

Argo watches the Oceans



Howard Freeland
Argo Director at

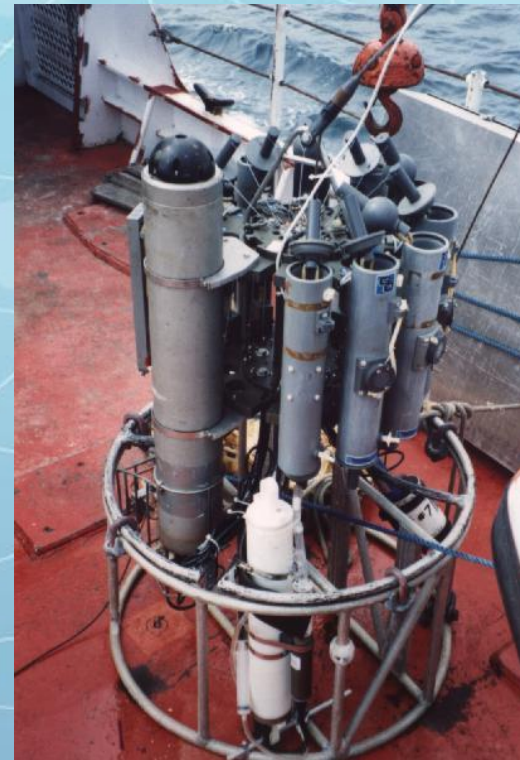
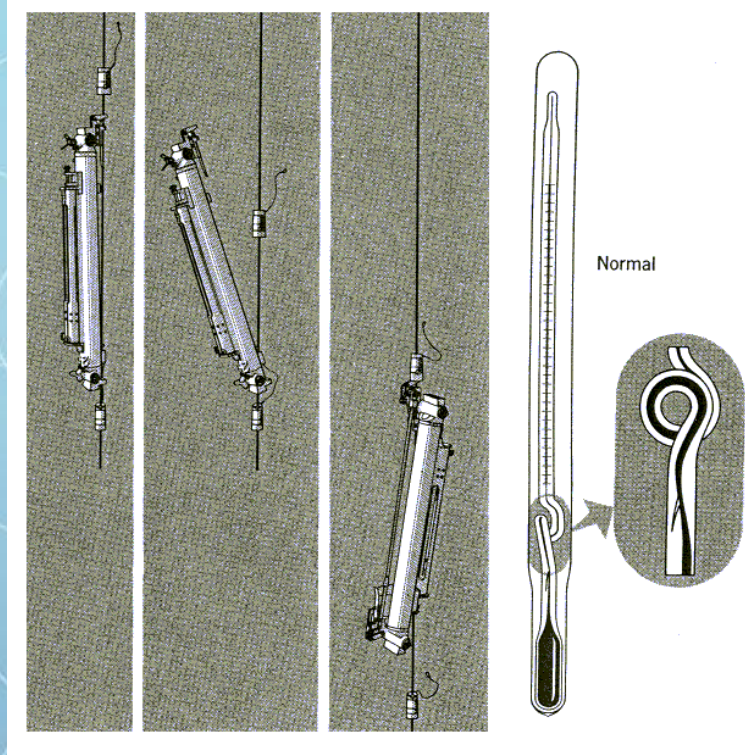
Institute of Ocean Sciences, Sidney, BC, Canada

Tel: (250)-363-6590

Email: Howard.Freeland@pac.dfo-mpo.gc.ca



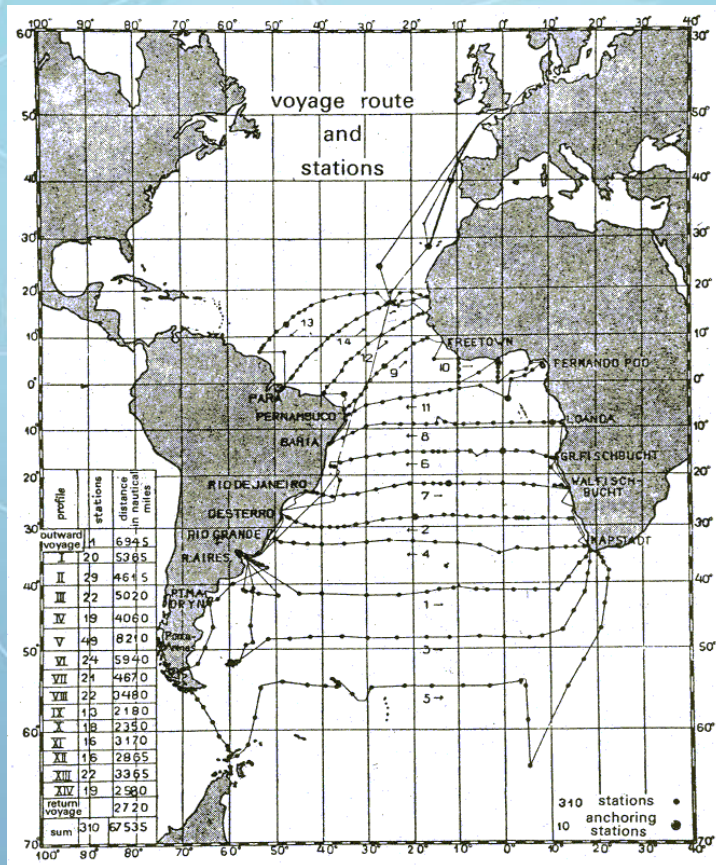
Why are we doing Argo?



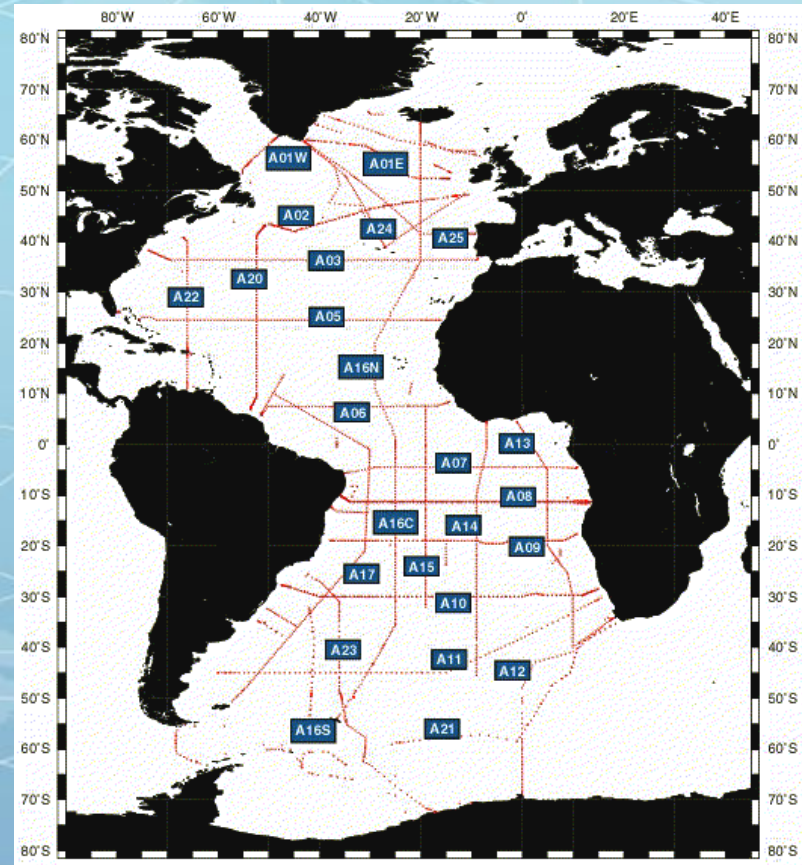
Measurements are made now with much greater accuracy and precision than before, but in some ways little progress has been made.

Why are we doing Argo?

Progress (?) during the last 70 years.



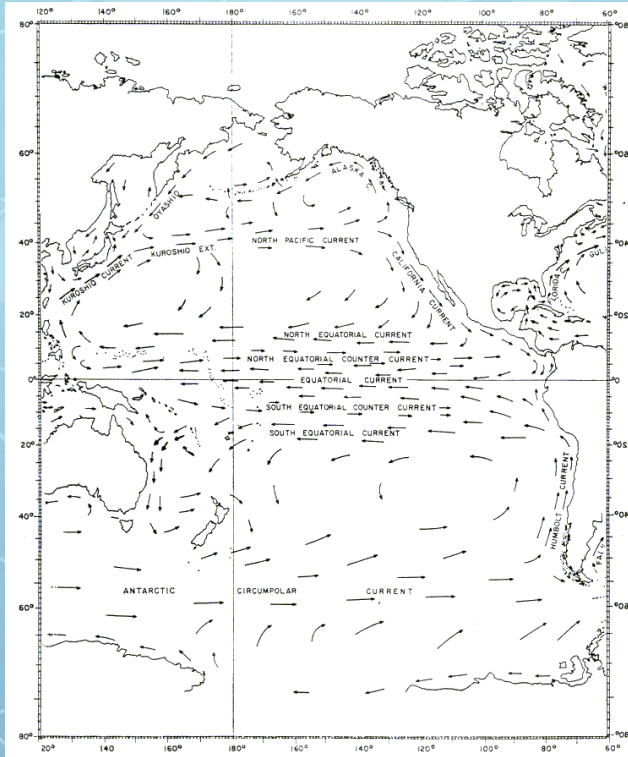
Stations occupied by the *Meteor* in the Atlantic Ocean 1925-27.



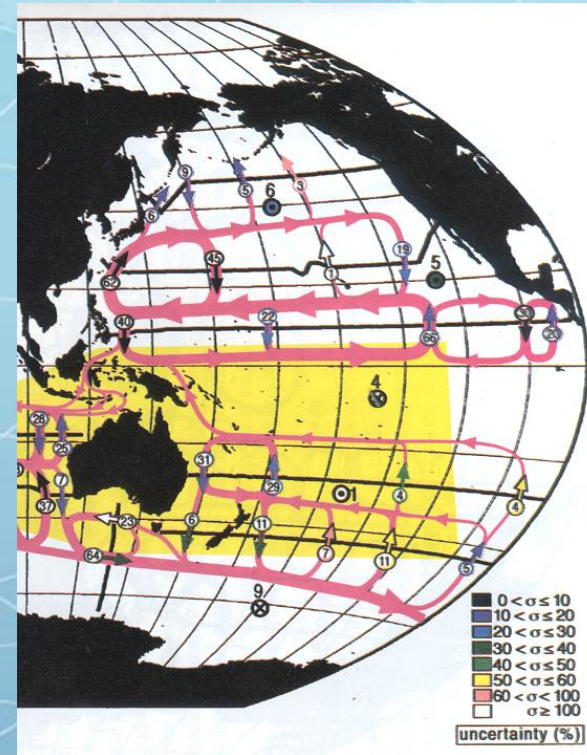
Stations occupied in the Atlantic during WOCE, 1991-97.



Why are we doing Argo?

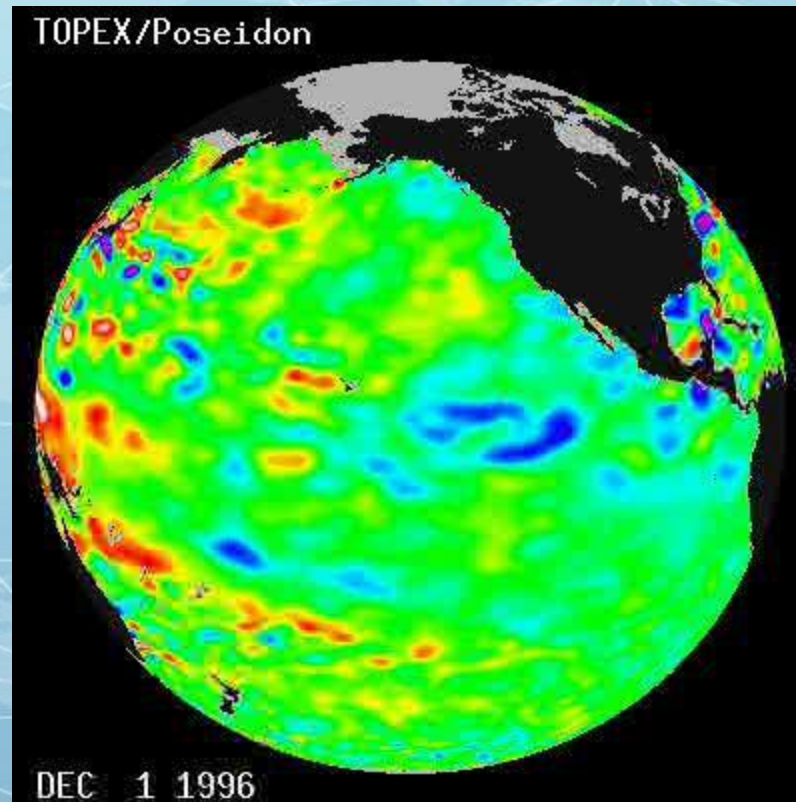


The circulation of the Pacific Ocean according to Hugh McLellan, 1965.

