National report of India (2018)

(Submitted by E. Pattabhi Rama Rao)

1. The status of implementation

1.1a Floats deployment

During the year 2018, 15 floats were deployed in the Indian Ocean, and five floats in Jan 2019, taking the total to 459. The new deployment includes 2 Bio-Argo floats with additional sensors like Doxy, FLBB, Chl-a and 1 Ice Float.

1.1b Performance Analysis of Floats deployed

Out of 15 floats deployed during 2018 all 14 are active and providing profiles. One Ice float died after providing 9 profiles.

1.2 Technical problems encountered and solved

None

1.3 Status of contributions to Argo data management

- **Data acquired from floats**

  India has deployed 459 floats so far (till Jan 31, 2019). Out of these 138 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 RTH.

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

  All the active floats (138) data are subject to real time quality control and are being sent to GDAC.

- **Web pages**

  INCOIS is maintaining Web-GIS based site for Indian Argo Program. It contains entire Indian Ocean floats data along with trajectories. Further details can be obtained by following the link:

  http://www.incois.gov.in/incois/argo/argo_home.jsp.

- **Statistics of Argo data usage**

  Argo data is widely put to use by various Organisations/ Universities/ Departments. Indian Meteorological Department (IMD) is using Argo data for their operational purpose. Scientists, Students and Researchers from INCOIS, NIO, SAC, C-MMACS, NRSA, IITM, NCMRWF, IISc etc are using Argo data in various analysis. Many paper based on Argo data were also published in reputed journals. See the references below. The demand for Bio-Argo data is increasing and the same is being supplied for research interest by various research institutes and universities. These data is also used for validation of Biogeochemical model outputs like ROMS with Fennel module.

INCOIS Argo web page statistics during the year 2018 are as shown below:

Page	Number
Argo Web Page Views	2862

Argo Data Download	1516
Argo Products	18419

Products generated from Argo data

- Value added products obtained from Argo data are continued. Continued to variational analysis method 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. More on this can be see in the RDAC functions.
- Version 2.2 of DVD on "Argo data and products for the Indian Ocean" is released to public for use with data corresponding to April 2018 updated. This DVD consists of ~ 3,30,000 profiles and products based on the Argo T/S. A GUI is provided for user to have easy access to the data. DVD product is discontinued and it is being made available via INCOIS and UCSD web sites.
- To cater to many users of INCOIS LAS, it is enhanced in term of capacity. New Server is procured and new products viz., model outputs, new wind products (OSCAT), fluxes are made available. New products as per the request received from the users in future are being made available. For further details visit http://las.incois.gov.in.

1.4 Status of Delayed Mode Quality Control process

- INCOIS started generating and uploading D files to GDAC form July 2006, and as of today, profiles belonging to all eligible floats have been subjected to DMQC.
- Advanced Delayed Mode Quality Control s/w developed by CSIRO is being put to use successfully. Using this s/w all the eligible floats are reprocessed to tackle pressure sensor offset problems, salinity hooks, thermal lag corrections, salinity drifts.
- Under the data search and archeology data from our own sister concerns is being obtained and put to use 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. Majority of the old dead float which are passed through DMQC are converted to Ver 3.1 and uploaded to GDAC

1.5 Trajectory files status:

Trajectory files in Ver 3.1 format for all APEX floats are being uploaded to GDAC and trajectories wrt to PROVOR and ARVOR floats will be uploaded shortly.

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

Indian Argo Project is fully funded by Ministry of Earth Sciences, (MoES), Govt. of India. Funding is secured for the deployment of 50 Argo floats per year including (3:2 Normal and Bio), Data management activities, Data analysis, etc. for the period 2017-2020. India plans to deploy 50 floats/per (40 tropical Indian Ocean and 10 in the Southern ocean).

Three Permanent and one temporary scientific/technical personnel are working under Indian Argo project, which include personal for deployment of Argo floats, Data system, Analysis of Data, etc.

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.

India is committed to deploy floats in the Indian Ocean wherever gap exists. India has committed 50 floats per year during 2017-2020 (40 in the Tropical Indian Ocean and 10 in the Southern ocean). Out of 50 floats, 20 floats will be bio-argo floats. After ascertaining the gap region and cruise plan of MoES research vessels, these floats will be deployed. The existing data management resources will continue until 2020.

