National Report of India (2024)

(Submitted by E. Pattabhi Rama Rao)

1. The status of implementation

1.1a Floats deployment

INCOIS has made a total contribution of 538 floats to the international Argo programme so far. During the 2023-24 period, INCOIS deployed 44 Argo floats in the Indian Ocean, of which 40 are Core Argo floats and 4 are BGC floats. Presently, 73 Argo floats are active and transmitting data. All the active float data are processed and sent to GDAC.

1.1b Performance Analysis of Floats Deployed

Of the 538 floats deployed so far, 73 are presently active and transmitting data.

1.2 Technical problems encountered and solved.

None

1.3 Status of contributions to Argo data management

- **Data acquired from floats.**

  India has deployed 538 floats so far (till Feb 29, 2024). Out of these, 73 floats are active. All the active float data are processed and sent to GDAC.

- **Data issued to GTS.**

  BUFR format messages from these floats are being sent to GTS via RTH New Delhi.

- **Data issued to GDACs after real-time QC**

  All the active floats (73) data are subject to real-time quality control and are being sent to GDAC.

- **Web pages**

  INCOIS continued maintaining a Web-GIS-based site for the Indian Argo Program. It contains the entire Indian Ocean float 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.

- **Statistics of Argo data usage**

  Statistics of Indian and Indian Ocean floats are generated and maintained on the INCOIS website. The density maps for aiding people with new deployments are made available on a monthly basis. For full details, visit the following link:

  http://www.incois.gov.in/Incois/argo/argostats_index.jsp.

- **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, and is being made available via INCOIS and UCSD websites. However, the older version of the same is still available for download.

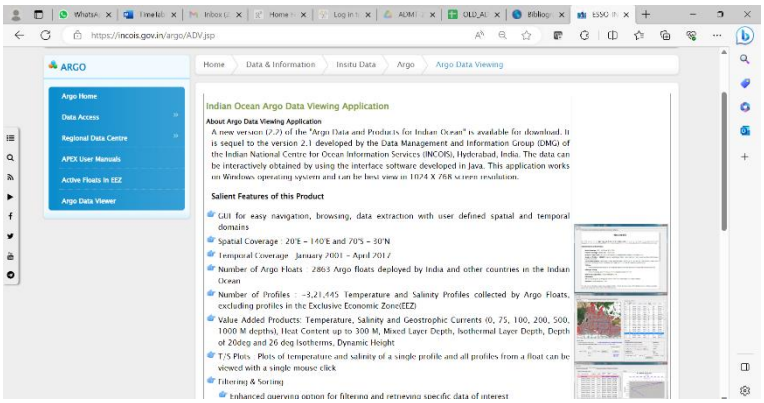


Fig: Web page of the Argo data viewer.

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

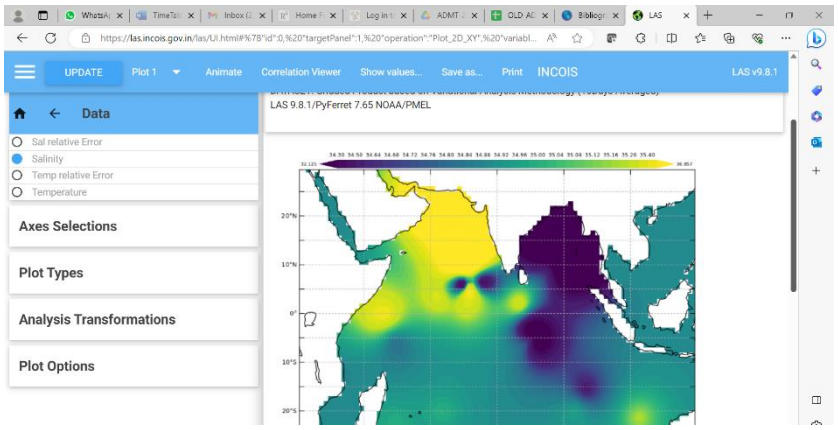


Fig: Screeshot of the LAS page for Argo value added products.

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

1.4 Status of Delayed Mode Quality Control process

In total, ~49% 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.

1.5 Trajectory files status:

INCOIS continued generating Ver 3.1 trajectory files and uploaded them to the GDAC.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

The Indian Argo Project is fully funded by the Ministry of Earth Sciences (MoES), Government of India. Currently, INCOIS has 06 BGC Argo floats (all 06 with CTD, DO, FLBB and pH sensors, and two floats with additional nitrate sensors) in stock, received in February 2024, and will be deployed in the coming months in the Indian Ocean. In March 2024, INCOIS placed a purchase order for 50 Argo floats (40 CORE and 10 BGC floats) for deployments in the Indian Ocean. Once these floats are received, INCOIS will make the deployment planning across various sectors of the Indian Ocean, including the Bay of Bengal, Arabian Sea, Equatorial Indian Ocean, and Southern Ocean (depending on ship-time availability)

Supporting the Indian Argo Project is a dedicated team of four scientific and technical personnel responsible for tasks such as float deployment, data management, and data analysis.