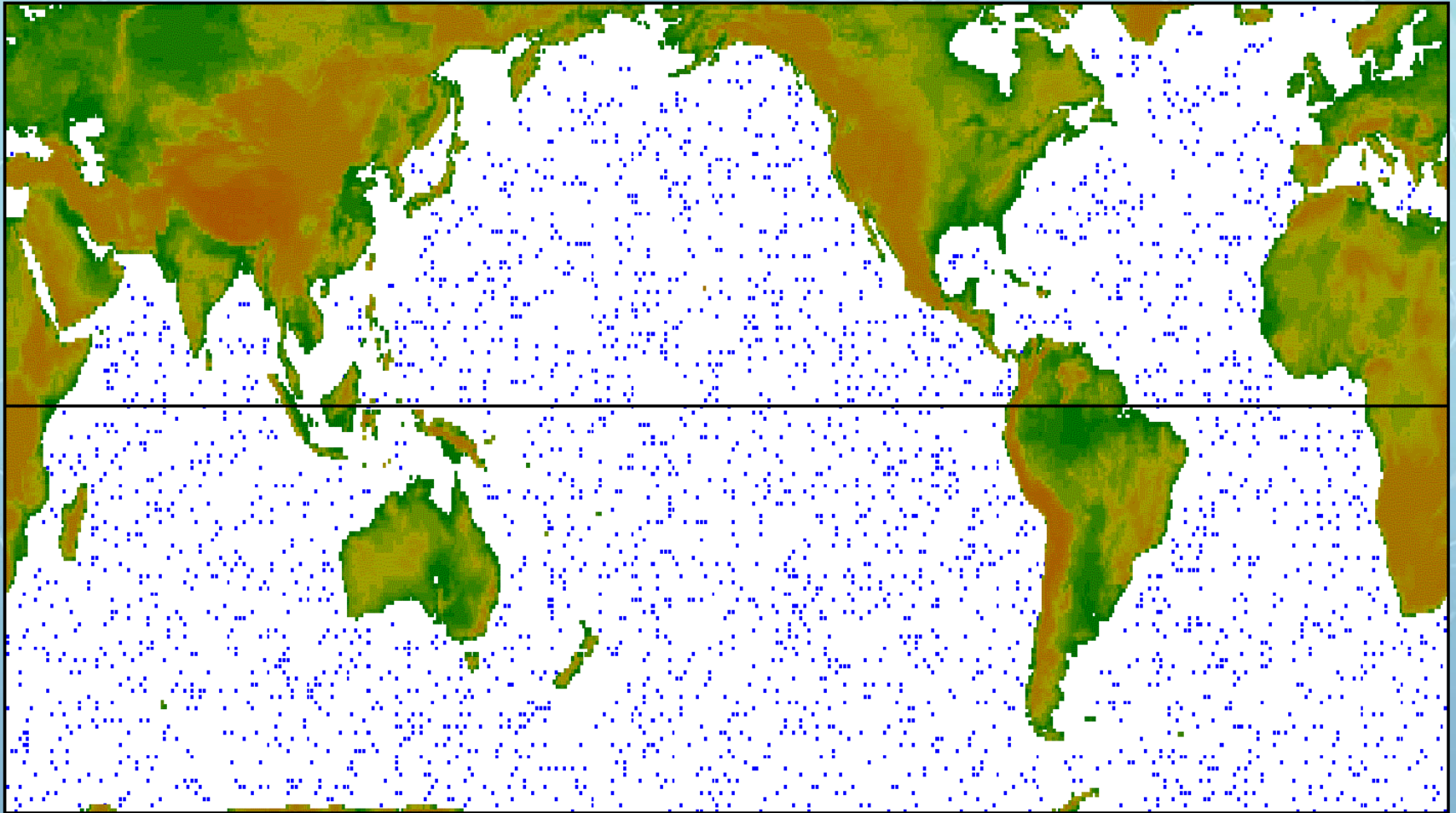


The circulation of the Pacific Ocean according to Allison McDonald, 1999.

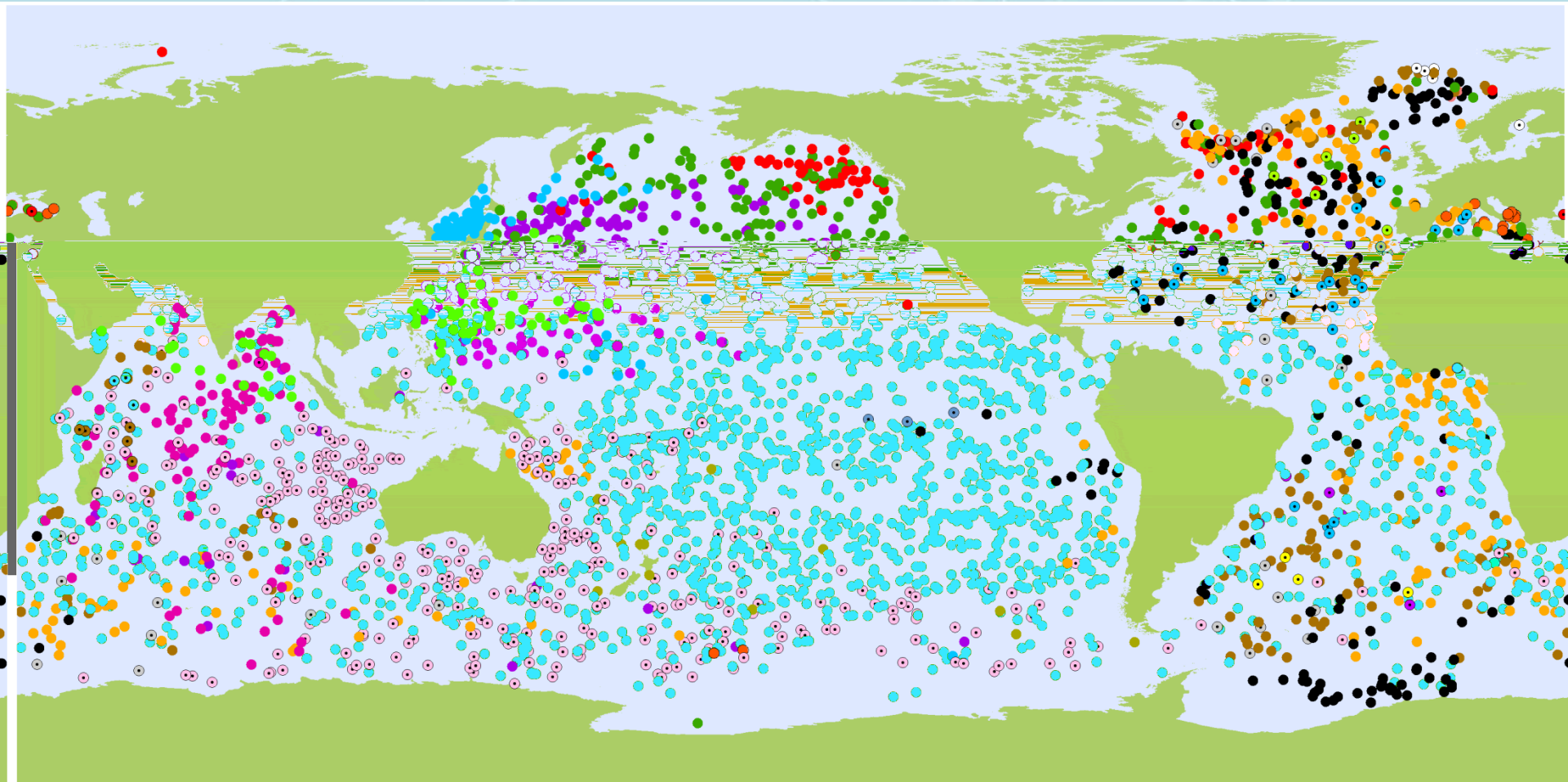
The ocean is in fact variable and the variability affects climate



The Argo community planned to deploy 3000 floats by 2007



How big is Argo now?



3634 Floats

● ARGENTINA (4)	● CANADA (92)	● FRANCE (257)	● IRELAND (10)	● SOUTH KOREA (84)	● NORWAY (2)	● SRI LANKA (1)
● AUSTRALIA (379)	● CHINA (87)	● GABON (1)	● ITALY (19)	● MAURITIUS (6)	● POLAND (0)	● TURKEY (2)
● BRAZIL (6)	● ECUADOR (3)	● GERMANY (178)	● JAPAN (215)	● NETHERLANDS (27)	● SOUTH AFRICA (2)	● UNITED KINGDOM (137)
● BULGARIA (3)	● FINLAND (5)	● INDIA (109)	● KENYA (3)	● NEW ZEALAND (12)	● SPAIN (29)	● UNITED STATES (1 961)

July 2013



How does a *profiling* float work?



NOVA



APEX

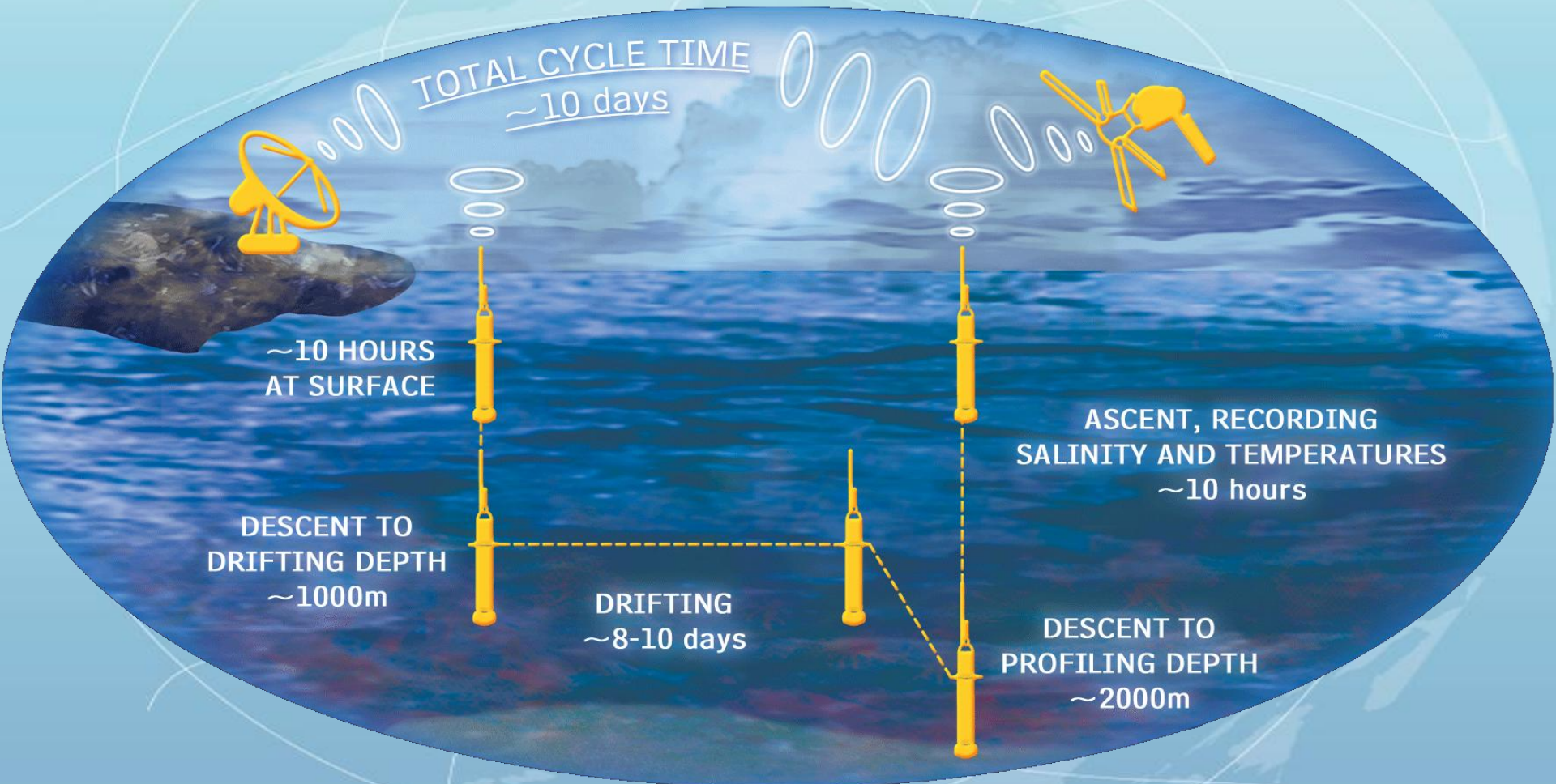


SOLOs

PROVOR



How does a *profiling* float work?



