The Future of Argo: Sustaining and Enhancing Global Ocean Observations

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Ocean Sciences Meeting
Portland February 13, 2018
The Future of Argo

• Argo Today: A decade of sampling the global upper-ocean by the multi-national Argo Program.

• Deep Argo: Extending Argo to full ocean depth.

• BGC Argo: Adding key biogeochemical (BGC) parameters to the Argo array.
Argo Float Technology:
Profiling floats:

- Developed in the early 1990s by R. Davis (Scripps) and D. Webb (Webb Research).
- 2007: Argo achieves 3000 active floats

Profiling float photo and schematic:
Measures temperature, salinity, pressure

Schematic of a single Argo float cycle

- Float transmits data to users via satellite
- Descent to depth – 6 hours
- 1000m – drift approx. 9 days
- Float descends to begin profile from a greater depth – 2000m
- Temperature and Salinity profile recorded during ascent – 6 hours
- Total cycle time – 10 days
**Argo: Transforming oceanography through systematic observation of the global ocean.**

**Uses of Argo data today:**

- **Basic research and education:** 3000 research papers, covering a broad range of topics, and 250 PhD theses have used Argo data.

- **Climate and Global Change:** Argo is the primary dataset measuring the global heat imbalance in the climate system, and for ocean observations of global-scale climate variations such as El Niño.

- **Ocean Reanalysis and Forecasting:** Argo provides the subsurface data for global ocean data assimilation and forecast models (U.S. Navy, NOAA, NASA, ECMWF, UK Met, BoM, JAMSTEC, and others).

**Argo today** 26 National Programs

**The Future of Argo:** Argo’s goal is to sample all of the ocean volume, and to describe the evolving physical, biogeochemical, and ecosystems state of the World Ocean.
**Argo Today:** How has ocean observing improved with Argo?

20th century temperature and salinity profiles (> 1000 m) per 1° square.

21st century Argo temperature and salinity profiles per 1° square. All Argo data are made immediately and publicly available.
The Future: Deep Argo

Motivation

• The ocean below 2000 m is warming, particularly in the Southern Hemisphere (Purkey and Johnson, 2010).
• Full-depth observations are necessary to close the Earth’s heat and freshwater budgets and for understanding the component of sea level rise due to thermal expansion.
• Important elements of deep ocean circulation are below 2000 m
• Model initialization/assimilation requires data below 2000 m.

Status and Evolution

• 69 Deep Argo floats are presently active.
• 4 Deep Argo float models are being demonstrated in regional pilot arrays.
• New CTDs are under assessment for accuracy and stability.
• Deep Argo will expand from its pilot phase to become a global surface-to-bottom array of over 1200 floats.

Conceptual plan for 1228 Deep Argo floats at nominal 5° x 5° spacing (Johnson et al, 2015).
The Future: Deep Argo

Operation

- A Deep SOLO cycle is like a regular Argo cycle, except to the sea bottom or 6000 m.
- Uses a spherical glass housing for high pressure tolerance.
- Capable of more than 200 cycles – for float lifetimes of more than 6 years.
- A passive bottom detection system enables Deep SOLO to sample within 3-m of the sea bottom.

(1) The Deep SOLO is deployed by a passing ship.
(2) It collects temperature, salinity, and pressure data while sinking
(3) ...to within 3 m of the sea bottom or 6000 m
(4) Rising to 5000 m
(5) Drifting for ~8 days
(6) Rising to the sea surface.
(7) Transmitting the data.

Temperature anomaly and salinity from a Deep SOLO float in the SW Pacific Basin.
Figure: N. Zilberman
### The Future: BGC Argo

#### Motivation

- Understand the fundamental bio-geochemical cycling in the oceans, and thus the foundation of biological productivity patterns and carbon uptake
- To track long term trends – e.g. there is already evidence of significant ocean oxygen changes
- Research topics include: Carbon uptake, Nitrate cycling, Acidification, Biological carbon pump, Phytoplankton communities

#### Status

- BGC Argo is coordinated by an international 14-member Steering Committee reporting to the Argo Steering Team to ensure that the Core and BGC programs are harmonized.
- 13 national programs are presently contributing to BGC Argo.
- Nearly 300 floats carry oxygen sensors, with smaller numbers for pH, nitrate, chlorophyll-a, suspended particles, downwelling irradiance.
- Regional pilot arrays include the Southern Ocean (SOCCOM), Sub-Polar North Atlantic, Marginal seas, and Oxygen Minimum Zones
- Data management, including delayed-mode quality control, is via partnership with the Argo Data system

About 100 SOCCOM (U.S. NSF/NASA) floats are presently active.
Conclusion and acknowledgements

- While sustaining global upper-ocean sampling and high quality data, Argo will expand to full-depth coverage and will include sampling of key biogeochemical parameters.

- All Argo data are made publicly available in near real-time and in scientifically QC’ed form (www.argo.net).

- The multi-institution U.S. Argo Program, including its Deep Argo pilot phase, is supported by the Ocean Observations and Monitoring Division of NOAA.

- The U.S. SOCCOM (BGC) project is supported by NSF and NASA, with some platforms provided by U.S. Argo.

- Argo is a multi-national collaboration, and the critical contributions made by many international partners are gratefully acknowledged.