International Argo: Achievements and perspectives

D. Roemmich and W.J. Gould

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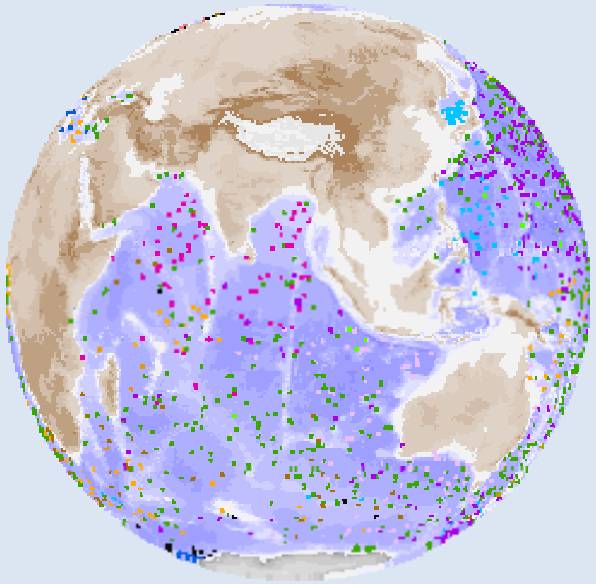
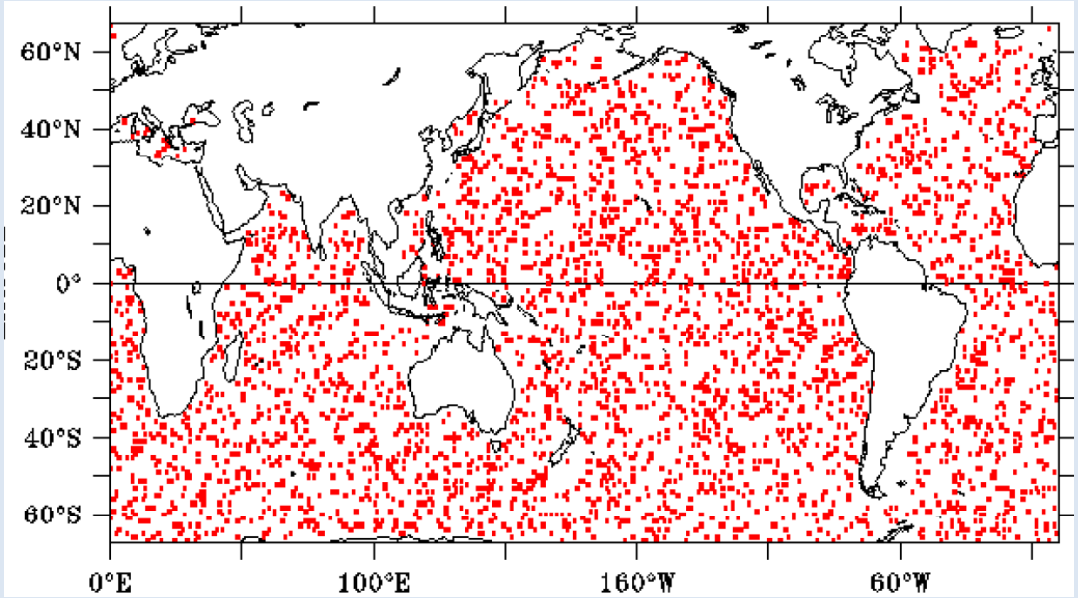
Outline



