

Diurnal variability of INSAT-3D SST in the Indian Ocean-intercomparison with in-situ and satellite observations

Swapna M, Santhoshi T, Rajesh Sikhakolli, Nayak R.K, Rajashree V Bothale.
National Remote Sensing Centre, ISRO, Hyderabad, India-500037.
swapna_m@nrsc.gov.in, swapna.geophysics@gmail.com

Introduction

- Sea Surface Temperature (SST) is an Essential Climate Variable (ECV) used in climate studies such as air-sea interaction, ocean mixing, boundary layer processes and ocean state forecast, which require high temporal resolution SST.
- Indian Geostationary Satellite INSAT-3D imager has been designed to provide 30 minute SST data for the tropical Indian Ocean with frequent sampling. In order to ascertain about the quality and usability of INSAT-3D SST products for various oceanographic studies its evaluation is essential to best access the accuracy of the retrieved SST product.
- In this regard, latest version (V02) of INSAT-3D SST data from May 2021 to December 2022 has been considered along with In-situ buoy measured SST data obtained from Indian Moored Buoy (IMB) network available at 1m depth for intercomparison. Contemporary MODIS SST is also used for the same period to understand the spatiotemporal variation in SST product accuracy in the Indian Ocean region.
- We have also attempted to study the diurnal variability of SST over Indian Ocean region, as the Indian Ocean is noted as one of the hot-spot region and significantly contributes for the global ocean warming.

Study area and Data

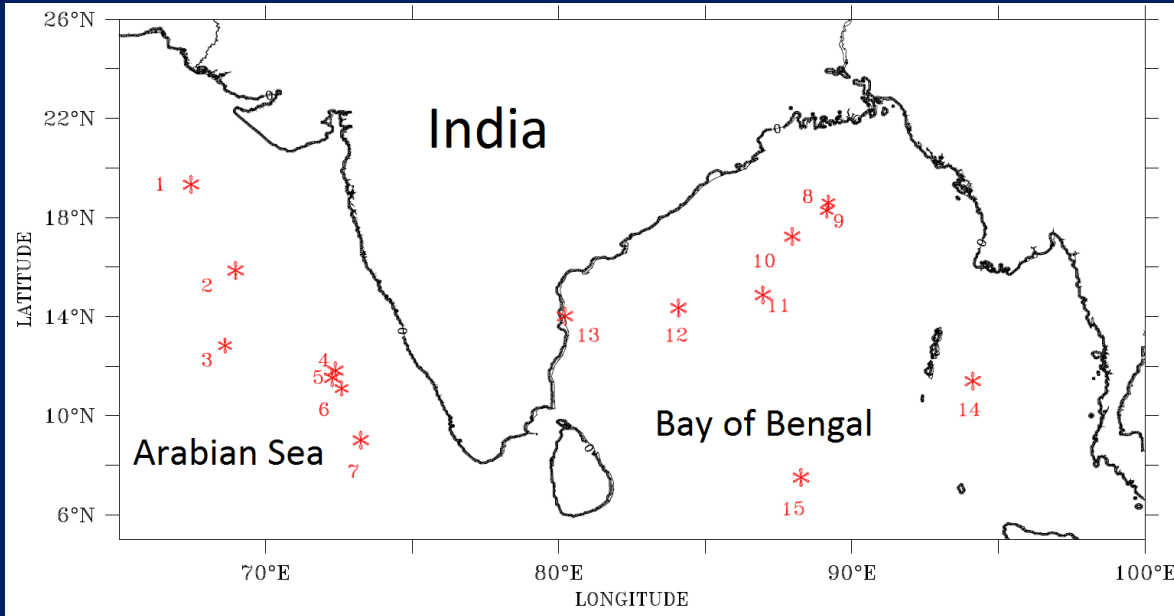


Figure1: Study area is North Indian Ocean (NIO) with IMB network denoted as '*'

Data used:

- INSAT-3D SST (V02) data from May 2021 to Dec 2022 with 4km spatial resolution obtained from Meteorological & Oceanographic Satellite Data Archival Centre (MOSDAC) of ISRO (Gangwar and Thapliyal, 2020)
- In-situ buoys SST for the same period obtained from Indian Moored Buoy (IMB) network provided by Indian National Centre for Ocean Information Services (INCOIS).
- NASA standard Level 3 daily 4 km spatial resolution SST from MODIS Aqua (<https://podaac-tools.jpl.nasa.gov/drive/files/allData/modis/L3/aqua/11um/v2019.0/4km/daily>).