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

We are dominated by requirements set by UNCLOS-3.

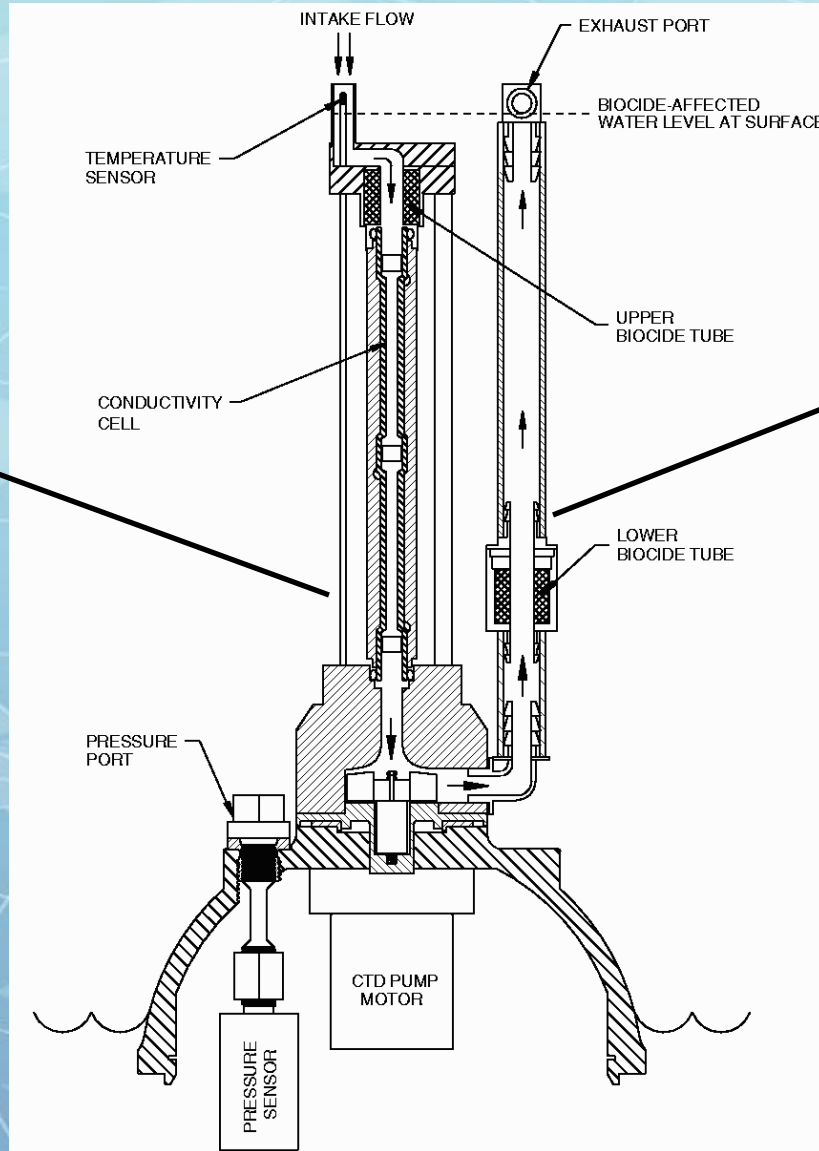
For a float to be called an “Argo float” the data *must* be released in near real-time with an open-access data policy.

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 .

$$\text{Deep density} = \rho_d = \frac{M}{V_0}$$

$$\text{Shallow density} = \rho_s = \frac{M}{V_0 + \delta V}$$

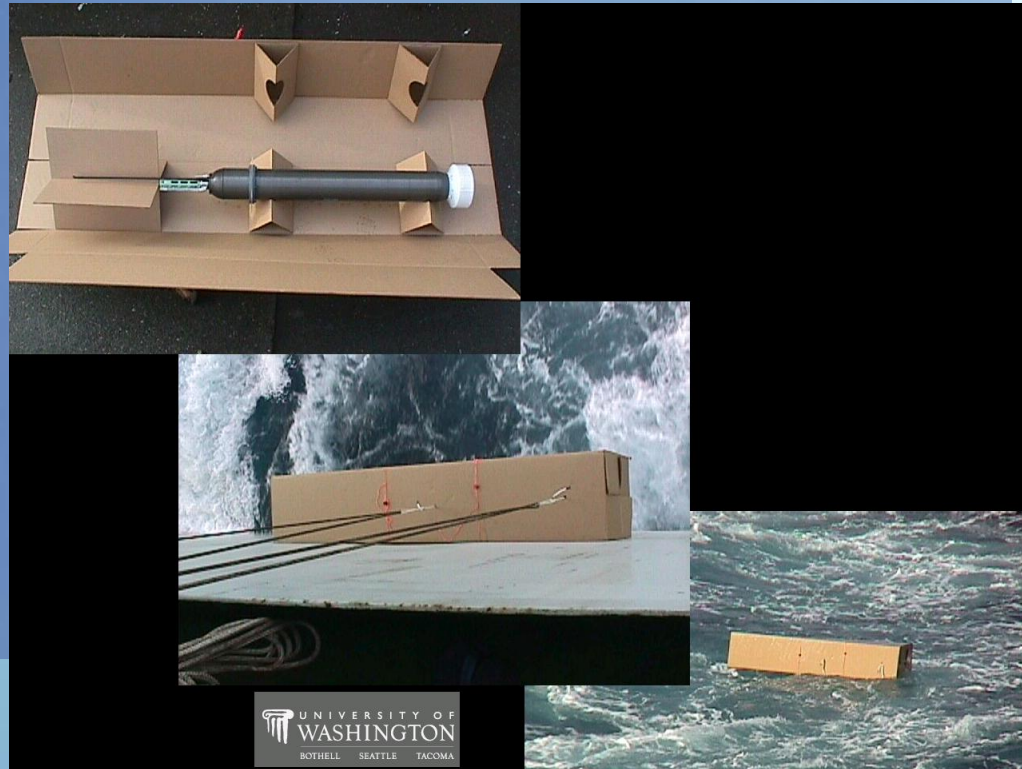
$$\text{So } \rho_d - \rho_s = \rho_d \frac{\delta V}{V_0}$$

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.



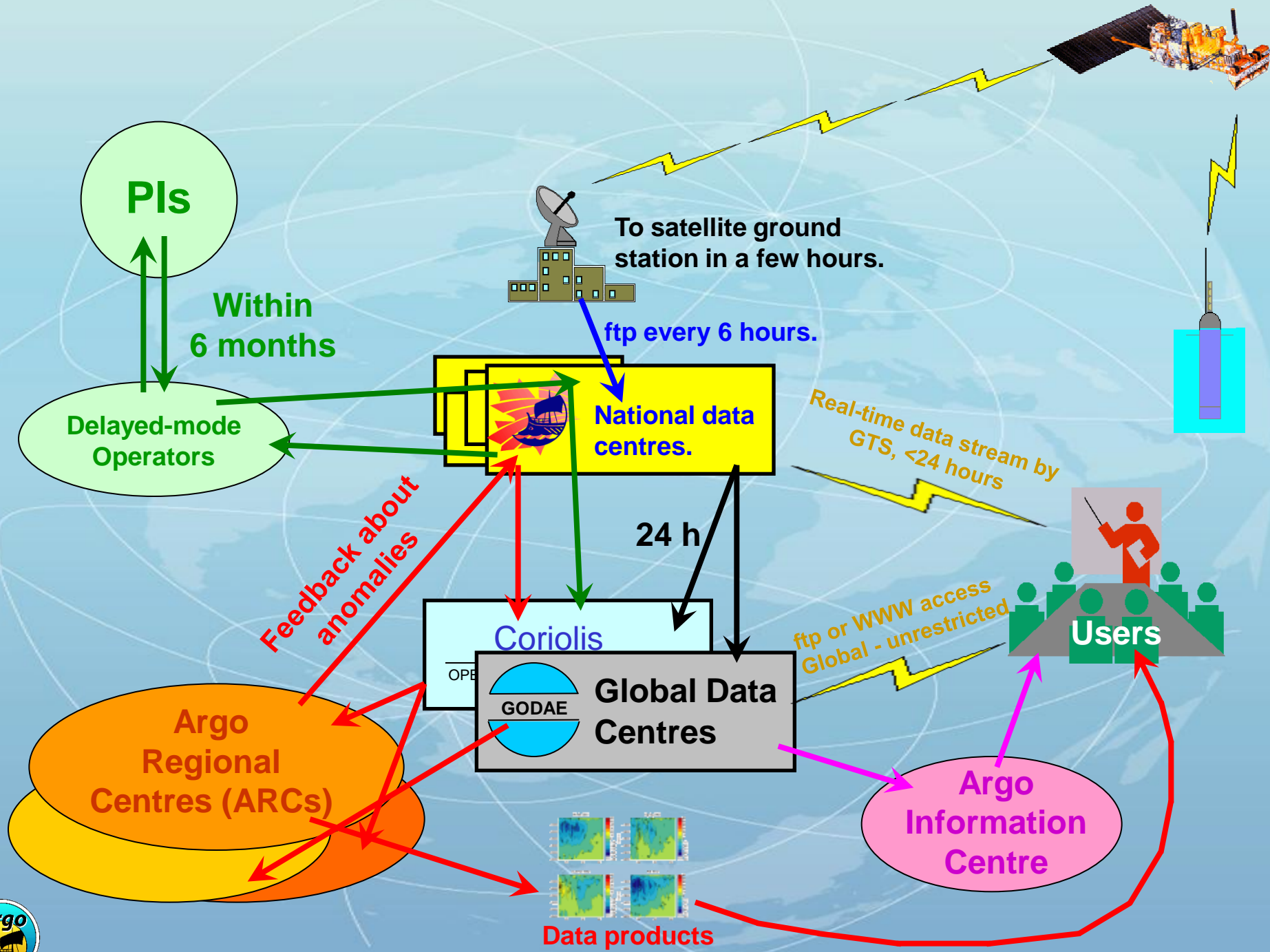
How are floats being launched?

