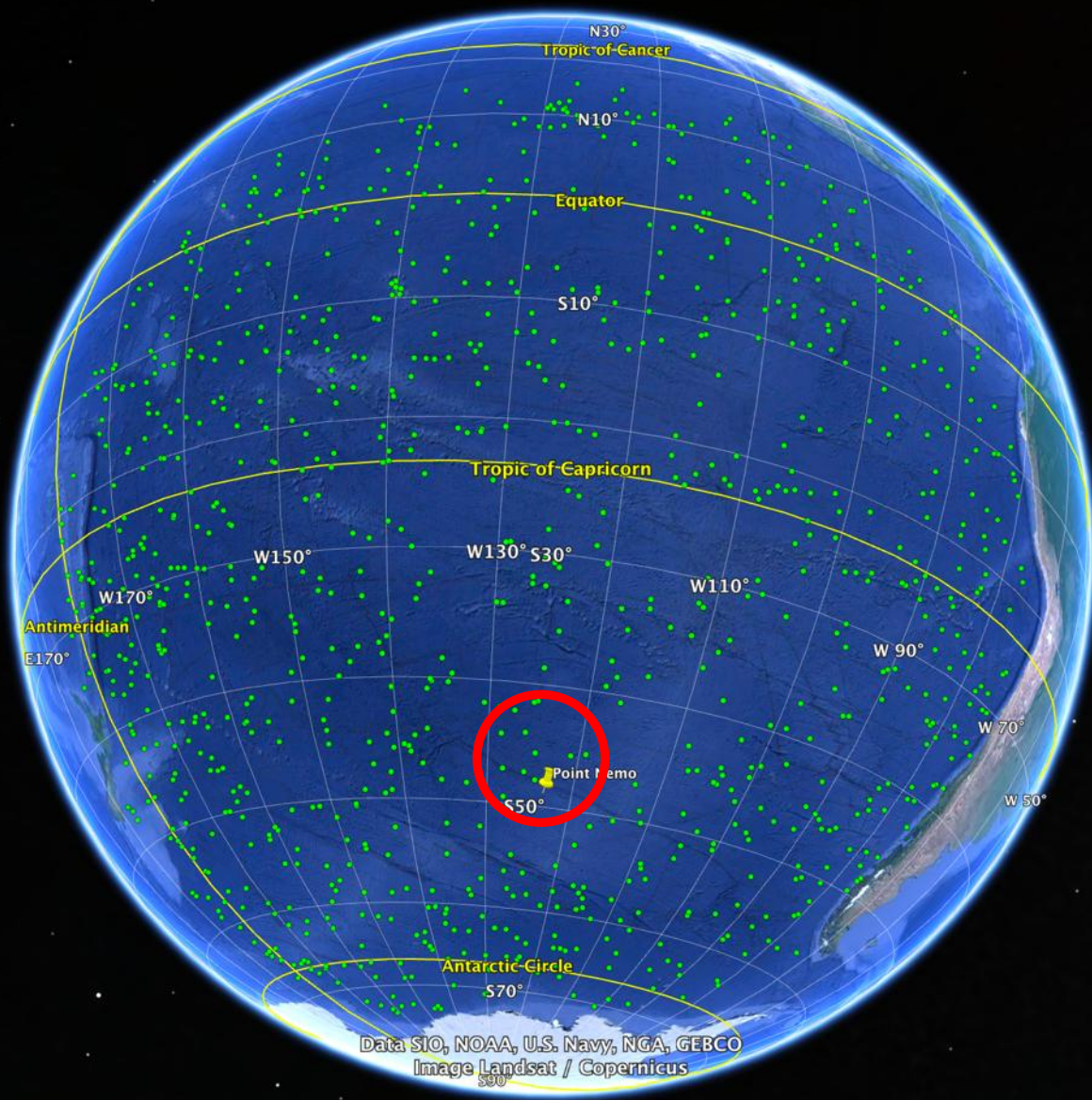




FROM THERMOMETERS TO ROBOTS

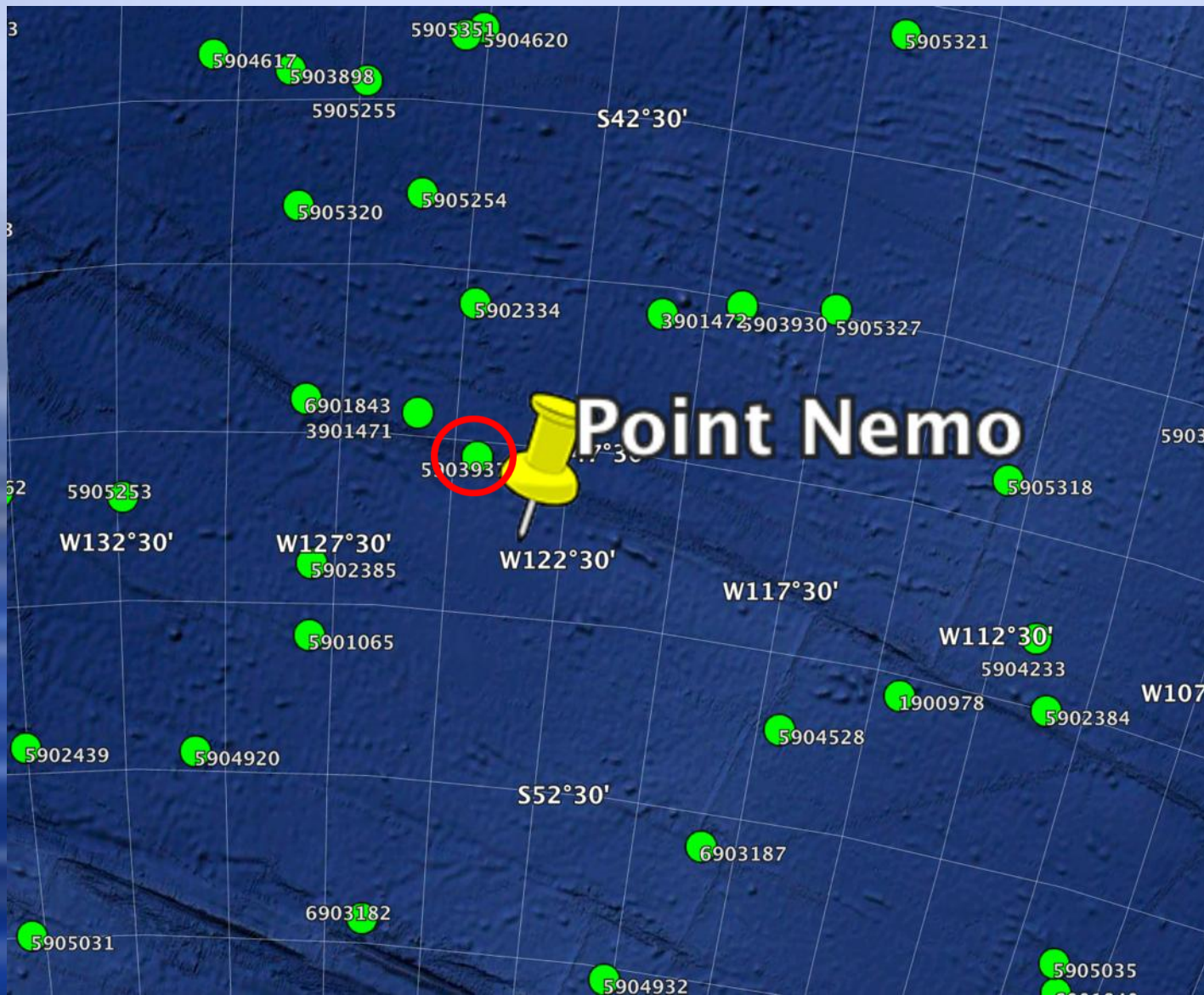
Evolution and revolution

**Dr John Gould
Emeritus Fellow
NOC, Southampton**



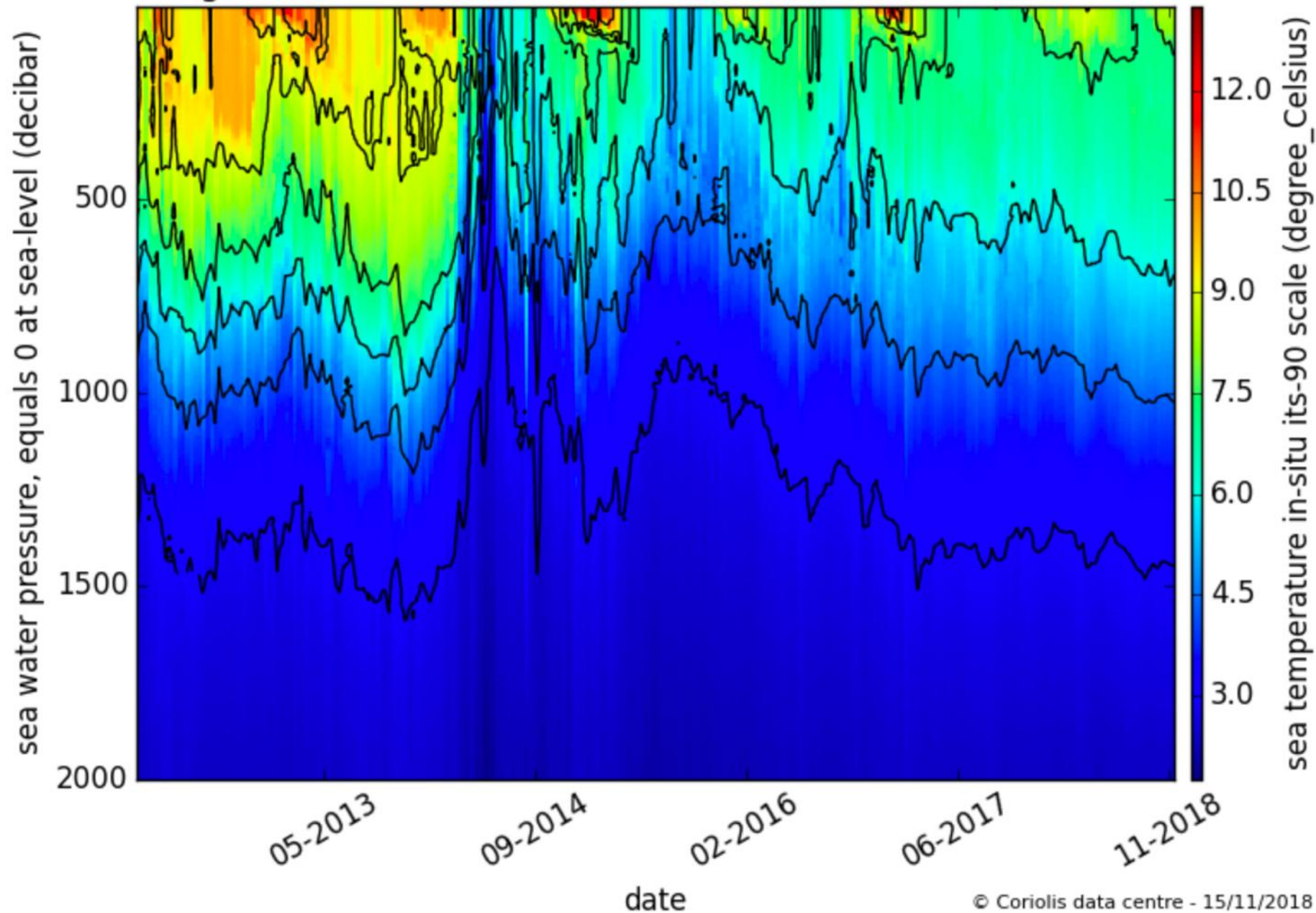
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus

Google Earth



