Argo National Data Management Report (2024) – India

1. Status

- **Data acquired from floats**
  INCOIS has deployed 24 new floats—6 in the Bay of Bengal, 1 in the Arabian Sea, and 16 along the Equatorial Indian Ocean in a north-south (meridional) pattern. With these deployments, India's total contribution since 2002 has reached 542 floats, of which 75 remain active. The data from all active floats are processed and sent to GDAC.

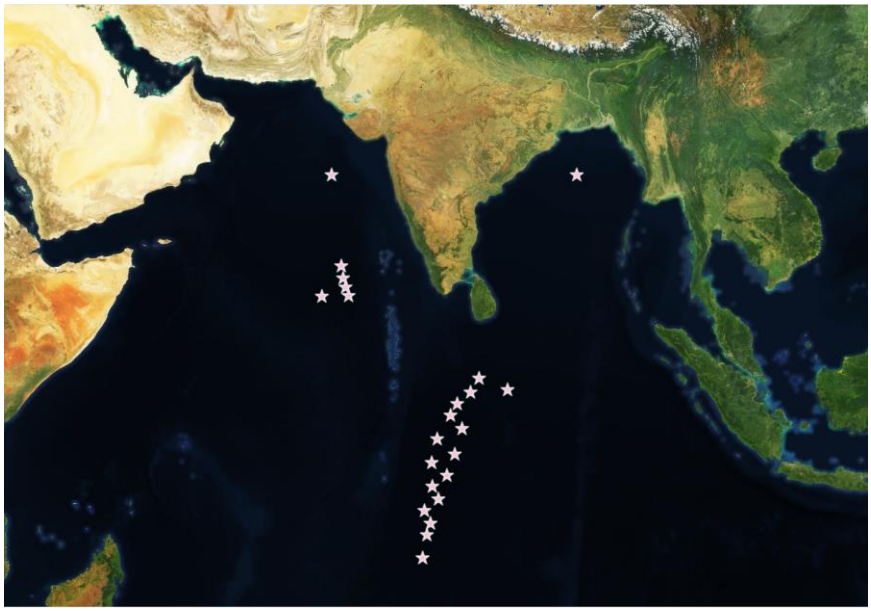


Fig: Map showing the deployment locations of Argo floats by INCOIS in 2024 across the Indian Ocean.

- **Data issued to GTS**
  All the 75 active floats data is being distributed via RTH New Delhi. Data in BUFR format is distributed to IMD, New Delhi and the same are distributed to GTS by assigning a time stamp.

- **Data issued to GDACs after real-time QC**
  All the active floats (75) data are subject to Real Time Quality Control (RTQC) and are being successfully uploaded to both GDACs.

- **Data issued for delayed QC**
  In total ~51% of the eligible profiles for DMQC are generated and uploaded to GDAC. Floats identified and notified through the ocean-ops are passed through DMQC and submitted to GDAC. Some more floats are grey listed, and the list is updated on GDAC.

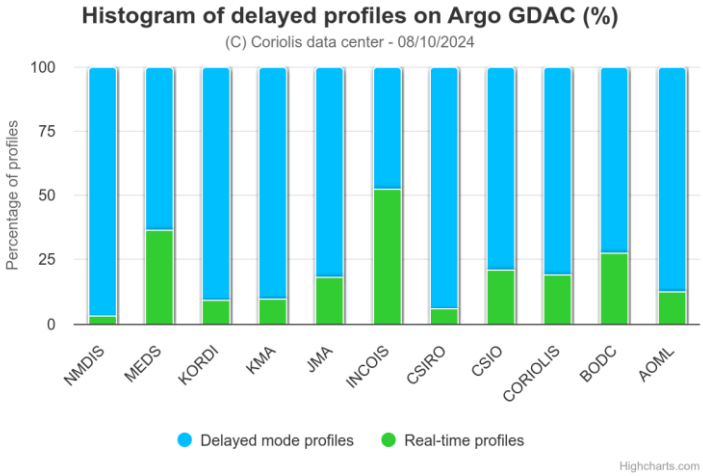


Fig: Histogram of DMQC profiles of all DACs

- **Web pages**
  - INCOIS continued maintaining Web-GIS based site for Indian Argo Program. It contains entire Indian Ocean floats data along with profile position. Further details can be obtained by following the link http://www.incois.gov.in/Incois/argo/argo_home.jsp. Apart from the floats deployed by India, data from floats deployed by other nations in the Indian Ocean are received from the Argo Mirror and made available in the INCOIS website. User can download the data based on his requirement.