Or deployed from container vessels

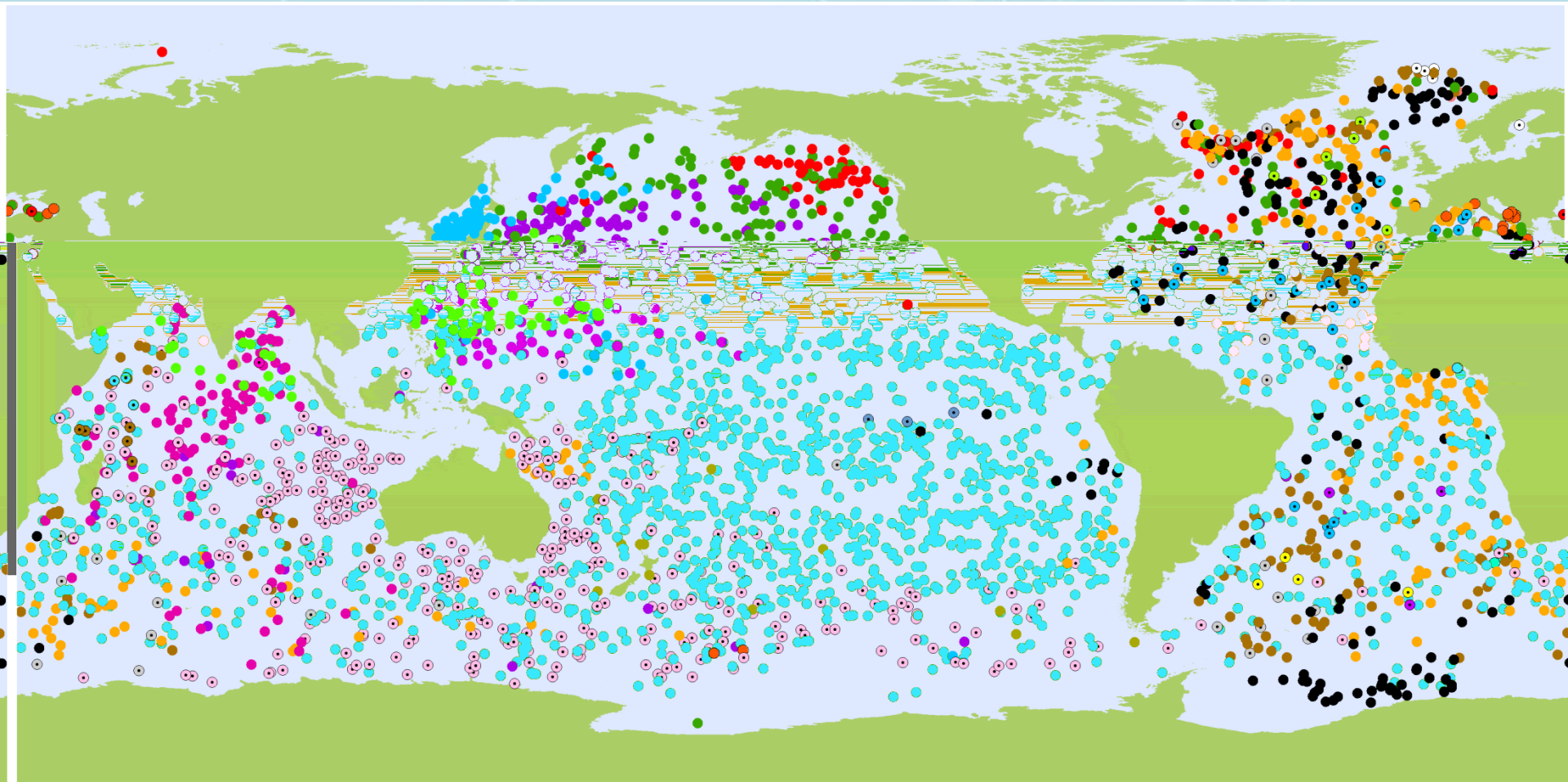


Argo floats can be launched from Aircraft, here a C-130 (Hercules)





How big is Argo now?



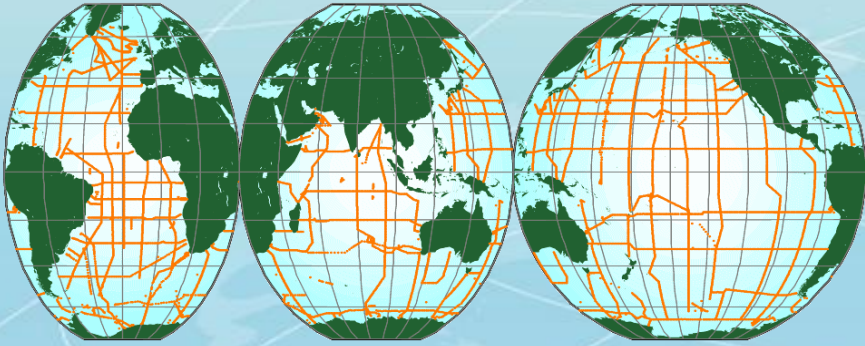
3634 Floats

● ARGENTINA (4)	● CANADA (92)	● FRANCE (257)	● IRELAND (10)	● SOUTH KOREA (84)	● NORWAY (2)	● SRI LANKA (1)
● AUSTRALIA (379)	● CHINA (87)	● GABON (1)	● ITALY (19)	● MAURITIUS (6)	● POLAND (0)	● TURKEY (2)
● BRAZIL (6)	● ECUADOR (3)	● GERMANY (178)	● JAPAN (215)	● NETHERLANDS (27)	● SOUTH AFRICA (2)	● UNITED KINGDOM (137)
● BULGARIA (3)	● FINLAND (5)	● INDIA (109)	● KENYA (3)	● NEW ZEALAND (12)	● SPAIN (29)	● UNITED STATES (1 961)

July 2013

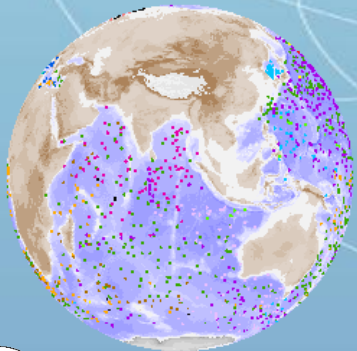
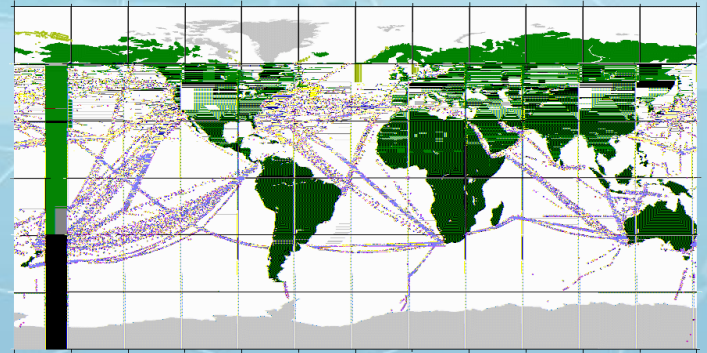


How big is Argo now?



< 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.

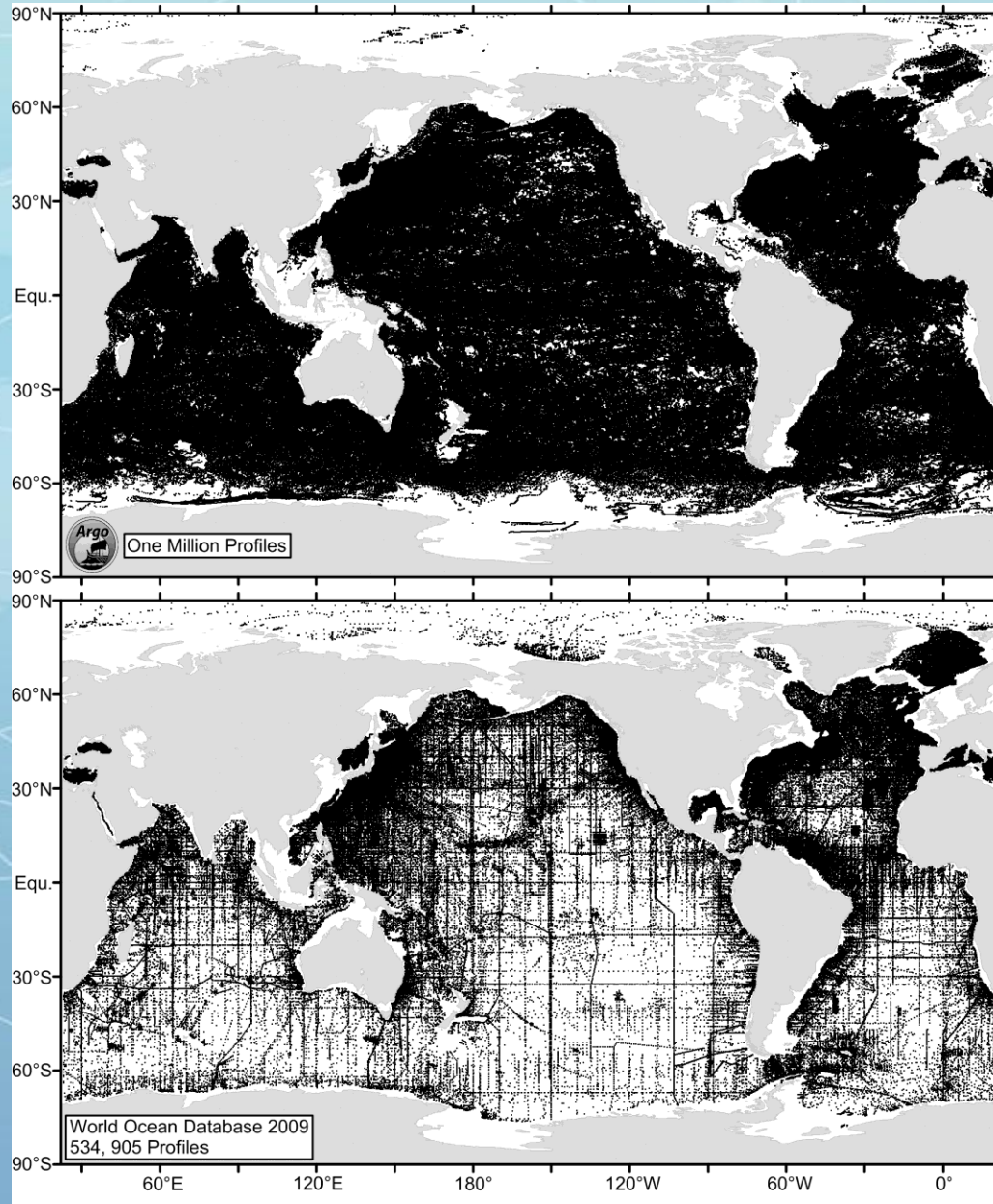
Another mainstay of the ocean climate monitoring network is the XBT program, in 2004 30,000 XBT stations were reported. But note large unsampled areas. Also, temperature is only $\pm 0.1^{\circ}\text{C}$ and there is no salinity observed.



