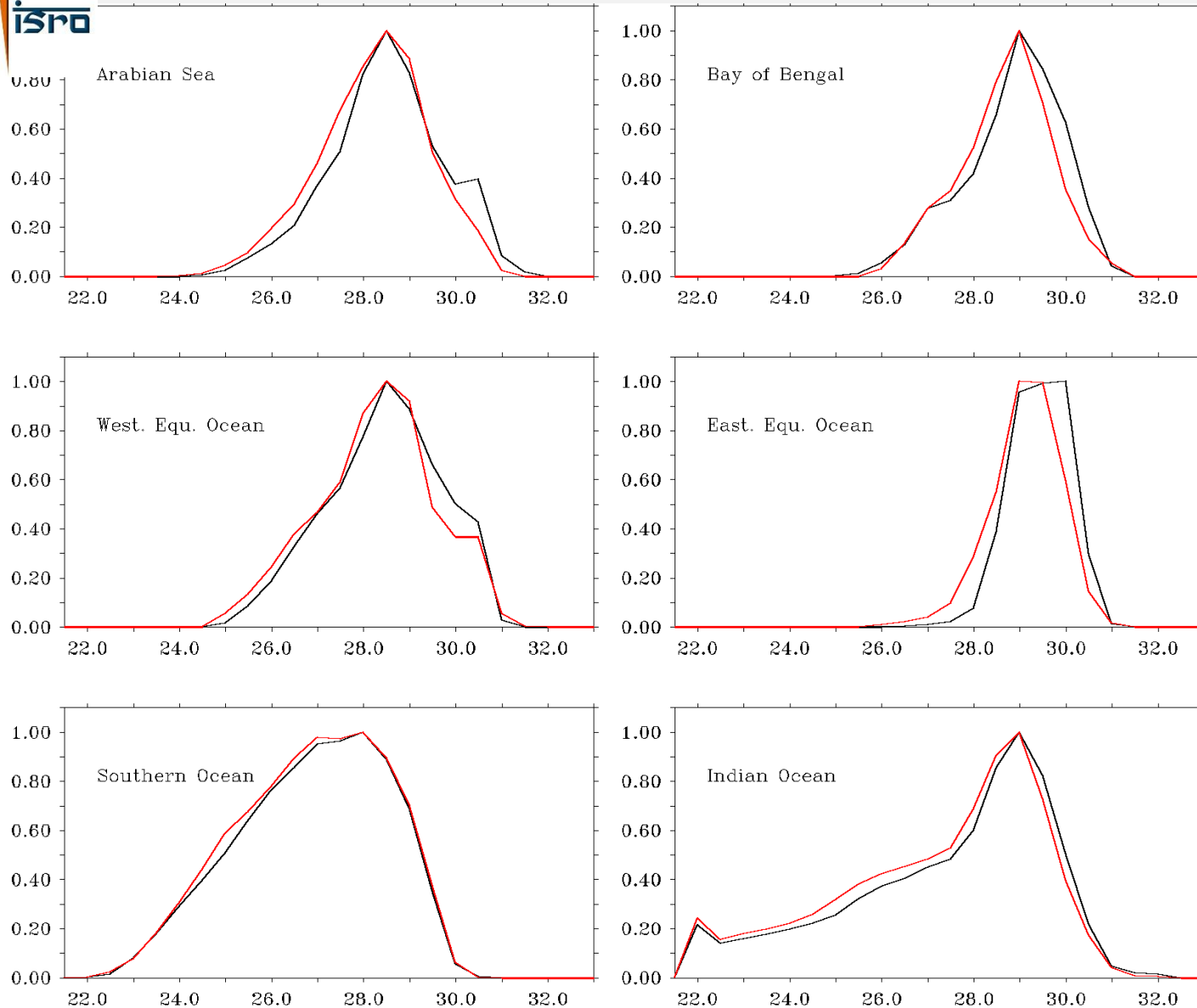


# Comparison with OISST

## Variance (Jan 2017 – June 2023)



- INSAT-3DR nicely captures observed SST variability
- Warm pool region has less variability
- High variability in the North Bay of Bengal, North Western Arabian Sea, Somali and African coast and Southern Indian Ocean region



