The state of the art of real-time monitoring
The Argo experience

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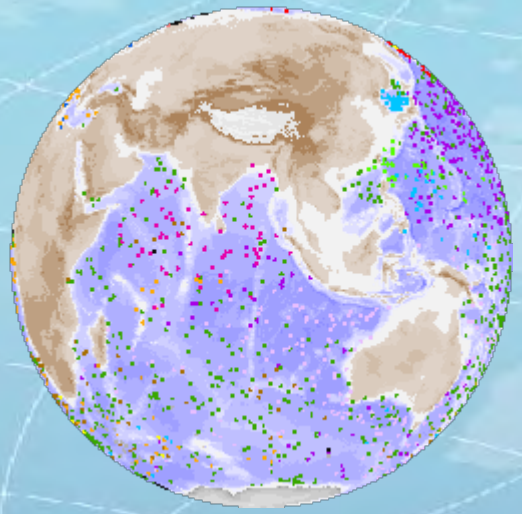

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Argo is 10 years old

The first Argo prospectus was distributed in 1997 and approved at the OceanObs'99 meeting in St Raphael, France.

The prospectus described an array of 3000 Argo floats profiling the oceans of the world between 60°S and 60°N and excluding marginal seas.

The prospectus described how we would have that array in place by some time in 2007.

Deployments started in earnest in 2001.

Argo is 10 years old

We have known for some time that a progress report would be expected from us at OceanObs'09. For Dean Roemmich and for me, this has been a major focus for our activities over the last 2 years.

The report was to include recommendations for modifying the Argo design and this required community input. To this end we ran Argo Science Workshop #3 in Hangzhou, China. The result was a strong community consensus which we took to the OceanObs'09 meeting in Venice in September.

This talk…..

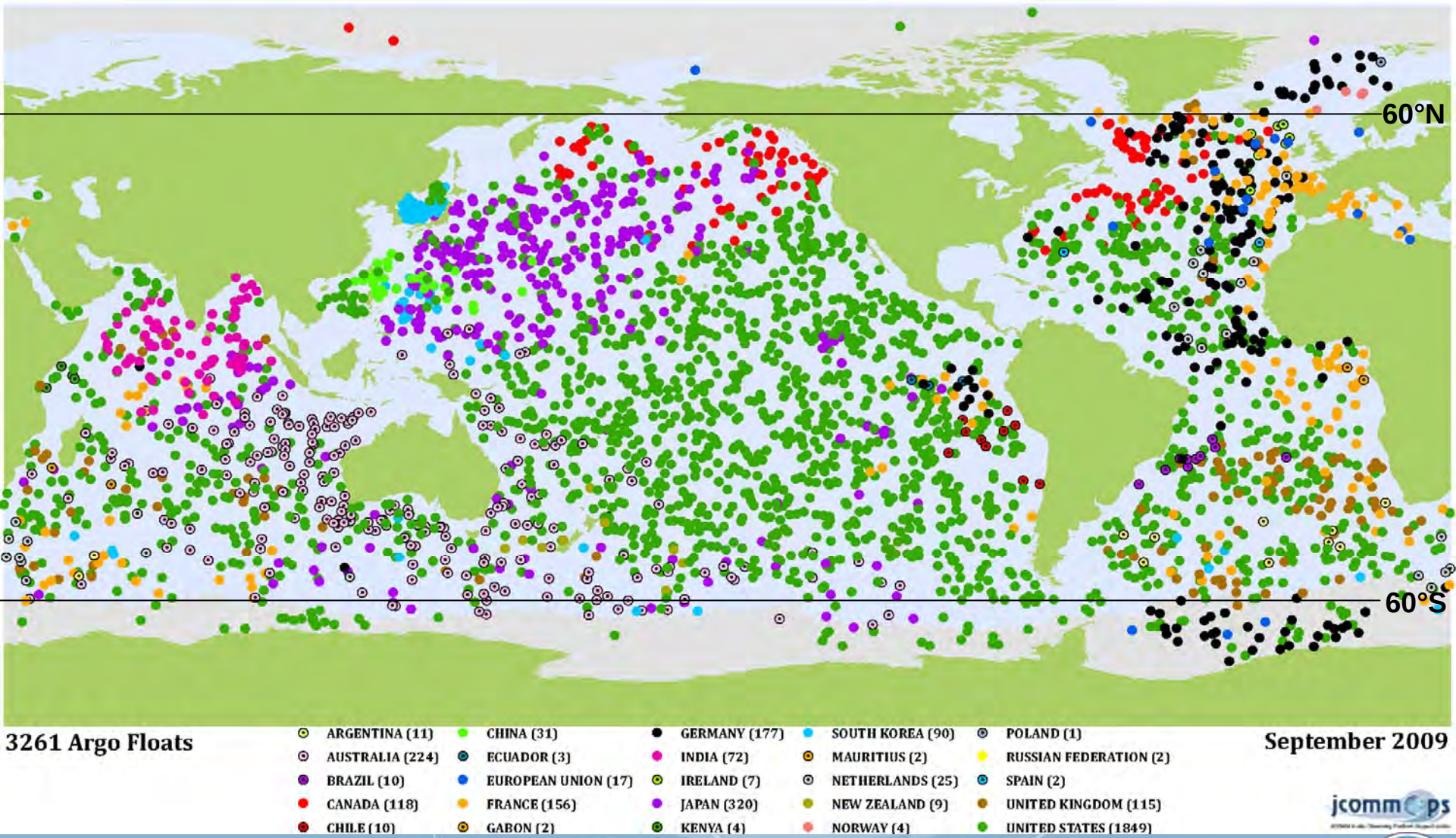
Clearly, Argo will be changing in the near future…..