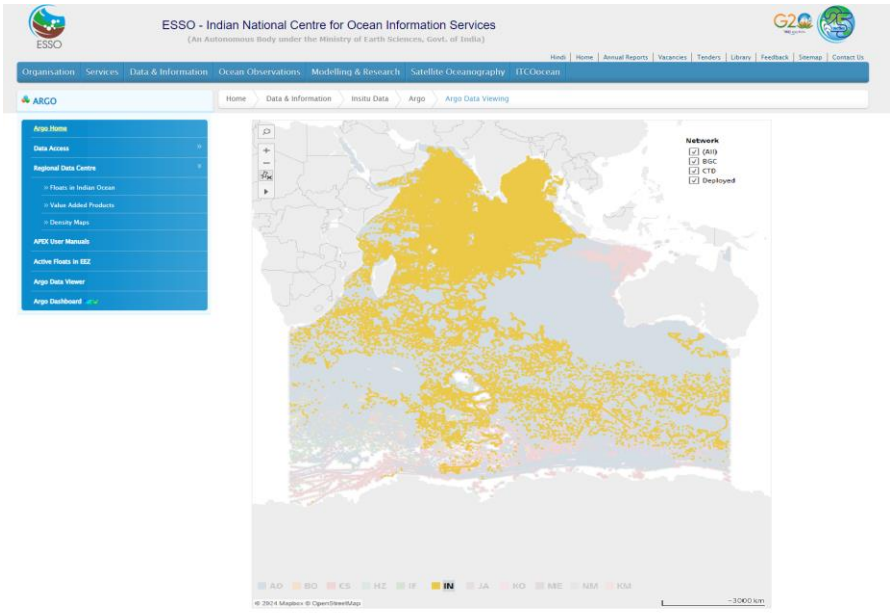


Fig: Snapshot of all the profiles being served by INCOIS website.

  - The Indian ARGO Dashboard is an interactive platform developed by INCOIS to monitor and display real-time data from Argo floats deployed across the Indian Ocean. It provides detailed statistics on the number of floats deployed, their current

status, and their geographic locations. The dashboard also displays key oceanographic data such as temperature, salinity, and pressure profiles, while offering insights into active and inactive floats, deployment history, and India's overall contribution to the global Argo program. The dashboard is scalable to the global ocean, enabling users to monitor Argo floats and analyze data across all oceans, contributing to worldwide ocean observation efforts. For full details visit https://incois.gov.in/argo/argo_dashboard.jsp

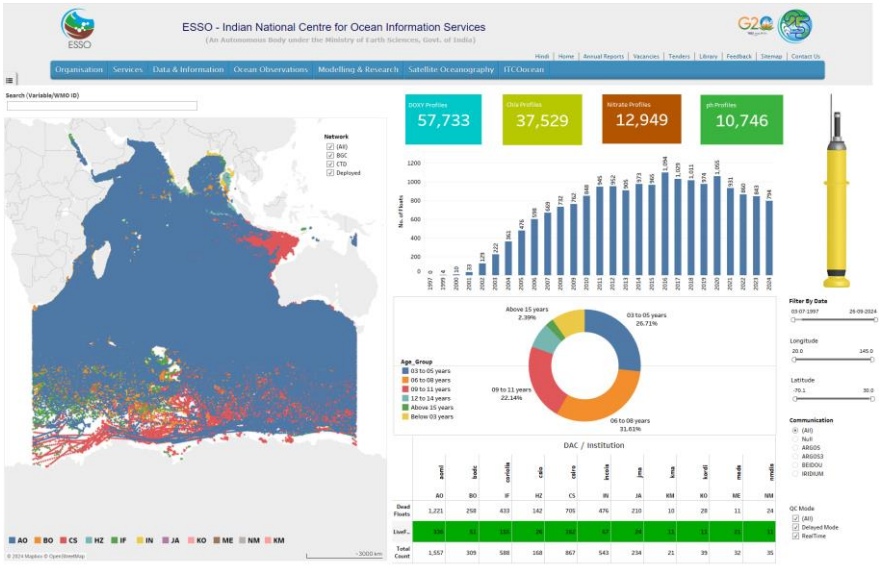


Fig: Indian ARGO Dashboard showcasing statistics of all the profiles available/archived at INCOIS.

