

On the beginnings of Argo: Ingredients of an ocean observing system

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Motivation

Any major expansion of Argo (Deep Ocean, Biogeochemical, Boundary Currents, Coastal) will have most of the same basic “ingredients” as the original program.

If we can understand what things worked well or not so well in starting Argo, then it may be possible to implement (or back away from) new enhancements.

Ingredients of Argo

- *Appropriate cost-effective technology.*
- A statement of requirements (program design).
- Consensus among user groups on value (science, operational applications, policy, education).
- Entrainment of agency sponsors/collaborators.
- International scientific collaboration.
- Intergovernmental coordination.
- Commercial partnerships.
- Determination.

Appropriate technology:

Development of the profiling float as an element of WOCE made global sampling possible.

Before floats, subsurface ocean data could only be collected by a ship or a fixed-point mooring.

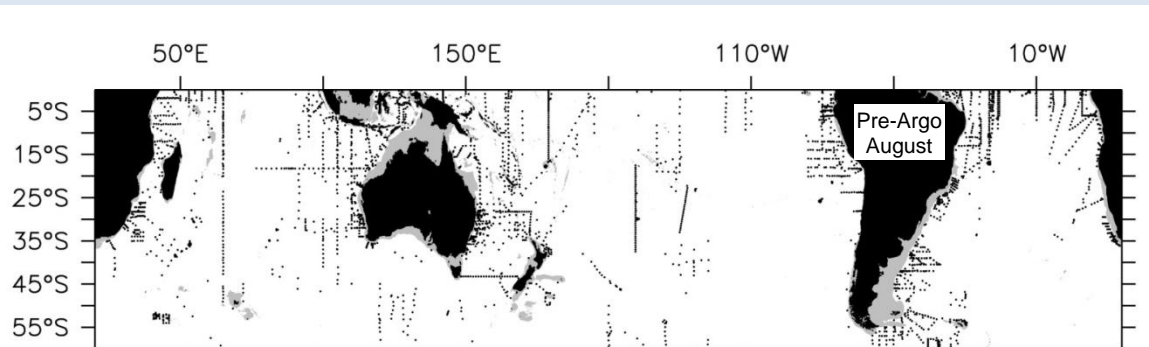


Cost of an Argo T,S profile is < \$200 (all-inclusive).

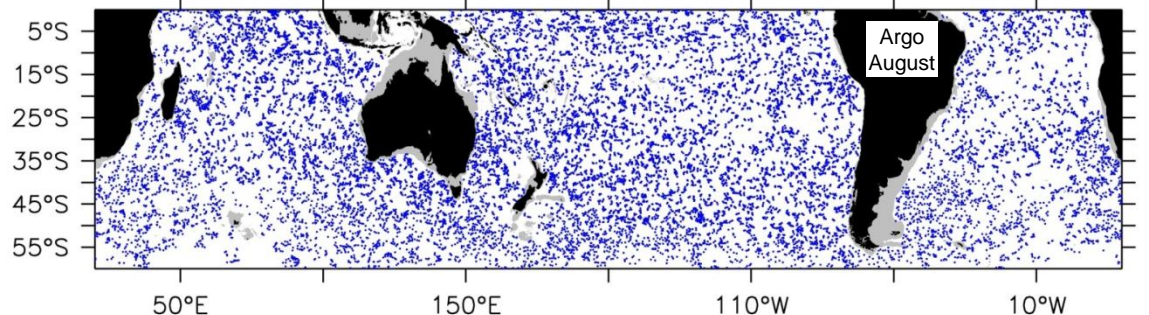
Cost of a WOCE profile was ~\$12,000.

All August research vessel Temperature/Salinity profiles (> 1000 m, 1951 – 2000, source: NODC).

Before Argo



The Argo era



5 years of August Argo T,S profiles (2007-2011).