100km

Argo float 5903937 between 21/02/2012 and 14/11/2018



1870s - Two global scale expeditions

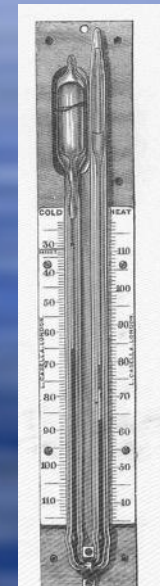
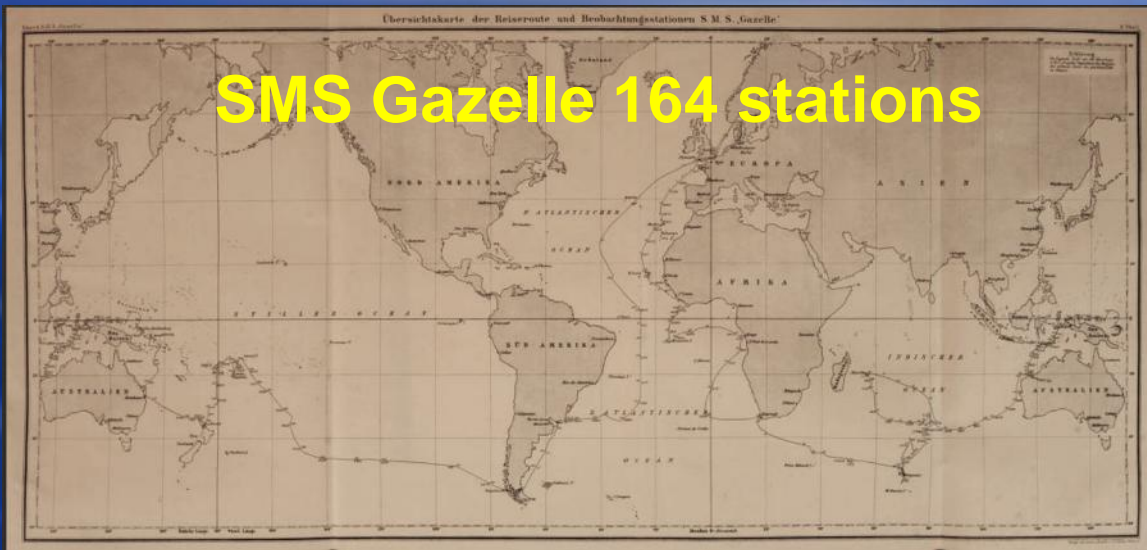
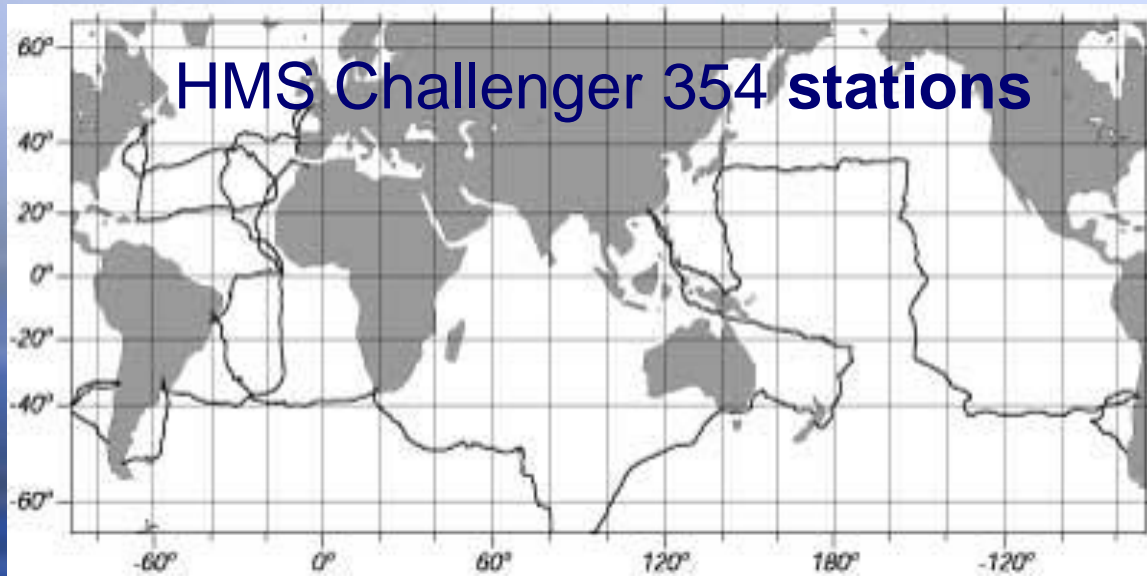
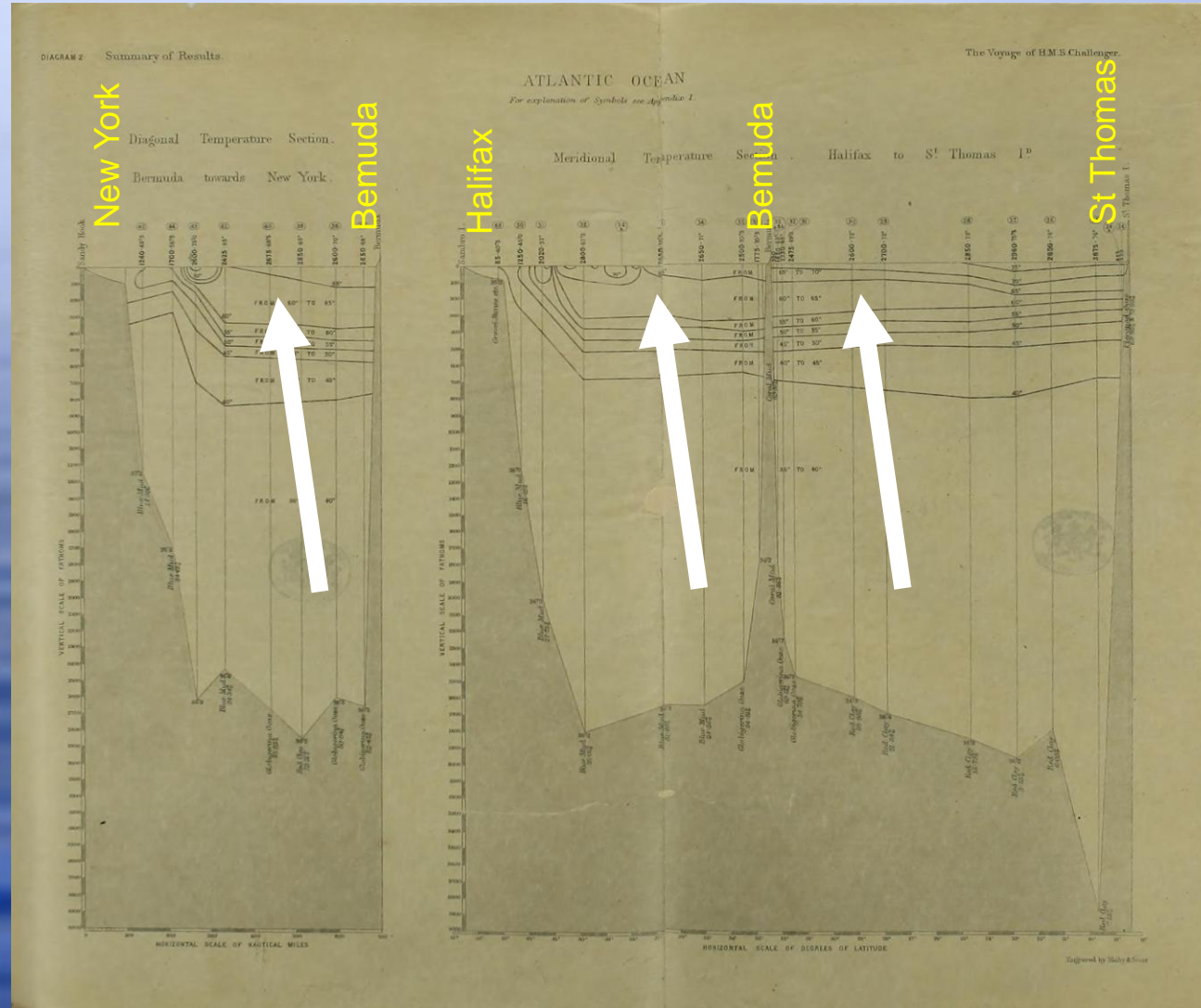
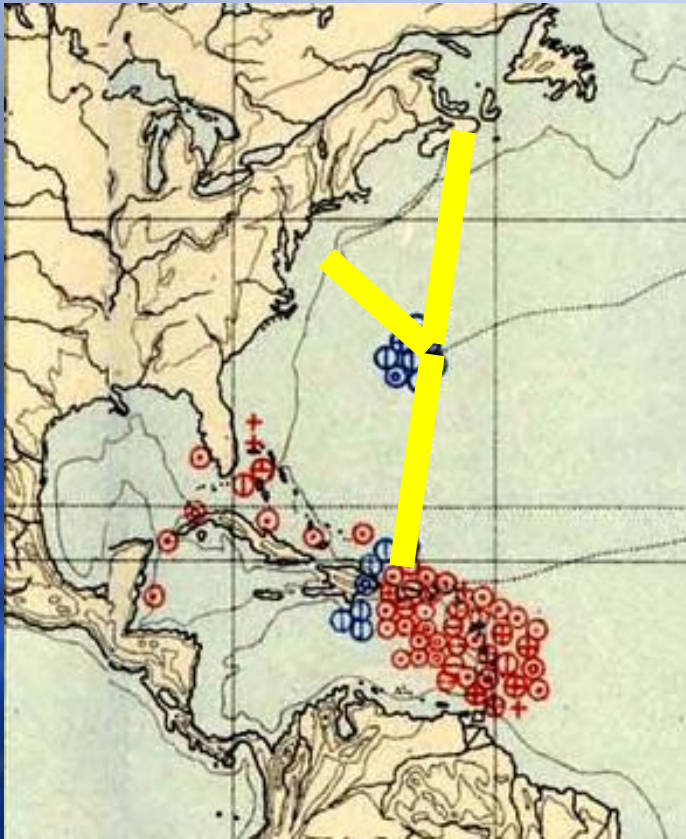