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

Operational: All Argo data are being routinely assimilated in Ocean Model for providing Global ocean analysis. This analysis is being used by Indian MET department for initialization of coupled ocean-atmosphere forecast of the Monsoon. From the year 2011, India is providing seasonal forecast of monsoon using dynamical model wherein Ocean analysis (with assimilation of Argo) is an important contribution. The analysis products are being made available through INCOIS live access server (las.incois.gov.in).

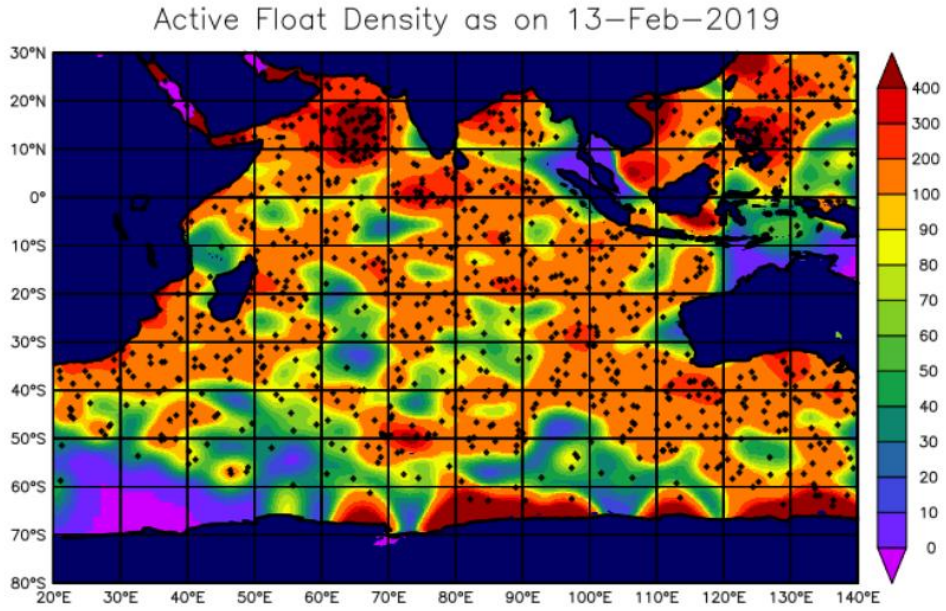
Research: Argo data are being widely used for many applications to understand the Indian Ocean dynamics, cyclone and monsoon system in relation to heat content, thermosteric component of sea level and validation of OGCM by various Indian institutions and university students.

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.
- Additionally SST from TMI, AMSRE and Wind from ASCAT, Chla from MODIS and OCM-2 are also made available on daily and monthly basis.
- Global wind products from OSCAT is also generated and made available on LAS along with TROP flux data sets.
- 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 http://www.incois.gov.in/Incois/argo/products/argo_frames.html
- Regional Co-ordination for Argo floats deployment plan for Indian Ocean. The float density in Indian Ocean as on 13 Feb, 2019 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 INCOIS are given below:

1. V. V. S. S. Sarma, T. V. S. Udaya Bhaskar, Ventilation of Oxygen to Oxygen Minimum Zone Due to Anticyclonic Eddies in the Bay of Bengal, Journal of Geophysical Research, https://doi.org/10.1029/2018JG004447.

2. Kakatkar, R., C. Gnanaseelan, J. S. Chowdary, A. Parekh, and J. S. Deepa, 2018: Indian summer monsoon rainfall variability during 2014 and 2015 and associated Indo-Pacific upper ocean temperature patterns. Theoretical and Applied Climatology, 131, 1235-1247, https://doi.org/10.1007/s00704-017-2046-4.

3. Karmakar, A., A. Parekh, J. S. Chowdary, and C. Gnanaseelan, 2018: Inter comparison of Tropical Indian Ocean features in different ocean reanalysis products. Climate Dynamics, 51, 119-141, https://doi.org/10.1007/s00382-017-3910-8.

