Argo watches the Oceans



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Why are we doing Argo?



Measurements are made now with much greater accuracy and precision than before, but in some ways little progress has been made.



Why are we doing Argo?

Progress (?) during the last 70 years.



Stations occupied by the *Meteor* in the Atlantic Ocean 1925-27.



Stations occupied in the Atlantic during WOCE, 1991-97.



Why are we doing Argo?



The circulation of the Pacific Ocean according to Hugh McLellan, 1965.



The circulation of the Pacific Ocean according to Allison McDonald, 1999.



The ocean is in fact variable and the variability affects climate





The Argo community planned to deploy 3000 floats by 2007









How does a profiling float work?





SOLOs PROVOR

How does a profiling float work?

~10 HOURS AT SURFACE

DESCENT TO DRIFTING DEPTH ~1000m

DRIFTING ~8-10 days

TOTAL CYCLE TIME

ASCENT, RECORDING SALINITY AND TEMPERATURES ~10 hours

DESCENT TO PROFILING DEPTH ~2000m



The data system turns a profiling float into an Argo float.

We are dominated by requirements set by UNCLOS-3.

For a float to be called an "Argo float" the data *must* be released in near real-time with an open-access data policy.

More than 90% of data are released within 24 hours on the GTS and within 48 hours on the Argo Global Data Centres.

The data sets served by the Argo Global Data Centres (GDACs) includes data presently from 30+ nations, with a single universal format and quality control system.



How does an Argo float work?



New sensors are appearing

Water intake and platinum resistance thermometer.

Conductivity cell

Aanderaa optode sensor, – for dissolved oxygen which has gained acceptance because of perceived high value for the data return, and has minimal impact on the primary Argo mission.



Longer term concerns & directions

Wet Labs FLNTU fluorometer & turbidity sensor.



But we have to be careful about adding extra sensors

Consider a float with a volume V_0 and mass M_0 with the piston retracted, it has a deep density of ρ_d and can make a volume change of δV to make the shallow density ρ_s .

Deep density = $\rho_d = \frac{M}{V_0}$ Shallow density = $\rho_s = \frac{M}{V_0 + \delta V}$ So $\rho_d - \rho_s = \rho_d \frac{\delta V}{V_0}$

Hence, if we add extra sensors we increase V_0 , and to execute the same vertical excursions we need to increase δV which by itself costs energy. Further, the extra sensor will need power. Adding an optode costs about 30% of the profiles a float can supply.

How are floats being launched?

Or deployed from container vessels





Argo floats can be launched from Aircraft, here a C-130 (Hercules)













< Over 8 years WOCE/HP gathered data from 20,000 CTD stations, used 25 ship-years with a total cost of US\$220M. But still left some areas weakly sampled. All observations were of the highest quality.

Another mainstay of the ocean climate monitoring network is the XBT program, in 2004 30,000 XBT stations were reported. But note large unsampled areas. Also, temperature is only $\pm 0.1^{\circ}$ C and there is no salinity observed.





In May 2013 Argo floats reported 11,771 profiles. All of high quality, all including salinity, all in real time. This is equivalent to ~139,000 profiles/year or 1 profile every 3.7 minutes. Unsampled areas are small and plans exist for eliminating them. In November 2012 Argo collected its 1-millionth profile.



Argo







Circulation in the Gulf of Alaska





THE DAY AFTER

Graphics are not mine, they are by Josh Willis, SIO.

Observing the AMOC at 41°N



Summary

AMOC at 41°N ~ 16 Sv
2.4 Sv RMS variability
~3 Sv error bar
Variability Mostly Ekman
No significant trend, 2002 to present

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Global Ocean analyses for forecast systems



Argo

JCOPE Ocean State Prediction



Analysis for 2nd February 2010.

Prediction for 2nd February 2010 initialised on 2nd January 2010.



JCOPE Ocean State Prediction



Analysis for 6th April 2010.

Prediction for 6th April 2010 initialised on 6th March 2010.



JCOPE Ocean State Prediction



Analysis for 13th April 2010.

Prediction for 13th April 2010 initialised on 13th March 2010.



Sea level rise



We know that sea-level is rising at 3.2 ± 0.4 mm/year, but how is that partitioned between water column expansion and new ocean mass?







Sea surface salinity



Plots adapted from Durack & Wijffels.

The Future of Argo

Argo is a very successful program, but it will change. We presented a report to OceanObs'09 (UNESCO) and received feedback on how Argo should evolve.

- We need to install western boundary current enhancements.
- We need to expand into marginal seas.
- We need to install an equatorial enhancement.
- We need to create a deep-Argo component.
- We are encouraged to develop a Bio-Argo program.



Conclusions

Argo is a going concern, will evolve and will be around for the remainder of my professional career!

Use it! (But please read the manual first)

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