

Call for National Reports for Argo Steering Team Meetings

National Report – INDIA

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1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2024)

a) *Floats deployed and their performance:*

INCOIS has contributed a total of 585 floats to the international Argo programme to date. During the 2024-25 period, INCOIS deployed 48 Argo floats in the Indian Ocean, comprising 40 Core Argo floats and 8 Biogeochemical (BGC) floats. Currently, 113 Argo floats remain active and are transmitting data. All data from these active floats are processed and submitted to the Global Data Assembly Centre (GDAC).

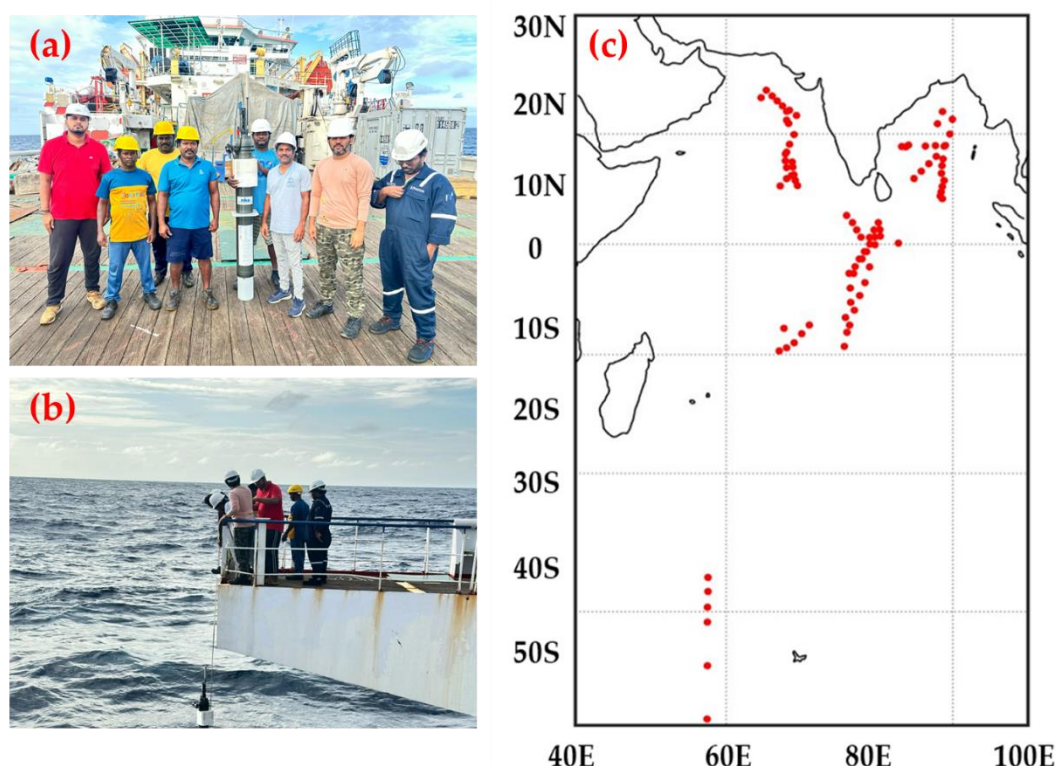


Figure (a) INCOIS team onboard RV Sagar Nidhi during deployment cruise (b) deploying floats in the ocean and (c) the deployment locations of 92 Argo floats since 2023

b) *Technical problems encountered and solved:*

INCOIS procured 6 BGC Argo floats in 2023 and an additional 6 in 2024, all equipped with pH sensors from M/s Teledyne Webb Research (TWR). Of the 12 floats procured, 4 were deployed; however, the pH sensors in these floats began malfunctioning within months after deployment. INCOIS raised this issue with M/s TWR, and following detailed discussions with the sensor manufacturer, Seabird, M/s TWR confirmed that the pH sensors have inherent issues, though the root cause remains unidentified.

c) Status of contributions to Argo data management:

All the floats deployed by India were processed in real time and the profiles were submitted to GDAC. Further INCOIS is also archiving all the profiles pertaining to the Indian Ocean for internal use and also generation of gridded product pertaining to the Indian Ocean.

d) Status of delayed mode quality control process:

The OWC software is being used for performing DMQC. All eligible floats were being passed through Delayed Mode Quality Control and 47% of the profiles were DMQCD and uploaded on to GDAC.