FIG. 53.—The Miller-Casella modification of Six's self-registering thermometer. The large bulb is double, with a layer of liquid and a bell of vapour between the shells, to relieve pressure.

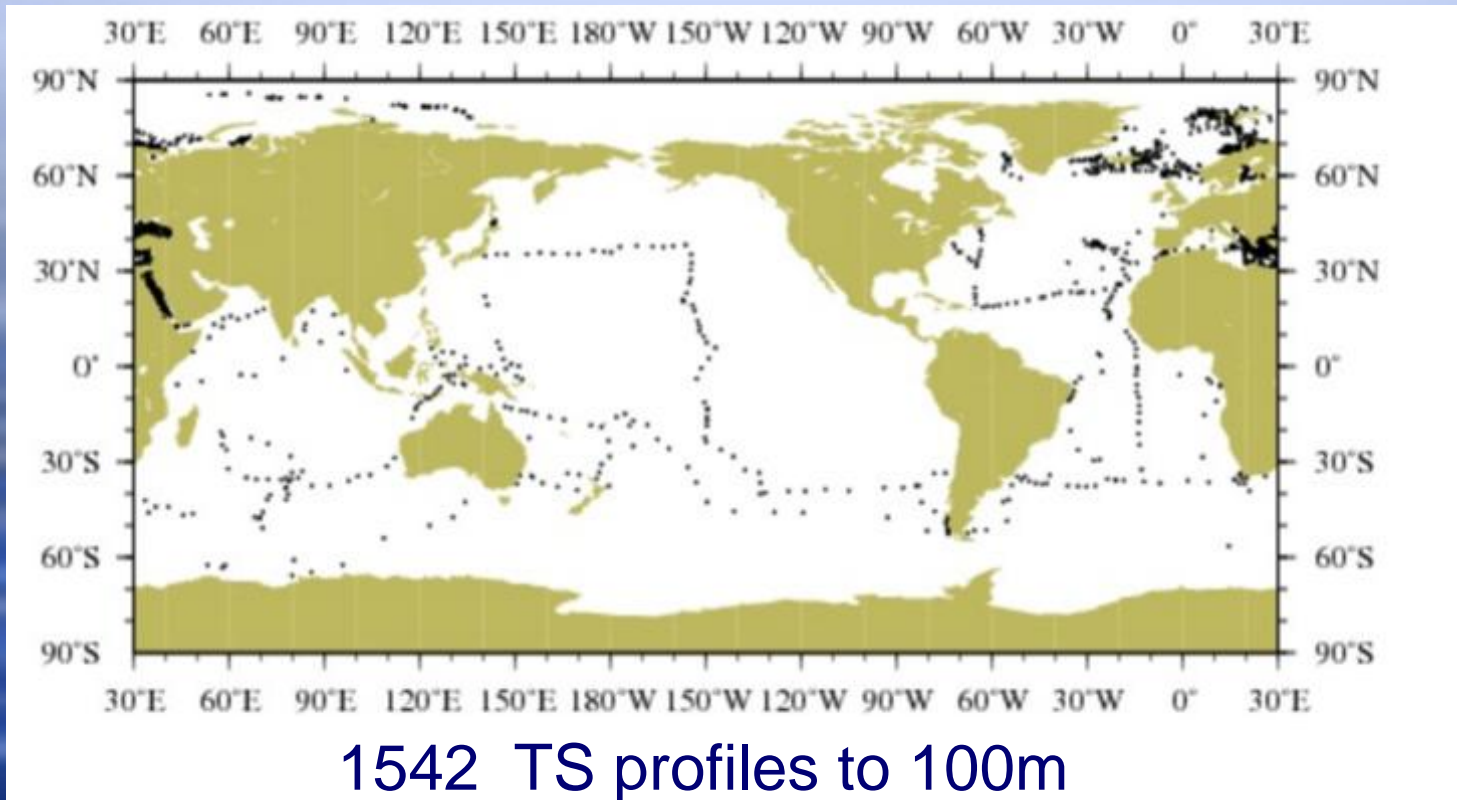
Miller-Casella thermometer as used on HMS Challenger



18C water in NW Atlantic from HMS Challenger



Up to 1900 - How much data?



Source NOAA World Ocean Database



Early 20th century- setting standards

- ICES established 1902 –promotes systematic observations
- Concept of salinity becomes defined after analysis of Challenger samples
- Helland-Hansen and Nansen develop the dynamic method
- Standard seawater starts to be distributed
- Reversing thermometers developed
- Observing methodologies become established and widely used