— OISST  
— INSAT-3DR

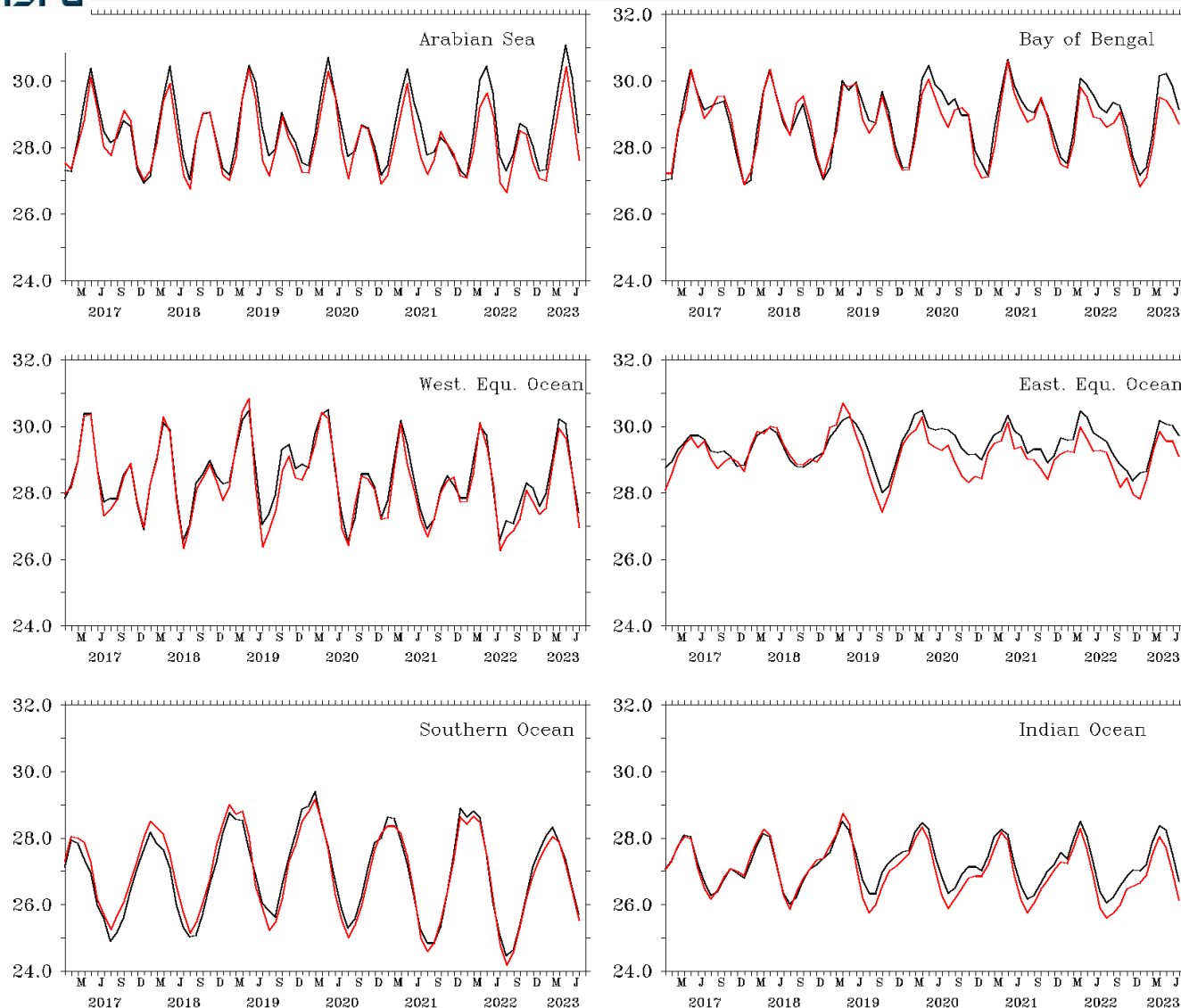
## Normalized Frequency Distribution

- Overall good match in the Indian Ocean
