A DEEP MISSION FOR ARGO?
REQUIREMENTS AND STATUS

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The deep ocean is changing

- broad scale abyssal warming detected since 1990
- freshening trends of bottom waters around Antarctica, strong water mass decadal variability in the GIN seas and North Atlantic
- significant contributions to both ocean heat content and sea level

Bottom Water warming from 1990’s to 2000’s
Purkey and Johnson (2010)
Freshening Bottom Water around the Antarctic

Purkey and Johnson (2013)
Tracking the planetary energy imbalance?

How correlated are DECADAL trends in SST or ocean heat content with the global energy change?  Hadley Centre Coupled Models:

SST tendency is a poor proxy for the radiation imbalance
Ocean Heat Content tendency is an excellent proxy!

Palmer et al (2011)
How deep to measure?

...in order to provide the best estimate of ocean heat uptake we must aim for comprehensive observation of the 0–4000 m layer in order to minimise the “noise” associated with natural variability.

CAVEAT – this is a model result. The bottom water changes are missing. Observations suggest that full depth sampling is needed.

Palmer et al (2011)
Deep Argo: a forecasting requirement

Ocean and climate reanalysis and forecasting teams are also asking for deeper data

- Poor deep stratification impacts on upper ocean (and thus climate) responses
- Decadal prediction requirements?

The deep ocean is recognised as vital, though sampling requirements have not yet determined

Labrador Sea Variability
(Yashayaev 2007)
Several Deep Profiling floats have been developed

Japan: JAMSTEC and Tsurumi Seiki Co. Ltd. (TSK) had developed Deep NINJA (4000 m). Deep NINJA has been on sale since April 2013. Oxygen to be added. NINJA has successfully taken deep profiles under the sea ice off the Antarctica.

France: Deep Arvor (4000m) – 2 prototypes successfully tested. Future deployments planned.

USA: Deep APEX has made successful prototype deployments (by Teledyne Webb) to 4000 m (near Hawaii) and 6000 m (Puerto Rico Trench). University of Washington Argo plans to test and evaluate the Deep APEX.

USA: A Deep SOLO 6000 m prototype float (Scripps float group) was deployed off central California in Jan 2013, and completed over 100 cycles, mostly to 4000 m, before it was successfully recovered in October 2013.
Pilot test deployments currently underway or completed
Future pilots: total of > 60 floats in the next several years, several will carry oxygen

- Japan: 7
- France: 30
- US: 12
- EU/Spain: 2
- UK: 4
- Australia: ~4
- EU: 10?
Sensor Requirements

For the Decadal and longer term change problems, a more accurate sensor suite is needed (especially for pressure and salinity)

A new CTD is under parallel development with improved sensor stability – SBE61

Field testing of this sensor and intercomparisons with ship-board CTDs is required. Plans are underway to start some of these tests and comparisons with float-borne CTDs off New Zealand in June

Several test deployments are combined with ship-based hydrography
The Argo Data Team are already working on automatic QC tests for deep Argo (below 2000 dbar)

Salinity gradient: Introduce new test value of 0.01 or maybe even 0.005?

Density inversion: no change needed

5 floats, # profiles with p>=2000 dbar:
- 88 profiles (PO)
- 1 profile (NE AO)
- 3 profiles (AO)
- 70 profiles (AO)
- 32 profiles (NE AO)

All TEMP are good. One PSAL has bad.

Salinity spike: Introduce new test value of 0.01?

Others that could get new test values:
S range: 33.5 to 35.5?
T range: -3 to 6°C?
T spike: 0.2°C?
T gradient: 0.02°C?
Design?
Target: decadal trends at ~500km scales

- Sample to 6000 m, 30-day cycle
- 5x5 degree spacing: ~1200 floats (target bottom > 3000 m?)
- Contribute about 12% of Argo profiles, valuable for T-S
- Start in N. Atlantic, S. Ocean, GIN Seas -> equator -> global

Johnson, pers. comm.
Design?
Target: explaining sea level variability

“For proper sampling of the deep steric variability, maintaining monthly observations at scales 2° would be desirable: >4000 floats!”

Ponte, 2012.
Next Steps:

Carry out a **regional scale pilots**:
1. Prove the technology and sampling strategies
2. Refine the cost basis (which impacts feasibility)

Work with the international community to generate a **global array design** which is
1. Feasible - based on the sensor, sampling and costs
2. Best value – that is, meets the needs of the largest number of applications deemed important
   - profile depth (4000m will miss AABW – problematic for global budgets)?
   - parking depth (bottom, 1000m,...)?
   - spatial density?
   - vertical resolution?
Thank you

Acknowledgements

- Argo Data Management Team

- The many, many agencies and nations that contribute to Argo in ways both small and large.

www.argo.net
The original mission and design

Provide an enhanced real-time capability for measurement of temperature and salinity through the upper 2000 m of the ocean and contribute to a global description of the seasonal cycle and interannual variability of the upper ocean thermohaline structure and circulation.

In the late 1990’s:

“The most serious defects in present observing networks are the lack of global span in thermal data and the lack of any systematic subsurface salinity data. These are major weaknesses, in effect limiting scientific progress in climate studies.”