Two major enterprises



Meteor 1925 -27

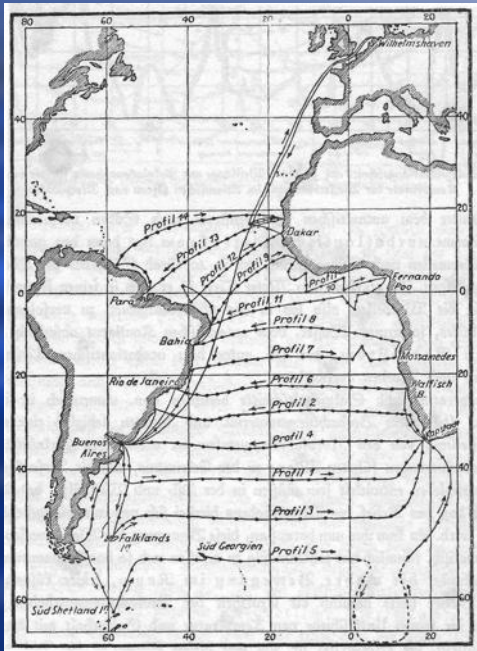


RRS Discovery
1925 - 1927

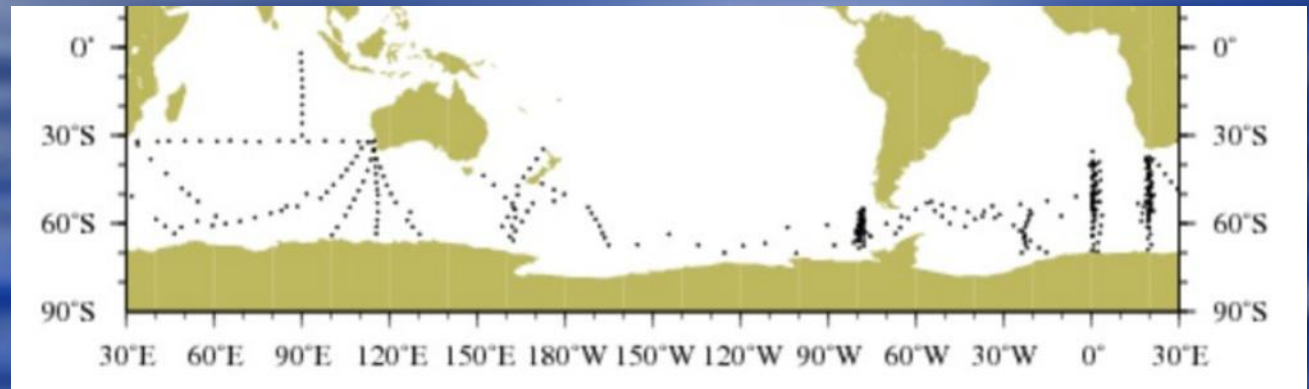


RRS Discovery II
1928-

Discovery Investigations 1925 onwards



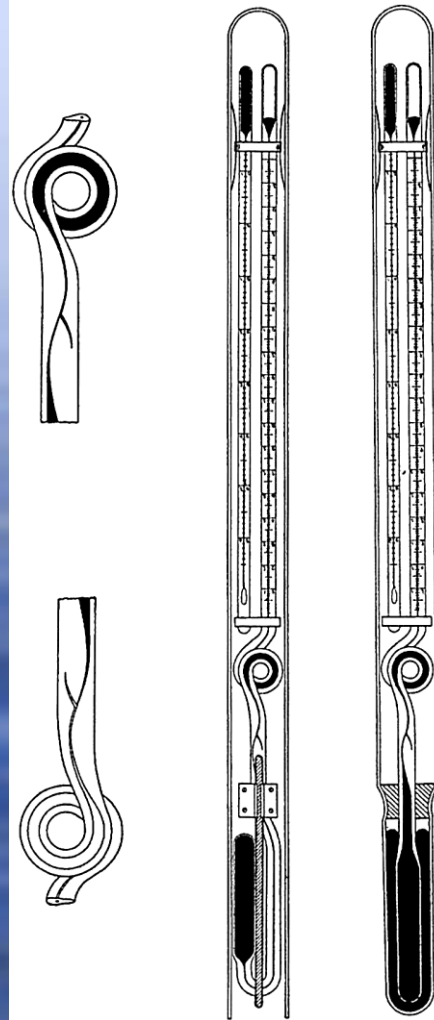
878 stations



366 stations



Nansen bottle casts

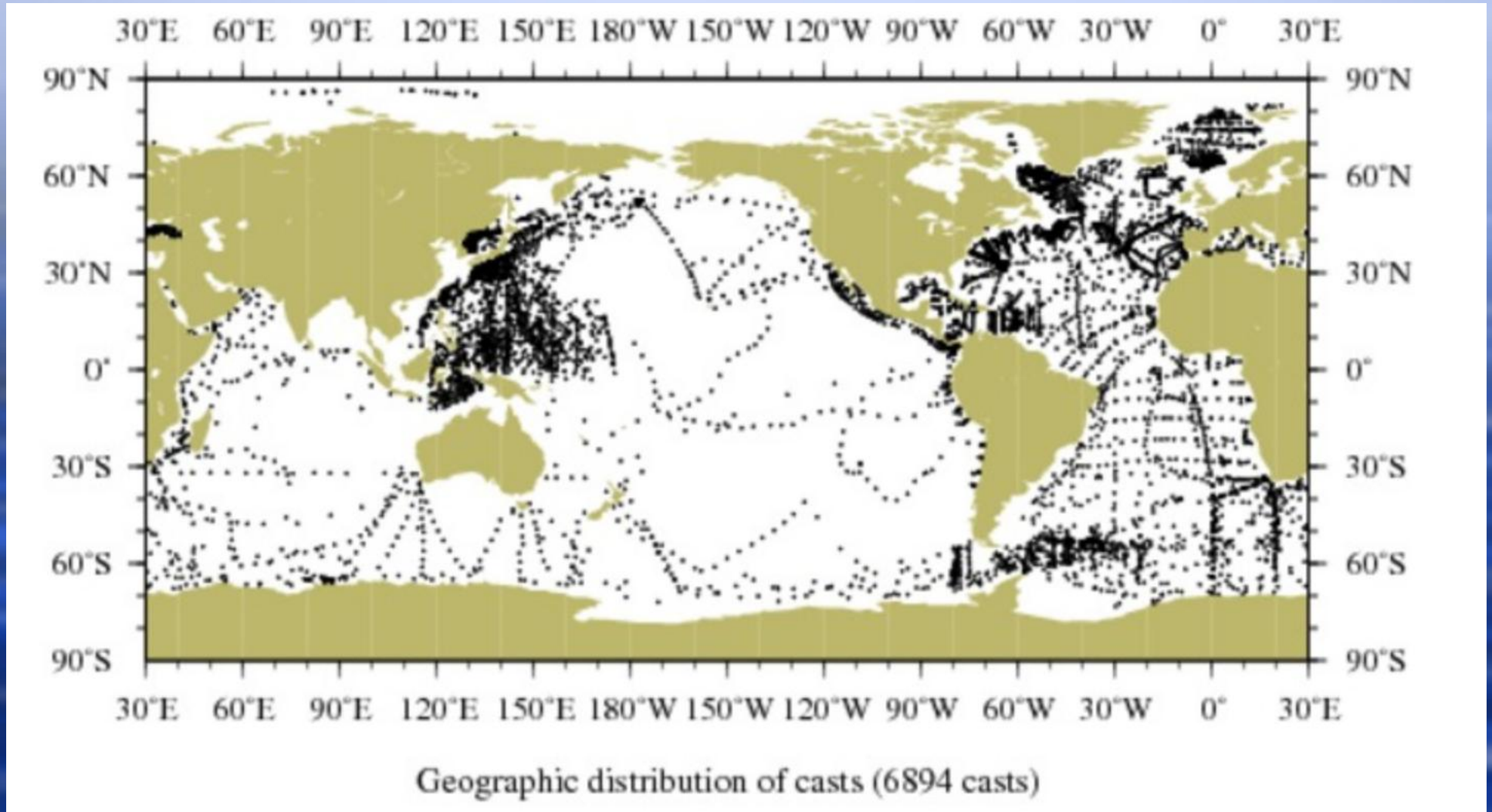


Hydro casts – typically only 20 points covering the water column

Images courtesy NOL and WHOI archives



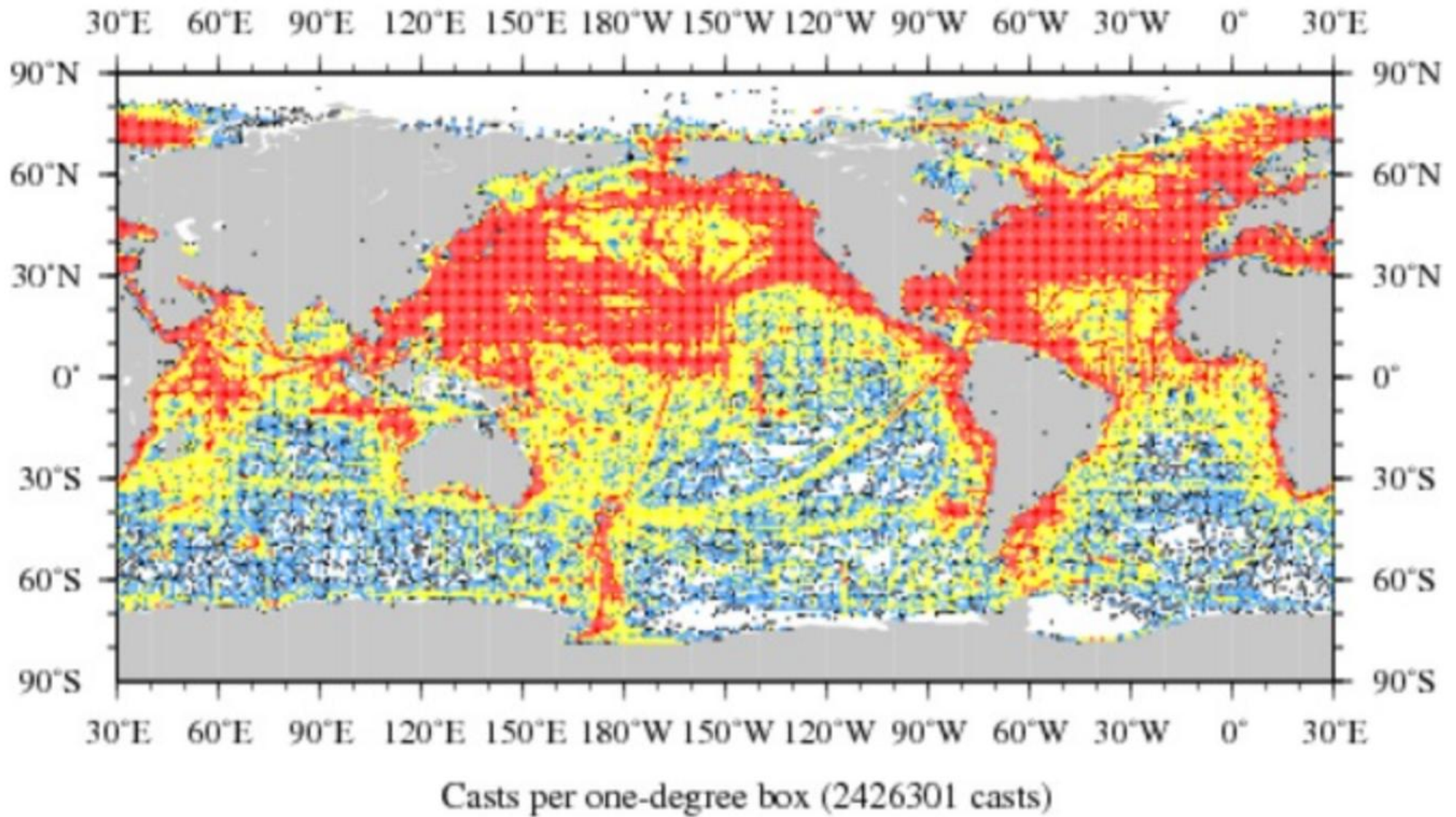
TS profiles to 1500m 1900-1940



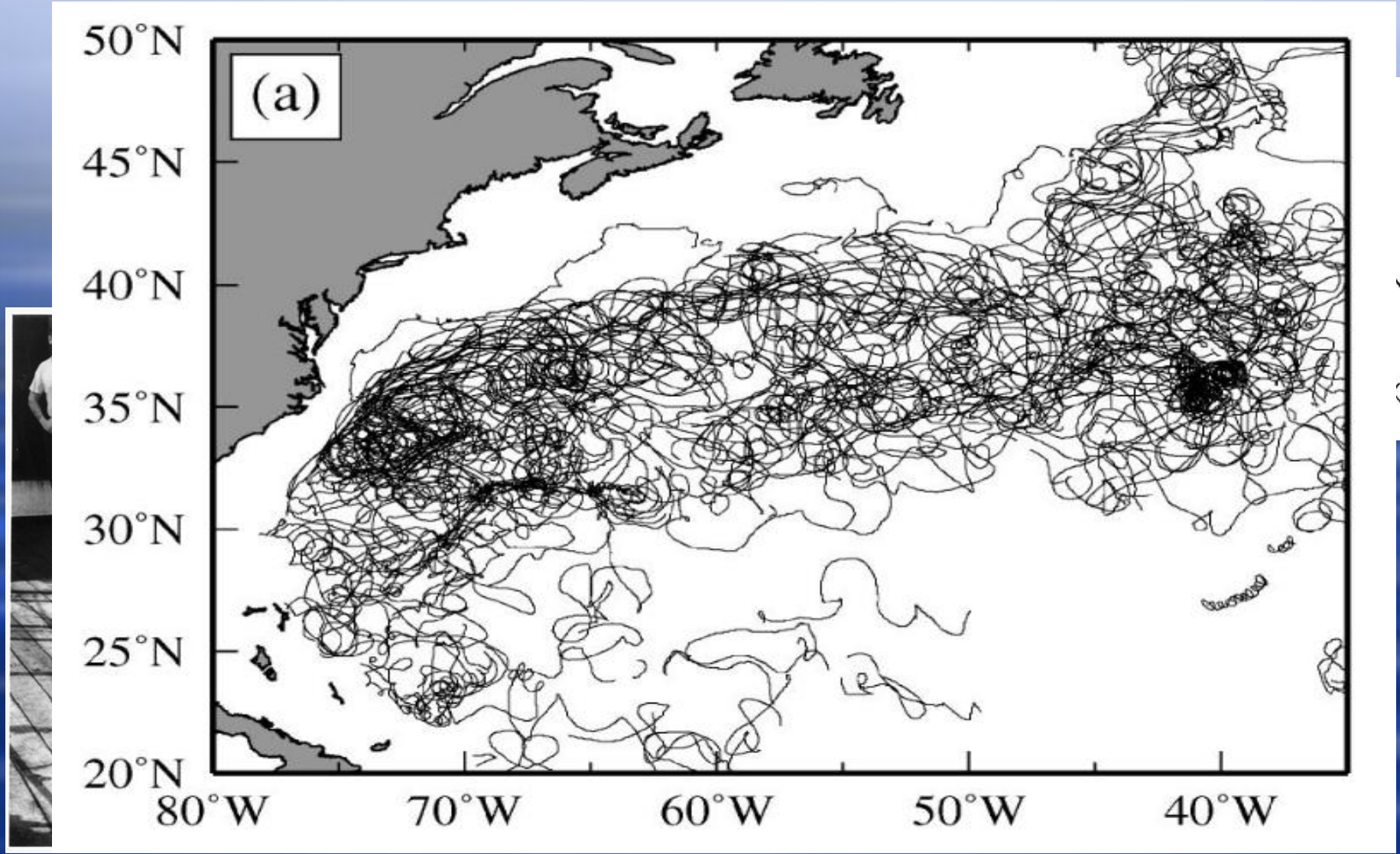
One station every 2 days!