1) This talk will briefly outline where we are now and what we think we can do today. In particular, what sort of an ocean monitoring system do we have? How robust is Argo? Did we get a passing grade in Venice?

2) What suggestions were received while we constructed the Argo-CWP (Community White Paper), did we get indications where there was room for improvement?

3) Of those suggestions which do we think we ought to be working on, and what is the logic?

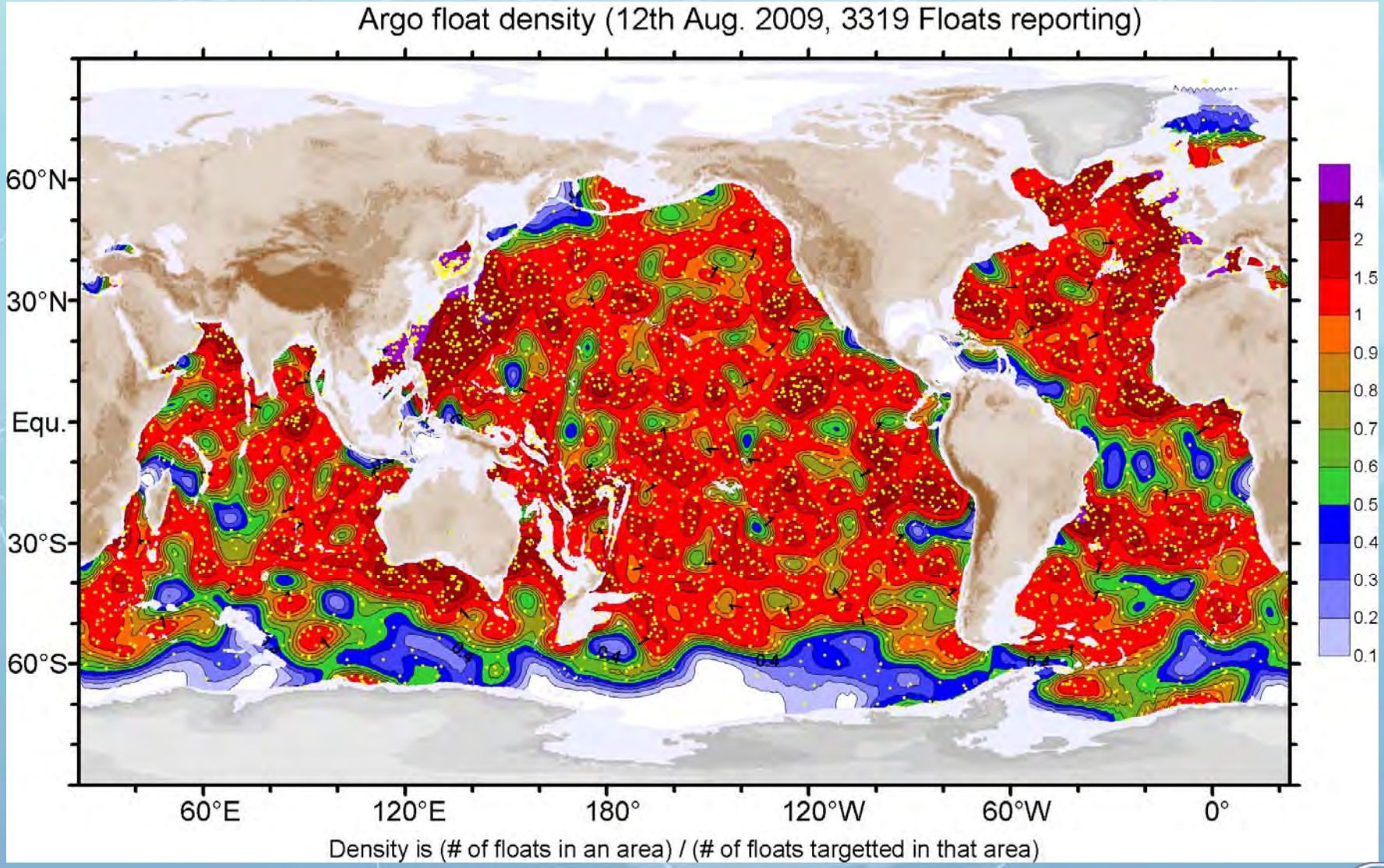
How well are we meeting that 3000 float target?