A statement of requirements

- October 1997 – A global ocean array of profiling floats is discussed over lunch in the NCAR cafeteria (D. Roemmich, B. Owens, E. Lindstrom).
- Late 1997 – *“The ARGO White Paper”*. (1-pager)
- Early 1998 – *“A Proposal for Global Ocean Observations for Climate: the Array for Real-time Geostrophic Oceanography (ARGO)”* by D. Roemmich; and, *“A Program for Global Ocean Salinity Monitoring (GOSAMOR)”* by R. Schmitt.
- 1999 – *“On the Design and Implementation of Argo”*, Argo Science Team

On The Design and Implementation of Argo A Global Array of Profiling Floats

The Argo Science Team[†]

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Preface

This document describes some initial ideas for the design and implementation of Argo, a global array of autonomous profiling floats. The original concept grew out of two independent, but connected, initiatives, “A Proposal for Global Ocean Observations for Climate: the Array for Real-time Geostrophic Oceanography” (ARGO), by Dean Roemmich, and “A program for Global Ocean Salinity Monitoring” (GOSAMOR), by Ray Schmitt. Early in 1998 the International Steering Team for GODAE (the Global Ocean Data Assimilation Experiment) endorsed the broad concept of such an array and undertook to develop a plan. In the 2nd quarter of 1998 the Upper Ocean Panel of CLIVAR also considered these proposals and unanimously agreed that such an initiative must be given high priority in the CLIVAR implementation plans.

In July of 1998 a Workshop was held in Tokyo to discuss the prospects for Argo and an initial outline for a plan was drawn up. At that Workshop, which was jointly convened by GODAE and the CLIVAR UOP, an Argo Science Team was appointed with the charge to produce an initial design and implementation plan. The present document is the response to that charge.

An initial draft of this document was widely circulated through the oceanographic and climate community for review. This review drew many comments and suggestions and raised a number of significant issues. Because of time constraints, and the need to have a document available for the CLIVAR Conference in December of 1998, we, as Chairs of the convening bodies, decided that a detailed revision was not wise, and probably not possible, on this time frame. Many of the issues require detailed scientific study and need some time for fuller consideration. As an interim measure, we have attended to a few of the more pressing issues, and prepared a consolidated list of issues and items for consideration by the Science Team at a later time.

This document then represents an initial set of ideas for the design and implementation of Argo, and presents the scientific rationale for proceeding with Argo. We think you will find the case for Argo a strong one, and that the initiative, though ambitious, both doable and worth doing.

We thank the Argo Science Team, and other contributors, for this paper, and look forward to the early development of a more detailed design and complete implementation plan.

Neville Smith
Chair of the International GODAE Steering Team

and

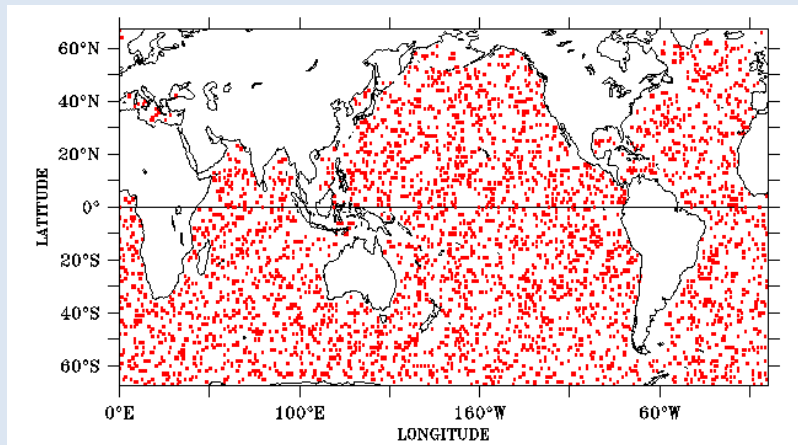
Chet Koblenz
Chair of the CLIVAR Upper Ocean Panel

[†] Dean Roemmich (chair), Olaf Boebel, Howard Freeland, Brian King, Pierre-Yves LeTraon, Robert Molinari, W. Brechner Owens, Stephen Riser, Uwe Send, Kensuke Takeuchi, Susan Wijffels.