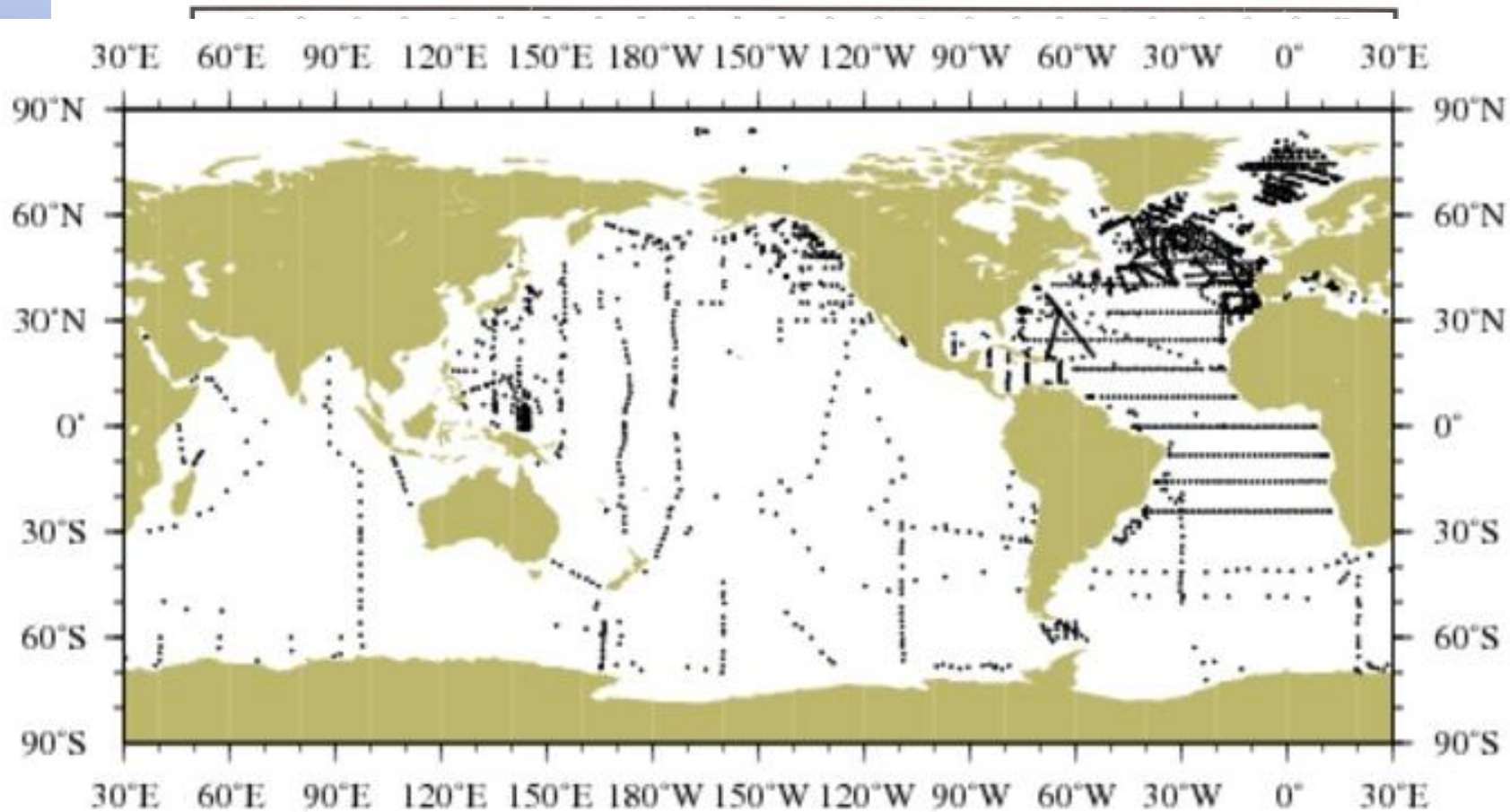
The bathythermograph



An important step in 1955



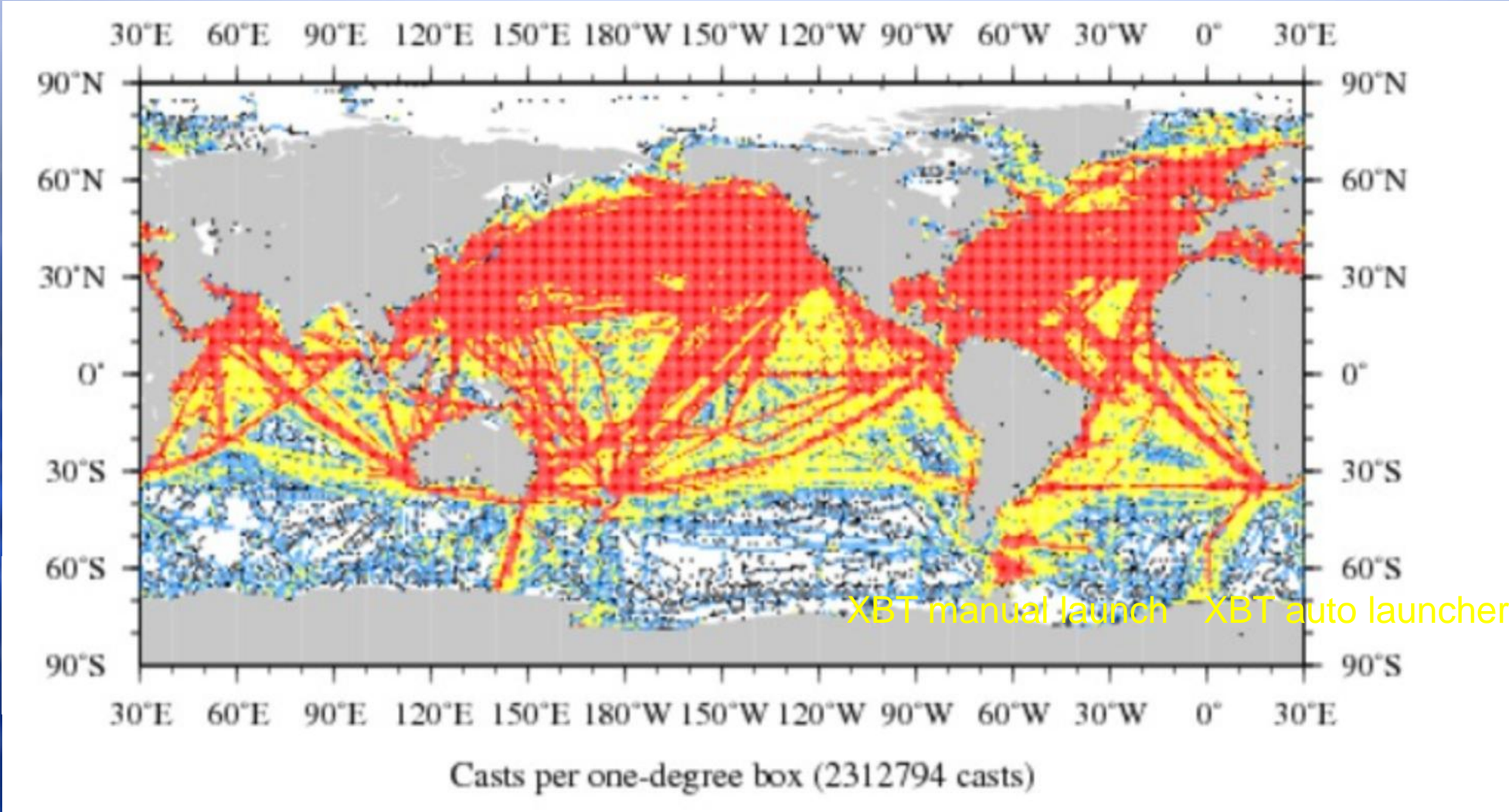
International Geophysical Year 1957-8



Geographic distribution of casts (2600 casts)



The Expendable Bathythermograph - XBT



CTDs the early days

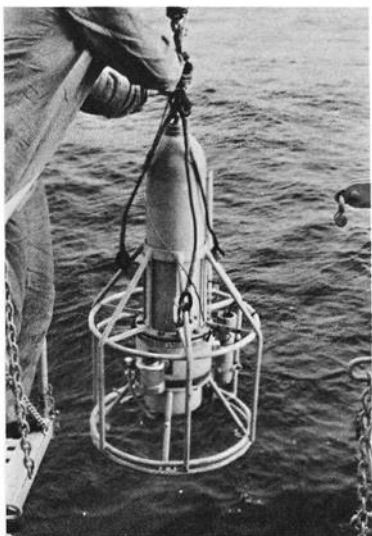


Fig. 6. — The Howaldt Bathysonde being lowered into the water.



Bathysonde
1967

Neil Brown CTD
Prototype CTD
Mid-Ocean Dynamics
Experiment 1972
1980s

Bissett Berman STD
1969



SEASAT 1978

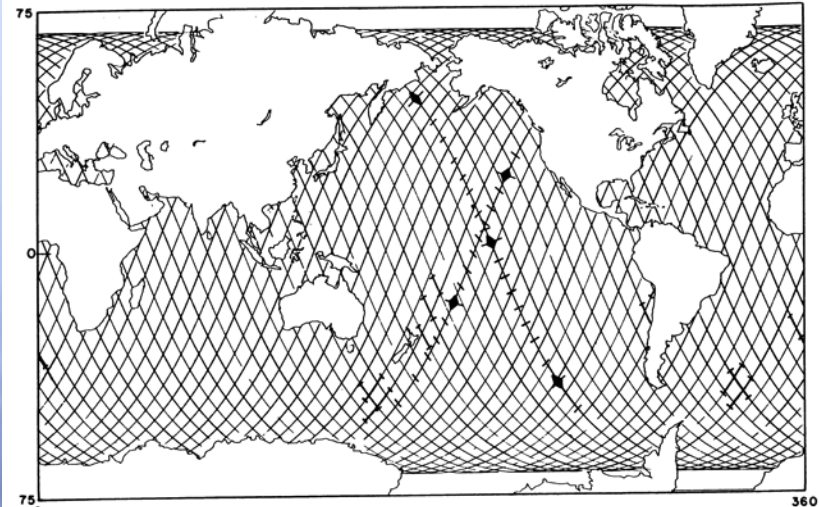
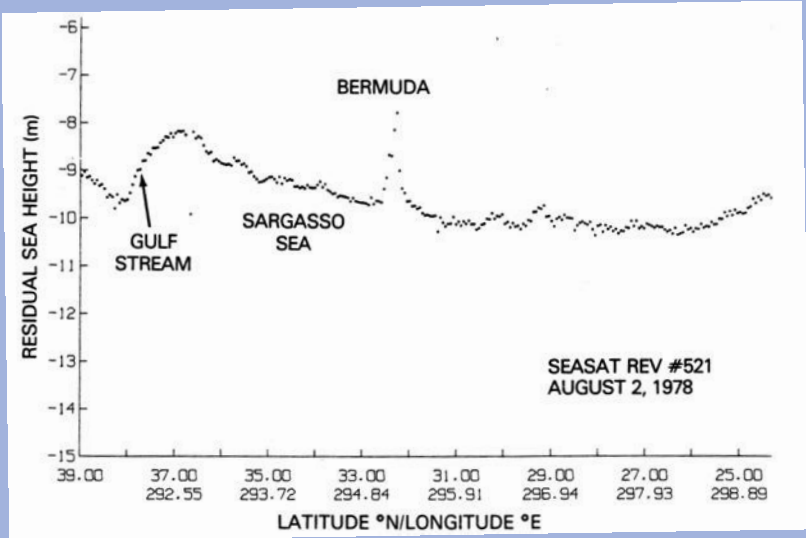
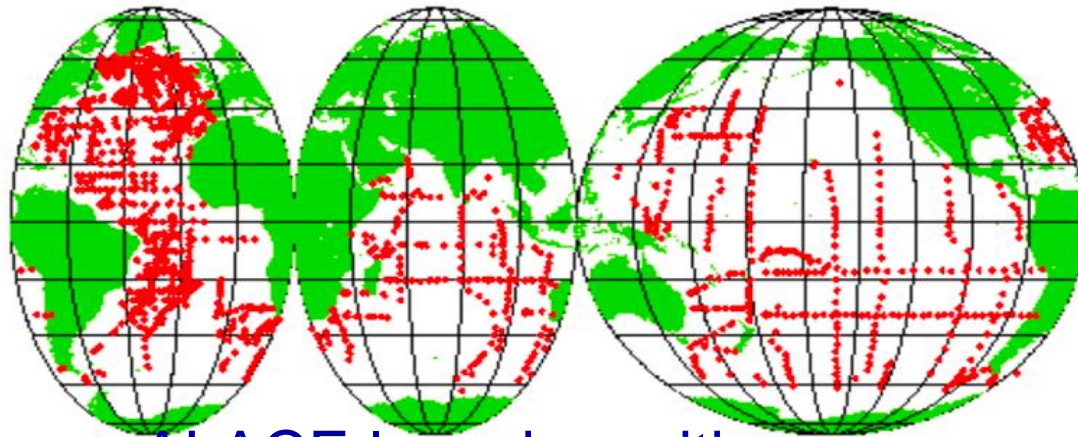


Fig. 1. Distribution of SEASAT altimeter data tracks for 15 days from September 15 to 30, 1978.