Fisheries and Oceans Pêches et Océans

Argo

Is the density of floats even?



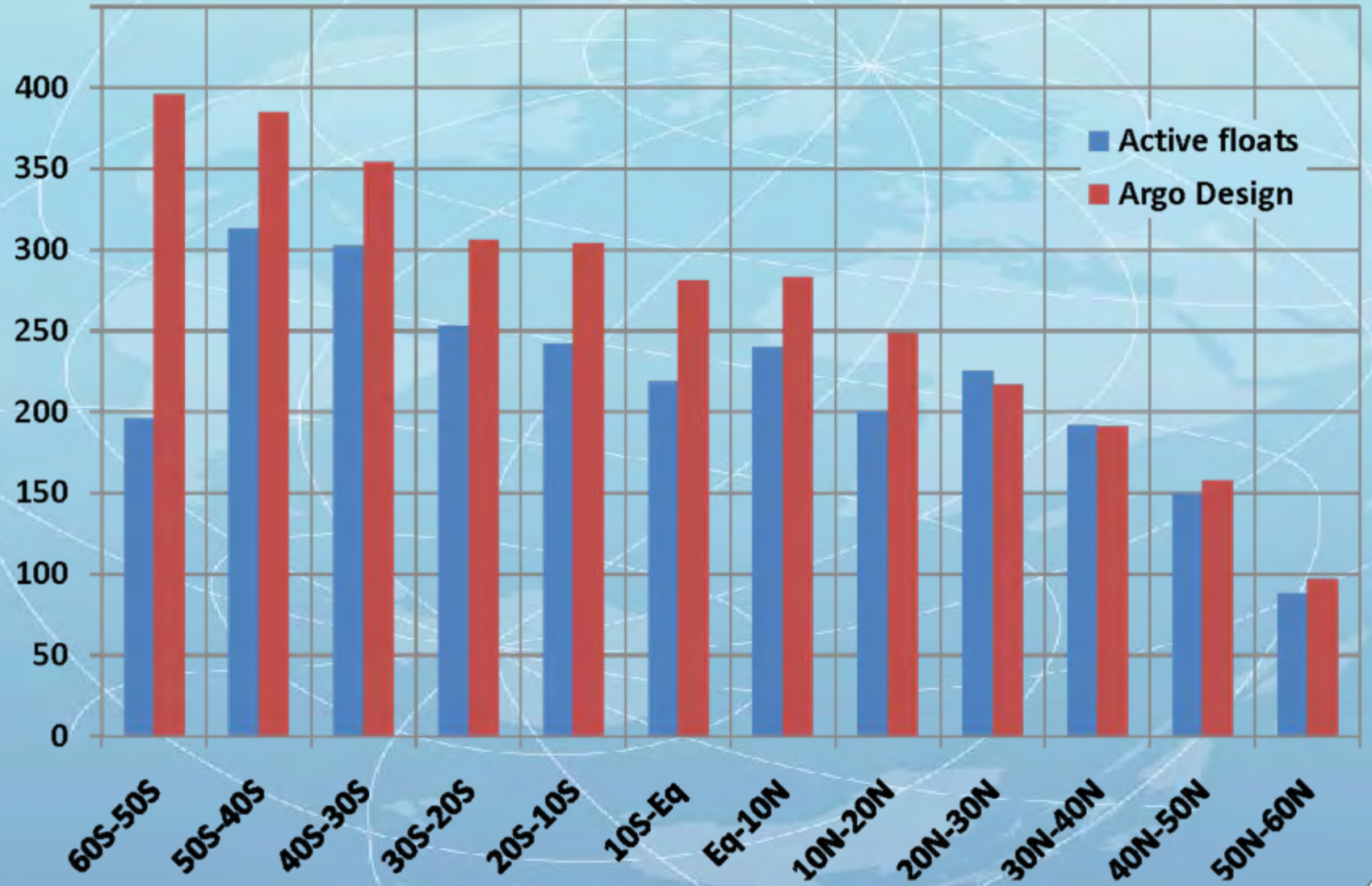
How big is Argo now?

< 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 but had limited availability for 2 years.