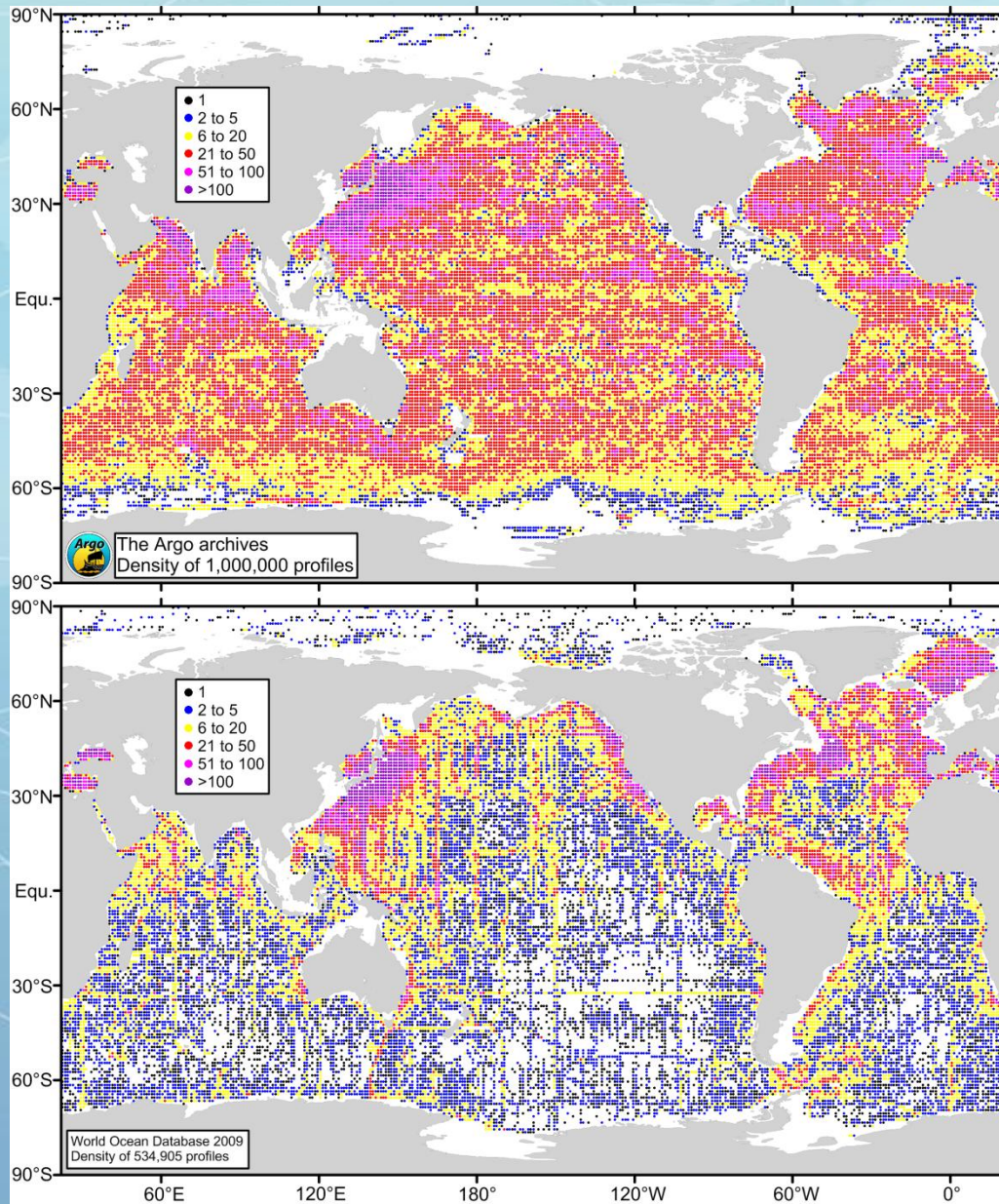
In May 2013 Argo floats reported 11,771 profiles. All of high quality, all including salinity, all in real time. This is equivalent to $\sim 139,000$ profiles/year or 1 profile every 3.7 minutes. Unsampled areas are small and plans exist for eliminating them. In November 2012 Argo collected its 1-millionth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



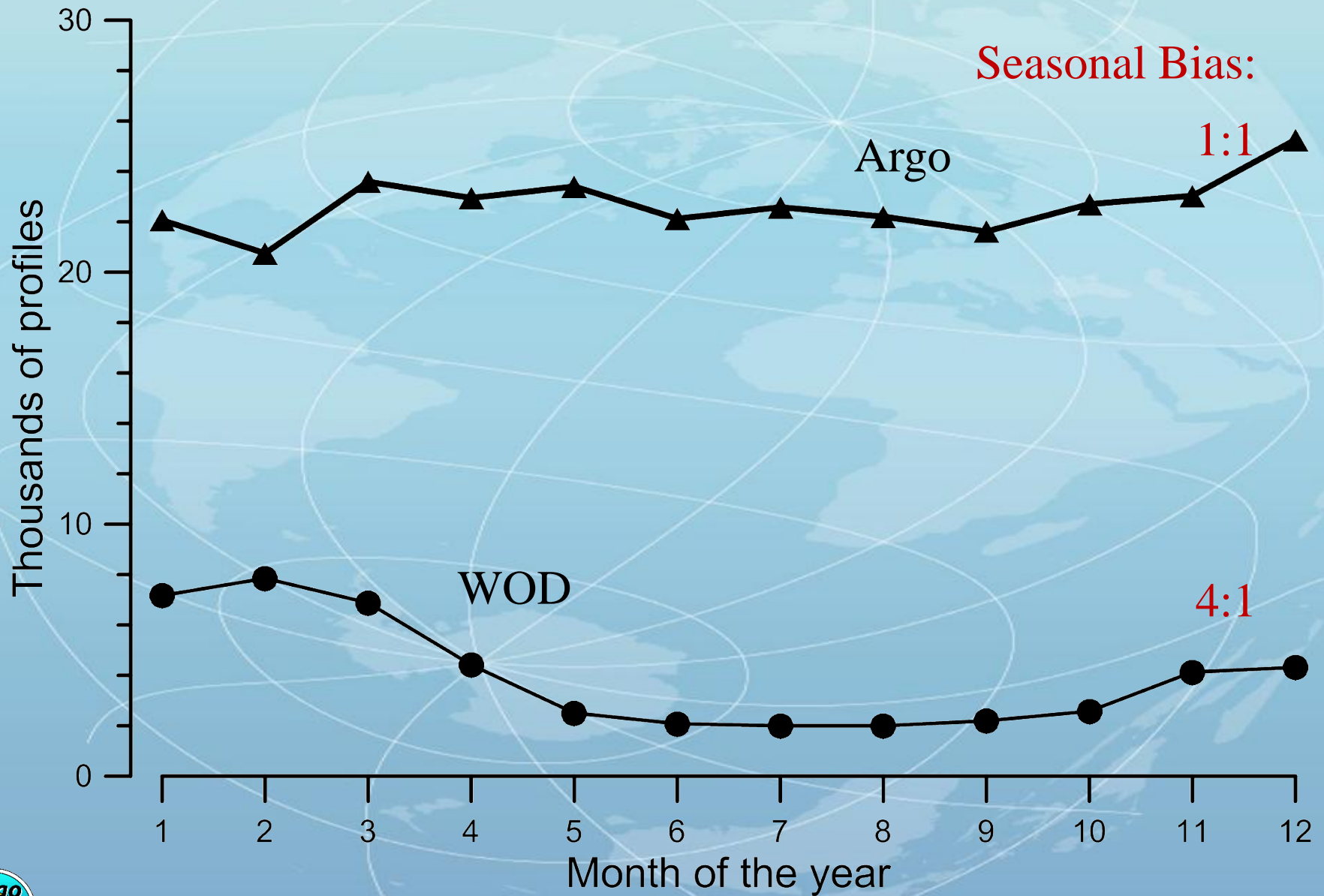
How big is Argo now?



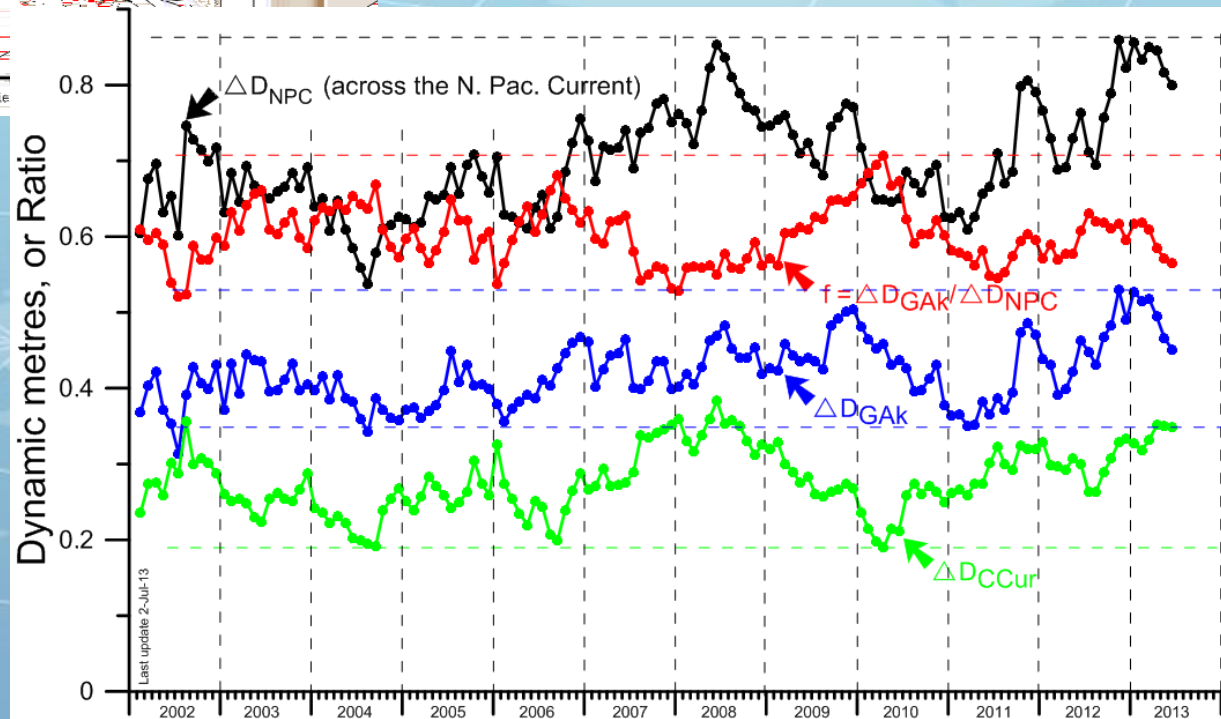
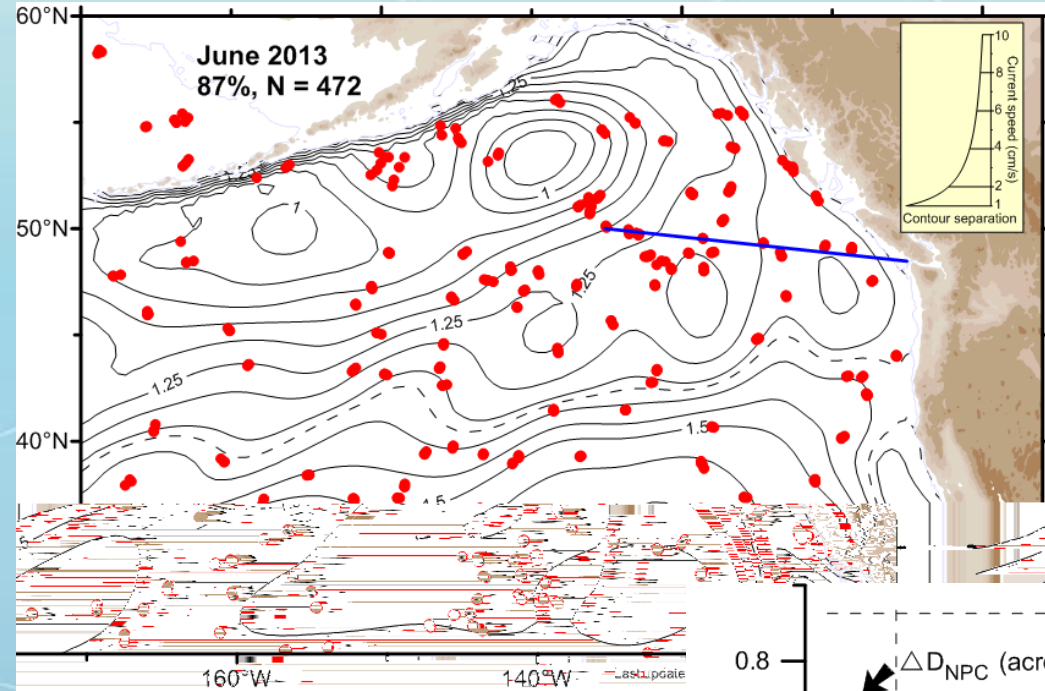
How big is Argo now?