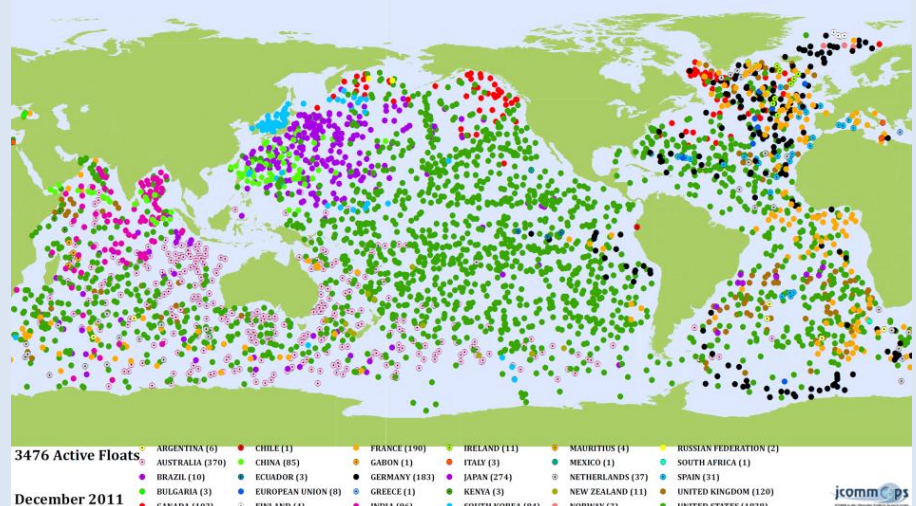


Consensus on scientific and operational applications

- Early 1998 – Endorsement of Argo by the Global Ocean Data Assimilation Experiment (GODAE) – global ocean data assimilation requires global ocean data.
- July 1998 – GODAE and the CLIVAR Upper Ocean Panel (UOP) Joint Workshop; the Argo Science Team is created to coordinate the national efforts.
- March 1999 – First meeting of the Argo Science Team in Easton MD; “On the Design and Implementation of Argo”
- August 1999 – Upper Ocean Thermal Review is conducted by the Ocean Observing Panel for Climate (OOPC) and the CLIVAR UOP; Argo is strongly endorsed.
- September 1999 – OceanObs’99 Conference (*“Argo: The Global Array of Profiling Floats”* in *Observing the Oceans in the 21st Century*, Eds: C. Koblinsky and N. Smith)



A randomly spaced array of 3300 locations. From:
“On the Design and Implementation of Argo” (1999)



The Argo array in December 2011

Agency buy-in and collaboration

- Mid-1998 – A series of seminars on Argo is invited by NOAA Administrator DJ Baker and staff. Argo is enthusiastically accepted as a global counterpart to NOAA's TAO array.
- 1999 – The US Argo pilot project is created via the National Ocean Partnership Program by NOAA and ONR; the multi-institution US Argo Float Consortium is funded.
- 1999-2001 - Baker and NOAA Senior Scientist WS Wilson entrain international Argo partners (Japan, India, U.K., France, Australia, SOPAC) through agency-to-agency contacts.
- 1999. Australia deploys the first Argo floats, followed by the U.S. in 2000.
- 2000 - 2002: International Argo Implementation Workshops are held for the Atlantic, Pacific, and Indian Ocean. Commitments increase, eventually to ~800 floats per year.



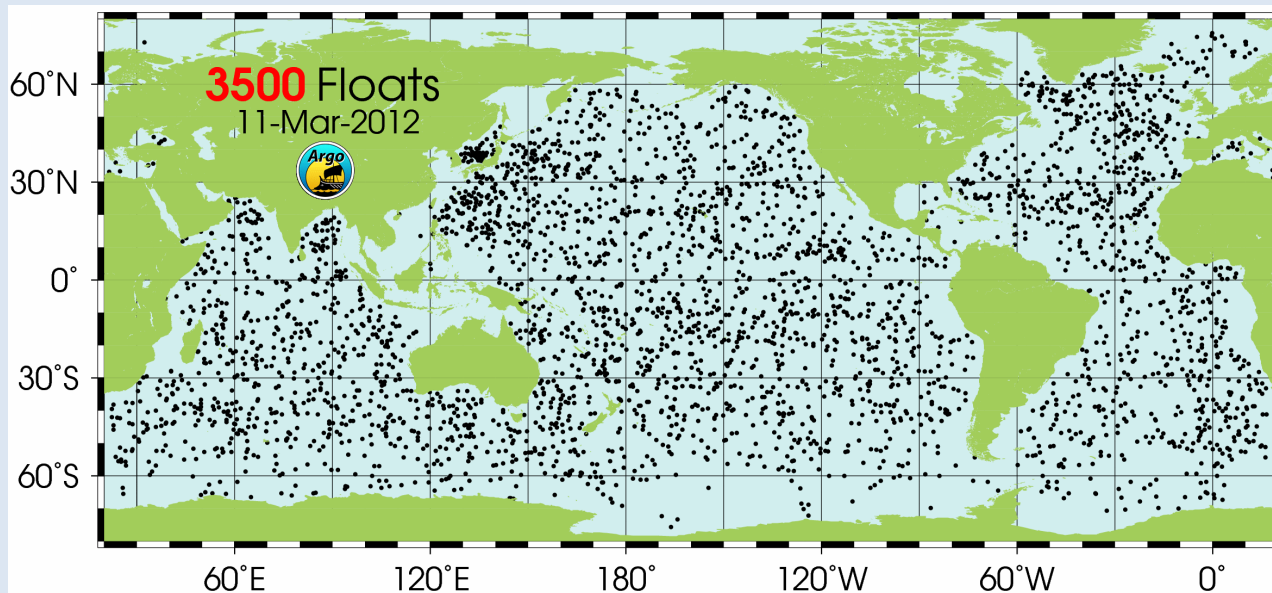
Stan Wilson with US President Bush, February 2002