- **Trajectory**
  INCOIS continued generating Ver 3.1 trajectory files and uploaded them to GDAC. The implementation of the ARGO trajectory using a new container-based approach is currently underway.
- **Statistics of Argo data usage**
  INCOIS continued Argo data outreach program specifically targeting students, researchers and research scholars. Argo data is popularized and being widely use by various Organisations/ Universities/ Departments. Scientists, Students and Researchers from INCOIS, NIO, SAC, C-MMACS, NRSA, IITM, NCMRWF, IISc etc are using Argo data in various analysis. Many publications based on Argo data were also published in reputed journals. See the references below. Bio-Argo data is continued to be supplied to researchers interested in using it. Data from BGC-Argo is continued to be used for validation of Biogeochemical model outputs like ROMS with Fennel module.

- **Products generated from Argo data**
  1. INCOIS continued to generate value added products using all Argo data (both national and international). Continued to use variational analysis method (DIVA) while generating value added products. Many products are generated using Argo temperature and salinity data. The Argo T/S data are first objectively analysed, and this gridded output is used in deriving value added products.

2. DVD on “Argo data and products for the Indian Ocean” is discontinued which is being made available via INCOIS and UCSD web sites. However, the older version of the same is still available for download.

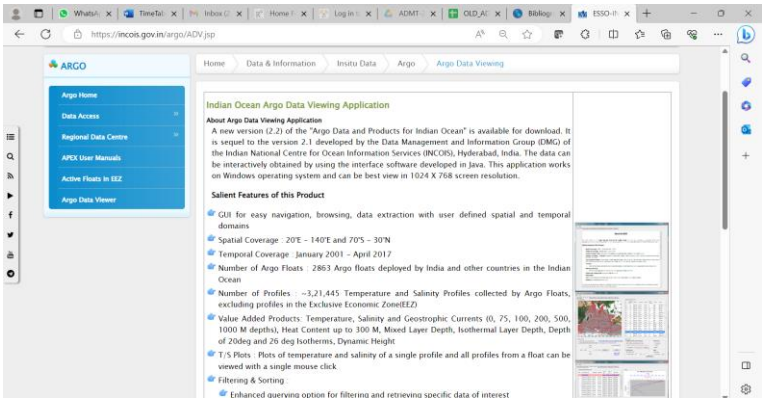


Fig: Web page of the Argo data viewer.

3. Argo valued products are continued to be made available through INCOIS LAS. For further details visit http://las.incois.gov.in.

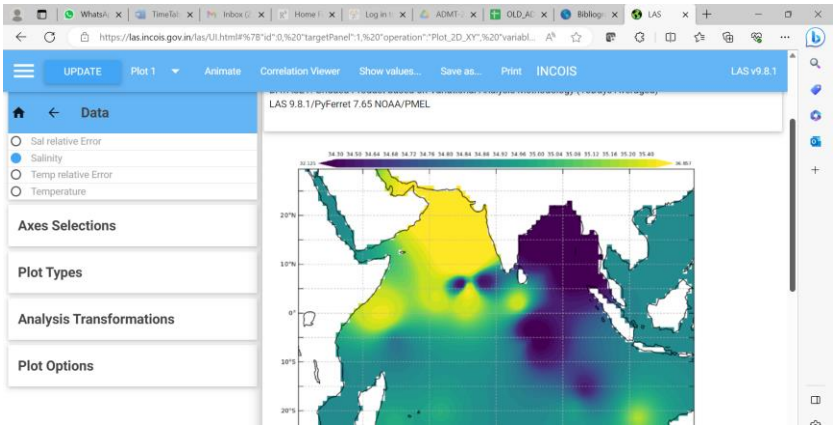


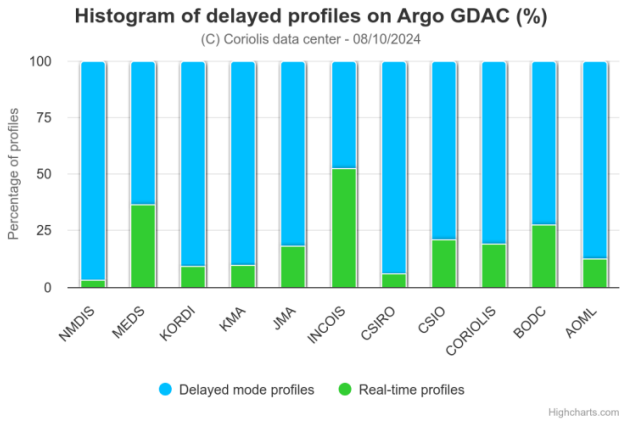
Fig: Screeshot of the LAS page for Argo value added products.