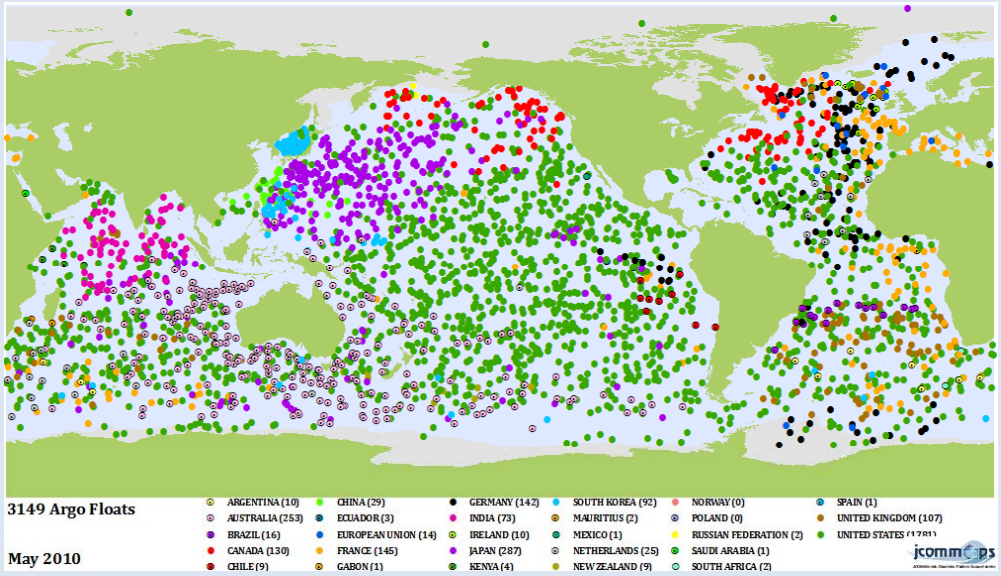
- What has Argo achieved relative to its initial objectives?
- What remains to be completed for Argo's core?
- How will Argo expand for new objectives?
- What are the key challenges for Argo to be sustained and to expand?

Did anyone believe Argo would deploy an array so much like the 1998 design?



Argo envisioned in the 1998 Argo Design:

3300 randomly distributed floats at 3º x 3º average spacing.



Argo: the real thing

And it took only 10 years from concept to 3000 float implementation.

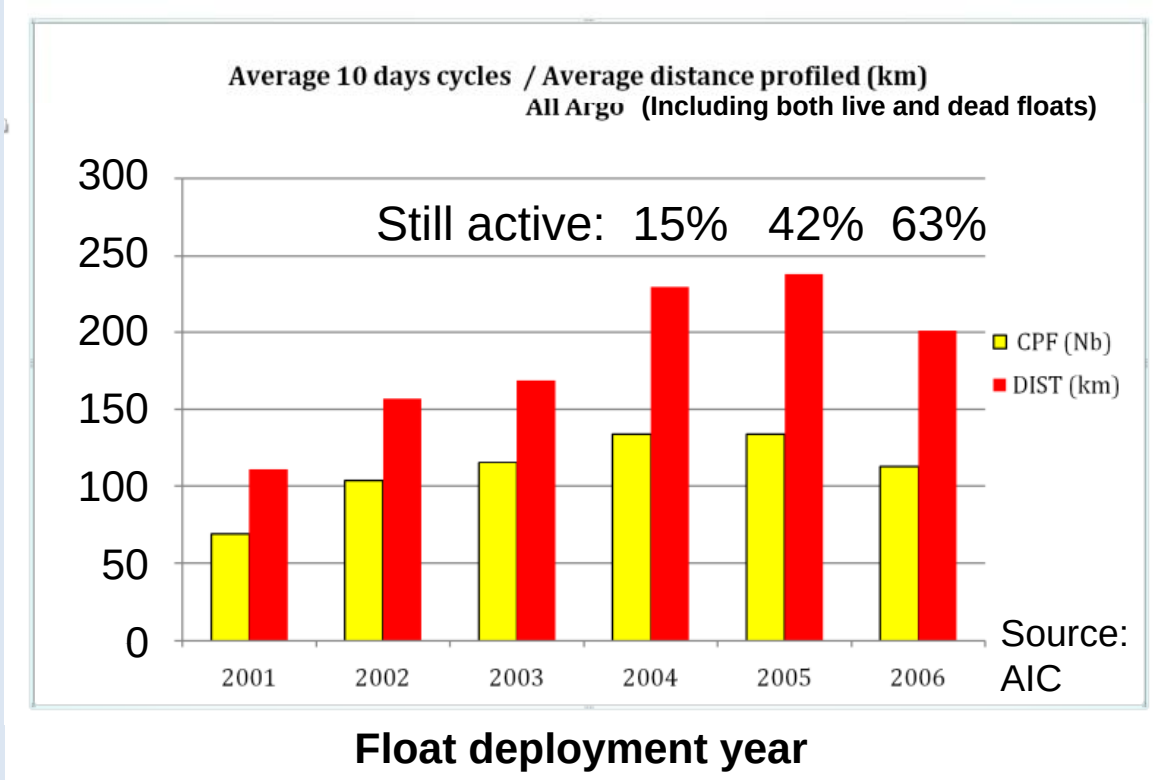
Argo has surpassed the original vision in:

