# National report of India (2023)

**(Submitted by E. Pattabhi Rama Rao)**

## 1. The status of implementation

### 1.1a Floats deployment

INCOIS has made a total contribution of 494 floats to the Argo programme so far. Though no floats were deployed during 2022-23 period, 52 floats previously deployed are still active and transmitting data. All the active floats data are processed and sent to GDAC.

### 1.1b Performance Analysis of Floats deployed

Of the 494 floats deployed so far, 52 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 had deployed 494 floats so far (till Jan 31, 2023). Out of these 52 floats are active. All the active floats 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 (52) data are subject to real time quality control and are being sent to GDAC.

- **Web pages**

  INCOIS maintains a comprehensive Web-GIS based site for the Indian Argo Program. This site contains all of the data on Indian Ocean floats, including their trajectories, providing a valuable resource for researchers and anyone interested in the program. For those who want to learn more, please follow the link to access additional details: https://incois.gov.in/argo/argo.jsp

- **Statistics of Argo data usage**

  In India, the Argo data is widely used by a diverse range of users, including students and researchers from academia, research centers, and operational centers. The Indian Meteorological Department (IMD), which serves as the nodal agency for monsoon forecasting in India, relies on Argo data for its operational purposes. Meanwhile, scientists, students, and researchers from organizations such as INCOIS, NIO, SAC, C-MMACS, NRSA, IITM, NCMRWF, and IISc have incorporated Argo data into various analyses and published numerous peer-reviewed scientific papers utilizing this data. Additionally, the increasing availability of biogeochemical variables from Argo floats is being used to validate biogeochemical model outputs like ROMS with Fennel module, and for basic research on biogeochemical aspects.

  INCOIS Argo web page statistics during the year 2022-23 are as shown below:

| Page | Number |
|---|---|
| Argo Web Page Views | 19219 |
| Argo Data Download | 1821 |
| Argo Products | 1547 |

Products generated from Argo data

- During the reporting period, the generation of value-added products from the Argo profile data was continued. The Argo T/S data was first objectively analyzed, and the resulting gridded output was used to derive a variety of value-added products for scientific use. These products include Depth of 20º isotherm, depth of 25º isotherm, dynamic height, geostrophic currents, heat content, isothermal layer depth, mixed layer depth, and geostrophic currents. All of these valuable data are readily available for free download via INCOIS LAS, and those seeking further details can visit the link: http://las.incois.gov.in.

**1.4 Status of Delayed Mode Quality Control process**

Since July 2006, INCOIS has been generating and uploading D files to GDAC, and all eligible floats' profiles have now undergone DMQC. To achieve this, the Enhanced Delayed Mode Quality Control software OWC has been used, enabling the addressing of various issues such as pressure sensor offset problems, salinity hooks, thermal lag corrections, salinity drifts, and more. As a result, approximately 55% of eligible profiles have undergone DMQC and the delayed mode profiles have been successfully uploaded to GDAC. Furthermore, a majority of old dead float profiles that have passed DMQC have been converted to Ver 3.1 and are now also available on GDAC.

**1.5 Trajectory files status:**

Ver 3.1 trajectory files for all Indian floats are generated and uploaded to GDAC. Few files rejected owing to format issues are attended to and uploaded back 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 is in the process of procuring 50 Argo floats (40 core floats and 10 BGC floats) through a global tender to be deployed in various sectors of the Indian Ocean, including the Bay of Bengal, Arabian Sea, Equatorial Indian Ocean, and Southern Ocean. The final number of floats procured/deployed will be determined by the ship-time availability and approved funding.

The Indian Argo project is supported by a dedicated team of four scientific and technical personnel, including individuals responsible for the deployment of Argo floats, 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 intends to address the significant data gaps in various sectors of the Indian Ocean by deploying more number of Argo floats. However, the final decision on the deployment location will depend on obtaining cruise approvals or collaborating with other research institutions that have research cruises planned in those data gap areas. Additionally, the availability of funds will also be a significant determinant in the final deployment status. Currently, INCOIS is moving forward with the procurement of 50 Argo floats, including 40 core floats and 10 BGC floats, to support the project.

**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. This analysis is utilized by the Indian MET department for initializing the coupled ocean-atmosphere forecast of the Monsoon. Since 2011, India has been providing seasonal forecasts of the Monsoon using a dynamical 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.

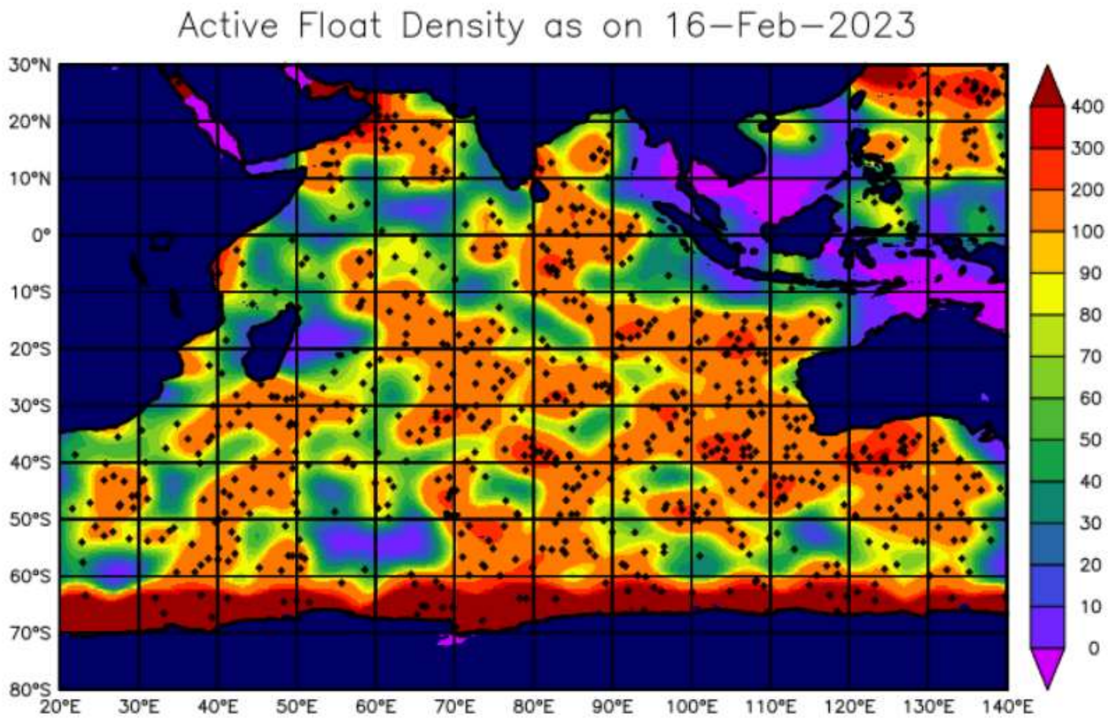
**Argo Regional Centre (ARC) - Indian Ocean**

**(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 February, 2023 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.**

None.

**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. 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:

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resolution regional ocean model, *Theoretical and Applied Climatology*, *151*(1), 169-182, doi: https://doi.org/10.1007/s00704-022-04275-2

**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 Covid19 pandemic-related constraints, INCOIS was not able to procure or deploy any floats in the reporting year. However, INCOIS continued to receive and process data from active floats deployed previously.

**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.**

Not decided.