Collocation criteria

- The matchup time window for INSAT-3D SST is kept as ± 30 minutes for temporal collocation and ± 4 km for spatial collocation with buoy SST. If the data is not available in the stipulated time window, the data has been rejected.
- The data which pass the temporal collocation criteria are only considered for spatial collocation in this study. In the case of a matchup with MODIS data, this temporal collocation is carried and subsequent matchup pixels are used.
- Additionally, the SST data considered within the range of $5^{\circ}\text{C} - 35^{\circ}\text{C}$ and $\text{mean} \pm 3$ standard deviation.
- The inter-comparison of INSAT-3D SST is performed against in-situ and MODIS SST observations using standard statistical parameters such as standard deviation (STD), correlation coefficient (r), Root Mean Square Error (RMSE), and bias.

Results: INSAT-3D Vs Buoy SST Intercomparison

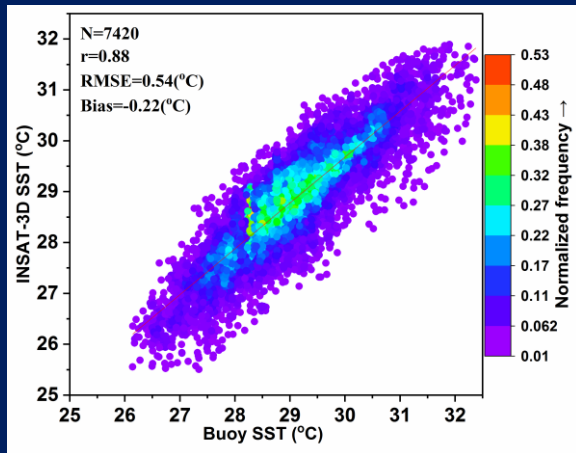


Figure 2: Scatter plot between collocated Buoy and INSAT-3D SST observations

Table 1: Validation of the INSAT-3D SST against Buoy SST observations for day and night

Buoys V/S INSAT-3D SST		
	Day	Night
N	4091	3329
r	0.89	0.87
RMSE (°C)	0.53	0.54
Bias (°C)	-0.15	-0.32

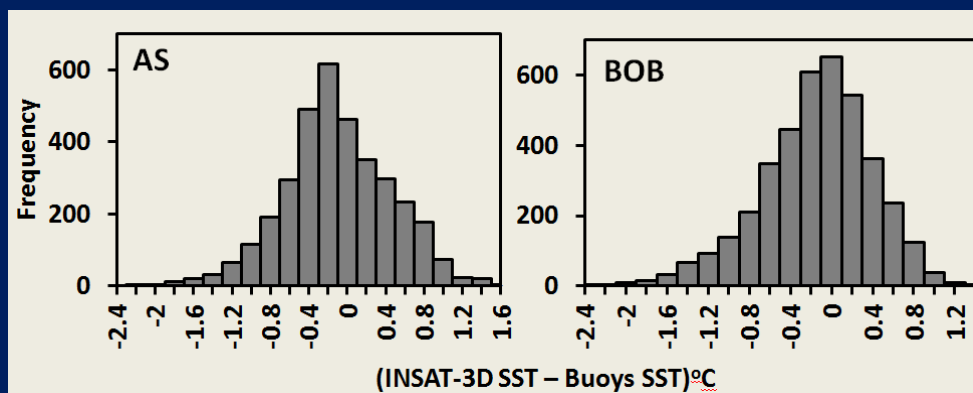


Figure 3: Frequency histogram of skin (INSAT-3D) and bulk (Buoy) SST difference in the AS and BOB