3. Summary of deployment plans (level of commitment, areas of float deployment) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

INCOIS plans to address the data gaps across different sectors of the Indian Ocean by deploying more Argo floats. However, the final decision on deployment locations depends on getting cruise approvals or chances to collaborate with other research institutions to plan cruises in those data gap regions. Moreover, the availability of approved funds is also crucial in determining the final number of Argo floats. Presently, INCOIS placed a purchase order for 50 Argo floats in March 2024, consisting of 40 core floats and 10 BGC floats.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers.

Operational: All Argo data is routinely assimilated into the Ocean Model to provide a global ocean analysis. The Indian MET department utilizes this analysis for initializing the coupled ocean-atmosphere forecast of the Monsoon. Since 2011, India has been providing seasonal Monsoon forecasts using a dynamic model in which Ocean analysis (with assimilation of Argo) plays a crucial role. The analysis products are accessible through the INCOIS live access server (las.incois.gov.in).

Research: Argo data is extensively used for various applications to understand the dynamics of the Indian Ocean, cyclone and monsoon system in relation to heat content, thermosteric component of sea level, and validation of OGCM by several Indian institutions and university students.

Argo Regional Centre (ARC) - Indian Ocean

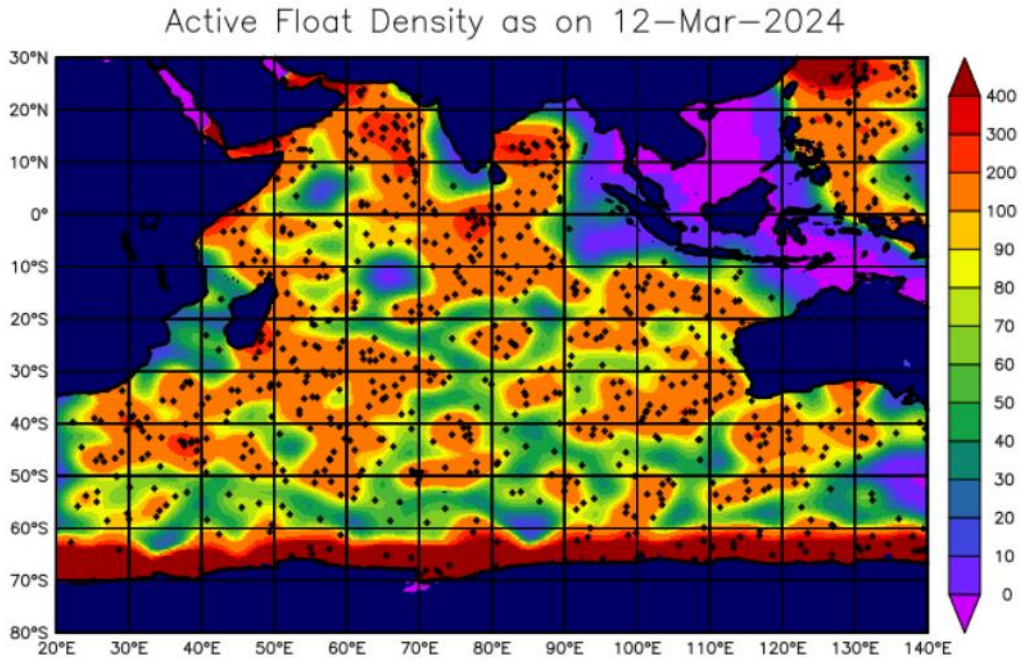
(http://www.incois.gov.in/argo/ARDCenter.jsp)

- Acquisition of Argo data from GDAC corresponding to floats other than deployed by India and made them available on INCOIS web site.
- All these data sets are made available to the user through a s/w developed with all GUI facilities. This s/w is made available through FTP at INCOIS and UCSC web sites.
- 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. These gridded data sets are made available through INCOIS Live Access Server (ILAS). Users can view and download data/images in their desired format.
- ERDDAP site was set up for the data and data products derived from Argo floats (http://erddap.incois.gov.in/erddap/index.html)

- Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators. These data are being utilized for quality control of Argo profiles.
- Value added products: Two types of products are currently being made available to various user from INCOIS web site. They are:
  (i) Time series plots corresponding to each float (only for Indian floats).
  (ii) Spatial plots using the objectively analysed from all the Argo floats data deployed in the Indian Ocean.

  These valued added products can be obtained from the following link https://incois.gov.in/argo/ANDCProducts.jsp

  float density in Indian Ocean as of March, 2024 is shown below.



5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

INCOIS is not getting ship time for float deployments in the Southern sector of the Indian Ocean. If AST could help INCOIS get cruise plans from other Argo member countries, INCOIS can collaborate with them to deploy floats in those regions.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators, wherever possible. These data are being utilized for quality control of Argo profiles.