4. Continued to provide the Argo and value-added products derived from Argo data through ERDDAP.
5. Argo data and products are made available through Digital Ocean. For more details users are requested to visit: http://do.incois.gov.in

2. Delayed Mode QC

- INCOIS started generating and uploading D files to GDAC from July 2006, and as of today, profiles belonging to all eligible floats have been subjected to DMQC.
- Modified DMQC S/W obtained from Cecil, IFREMER is also being used. Using this s/w all the eligible floats are reprocessed to tackle pressure sensor offset problems, salinity hooks, thermal lag corrections, salinity drifts.
- Floats, specifically falling in serial numbers above 10,000 are specifically subjected to DMQC in collaboration with CSIRO. Those identified as having ASD were grey listed and Dmoded files were uploaded to GDAC.
- Data obtained from sister concerns and archived is continued to be used in the delayed mode processing.

- About 51% of the eligible profiles are subjected to DMQC and the delayed mode profiles are uploaded on to GDAC.



3. GDAC Functions

INCOIS is not operating as a GDAC.

4. Regional Centre Functions

- INCOIS continued acquisition of Argo data from GDAC corresponding to floats other than deployed by India and made them available on INCOIS web site.
- Delayed Mode Quality Control (Refer 2.0 above).
- Data from the Indian Ocean regions are gridded into 1x1 box for monthly and 10 days and monthly intervals using Variational Analysis (DIVA) and Objective Analysis. These gridded data sets are made available through INCOIS Live Access Server (ILAS).
- ERDDAP site was set up for the data and data products derived from Argo floats.
- INCOIS continued acquisition of data Sets (CTD, XBT, Subsurface Moorings) from principle investigators. The CTD data are being utilized for quality control of Argo profiles.
- Value added products:
  Products are currently being made available to various user from INCOIS web site. They are:
  (i) Spatial plots using the objectively analysed from all the Argo floats data deployed in the Indian Ocean.
  (ii) Spatial plots using the DIVA method from all the Argo floats data deployed in the Indian Ocean

  These valued added products can be obtained from the following link http://www.incois.gov.in/Incois/argo/products/argo_frames.html and also through Live Access Server (LAS).
- Regional Co-ordination for Argo floats deployment plan for Indian Ocean. Coordinating the deployment of floats based on the density maps. These maps are generated before cruise beginning and possible regions with low density are targeted for deployment provided, they are within the regions of planned cruises.

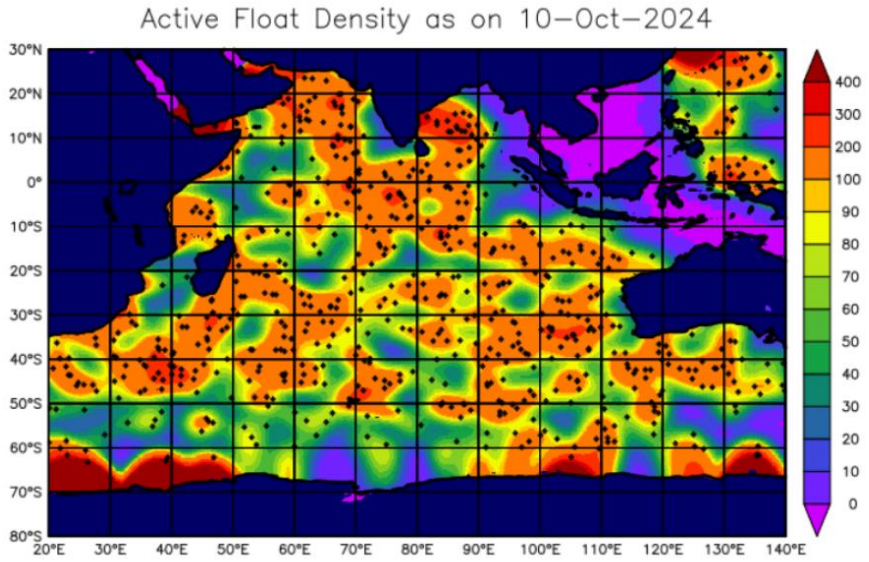


Fig : Argo density map of all available floats as on 10th Oct 2024.