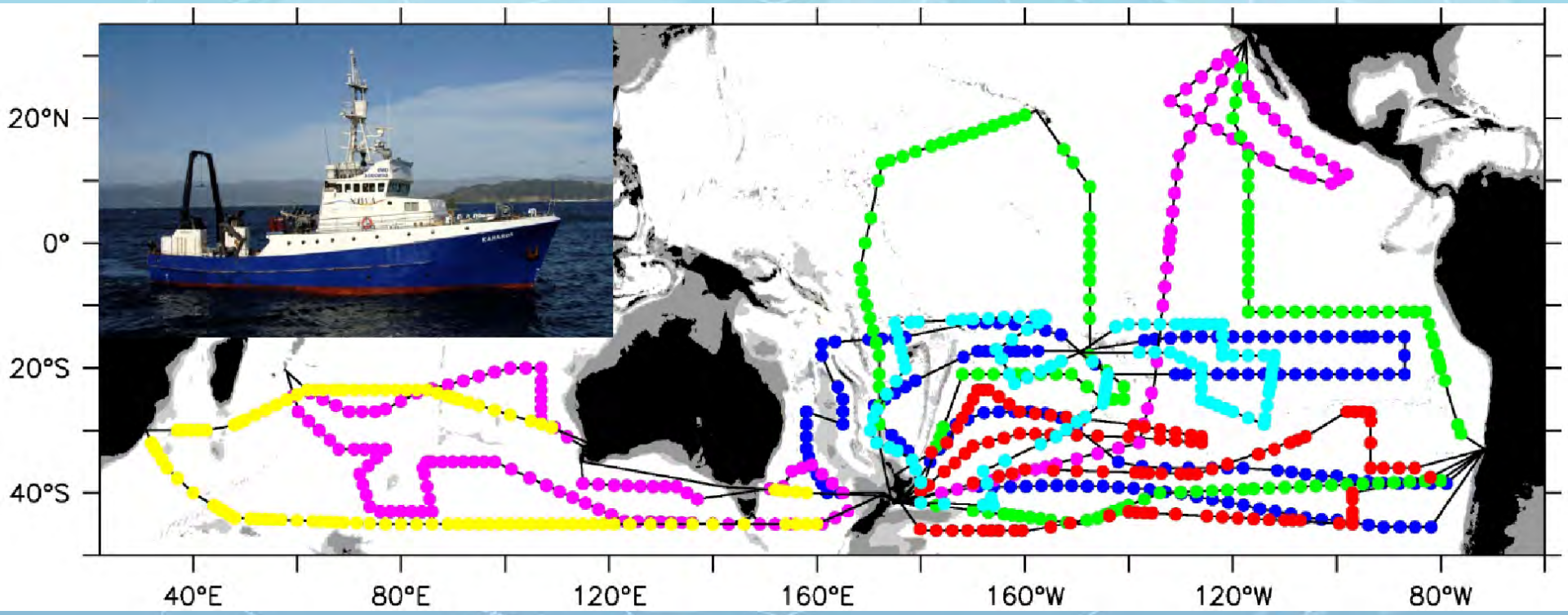
Another mainstay of the ocean climate monitoring network is the XBT program, in 2004 30,000 XBT stations were reported. But note large unsampled areas. Also, temperature is only ±0.1°C and there is no salinity observed. Data available in real time through the GTS.

In July 2009 Argo floats reported 10,659 profiles. All of very high quality, all including salinity, all in real time. This is equivalent to ~126,000 profiles/year. Unsampled areas are small and plans exist for eliminating them. All data available in near real-time.

OK, Argo is big, is it big enough?



The R/V Kaharoa
the top float deployer!