7. Argo bibliography

INCOIS is actively involved in utilization of Argo data in various studies pertaining to Indian Ocean. Also INCOIS is encouraging utilization of Argo data by various universities by funding them. Some of the publications resulted from Argo data which includes scientists from INDIA are given below:

1. Akhil, V. P., M. Lengaigne, K. S. Krishnamohan, M. G. Keerthi, and J. Vialard (2023), Southeastern Arabian Sea Salinity variability: mechanisms and influence on surface temperature, Climate Dynamics, doi: https://doi.org/10.1007/s00382-023-06765-z.
2. Anjaneyan, P., J. Kuttippurath, P. V. Hareesh Kumar, S. M. Ali, and M. Raman (2023), Spatio-temporal changes of winter and spring phytoplankton blooms in Arabian sea during the period 1997–2020, Journal of Environmental Management, 332, 117435, doi: https://www.sciencedirect.com/science/article/pii/S0301479723002232.
3. Bhattacharya, T., K. Chakraborty, P. K. Ghoshal, J. Ghosh, and B. Baduru (2023), Response of Surface Ocean pCO2 to Tropical Cyclones in Two Contrasting Basins of the Northern Indian Ocean, Journal of Geophysical Research: Oceans, 128(4), e2022JC019058, doi: https://doi.org/10.1029/2022JC019058.
4. Chacko, N. (2023), On the rapid weakening of super-cyclone Amphan over the Bay of Bengal, Ocean Dyn., 73(6), 359-372, doi: https://doi.org/10.1007/s10236-023-01555-x.
5. Jha, R. K., and T. V. S. U. Bhaskar (2023), Generation and Assessment of ARGO Sea Surface Temperature Climatology for the Indian Ocean Region, Oceanologia, 65(2), 343-357, doi: https://doi.org/10.1016/j.oceano.2022.08.001.
6. Konda, G., V. S. Gulakaram, and N. K. Vissa (2023), Intraseasonal variability of subsurface ocean temperature anomalies in the Indian Ocean during the summer monsoon season, Ocean Dyn., 73, 165-179, doi: https://doi.org/10.1007/s10236-023-01547-x.
7. Maneesha, K., S. Ratheesh, and T. V. S. U. Bhaskar (2023), Impact of the Upper Ocean Processes on Intensification of Cyclone Amphan, Journal of the Indian Society of Remote Sensing, 51(2), 289-298, doi: https://doi.org/10.1007/s12524-022-01592-x.
8. Mohanty, S., V. S. Bhadoriya, and P. Chauhan (2023), Upper Ocean Response to The Passage of Cyclone Tauktae in The Eastern Arabian Sea Using In Situ and Multi-Platform Satellite Data, Journal of the Indian Society of Remote Sensing, 51(2), 307-320, doi: https://doi.org/10.1007/s12524-022-01621-9.
9. Mohanty, S., M. Swain, R. Nadimpalli, K. K. Osuri, U. C. Mohanty, P. Patel, and D. Niyogi (2023), Meteorological Conditions of Extreme Heavy Rains over Coastal City Mumbai, Journal of Applied Meteorology and Climatology, 62(2), 191-208, doi: https://doi.org/10.1175/JAMC-D-21-0223.1.
10. Prasanth, R., V. Vijith, and P. N. Vinayachandran (2023), Formation, maintenance and diurnal variability of subsurface chlorophyll maximum during the summer monsoon in the southern Bay of Bengal, Prog. Oceanogr., 212, 102974, doi: https://doi.org/10.1016/j.pocean.2023.102974.
11. Rahaman, H., L. Kantha, M. J. Harrison, V. Jampana, T. M. B. Nair, and M. Ravichandran (2023), Impact of initial and lateral open boundary conditions in a Regional Indian Ocean Model on Bay of Bengal circulation, Ocean Model., 184, 102205, doi: https://doi.org/10.1016/j.ocemod.2023.102205.

12. Thandlam, V., H. Rahaman, A. Rutgersson, E. Sahlee, M. Ravichandran, and S. S. V. S. Ramakrishna (2023), Quantifying the role of antecedent Southwestern Indian Ocean capacitance on the summer monsoon rainfall variability over homogeneous regions of India, Scientific Reports, 13(1), 5553, doi: https://doi.org/10.1038/s41598-023-32840-w.
13. Thoppil, P. G. (2023), Enhanced phytoplankton bloom triggered by atmospheric high-pressure systems over the Northern Arabian Sea, Scientific Reports, 13(1), 769, doi: https://doi.org/10.1038/s41598-023-27785-z.

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

Due to COVID-19 pandemic-related constraints, INCOIS was not able to procure any floats during the 2019-2022 period. However, INCOIS procured 50 Argo floats during the 2022-23 period, and 44 of them were deployed. Additionally, INCOIS placed a purchase order for another 50 floats during March 2024.

9. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2023 and 2024 (if known) and where they might be deployed.

INCOIS, so far, only deployed pumped CTD-based Argo floats and do not have any immediate plans to procure RBR unpumped CTD floats due to a reported salinity bias issue (Dever et al. 2022). However, INCOIS welcomes a wide range of sensor and float manufacturers to promote competitive pricing and meet the global requirements and timelines in the current international supply chain situation following the Covid-19 pandemic. INCOIS requests that AST come up with a detailed plan and recommendations for using unpumped CTDs in Argo floats.