- Float lifetime and capabilities

“The initial profiling depth of 1500 m is based on practical considerations. The goal is to reach as great a depth as possible without compromising the requirement of 100 (14-day) cycles per float lifetime. A profiling depth of 2000 m will provide substantial scientific benefits, and should be adopted when feasible.” (1998 Design Document)

Original goals for 100 cycles/ 150 km were met with floats deployed in 2002.

Present designs: 200 cycles/ 400 km.



Argo has surpassed the original vision in:

- Stability and accuracy of salinity

Because of the slow drift of SBE salinity sensors, a large fraction of non-drifting profiles is available for DMQC of those that do drift. Otherwise, there would not be enough shipboard CTD profiles to adjust Argo salinity on a global basis.

- Data management: completeness, DMQC, timeliness.

While the Argo data management system evolved from that of the upper ocean thermal networks, its subsequent development has been groundbreaking and original. Argo data management is now the model emulated by other observing systems.

Salinity stability: After 100 cycles, nearly 90% of floats have < 0.01 psu drift.

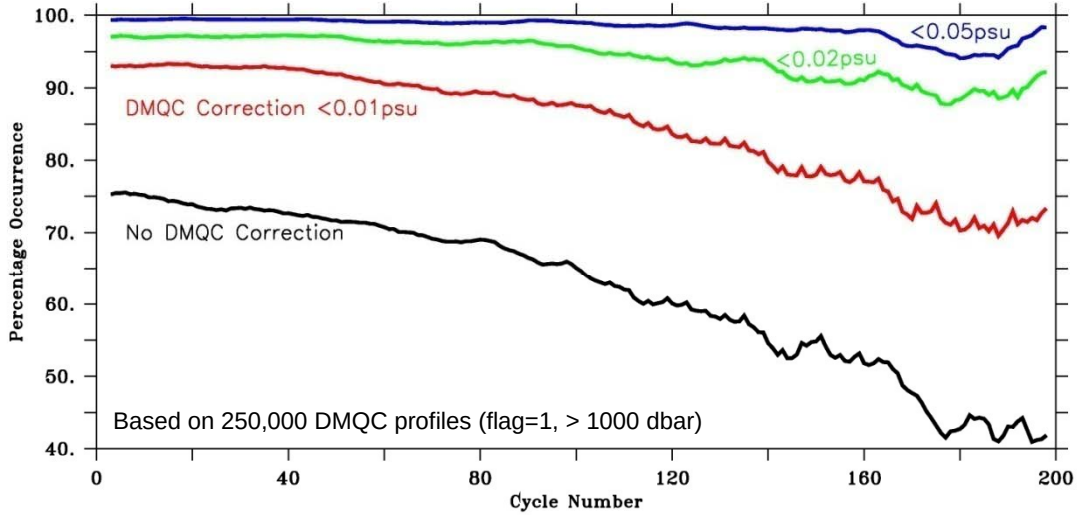


Fig by J. Gilson

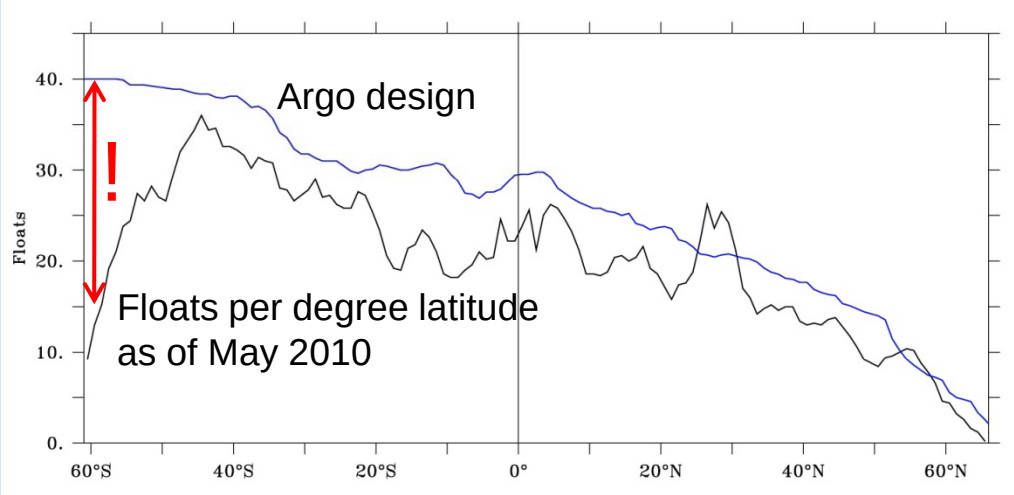
AST-1 envisioned the outcome of a 10-year Argo time-series in “The Principal Achievements of Argo”