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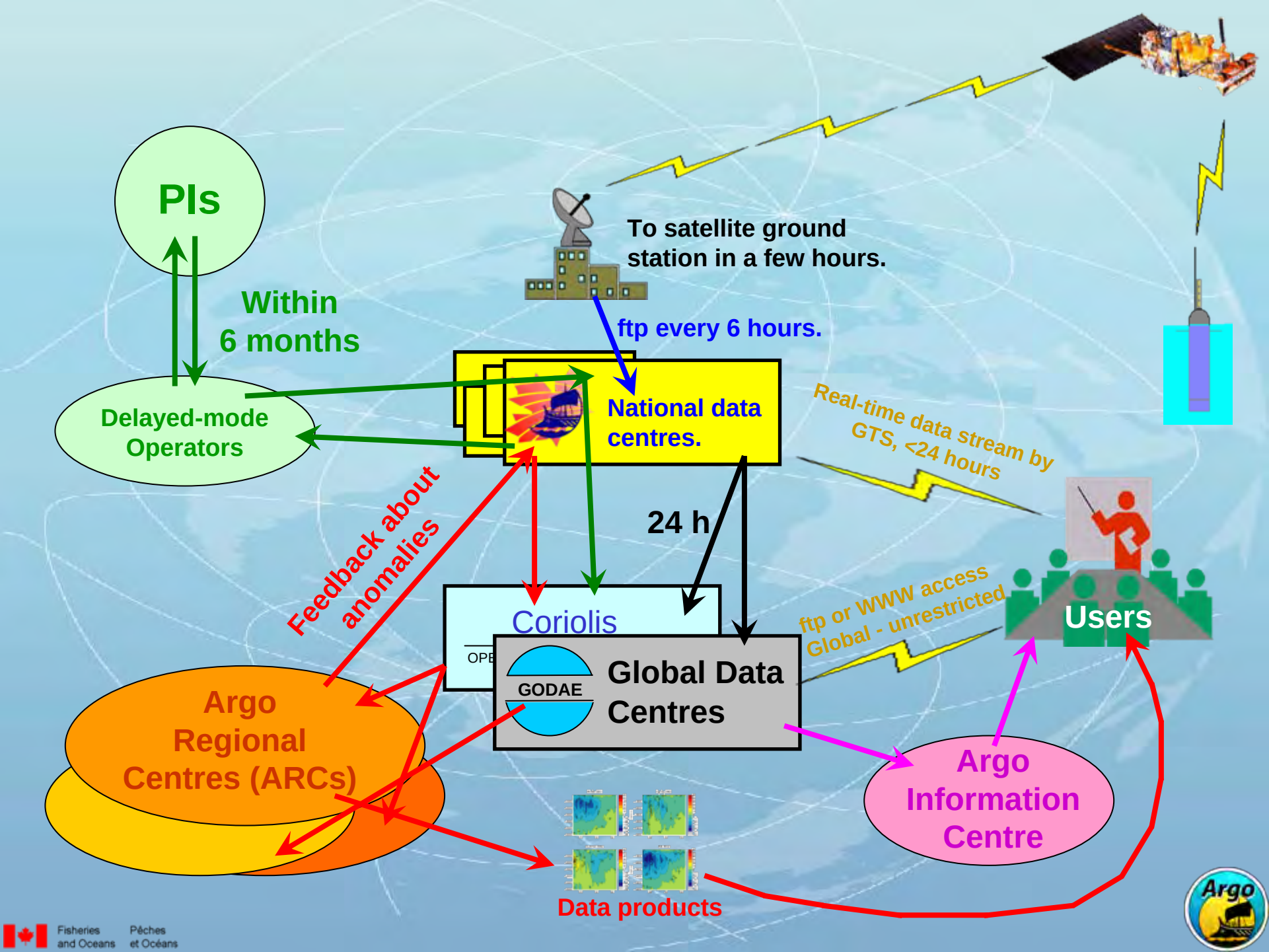
PIs
Within
6 months
Delayed-mode
Operators
To satellite ground
station in a few hours.
ftp every 6 hours.
National data
centres.
Real-time data stream by
GTS, <24 hours
24 h
Feedback about
anomalies
Coriolis
GODAE
Global Data
Centres
ftp or WWW access
Global - unrestricted
Users
Argo
Regional
Centres (ARCs)
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Centre
Data products
Fisheries
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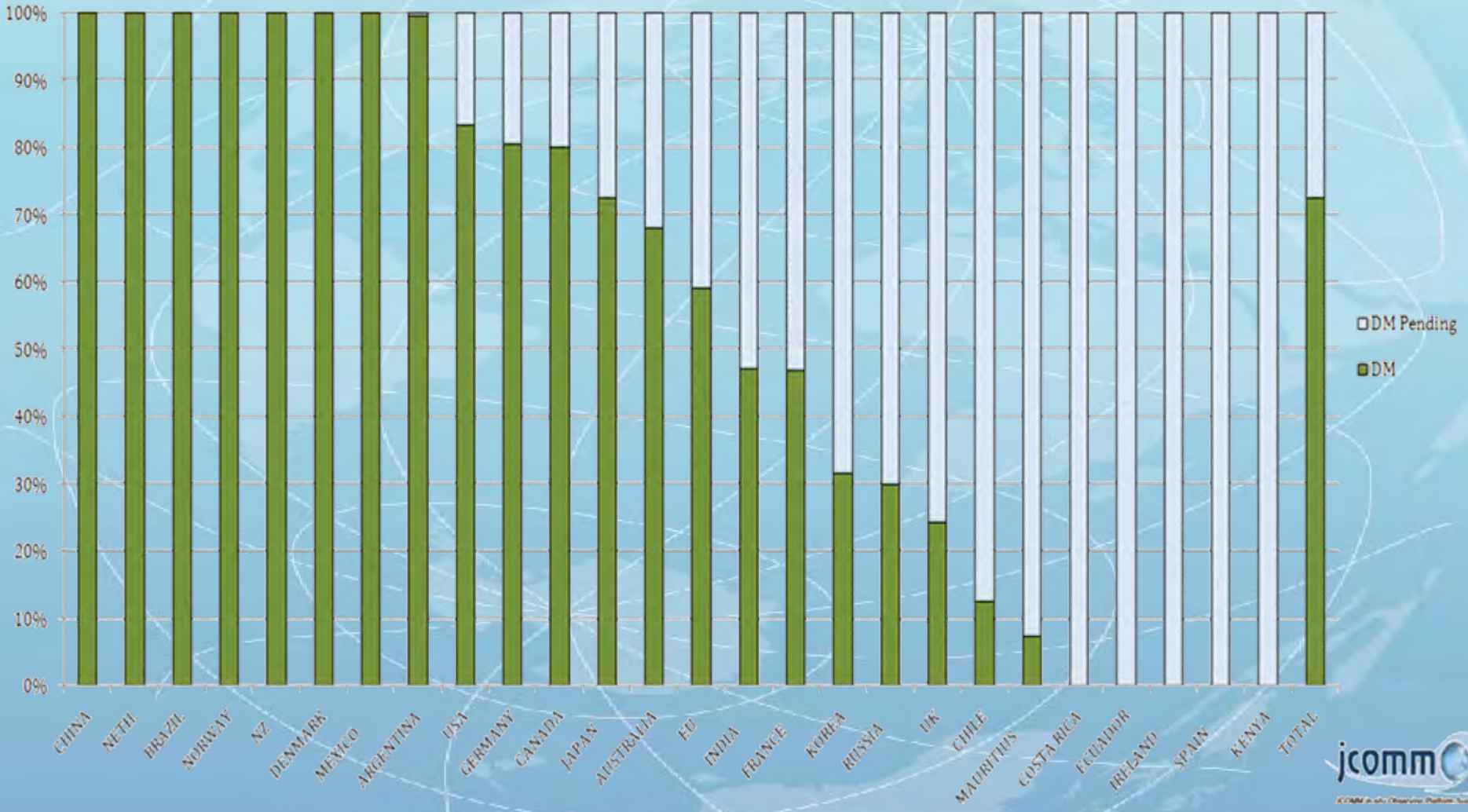
et Océans
Argo