- Slight discrepancy in the AS and EQE



# Regional Analysis

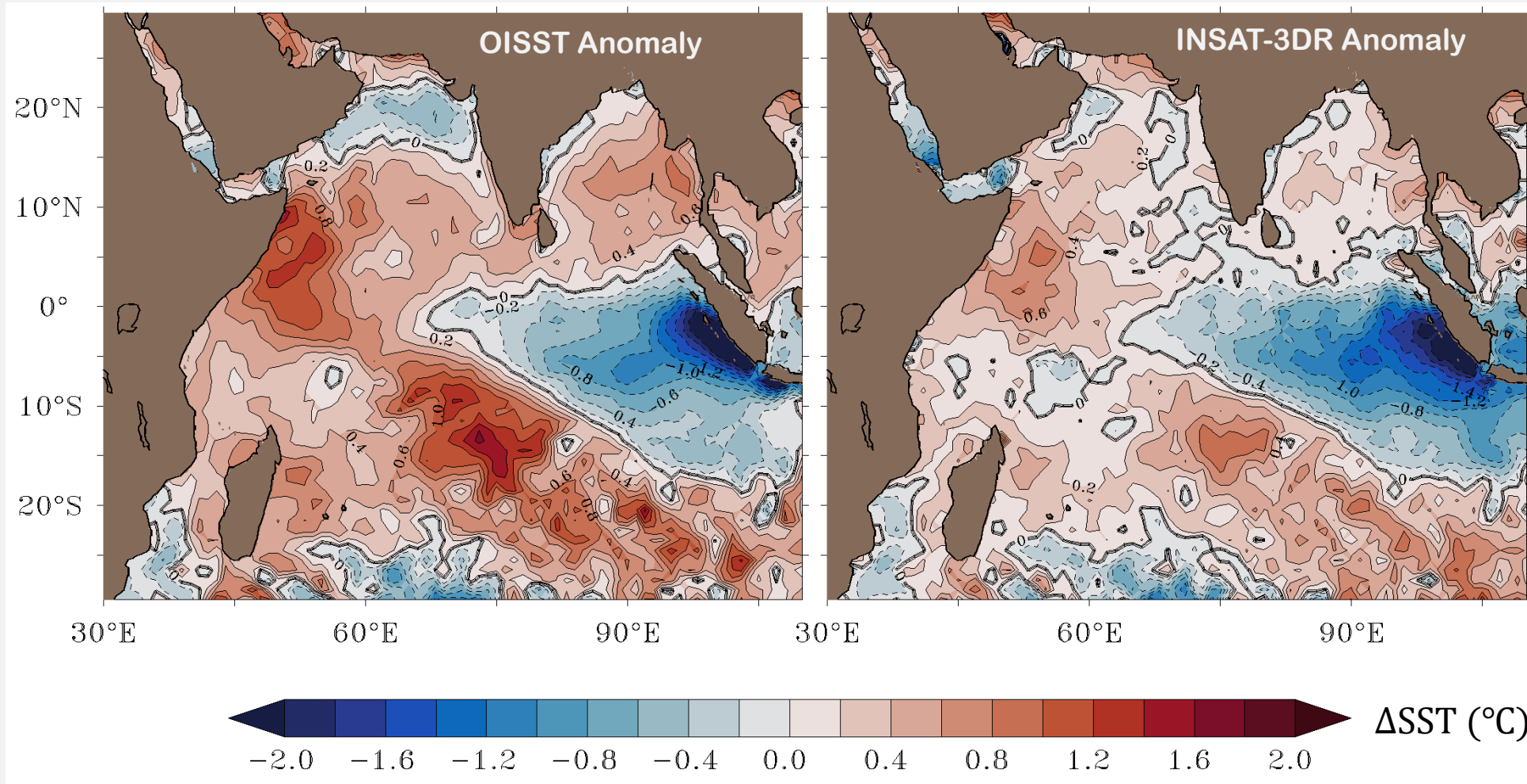
SST (°C)