Susan Wijffels with Australian Prime Minister Gillard, Jan 2012

International scientific collaboration

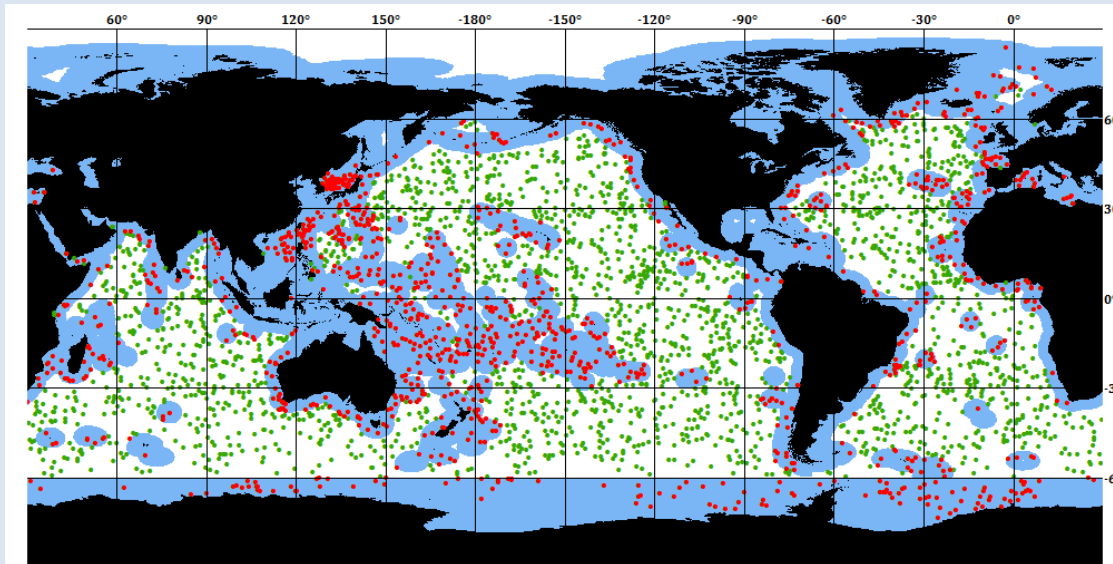
- The Argo Steering Team, Argo Data Management Team, Argo Science Workshops, and Argo Technical and Training workshops have been critically important for coordinating national priorities in order to produce a global array with uniformly high data quality, and for insuring high utilization of Argo data.
- All national programs have agreed that building and sustaining the global array is the highest priority.
- Argo succeeded and continues to progress because many individuals understood the value of the program and have made large and original contributions.



Coverage is good, but could be improved. The same can be said for data quality.

Intergovernmental coordination

- 1999: IOC Resolution XX-6 **Accepts** the *Argo* project as an important contribution to the operational ocean observing system of GOOS and GCOS, as well as a major contribution to CLIVAR and other scientific research programmes. (+ EC XLI.4 in 2008, providing guidelines for implementation of XX-6; relabels Argo Programme)
- 2001: Argo Information Center established to fulfill requirements of XX-6 with regard to informing coastal states of float deployments.
- Major problems remain: (i) no consensus on deployment inside EEZs (though agreed by many nations) (ii) cutoff of all US funding to UNESCO (iii) Biogeochemical Argo floats may present new challenges.



Argo Floats & Maritime Zones

September 2009

About 30% of Argo floats are operating inside an EEZ

Coverage would be improved if more nations concurred with float deployment in EEZs

Commercial partnerships

- Many private companies have made vital contributions to Argo's success including sensor manufacturers, float manufacturers, communications providers, machine shops, bladder manufacturers, electronics firms, and others.
- In particular, SeaBird Electronics has made innovations in CTD stability and low power performance, that are among the most critical and technically difficult contributions to Argo.



Determination...