Insufficient Progress is being made in DMQC

(but it is getting better)



jcommops

Argo

Fisheries and Oceans Pêches et Océans

Use of Argo was shown at OceanObs'09

1) David Anderson (UK Met. Office reviewed ocean prediction) and quoted Klaus Wyrtki "To call this event an El Niño would be a case of child abuse." – October 1982.

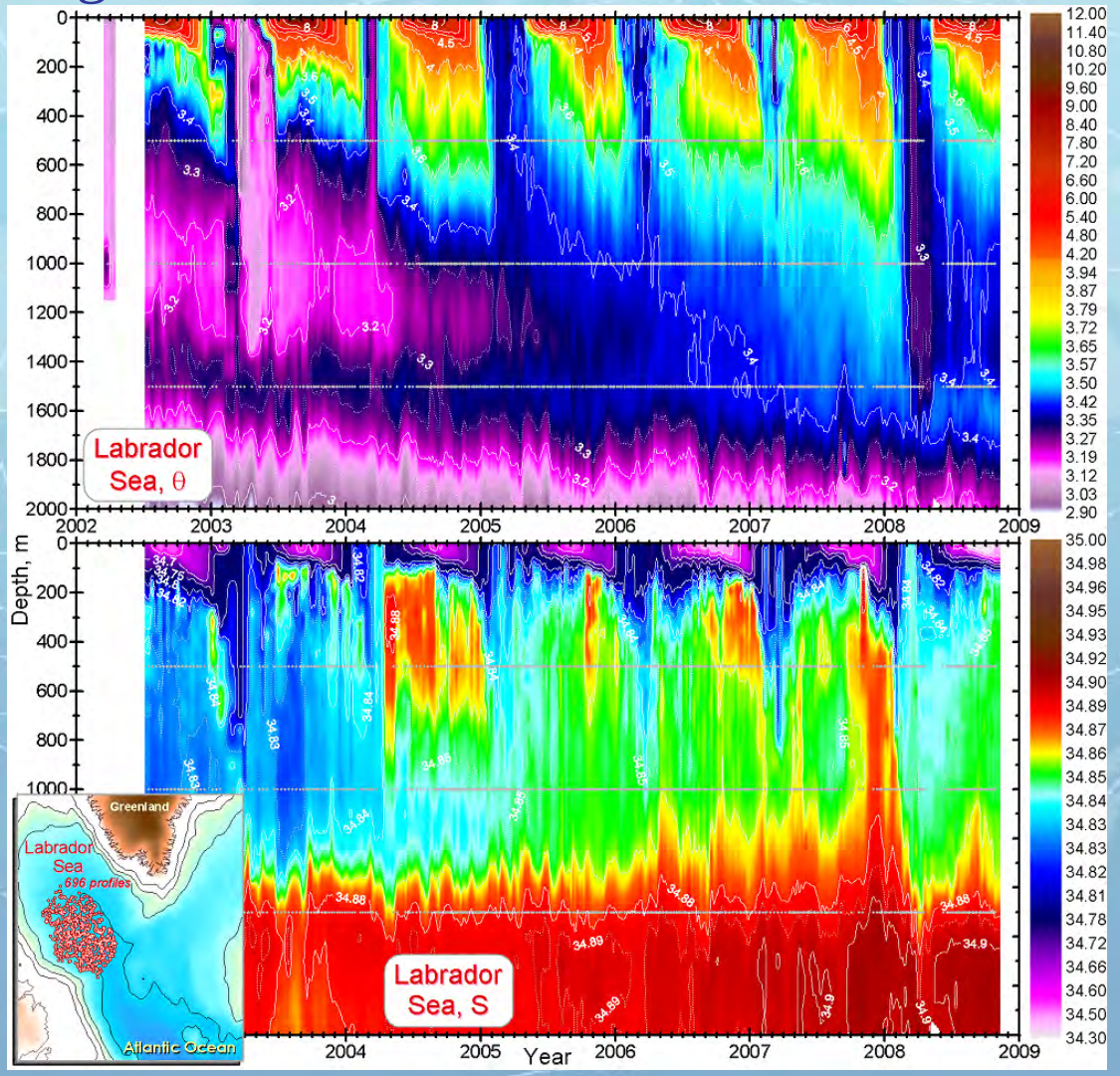
2) Magdalena Balmaseda showed evidence of progress in seasonal climate prediction. Argo and Jason being essential components.