## Time Series Comparison

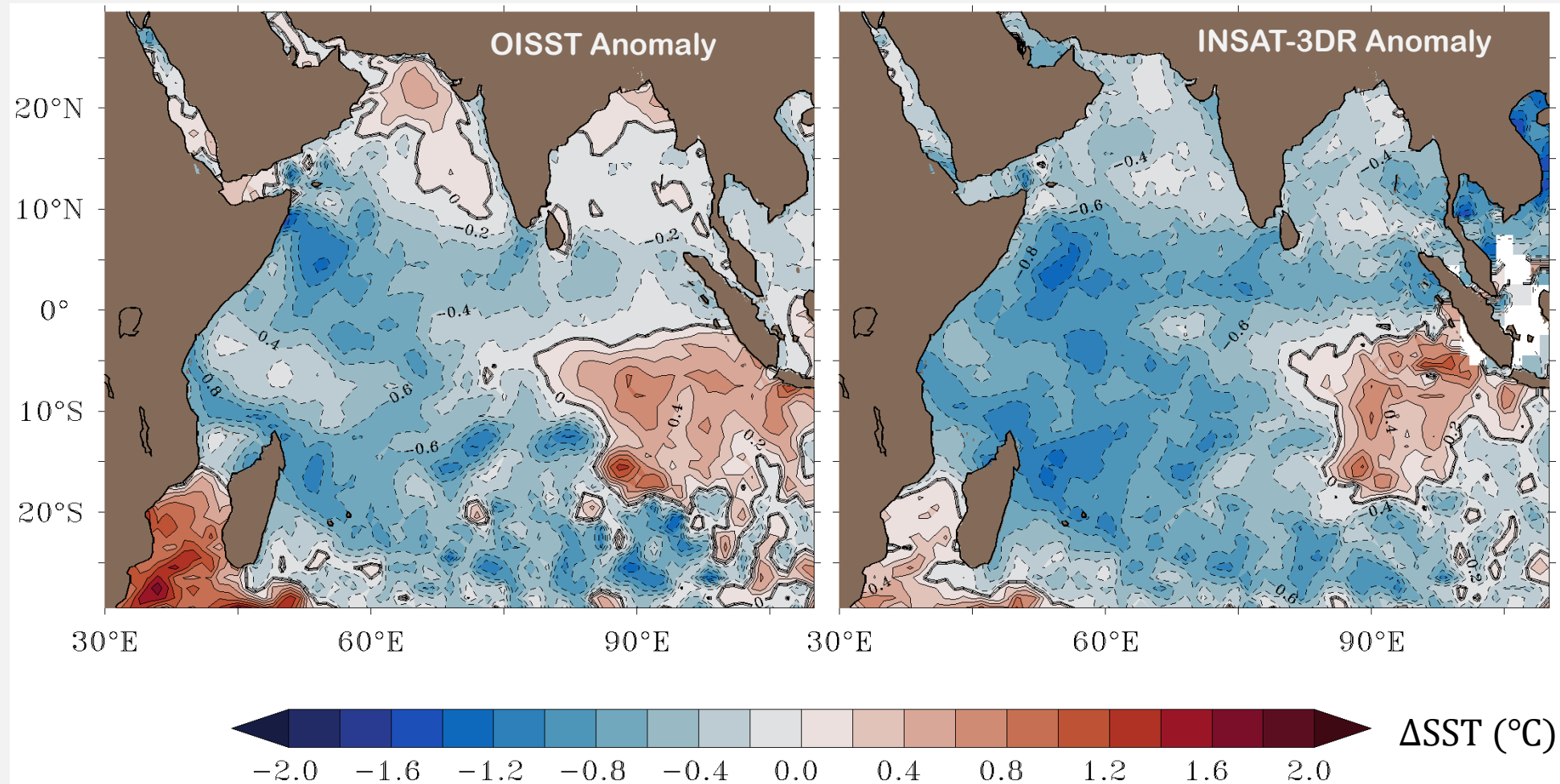
- Good Match in most of the regions
- More deviation in the BoB and EQE
- Inter-annual variability nicely represented in INSAT-3DR
- Signatures of regional trends present in INSAT-3DR

