10 years of Indian Argo

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Outline

• Present status of Floats deployed by India
• Status of floats in the Indian Ocean
• Utilization of Argo data
  – New in-sights (Science)
  – Operational (Products and services)
  – Catalyst for other *in-situ* observing system
• Capacity building
• Deployment opportunities
Argo India - start

- Implementation planning meeting held at Hyderabad (July 2001)
- Dr. Howard Freeland provided a float to deploy in the Arabian Sea
Canadian Argo Float deployed by India in Dec. 2001
(A Typical Case in South Arabian Sea)

APEX Float with Sea Bird Sensors, Parking Depth of 1200 metre, 180 cc Fluid, 10 day cycle
Launching Indian Argo Programme

Oct 2002
Five year plans

- First five year plan (2002-2007)
  - To deploy 150 floats (30 floats per year)

- Second five year Plan (2007-2012)
  - To deploy 150 floats (30 floats per year)

- Third five year Plan (2012-2017)
  - To deploy 200 floats (40 floats per year)
  - 50 floats are Bio-Argo (10 floats per year)

  -- Argo data center (DAC and ARC)
  -- Data utilization (Products, analysis and Science)
Deployment locations

**Type of Sensors**

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Count</th>
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<tbody>
<tr>
<td>CTD alone</td>
<td>244</td>
</tr>
<tr>
<td>CTD + Near Surface Temperature</td>
<td>15</td>
</tr>
<tr>
<td>CTD + Dissolved Oxygen</td>
<td>16</td>
</tr>
<tr>
<td>Bio-Argo (CTD + Chla + DO + FLBB)</td>
<td>9</td>
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**Type of Communication**

<table>
<thead>
<tr>
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<tr>
<td>ARGOS</td>
<td>250</td>
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<tr>
<td>IRIDIUM</td>
<td>34</td>
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</table>
Present location of Indian Active floats

Not many floats in the Arabian Sea due to Piracy issue
Argo Float Data – Indian Ocean

- Data availability: Jan 2001 - till date
- Active No. of Floats: 745
- Total No. of Floats: 1982
- Indian Floats: 284
- T and S Profiles: ~ 2,20,000
- Data formats: ASCII, NetCDF, Plots
Argo float density

Locations varies with season
Float statistics – Indian Ocean

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<thead>
<tr>
<th>Page</th>
<th>Views</th>
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<tr>
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<td>1017</td>
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<td>Argo products</td>
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**Age of Floats**

- 0 to 1 yrs (26.28%)
- 1 to 2 yrs (19.17%)
- 2 to 3 yrs (19.90%)
- 3 to 4 yrs (13.84%)
- 4 to 5 yrs (9.42%)
- 5 to 6 yrs (6.46%)
- 6 to 7 yrs (2.48%)
- (1.88%)
- (0.81%)
- (0.43%)
- (0.22%)
- (0.11%)
Argo – Data utilization in India

• New In-sights ( ~ 75 papers)
• Operational – Value added products and Ocean Analysis
• Other in-situ ocean observation in the Indian Ocean - IndOOS
New in-sights
Indian Ocean process studies

- Buoyancy flux changes in the Bay of Bengal
- Upper ocean response of T & S to local atmospheric forcing
- ISO thermocline and BL variability in the Bay
- Cyclone genesis and Intensity
- Water mass properties in the Arabian Sea
- Mixed layer variability in the North Indian Ocean
- Delineating upwelling zones
- Role of salinity in thermal inversion in the Arabian sea
- Contribution of halo-steric height in dynamic height
- .....
New in-sights
Indian Ocean dynamics and validation of models

• Impact of summer monsoon ISO in tropical Indian ocean using Argo and OGCM
• Surface currents from Argo, altimeter and scatterometer
• Validation of OGCM using Argo observations
• Analysed Ocean state using Argo and OGCM
• New climatology and Atlases
New In-sights
Indian Ocean dipole and monsoon