1. Obtain an unprecedented dataset for model initialization and data assimilation …
2. Enable operational real-time global ocean forecasting...
3. Produce an accurate global climatology, with error bars and statistics of variability…
4. Produce accurate time-series of heat and freshwater storage...
5. Provide large-scale constraints for atmospheric model-derived surface heat and freshwater fluxes…
6. Complete the global description of the mean and variability of large-scale ocean circulation…
7. Determine the dominant patterns and evolution of interannual variability in temperature and salinity…
8. Provide global maps of the absolute height of the sea surface…
9. Enable the interpretation of (altimetric) sea surface height…
10. Directly interpret sea surface height anomalies….

After the first 5 years with a global array, all of these are well advanced.

What remains for Argo's core objectives?

- Increase deployments in the southern hemisphere esp > 45ºS.
- Implement coverage in marginal seas (grounding problem), e.g. Caribbean Sea and Gulf of Mexico.
- Sustain the Argo Program for long enough to demonstrate its value, with improvements in data (p,S,v) quality.
- Increase Argo's involvement in education and outreach.



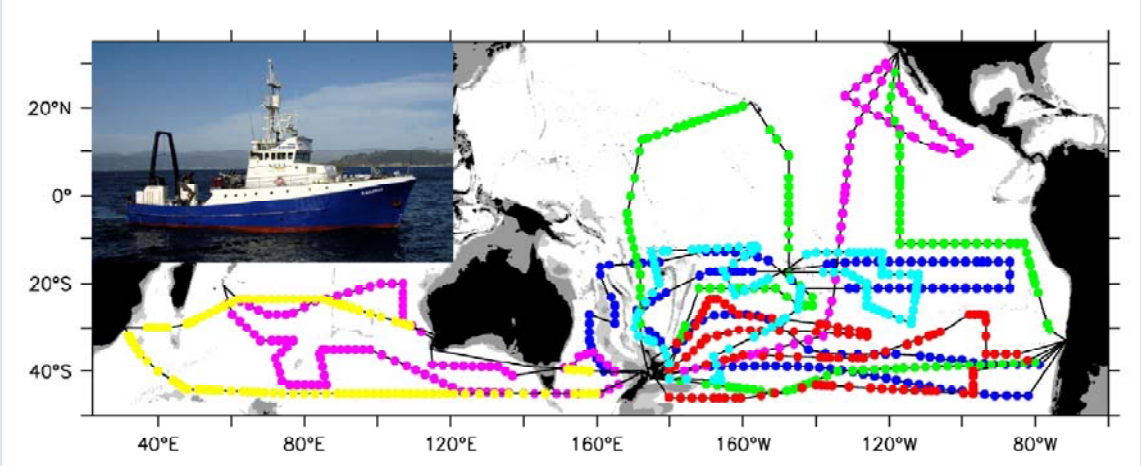
The distribution of floats per degree of latitude, not including high latitudes, marginal seas, and grey list. RV Kaharoa deployments are equatorward of 45ºS.