## Inter-annual Variability (IOD Positive Phase October 2019)



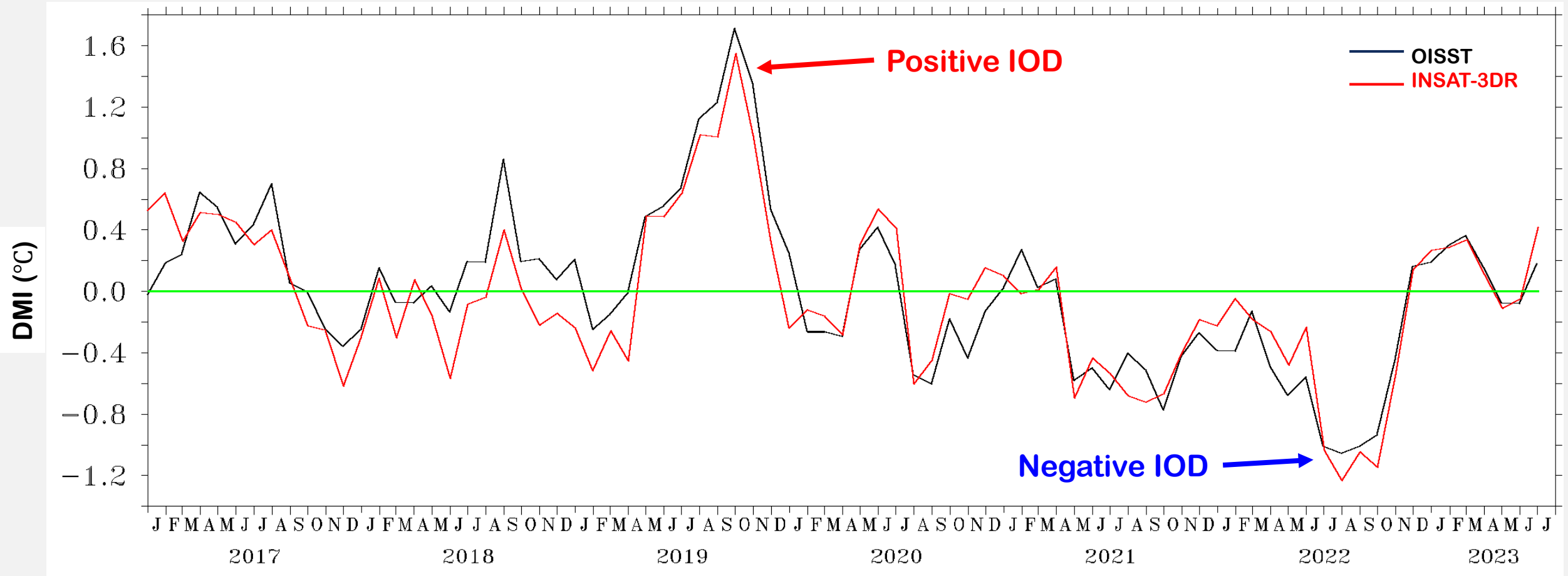
- IOD Patterns nicely picked up by INSAT-3DR
- Under estimation of Positive SST Anomalies

## Inter-annual Variability (IOD Negative Phase October 2022)



- IOD Patterns nicely picked up by INSAT-3DR
- Under estimation of Positive SST Anomalies