3) Susan Wijffels (CSIRO) reviewed the contributions to Argo in constraining the steric component of sea-level rise. Again Argo is essential.

4) Steve Rintoul (CSIRO) reviewed observations of the MOC, simulating sections with Argo leads to the conclusion that the MOC is not slowing down as Bryden suggests.

Use of Argo was shown at OceanObs'09

5) Several speakers showed the following slide by Yashayaev and Loder, showing the return of convection to the Labrador Sea.



Recommendations from OceanObs'09

1) Almost all presentations stated clearly that the paramount issue is to sustain and maintain Argo as it is, and expand it slowly. The Argo steering team will agree.

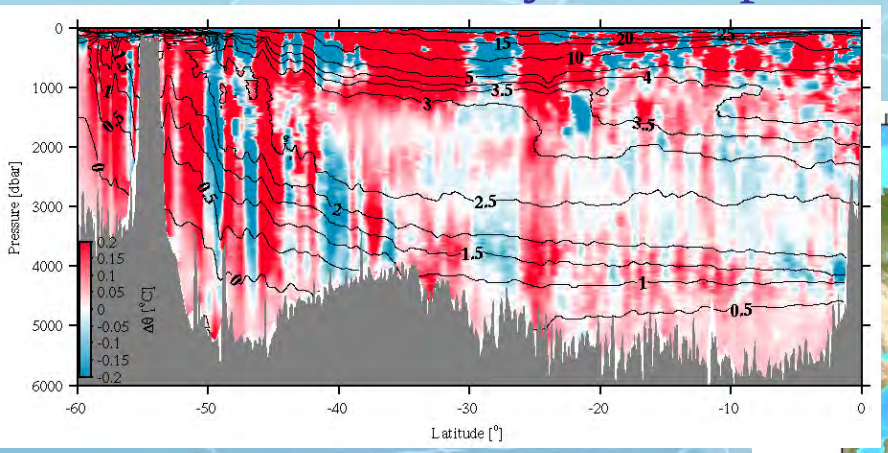
2) Repeatedly there were calls to establish bio-geochemical sensors on Argo floats. However, the AST will note that these sensors are generally insufficiently mature for use on Argo floats with the major exception of oxygen.

3) Repeatedly there were calls for extension of Argo into high latitudes and marginal seas. This can be done but requires an expansion of the global array to about 3600 floats. The AST will adopt this.