Southern hemisphere / total floats:

Australia:	250 / 254	98%
U.S.:	1182 / 1786	66%
All Europe:	201 / 444	45%

Challenges for Argo's core:

- A continuing focus on (i) technology improvement and (ii) data management is required to reduce systematic errors in pressure and salinity (for global change studies), and to avoid or identify major technical failures.
- A global Argo float deployment strategy is needed that includes resources for dedicated vessel time.
- An international consensus is required on collecting climate data from all of the ocean (practical guidelines). The present regime places an unsustainable burden on float providers.
- Argo data policy (immediate public release of all data) applied to multi-sensor floats and Argo-equivalent floats creates unfunded requirements on data management.
- Argo's open data policy encourages hasty publication. The maturation time for best quality data is years (i.e. longer than DMQC turnaround).



Location of 750 Argo floats deployed by RV Kaharoa since 2004.

How will Argo expand for new objectives?

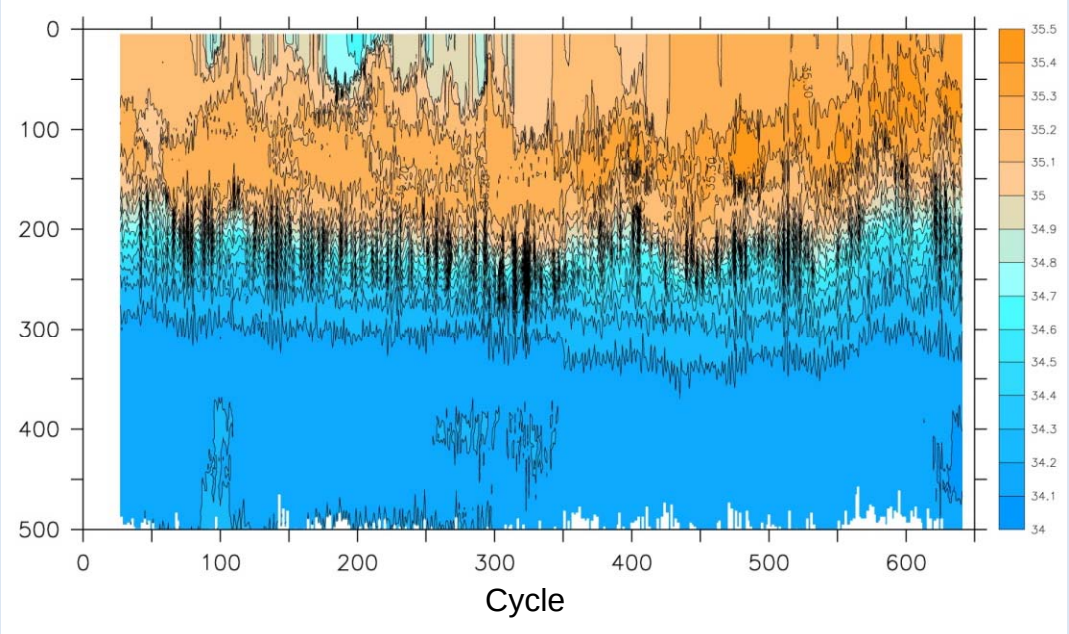
Incremental expansions:

- High latitudes and marginal seas (ice-capable floats being tested with mixed success; uneven and non-coverage in marginal seas).
- Improved surface layer sampling.
- Enhanced vertical resolution.
- Active array management.