2. Present level of, and prospects for, national funding for Argo

The Indian Argo Project is fully funded by the Ministry of Earth Sciences (MoES), Government of India. INCOIS has recently placed a purchase order for 40 Core Argo floats and 10 BGC Argo floats, with deployment planning to be finalized across various Indian Ocean sectors (Bay of Bengal, Arabian Sea, Equatorial Indian Ocean, and Southern Ocean) based on ship-time availability. Additionally, INCOIS has initiated the procurement process for 50 more floats (40 Core and 10 BGC) for the fiscal year 2025-26. A dedicated team of five scientific and technical personnel supports the project, handling float deployment, data management, and analysis. Funding remains stable as of now, with prospects for sustaining the Argo program objectives.

3. Summary of deployment plans

INCOIS aims to address data gaps in the Indian Ocean by strategically deploying Argo floats across various sectors. Deployment locations will be finalized based on cruise approvals, opportunities for collaboration with research institutions, and the availability of approved funds. In March 2025, INCOIS placed a purchase order for 50 Argo floats (40 Core and 10 BGC), with an additional procurement process initiated for 50 floats (40 Core and 10 BGC) for 2025-26. The deployment plan spreadsheet will be completed and submitted as requested.

4. Summary of research and development efforts over the past year

Operational: Since April 2024, approximately 2,500 temperature and salinity profiles from INCOIS-maintained Argo floats have been transmitted to the Global Telecommunication System (GTS). These data are assimilated into ocean models to generate global ocean analyses, which are critical for the Indian Meteorological Department's monsoon forecasts. The analysis products are accessible via the INCOIS Live Access Server (las.incois.gov.in).

Research: Argo data supports extensive research on Indian Ocean dynamics, cyclone and monsoon systems, heat content, thermocline sea level components, and validation of ocean general circulation models (OGCMs) by Indian institutions and university students. INCOIS continues to collaborate with vendors and partners to improve float performance by reporting the issues identified in the deployed floats.

5. Summary of national research and operational uses of Argo data

INCOIS hosts the Argo Regional Centre (ARC) for the Indian Ocean (<http://www.incois.gov.in/argo/ARDCenter.jsp>), providing access to Argo data from floats deployed by India. Data are processed, gridded, and made available through the INCOIS Live Access Server (ILAS) and ERDDAP site (<http://erddap.incois.gov.in/erddap/index.html>). Value-added products, including time series and spatial plots, are accessible at <https://incois.gov.in/argo/ANDCProducts.jsp>. INCOIS also acquires supplementary datasets (e.g., CTD, XBT, subsurface moorings) from principal investigators whenever available for quality control purposes.

6. Issues for consideration by the Argo Steering Team

INCOIS highlights the persistent issue with pH sensors in BGC Argo floats procured in 2023 and 2024 from M/s Teledyne Webb Research. The root cause of the malfunctions remains unresolved as per the information received from the float manufacturer M/s TWR, impacting data quality. INCOIS seeks guidance from the Argo Steering Team on addressing this challenge and improving sensor reliability.

7. Outreach and communication

INCOIS engages with over 5,000 college and university students annually through interactive sessions, showcasing operational oceanography and observation platforms like Argo floats. These efforts aim to inspire future oceanographers and raise awareness of INCOIS's contributions. Social media engagement includes:

- **Facebook:** <https://www.facebook.com/people/INCOISofficial/>
- **LinkedIn:** <https://in.linkedin.com/company/indian-national-centre-for-ocean-information-services-incois->
- **X:** https://x.com/ESSO_INCOIS



Figure: In one of the live interactive sessions with university students, INCOIS scientist explains about the Argo float

8. CTD cruise data for the reference database

During 2024-25, INCOIS did not collect reference database CTD data at float deployment sites. However, efforts continue to acquire CTD, XBT, and subsurface mooring data from principal investigators for quality control purposes. Any relevant CTD data collected in the future will be shared with the community, including cruise dates and principal investigator contacts.