- Generation and termination of IOD mechanism
- Summer cooling in the Arabian Sea
- Impact of IOD on SSS revealed from Argo
- Role of subsurface Temp anomalies in the SW Indian Ocean during 2006 dipole event
- Monsoon interactions and drought over India in relation to Indian ocean sub-surface features
To provide an accurate estimate of the ocean state, which is used to initialize coupled model for the seasonal monsoon forecast and to understand the variability of ocean in different time scales.
Impact of Argo in Ocean analysis

- **REF**- Assimilates T&S observations from all Ocean Observing Systems (OOS)
- With held assimilation of T&S observations from
  - Moored buoys (e.g. RAMA, TAO/PIRATA, TRITON): XBU
  - Profiling floats (ARGO): XPR
  - Ship-based measurements (e.g. XBT, CTD): XSH
- **PRF**- Assimilates T&S observations from Argo Profiling floats alone
Positive values indicate that errors grow large in the absence of ARGO T&S profiles.
Sub-surface currents in the Equator

(i) ADCP

(ii) REF

(iv) XPR

Degradations
Argo Data Products

Monthly Gridded Data Products

- Temperature, Salinity and Geostrophic Currents (0, 75, 100, 200, 500, 1000 M depths)
- Heat Content up to 300 M
- Mixed Layer Depth, Isothermal Layer Depth
- Depth of 20° and 26° Isotherms
- Dynamic Height
- Sea Surface Height Anomaly

Float-wise Plots

- Water Plot of Temperature
- Water Plot of Salinity
- Temp Vs Sal Plot
- Time Series Surface Temperature
- Time Series Bottom Pressure
- Time Series Surface Salinity
- Time Series Surface Pressure
- Float Trajectory
Other Valued Added products from Argo

- Objective Analysis
- Variational Analysis

- MLD Climatology for the Indian Ocean based using Argo Observations
Other in-situ observations in the Indian Ocean

- Before Argo, Indian Ocean is a data void region compared to Atlantic and Pacific
- In the year 2002, Argo floats were deployed in the Indian Ocean by many countries
- Provoked, Why not other in-situ?
- IndOOS (Indian Ocean Observing system) implementation plan started
Indian Ocean Observing System (IndOOS)

Multi-platform
Multi-national
Multi-institutional
Long-term Ocean Observation Network
Ocean Observing System – Indian Ocean

Green – Argo, Red line – XBT, Blue – Drifters, red square – RAMA, Yellow- CODAR, green oval- ADCP, Red oval – Moorings, white mark - TG
Next 5 Years

- 12 moored buoy in the open ocean
- 4 moored buoy in the coastal ocean
- 40 Argo floats / year
- 30 drifters/year
- 4 XBT lines
- 10 pairs of adcp mooring
- 5 pairs of HF Radar
- 10 wave rider buoys
- 20 AWS onboard research vessels
- Bay of Bengal Observatory
- 10 bottom mounted tide gauges in the shelf
- 35 tide gauge along the coast of India
- 8 tsunami buoys
- 3+3 Glider sections
- R & D Ocean Observations
- RAMA moorings – Ship time
Education and Outreach

- **Argo Data and Data Products for the Indian Ocean** (*Version 1.0, Feb’2009, Version 2.1 – Apr 2013*)
  - T-S Profiles (~210,000)
  - Period: Jan 2002- Dec 2012
  - Gridded Data Products (plots)
  - ASCII & netCDF Formats
  - GUI for easy navigation, browsing, data extraction with user defined spatial and temporal domains
  - Software for viewing the NetCDF files

- User interaction meet every year on February 03.
- “Data aware program” to bring about awareness about the Argo data to student community.
- “Argo DVD” - data and products pertaining to India Ocean, mainly targeting the students at University with low bandwidth.
Deployment opportunities

Cruise track for ORV SK and ORV SN

November – BoB
Mar-Apr /Oct– Equator
Dec-Jan – Southern Ocean
Thank you for your kind attention