} Via 2-way communications and increased bandwidth.

Major expansions:

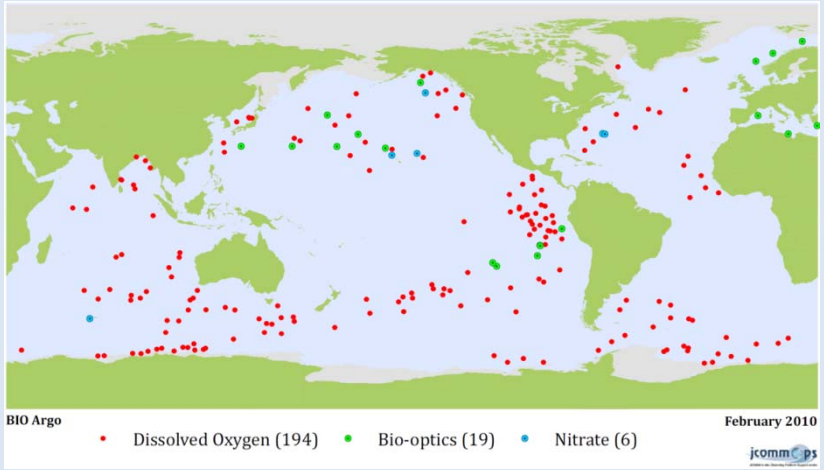
- Deep ocean profiling.
- Multidisciplinary sensors.
- Boundary currents.



Salinity (600 9-hour cycles to 500 m @ 2-dbar resolution) from a thermally-powered SOLO-II float.

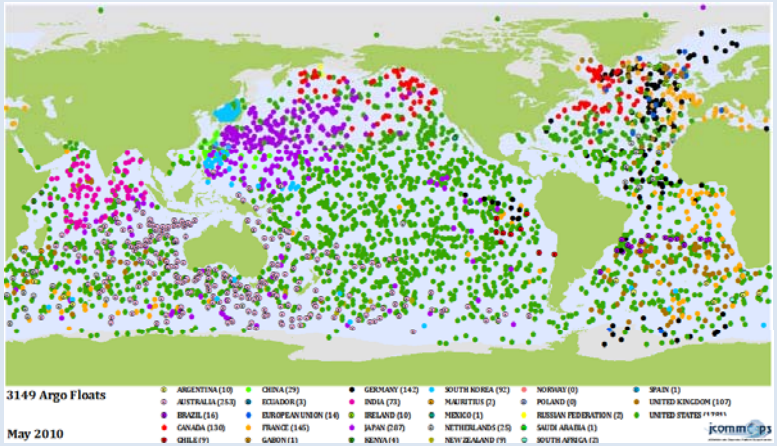
Challenges for expanding the core mission:

- Expansions should not go forward without proportional new resources (*in manpower, including data management,* and *floats*).
- Argo's evolution must maximize the value of the integrated ocean climate observing system. How can this best proceed (i.e. for Argo/gliders, Deep-Argo/repeat hydrography, Argo/Bio-GC-Argo)?
- Additional sensors beyond T,S increase EEZ sensitivities and reduce chances for international consensus on global deployment.
- Deep-Argo and Bio-GC-Argo both present difficult technology development problems.
  - Deep Argo may be resource-limited (high cost per profile).
  - Bio-GC-Argo may be manpower-limited (sensor and data quality expertise).



Argo floats with oxygen, bio-optical, and nitrate sensors

Conclusion



- Argo exceeded expectations by implementing the first systematic observations of the global subsurface ocean, providing climate-quality data, freely-available.
- After (or because of) Argo's initial success, expectations have increased much more than resources.
- Argo should be improved and sustained, but this cannot happen without broad international support and acceptance.
- The expansion of Argo is a valuable opportunity, but it poses dangers to the core array if underfunded and not done carefully.

Individual European nations and EU float activities have key roles to play in sustaining and expanding Argo, not only in floats but in data management and program leadership.