9. Argo bibliography and thesis citations

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- 2) **Athira, K. S., Attada, R., & Rao, V. B.** (2024). Synoptic dynamics of cold waves over north India: Underlying mechanisms of distinct cold wave conditions. *Weather and Climate Extremes*.
- 3) **Bhanu Deepika, P., Mohan, S., & Srinivas, G.** (2024). Intercomparison of tropical Indian Ocean circulation in ocean reanalysis and evaluation in CMIP6 climate models. *Dynamics of Atmospheres and Oceans*.
- 4) **Bhavani, I. V. G., Hamza, F., Smitha, B. R., & Valsala, V.** (2024). Quantifying the role of silicate and dissolved nitrogen in co-limiting the primary and secondary productivity of the Bay of Bengal euphotic zone. *Journal of Geophysical Research: Oceans*.
- 5) **Chaudhuri, D., Sengupta, D., D'Asaro, E., Farrar, J. T., Mathur, M., & Ranganathan, S.** (2024). Near-inertial response of a salinity-stratified ocean. *Journal of Physical Oceanography*.

- 6) **Das, S., & Sil, S.** (2024). Diel variations in the upper layer biophysical processes using a BGC-Argo in the Bay of Bengal. *Deep Sea Research Part II: Topical Studies in Oceanography*.
- 7) **Garg, S., Gauns, M., & Bhaskar, T. V. S. U.** (2024). Dynamics of subsurface chlorophyll maxima in the northern Indian Ocean. *Marine Pollution Bulletin*.
- 8) **Ghosh, J., Chakraborty, K., Valsala, V., Bhattacharya, T., & Ghoshal, P. K.** (2024). A review of the Indian Ocean carbon dynamics, acidity, and productivity in a changing environment. *Progress in Oceanography*.
- 9) **Girishkumar, M. S., Ashin, K., & Rama Rao, E. P.** (2024). Diapycnal mixing induced by salt finger and internal tides on the northwest coast of India. *Continental Shelf Research*.
- 10) **Gnanaseelan, C., Kakatkar, R., Anila, S., Mohapatra, S., Parekh, A., & Chowdary, J. S.** (2024). Role of strong subsurface mode on the anomalous basin-wide surface warming of the Tropical Indian Ocean in 2019–2020. *Journal of Earth System Science*.
- 11) **Gupta, H., Deogharia, R., & Sil, S.** (2024). Influence of the solar penetration depth and heat-fluxes on the sea surface temperature using an ocean mixed layer model. *Regional Studies in Marine Science*.
- 12) **Mandal, A. K., Seemanth, M., & Ratheesh, R.** (2024). Characterization of internal solitary waves in the Andaman Sea and Arabian Sea using EOS-04 and Sentinel observations. *International Journal of Remote Sensing*.
- 13) **Maneesha, K.** (2024). Effect of "spiciness" on the intensification of cyclones over Arabian Sea – A case study on Biparjoy. *Climate Dynamics*.
- 14) **Rahman, R., & Rahaman, H.** (2024). Impact of bathymetry on Indian Ocean circulation in a nested regional ocean model. *Scientific Reports*.
- 15) **Ray, A., Das, S., & Sil, S.** (2024). Role of anomalous ocean warming on the intensification of pre-monsoon tropical cyclones over the Northern Bay of Bengal. *Journal of Geophysical Research: Oceans*.
- 16) **Shee, A., Sil, S., & Deogharia, R.** (2024). Three-dimensional characteristics of mesoscale eddies in the western boundary current region of the Bay of Bengal using ROMS-NPZD. *Dynamics of Atmospheres and Oceans*.
- 17) **Sridevi, B., Ashitha, M. K., Sarma, V. V. S. S., Bhaskar, T. V. S. U., Chakraborty, K., Bhavani, I. V. G., & Valsala, V.** (2024). A new climatology of depth of nitracline in the Bay of Bengal for improving model simulations. *Journal of Geophysical Research: Biogeosciences*.
- 18) **Vijaya Bhaskara Rao, S., Pradhan, P. K., Raman, M. R., Kumar, V., Sunilkumar, K., Jena, B., & Koteswara Rao, K.** (2024). Regional and remote influences of ocean-atmospheric processes on northeast monsoon rainfall during 2021 over India. *International Journal of Climatology*.

10. Deployment plans for RBR floats

INCOIS has no specific plans to deploy RBR CTD floats in 2025 or 2026 at this stage. However, INCOIS is open to considering RBR float deployments if recommended by AST, with decisions contingent on funding and operational priorities.