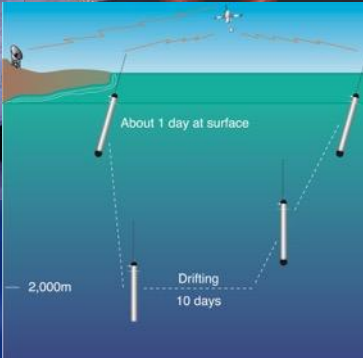
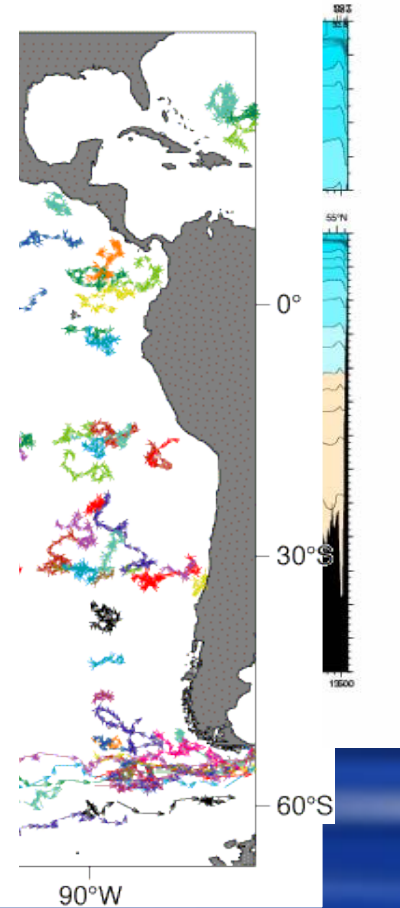
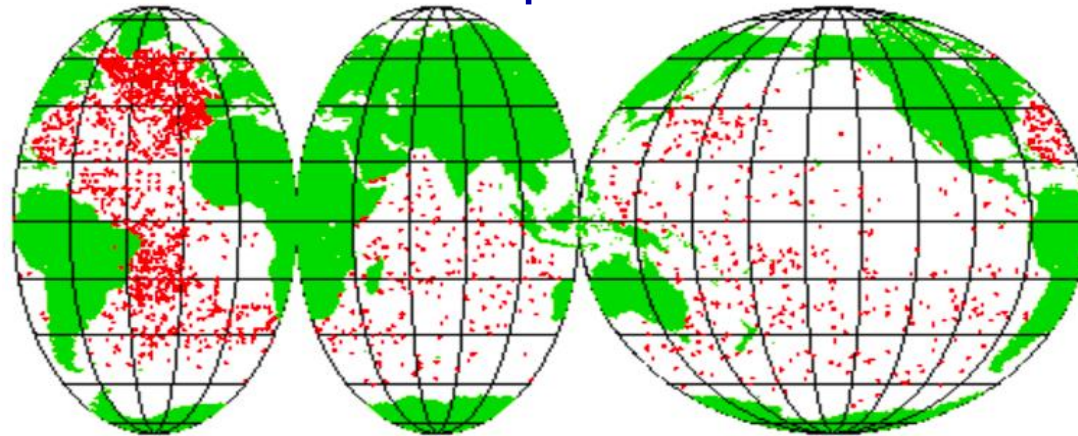