The Number of profiles S of 30°S



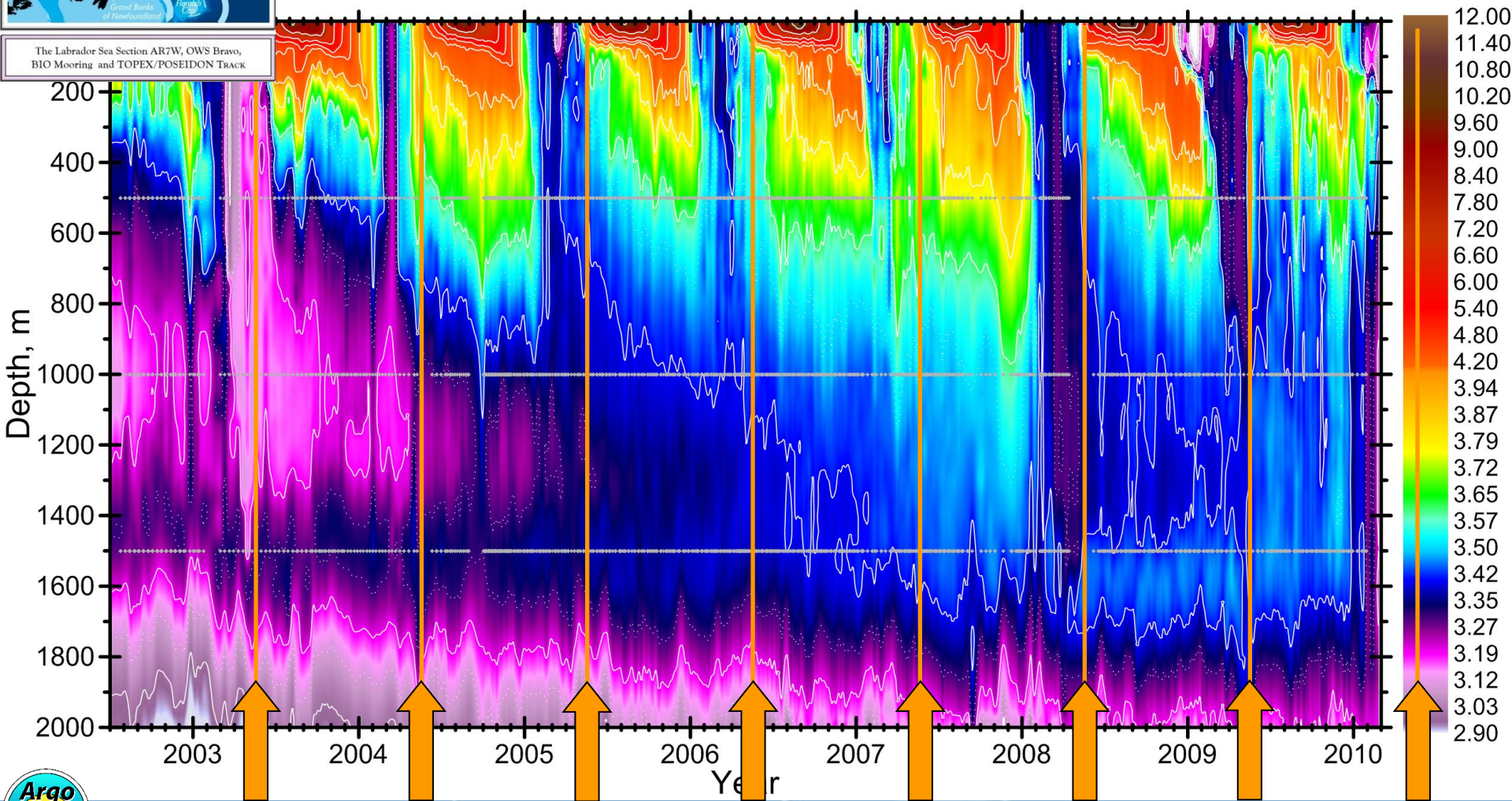
Circulation in the Gulf of Alaska



Stratification at Ocean Station Bravo (temperature using Argo floats)



The Labrador Sea Section AR7W, OWS Bravo, BIO Mooring and TOPEX/POSEIDON TRACK

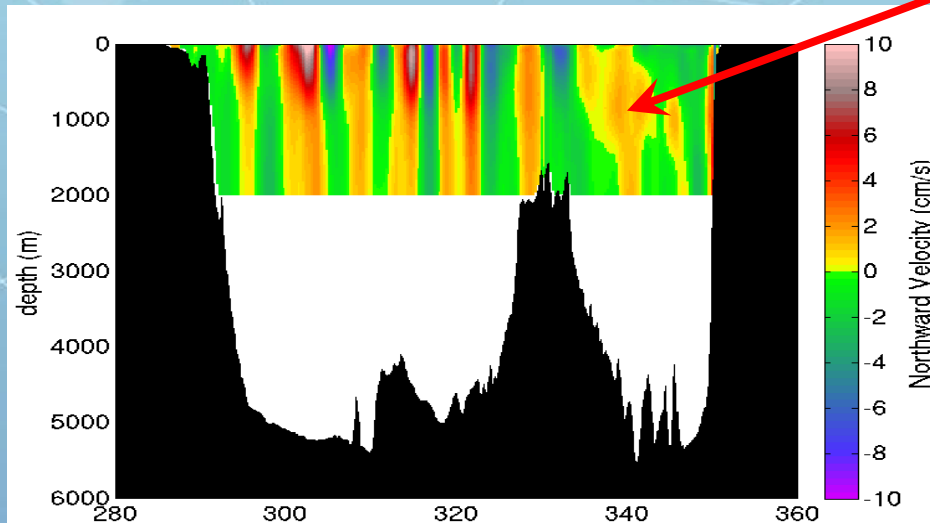
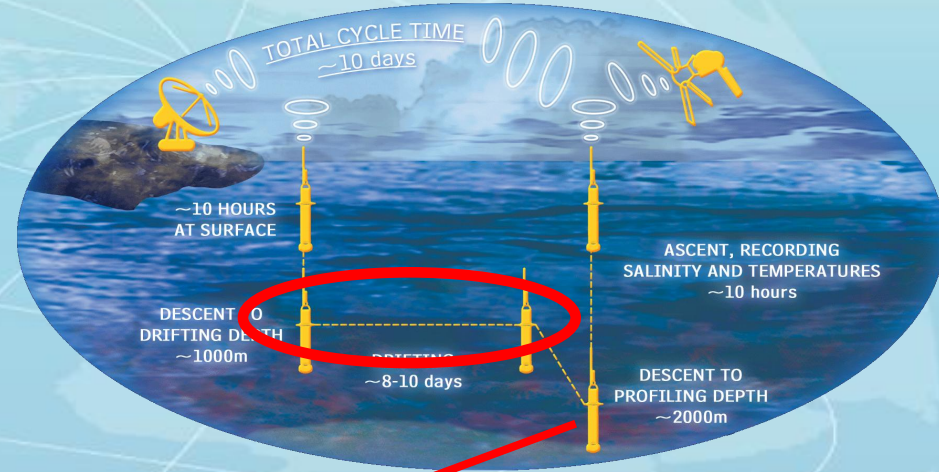
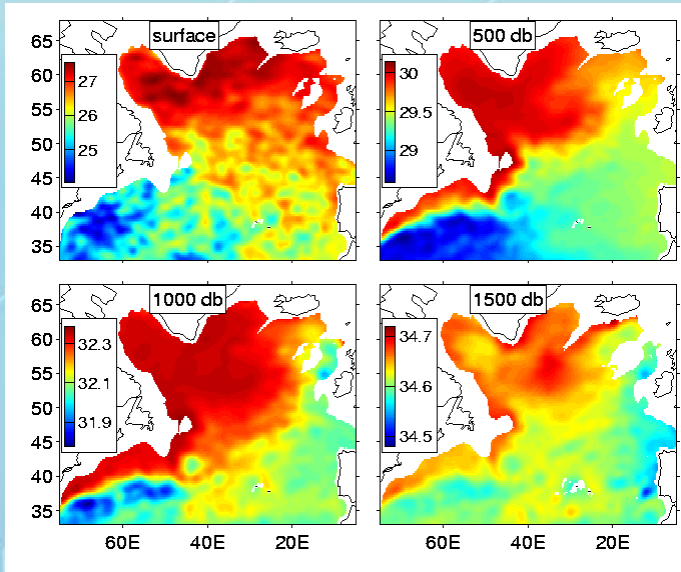




THE DAY AFTER TOMORROW

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

Observing the AMOC at 41°N



Summary

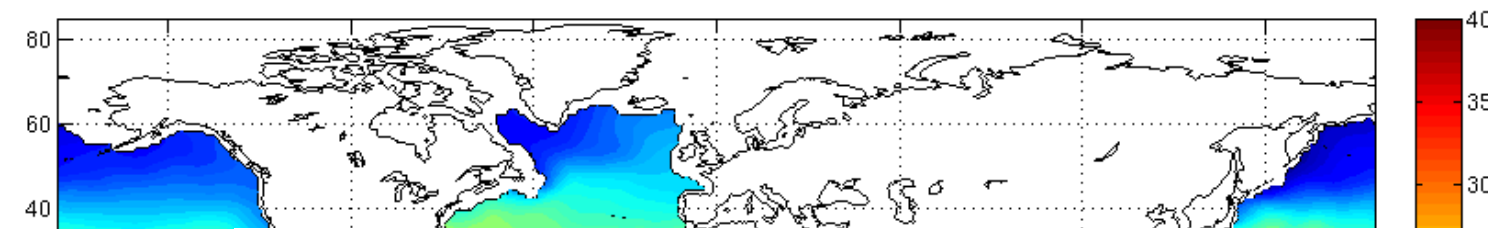
- AMOC at 41°N ~ 16 Sv
 - 2.4 Sv RMS variability
 - ~3 Sv error bar
 - Variability Mostly Ekman
- No significant trend, 2002 to present