Buoys VS INSAT-3D SST		
	AS	BOB
N	3482	3938
r	0.85	0.9
RMSE (°C)	0.54	0.53
Bias (°C)	-0.2	-0.25

Table 2: Regional validation over Arabian Sea (AS) and Bay of Bengal (BOB)

Diurnal variability of INSAT-3D Vs Buoy SST

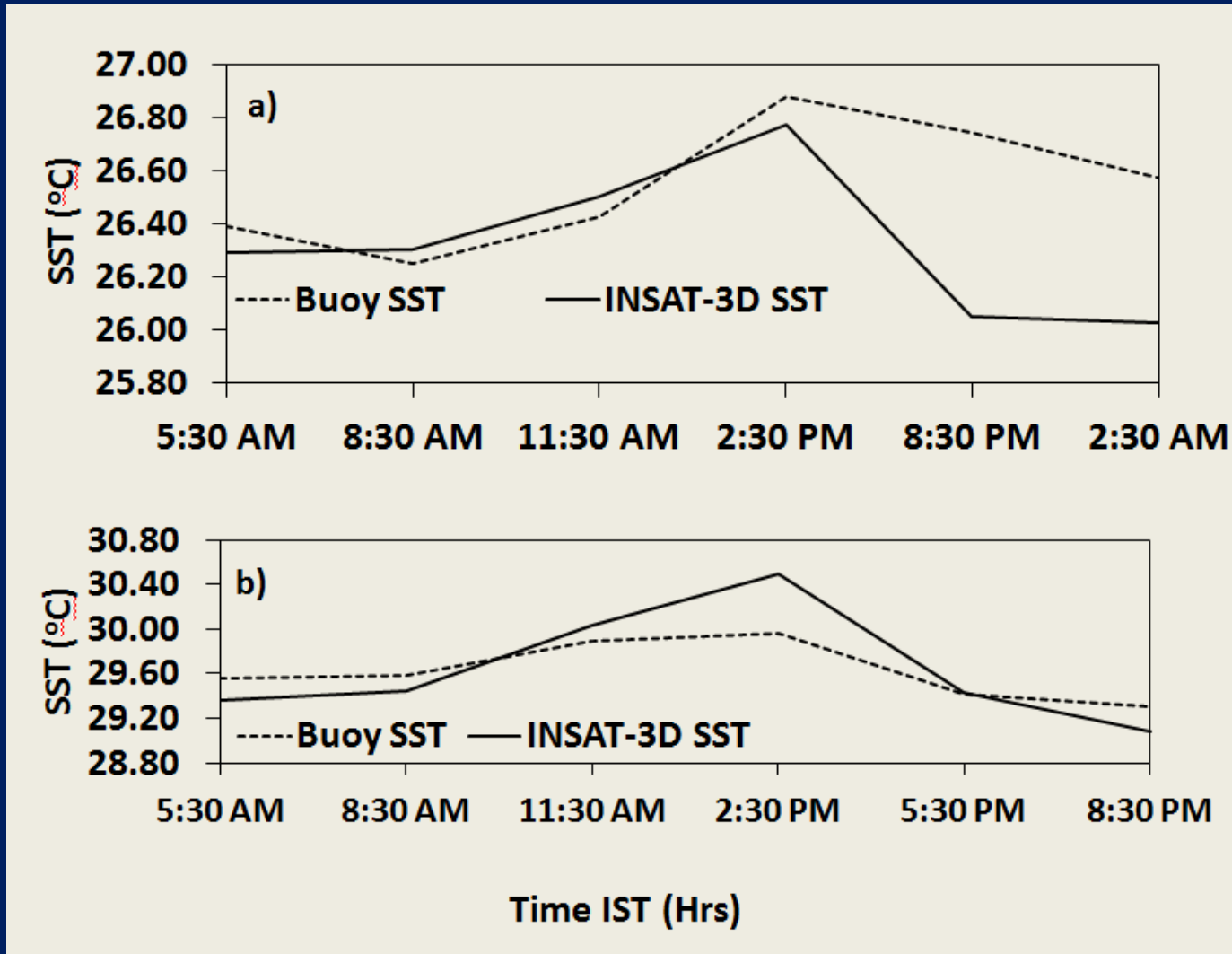


Figure 4a). Typical Diurnal variability at Buoy location 1 (in Fig.1) on 16 Mar 2022. b) At Buoy location 10 on 11 Apr 2022

Diurnal variability of INSAT-3D Vs Buoy SST

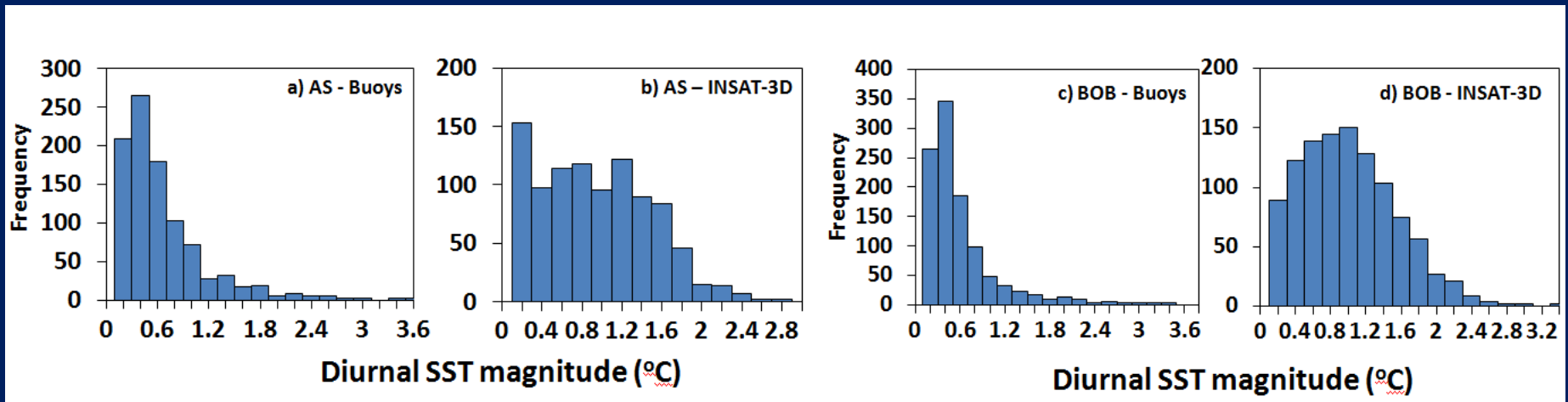


Figure 5) Histogram distribution of Diurnal SST magnitude over AS for a) Buoy and, b) INSAT-3D. C) Over BOB for Buoy and, d) for INSAT-3D

- The average diurnal variability of INSAT-3D SST is 0.87°C and Buoy is 0.54°C over NIO.

INSAT-3D V/S MODIS SST Inter-comparison

- INSAT-3D SST has been compared with MODIS Aqua day SST for the NIO region from 5°N to 26° N and 65°E to 100°E. INSAT-3D SST at the respective times is considered for inter-comparison. Post monsoon data from Oct 2021 to Feb 2022 is considered for this study.
- It is observed that, with MODIS Terra day SST, INSAT-3D SST resulted in a correlation of 0.86, a bias of -0.11°C and RMSE of 0.6°C .

Table 3: MODIS and INSAT-3D SST mean and Standard Deviation (STD) values.