Recommendations from OceanObs'09

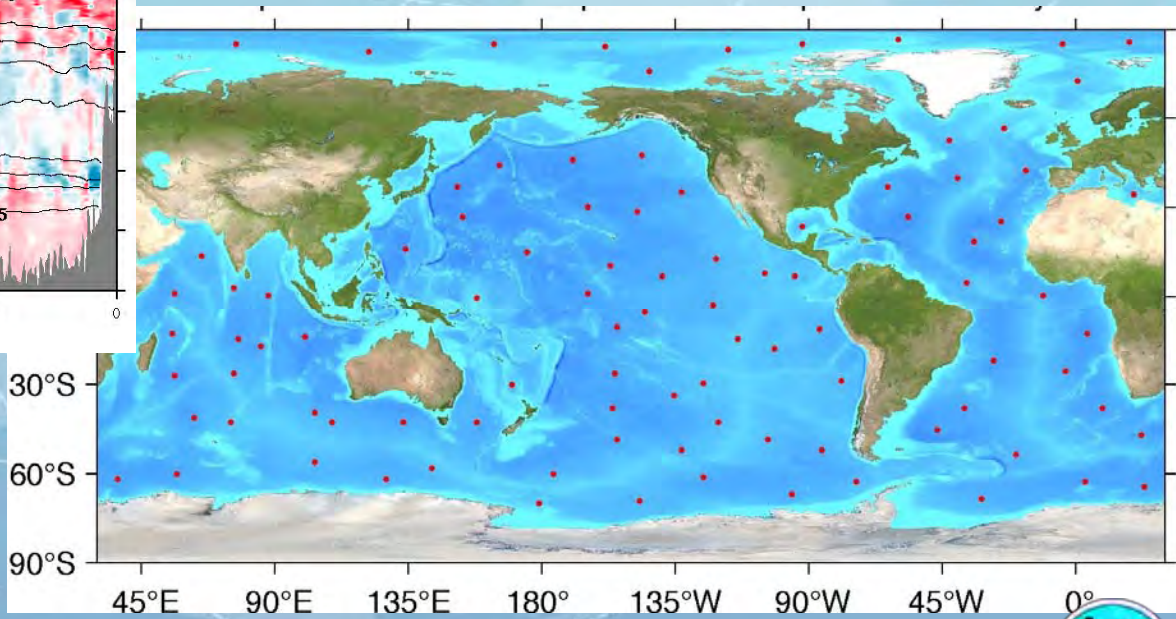
4) Calls were made for sea surface temperature and sea surface salinity and had a mixed reception within Argo steering team membership.

5) Calls were made to sample abyssal waters with Argo-like floats. This will likely be adopted by the AST



↑Abyssal warming in the S. Pacific (Johnson & Doney 2007)

A 5% subsample ↓ (Susan Wijffels)



Recommendations from OceanObs'09

6) We really do need to continue ship-based observations, such as the WHP repeat hydrography program. Both for recalibration of Argo and for things Argo does badly.

To quote Lynne Talley, it would be dangerous to dump everything we want to do on Argo.

Recommendations from OceanObs'09

7) Jen MacKinnon proposed alterations to the data handling on board floats to enable Thorpe Scales to be estimated. This requires a switch to Iridium communications and could be a cheap option.

I think this warrants some very serious thought. In particular it isn't immediately obvious to me what the best strategy would be, two options suggest themselves:-

a) Transmit high-resolution CTD data and compute Thorpe Scales at home in the laboratory.

b) Make the floats smarter. Observe a very high resolution profile, compute Thorpe Scales on board the float, transmit a well-resolved profile and Thorpe Scales if interesting.

The constraints on expanding Argo

A standard Argo float is a tightly-engineered device.

- There is an energy source (2 alkaline battery packs) on a standard Argo float that will power a SeaBird CTD, and the buoyancy engine for about 200 profiles from 2000 metres to the surface. The CTD and buoyancy engine are about equally demanding.
- Double the profiling depth and double the energy demand of the buoyancy engine and CTD, halve the profiles.
- Increasing the mass of the float reduces the battery payload.
- Adding sensors increases the power drain, and not all sensors are created equally. Adding an Aanderaa Optode sensor is rather different from adding acoustic packages for counting zooplankton.

The constraints on expanding Argo

5) Adding volume to a float reduces the floats ability to profile, potential density change is proportional to $\delta V/V_0$, so if we increase V_0, we need to increase δV, which costs energy.

6) As long as we sample P, T, S and D.O. we are covered as a monitoring activity under UNCLOS, if we add anything that might be claimed to infringe on the ability of a coastal nation to manage its resources we are MSR = Marine Scientific Research.

7) Floats in ice-infested waters have a relatively poor survival record, but the perceived value is high. Tracking underwater and probing for leads is energetically expensive.

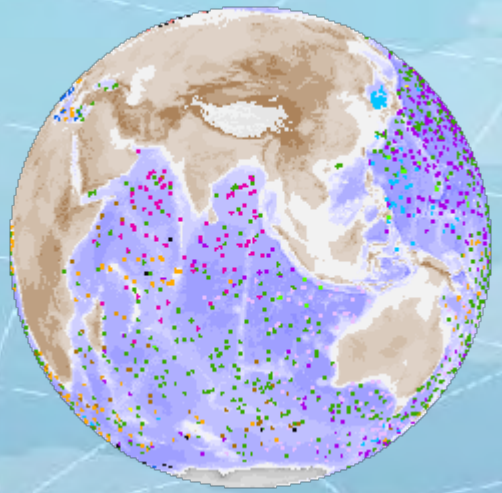
8) Floats in marginal seas tend to get blown onto beaches, with low survival records. But we might be fixing that with Iridium.

9) $$

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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