THE DAY AFTER

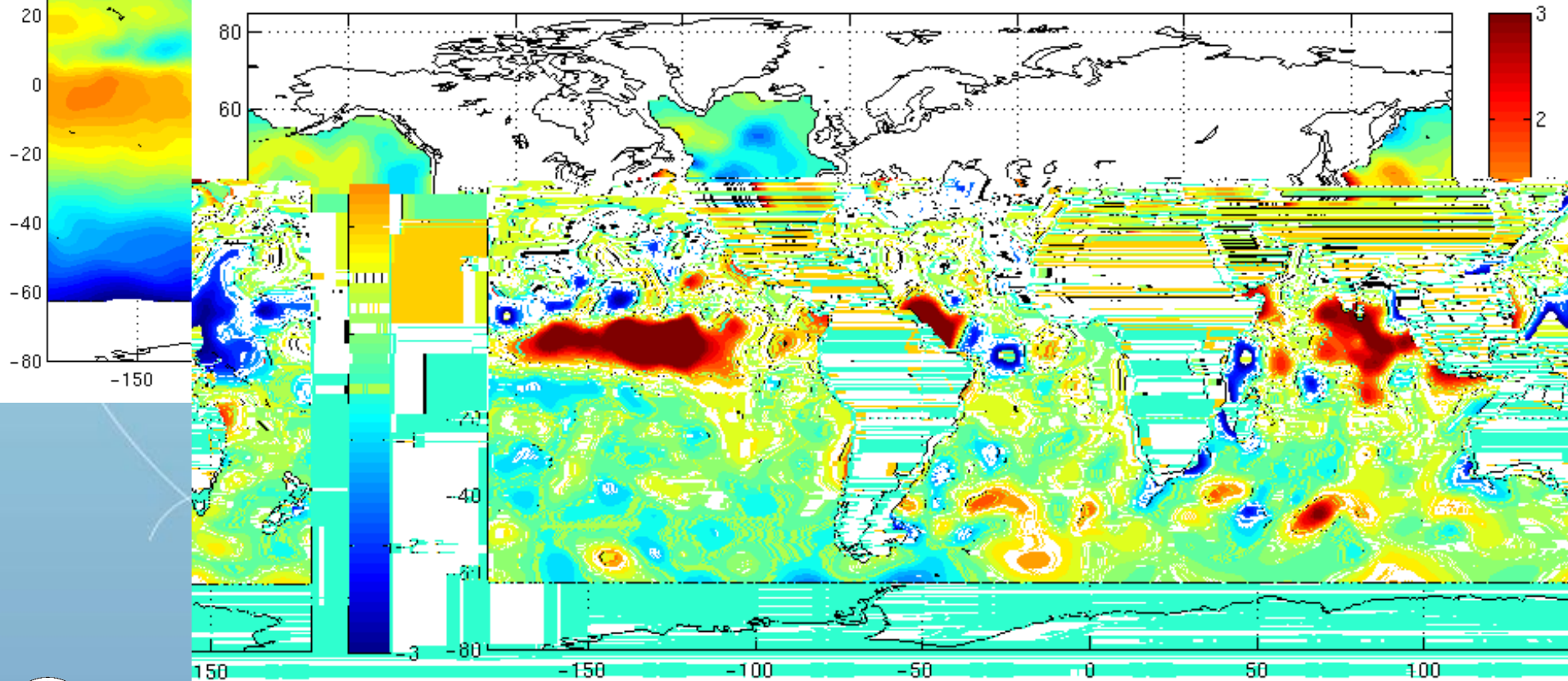
Argo

Global Ocean analyses for forecast systems

T at 0100m in 2010 Jan



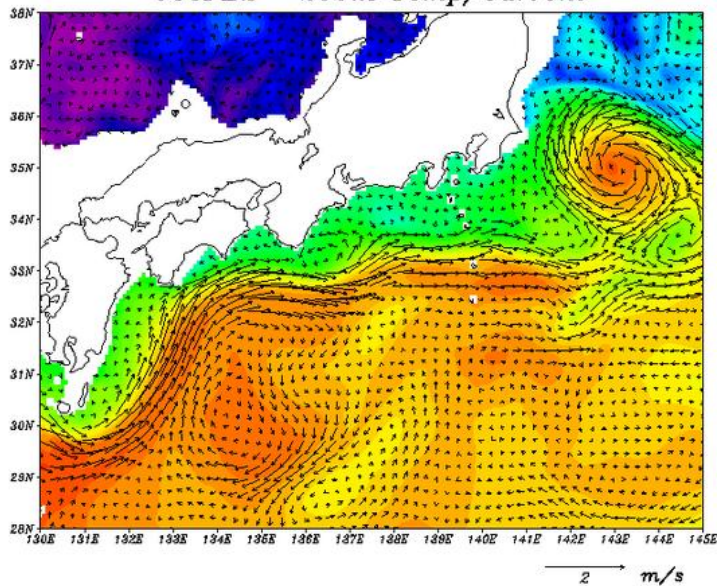
T anomaly (relative to 2005–2009 monthly mean) at 0100m in 2010 Jan



JCOPE Ocean State Prediction

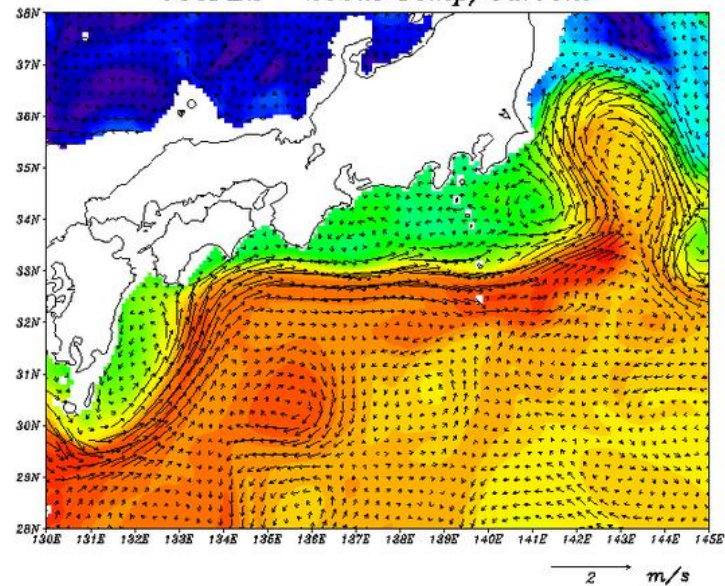
2010/02/02

JCOPE2 200m Temp/Current



2010/02/02

JCOPE2 200m Temp/Current



Analysis for 2nd February
2010.

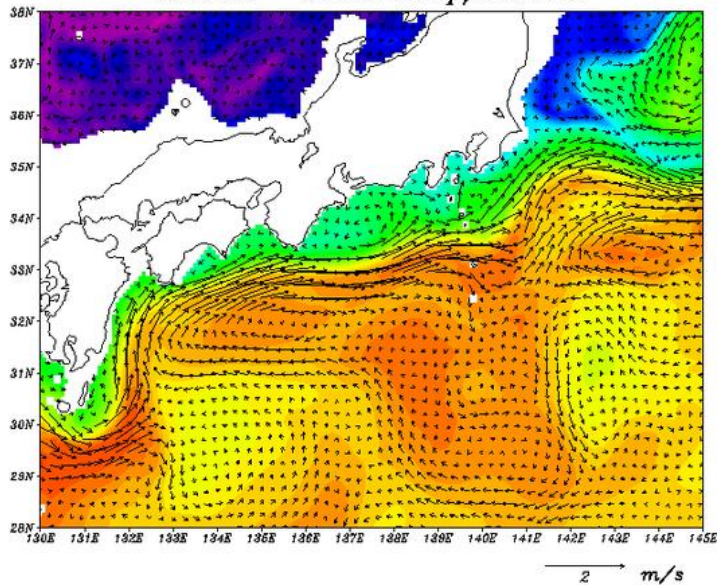
Prediction for 2nd February
2010 initialised on 2nd
January 2010.



JCOPE Ocean State Prediction

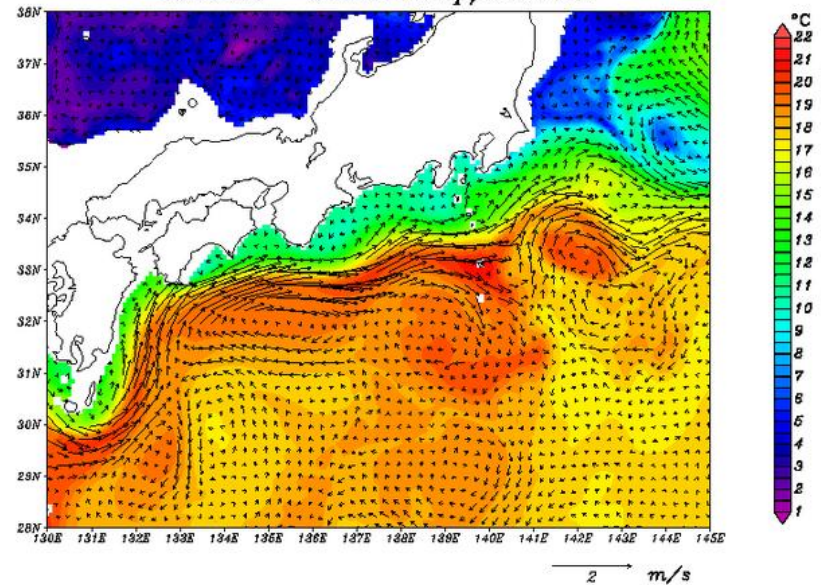
2010/04/06

JCOPE2 200m Temp/Current



2010/04/06

JCOPE2 200m Temp/Current



Analysis for 6th April 2010.

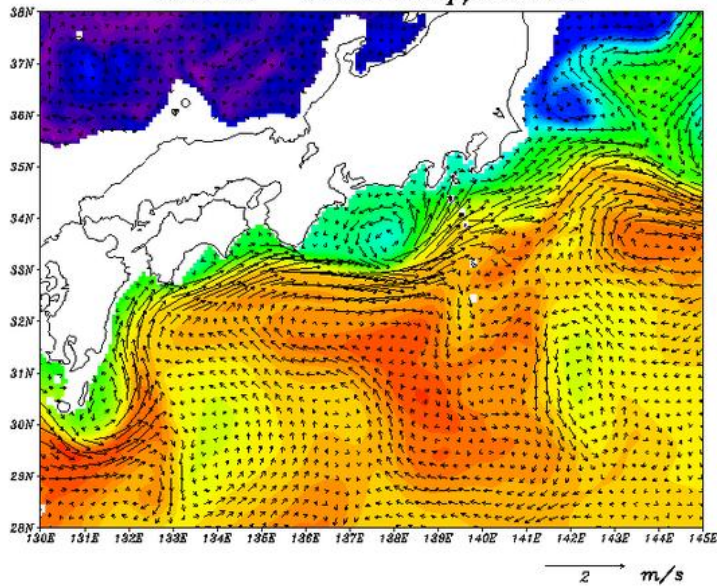
Prediction for 6th April 2010
initialised on 6th March 2010.