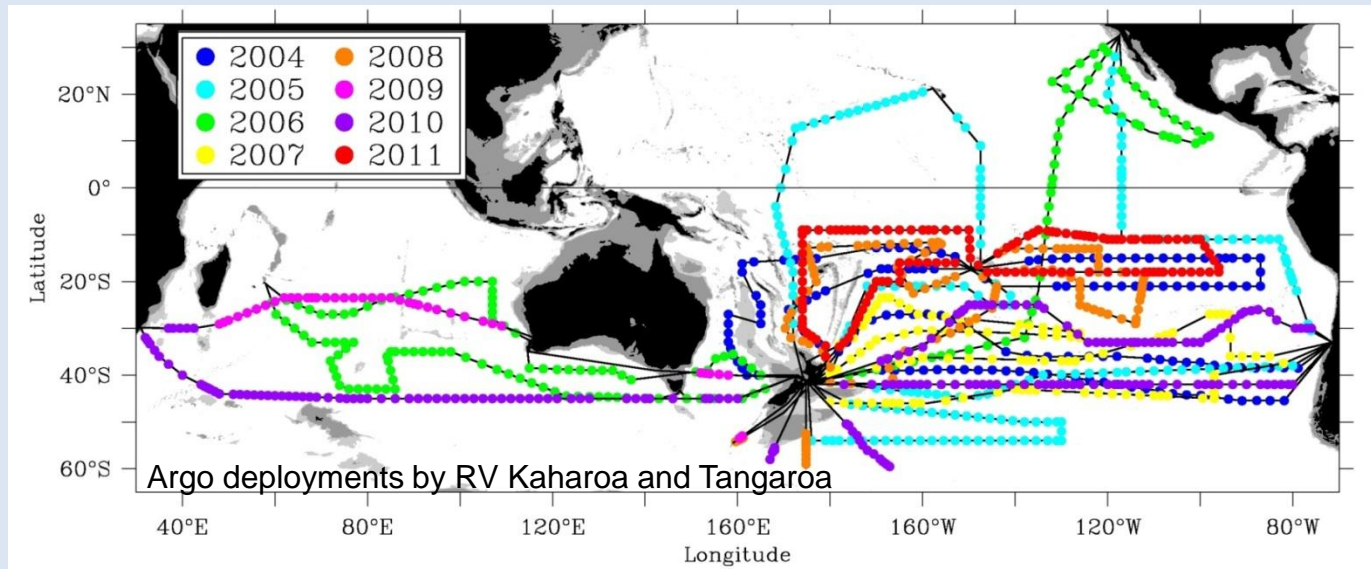
RV Kaharoa; 28 m length, crew of 6

People make it happen:

USA/NZ/Aus
collaboration, RV
Kaharoa has deployed
985 Argo floats.



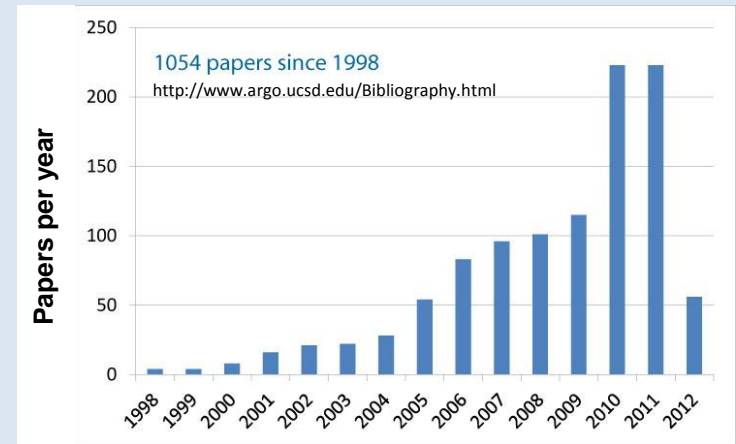
Argo float receiving care and attention
from deployment World Record holder.



This is just one example. Many of Argo's most difficult problems have been overcome through creativity and determination by individuals.

Finally

Research: 223 papers using Argo data in 2011.
Operational centers (> 15) using Argo data
National and international assessments
Education and outreach



- In the late 1990's, many colleagues believed Argo was needed and valuable, and began investing time and energy.
- A decade ago, almost no one thought that the global array would be realized.
- The coming decade should see equally large changes, with Argo extended into the deep ocean, enhanced in the marginal and coastal seas, seasonal ice zones, and western boundary current regions, and including new biogeochemical sensors.