World Ocean Circulation Experiment 1990-97

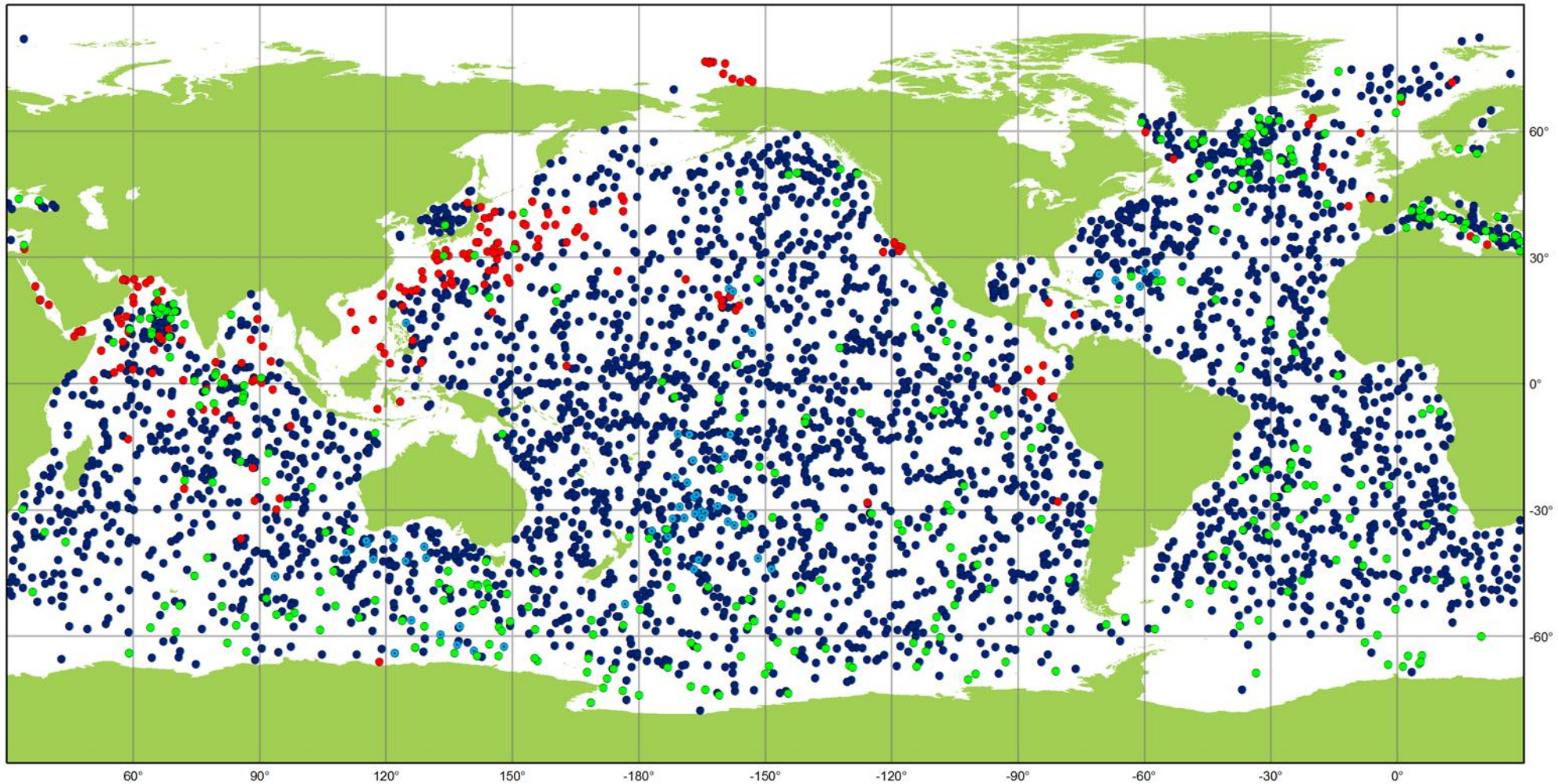


ALACE launch positions

ALACE dispersion



OceanObs '99 Conference



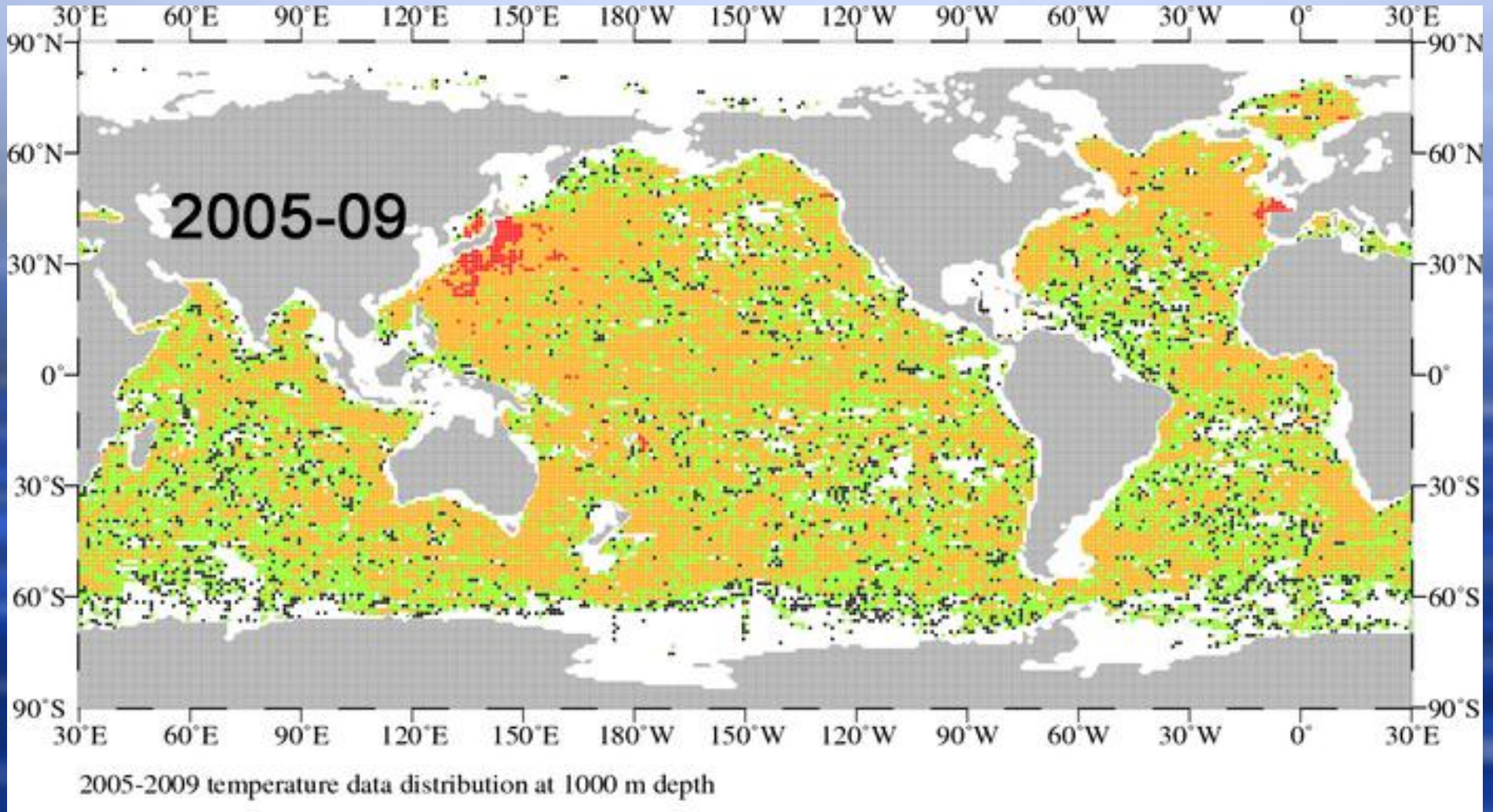
Argo

Networks