JCOPE Ocean State Prediction

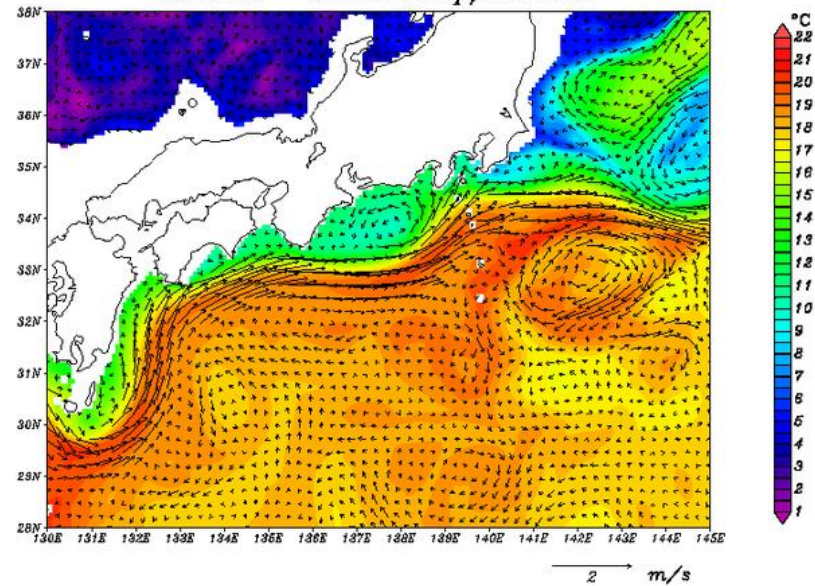
2010/04/13

JCOPE2 200m Temp/Current



2010/04/13

JCOPE2 200m Temp/Current

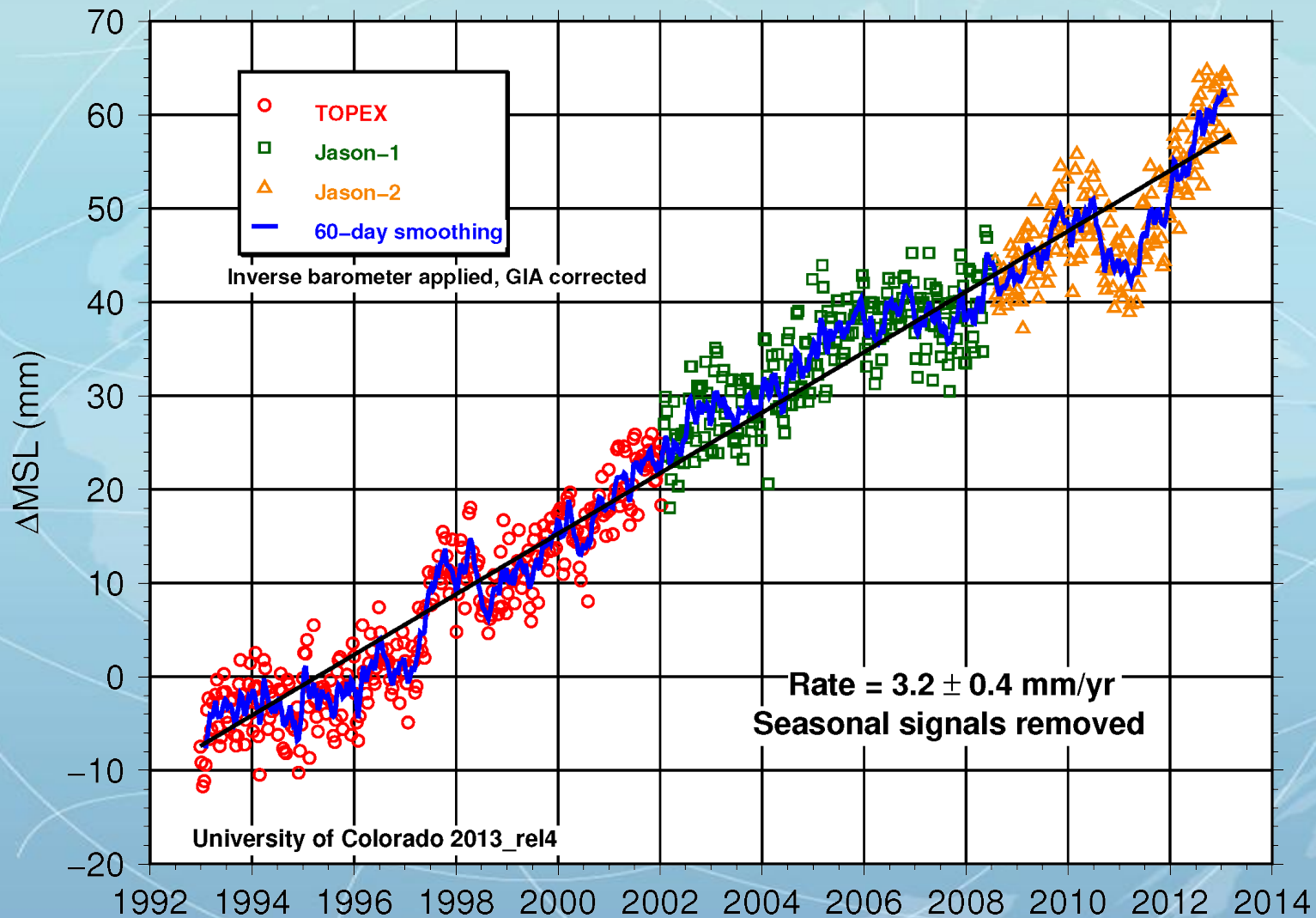


Analysis for 13th April 2010.

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



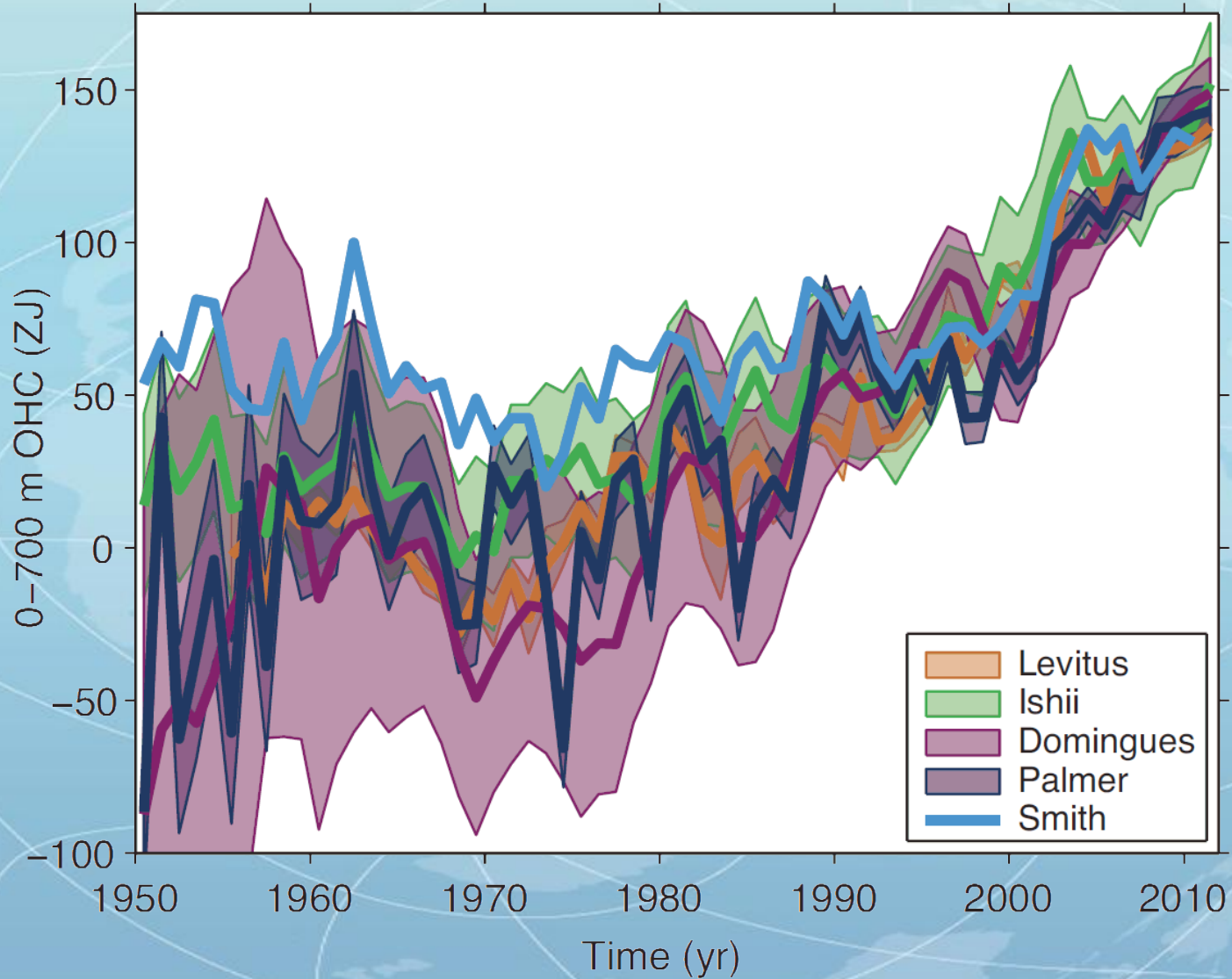
Sea level rise



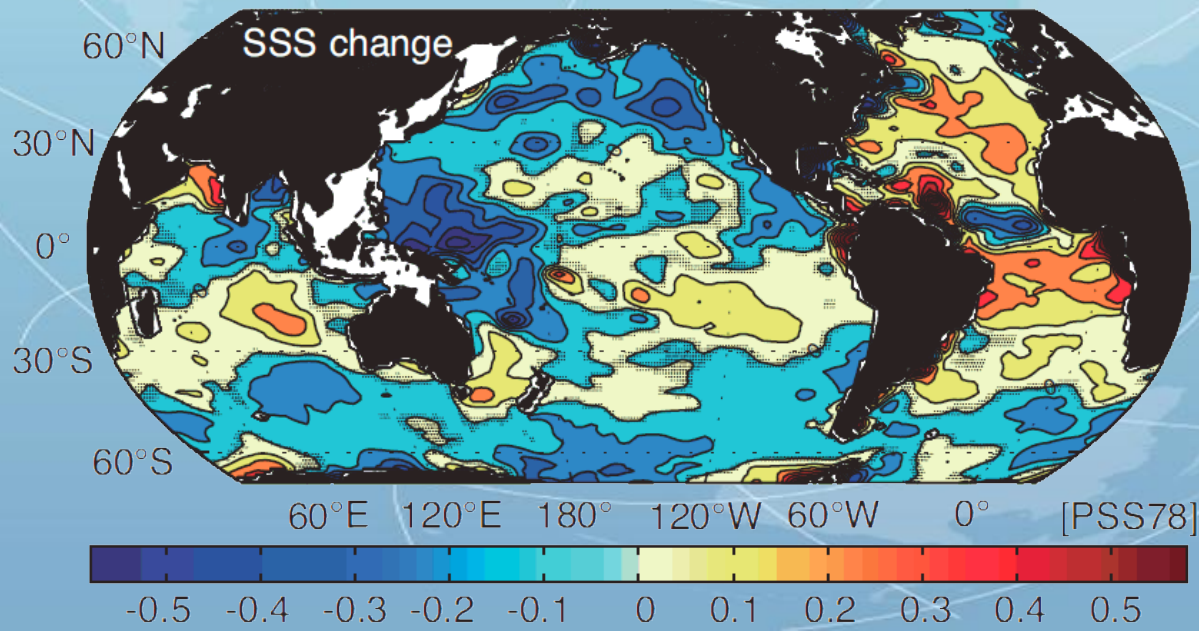
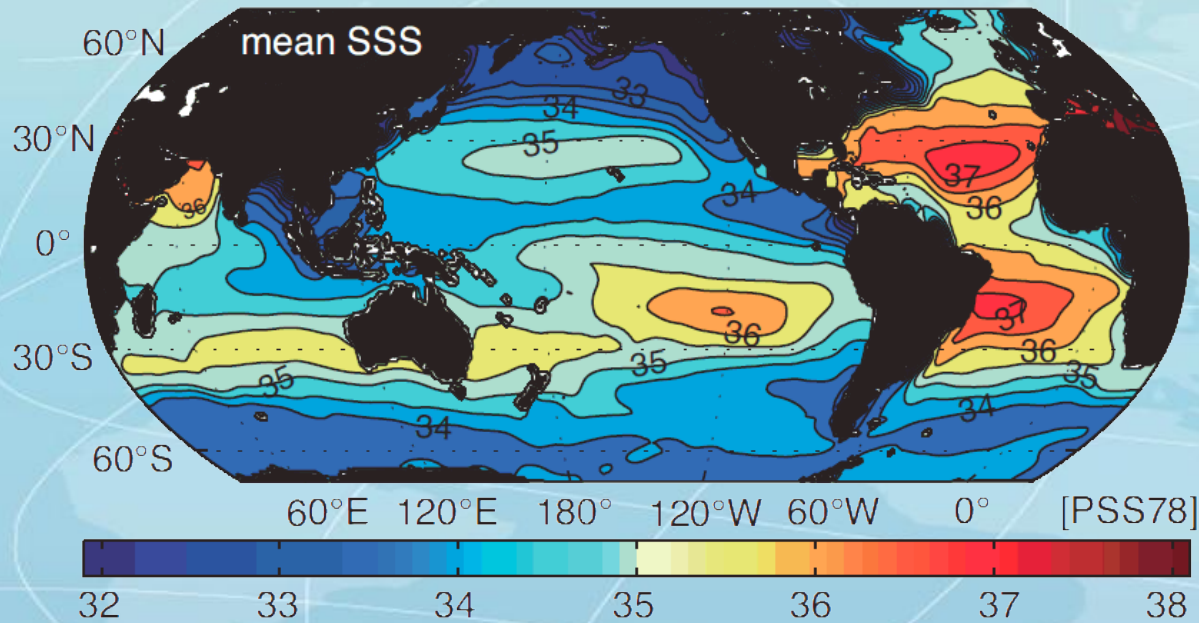
We know that sea-level is rising at 3.2 ± 0.4 mm/year, but how is that partitioned between water column expansion and new ocean mass?



Ocean heat content



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.

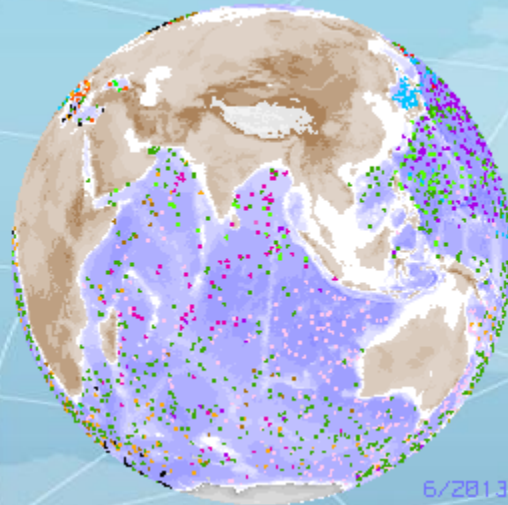
-  We need to install western boundary current enhancements.
-  We need to expand into marginal seas.
-  We need to install an equatorial enhancement.
-  We need to create a deep-Argo component.
-  We are encouraged to develop a Bio-Argo program.



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)



July 14th, 2013
3525 floats active!

Howard Freeland

Argo Director at

Institute of Ocean Sciences, Sidney, BC, Canada

Tel: (250)-363-6590

Email: Howard.Freeland@dfo-mpo.gc.ca