4. Lotliker, A. A., S. K. Baliarsingh, V. L. Trainer, M. L. Wells, C. Wilson, T. V. S. Udaya Bhaskar, A. Samanta, and S. R. Shahimol, 2018: Characterization of oceanic Noctiluca blooms not associated with hypoxia in the Northeastern Arabian Sea. Harmful Algae, 74, 46-57, https://doi.org/10.1016/j.hal.2018.03.008.

5. Misra, T., R. Sharma, R. Kumar, and P. K. Pal, 2018: Ocean Remote Sensing: Concept to Realization for Physical Oceanographic Studies. Observing the Oceans in Real Time, R. Venkatesan, A. Tandon, E. D'Asaro, and M. A. Atmanand, Eds., Springer International Publishing, 165-202, https://doi.org/10.1007/978-3-319-66493- 4_9.

6. Pattabhi Rama Rao, E., T. V. S. Bhaskar, R. V. Seshu, N. S. Rao, K. Suprit, and G. Geetha, 2018: Marine Data Services at National Oceanographic Data Centre-India. Data Science Journal, 17, 11, http://doi.org/10.5334/dsj-2018-011.

7. Ravichandran, M. and M. S. Girishkumar, 2018: Applications of Ocean In-situ Observations and Its Societal Relevance. Observing the Oceans in Real Time, R. Venkatesan, A. Tandon, E. D'Asaro, and M. A. Atmanand, Eds., Springer International Publishing, 303-313, https://doi.org/10.1007/978-3-319-66493-4_15.

8. Santhanam, H. and T. Natarajan, 2018: Short-term desalination of Pulicat lagoon (Southeast India) due to the 2015 extreme flood event: insights from Land-Ocean Interactions in Coastal Zone (LOICZ) models. Ecological Processes, 7, 10, https://doi.org/10.1186/s13717-018-0119-7.

9. Sarangi, R. K., S. K. Shrinidhi, P. Chauhan, and B. R. Raghavan, 2018: Remote sensing and in situ platform based study on impact of Bay of Bengal cyclones (Phailin, Helen, Lehar, and Madi) on ocean chlorophyll and associated physical parameters. Natural Hazards, 93, 413-451, https://doi.org/10.1007/s11069-018-3307-y

10. Seelanki, V., P. Sreenivas, and K. V. S. R. Prasad, 2018: Impact of Aquarius SeaSurface Salinity Assimilation in Improving the Ocean Analysis Over Indian Ocean. Marine Geodesy, 41, 144-158, https://doi.org/10.1080/01490419.2017.1422817.

11. Sherin, V. R., F. Durand, V. V. Gopalkrishna, S. Anuvinda, A. V. S. Chaitanya, R. Bourdallé-Badie, and F. Papa, 2018: Signature of Indian Ocean Dipole on the western boundary current of the Bay of Bengal. Deep Sea Research Part I: Oceanographic Research Papers, 136, 91-106, https://doi.org/10.1016/j.dsr.2018.04.002.

12. Tyagi, G., K. N. Babu, A. K. Mathur, and H. A. Solanki, 2018: INSAT-3D and MODIS retrieved sea surface temperature validation and assessment over waters surrounding the Indian subcontinent. International Journal of Remote Sensing, 39, 1575-1592, https://doi.org/10.1080/01431161.2017.1407051.

13. Valsala, V., S. Singh, and S. Balasubramanian, 2018: A Modeling Study of Interannual Variability of Bay of Bengal Mixing and Barrier Layer Formation. Journal of Geophysical Research: Oceans, 123, 3962-3981, https://doi.org/10.1029/2017JC013637.

14. Venkatesan, R., A. Tandon, D. Sengupta, and K. N. Navaneeth, 2018: Recent Trends in Ocean Observations. Observing the Oceans in Real Time, R. Venkatesan, A. Tandon, E. D'Asaro, and M. A. Atmanand, Eds., Springer International Publishing, 3- 13, https://doi.org/10.1007/978-3-319-66493-4_1.

15. Vidya, P. J. and S. Kurian, 2018: Impact of 2015–2016 ENSO on the winter bloom and associated phytoplankton community shift in the northeastern Arabian Sea. Journal of Marine Systems, 186, 96-104, https://doi.org/10.1016/j.jmarsys.2018.06.005.