	Mean (°C)	STD (°C)
MODIS	28.22	0.92
INSAT-3D	28.11	0.64

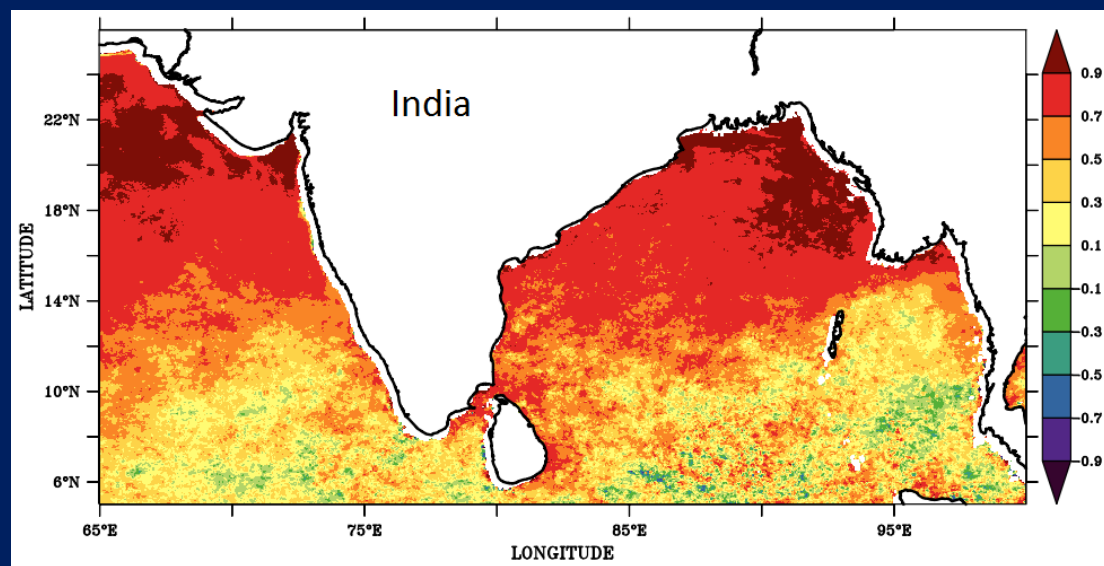


Figure 6. Spatial correlation map between the MODIS Aqua day SST and corresponding INSAT-3D SST.

Conclusions

- Day, Night and regional validation of the latest version (V02) of INSAT-3D SST against in-situ Buoy SST was carried out over NIO and found a strong correlation of 0.88 with a RMSE of 0.54°C (which was improved from its earlier version(V01) of data having RMSE (r) of 1.28 °C and r value of 0.7 (Swapna et.al., 2022)).
- Daytime data are relatively better in correlation compared to Nighttime SST data.
- Skin SST (INSAT-3D) has a large variability in comparison with the Buoy (Bulk) SST.
- INSAT-3D SST (Buoy SST) has shown average diurnal variability of 0.86°C (0.57°C).
- The V02 version of INSAT-3D SST data shown reduction in high diurnal variability magnitude (2.24°C) from version V01 of INSAT-3D SST.
- Inter-comparison of INSAT-3D SST with MODIS Aqua day SST for the North Indian Ocean region has shown a strong correlation coefficient (~0.86) with spatial and temporal consistency.
- The latest version (V02) of INSAT-3D SST which was derived using 1DVAR technique has shown improvement in terms of RMSE, r, and well represented the diurnal variability in comparison with Buoys SST.

Reference:

- Swapna M, R.K. Nayak, T. Santhoshi, M.V.R. Sessa Sai, S.S. Rajashekhar. (2022). INSAT-3D SST and its diurnal variability assessment using in-situ and MODIS observations. Progress in Oceanography, Volume 201, 102739, ISSN 0079-6611, <https://doi.org/10.1016/j.pocean.2022.102739>.
- Gangwar, R.K. and Thapliyal, P.K., 2020. Variational Based Estimation of Sea Surface Temperature from Split-Window Observations of INSAT-3D/3DR Imager. Remote Sens. 12, 3142. <https://doi.org/10.3390/rs12193142>.

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Thank you



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