# Dipole Mode Index

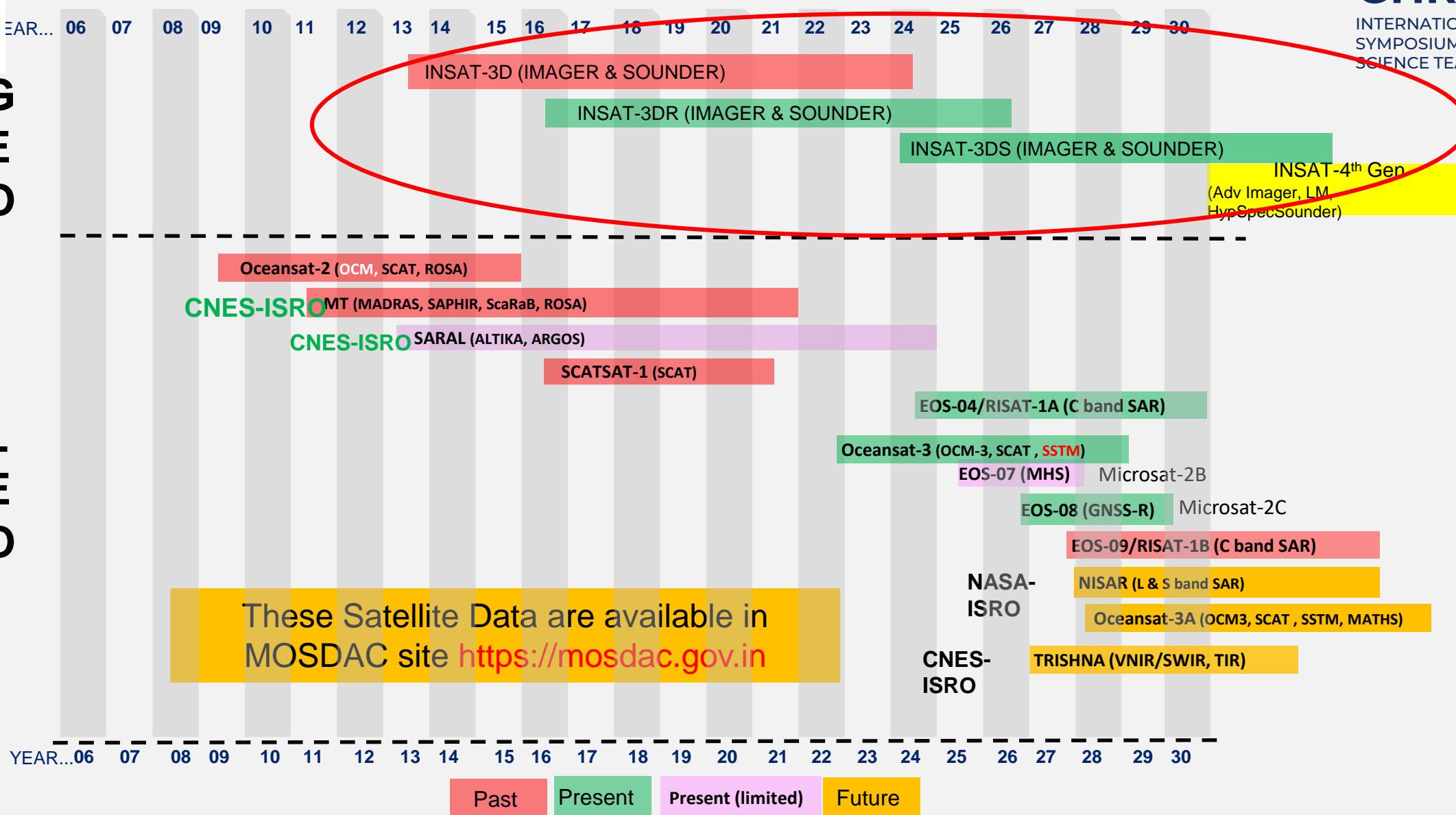


**Positive/Negative Phase of DMI picked up consistently in INSAT-3DR**

# Summary and Way Forward

- 8 year INSAT-3DR SST data analysed
- Large scale mean and variability patterns are nicely captured
- Regional analysis suggest more deviations in BoB and EQE regions
- Dominant modes of inter-annual variability reproduced well in INSAT-3DR
- Extend the time-series to include INSAT-3D and INSAT-3DS SST
- Make the entire dataset available in GHRST format





THANK YOU