Publications:

INCOIS continued to actively utilize Argo data in various studies pertaining to Indian Ocean. Also INCOIS is encouraging utilization of Argo data by various universities by bringing awareness about the data. Some of the publications resulted from Argo data which includes scientists from INCOIS are given below:

1. Akhter, S., F. Qiao, K. M. A. Chowdhury, X. Yin, and M. K. Ahmed (2024), Simulation of the upper oceanic response to the super cyclonic storm Amphan in the Northern Bay of Bengal, *Journal of Sea Research*, *198*, 102484, doi: https://doi.org/10.1016/j.seares.2024.102484
2. Aravind, H. M., H. S. Huntley, A. D. Kirwan, and M. R. Allshouse (2024), Drifter Deployment Strategies to Determine Lagrangian Surface Convergence in Submesoscale Flows, *J. Atmos. Ocean. Technol.*, *41*(1), 95-112, doi: https://doi.org/10.1175/JTECH-D-22-0129.1
3. Athira, K. S., R. Attada, and V. B. Rao (2024), Synoptic dynamics of cold waves over north India: Underlying mechanisms of distinct cold wave conditions, *Weather and Climate Extremes*, *43*, 100641, doi: https://doi.org/10.1016/j.wace.2024.100641
4. Bhanu Deepika, P., S. Mohan, and G. Srinivas (2024), Intercomparison of tropical Indian Ocean circulation in ocean reanalysis and evaluation in CMIP6 climate models, *Dynamics of Atmospheres and Oceans*, *106*, 101456, doi: https://doi.org/10.1016/j.dynatmoce.2024.101456
5. Chandra, A., N. Keenlyside, L. Svendsen, and A. Singh (2024), Processes Driving Subseasonal Variations of Upper Ocean Heat Content in the Equatorial Indian Ocean, *Journal of Geophysical Research: Oceans*, *129*(2), e2023JC020074, doi: https://doi.org/10.1029/2023JC020074
6. Ghosh, J., K. Chakraborty, V. Valsala, T. Bhattacharya, and P. Kanti Ghoshal (2024), A review of the Indian Ocean carbon dynamics, acidity, and productivity in a changing environment, *Prog. Oceanogr.*, *221*, 103210, doi: https://doi.org/10.1016/j.pocean.2024.103210

7. Girishkumar, M. S., K. Ashin, and E. P. Rama Rao (2024), Diapycnal mixing induced by salt finger and internal tides on the northwest coast of India, *Cont. Shelf Res.*, *273*, 105172, doi: https://doi.org/10.1016/j.csr.2024.105172
8. Gulakaram, V. S., N. K. Vissa, and P. K. Bhaskaran (2024), Processes responsible for mixed layer variations near mesoscale eddies in the Bay of Bengal, *Ocean Dyn.*, doi: https://doi.org/10.1007/s10236-024-01612-z
9. Jarugula, S., D. Sengupta, E. Shroyer, and F. Papa (2024), Mixing of Rain and River Water in the Bay of Bengal From Basin-Scale Freshwater Balance, *Geophys. Res. Lett.*, *51*(3), e2023GL106451, doi: https://doi.org/10.1029/2023GL106451
10. Kumar, R., P. S. Pippal, A. Chauhan, R. P. Singh, R. Kumar, A. Singh, and J. Singh (2024), Dynamics of land, ocean, and atmospheric parameters associated with Tauktae cyclone, *Environmental Science and Pollution Research*, *31*(8), 12561-12576, doi: https://doi.org/10.1007/s11356-023-31659-2
11. Kumar, V., D. Sumangala, and H. Warrior (2024), Salinity data curation using CMIP6 projections and artificial neural network for the Bay of Bengal, *ISH Journal of Hydraulic Engineering*, *30*(2), 218-227, doi: https://doi.org/10.1080/09715010.2023.2291796
12. Rahman, R., and H. Rahaman (2024), Impact of bathymetry on Indian Ocean circulation in a nested regional ocean model, *Scientific Reports*, *14*(1), 8008, doi: https://doi.org/10.1038/s41598-024-58464-2
13. Raja, K. J., M. C. Buijsman, A. Bozec, R. W. Helber, J. F. Shriver, A. Wallcraft, E. P. Chassignet, and B. K. Arbic (2024), Spurious internal wave generation during data assimilation in eddy resolving ocean model simulations, *Ocean Model.*, *188*, 102340, doi: https://doi.org/10.1016/j.ocemod.2024.102340