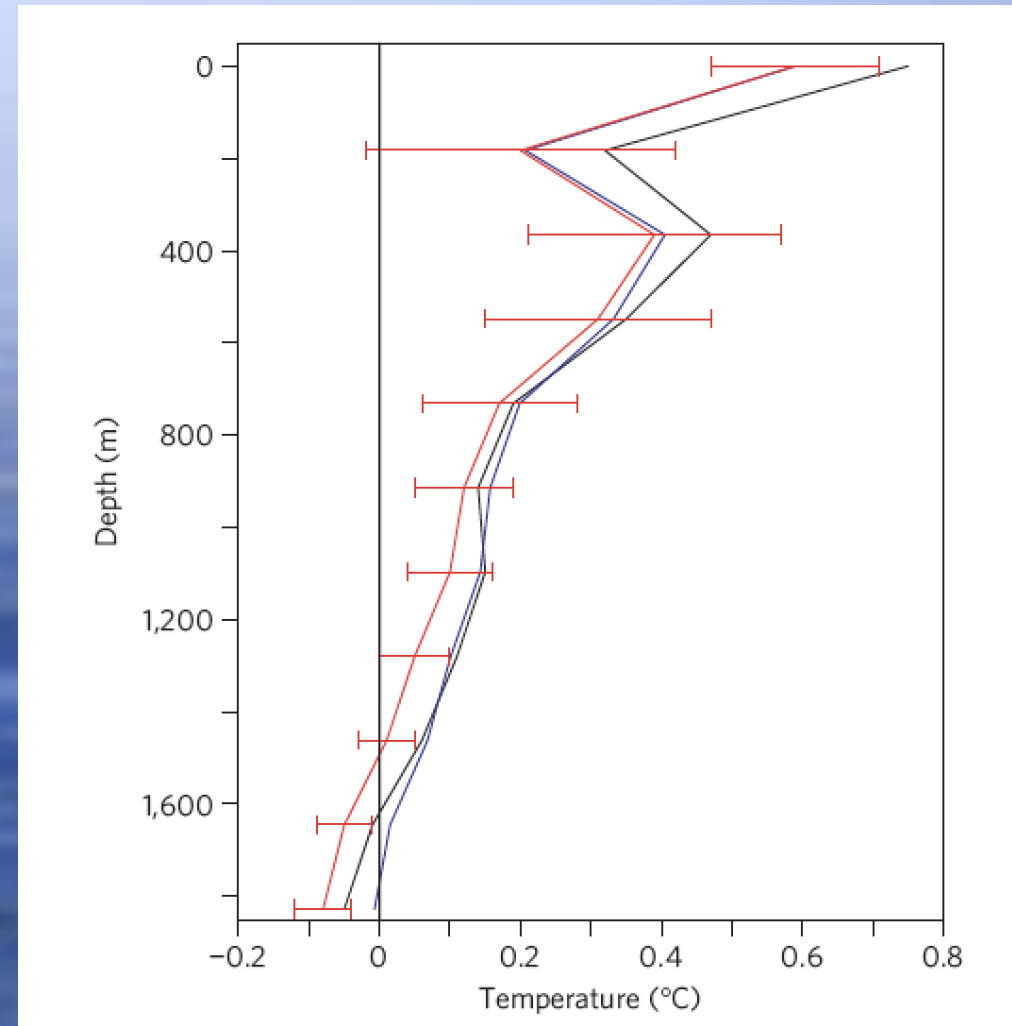
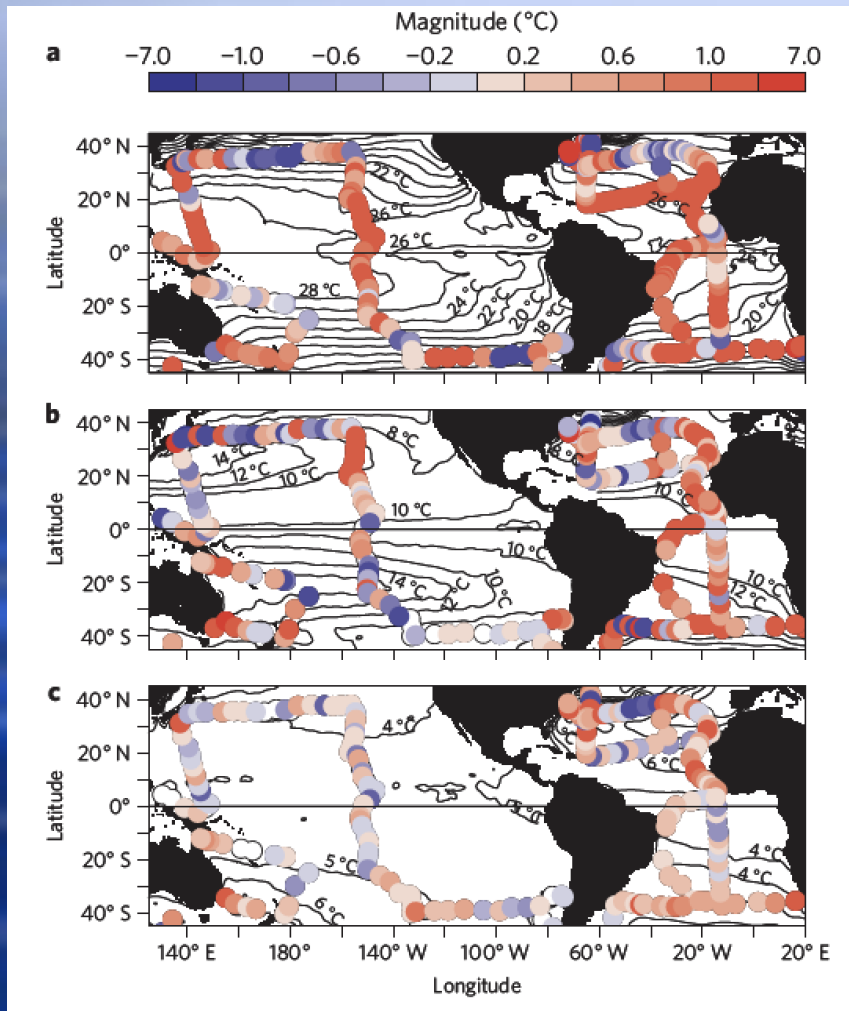
October 2018



The evidence of progress

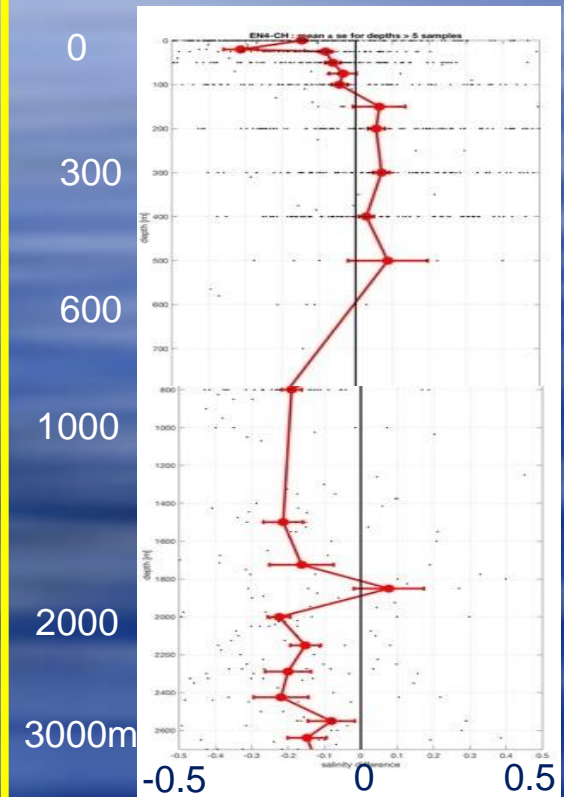
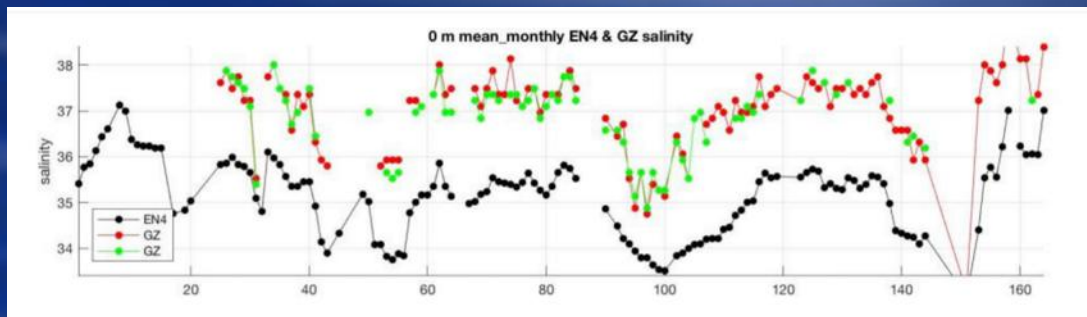
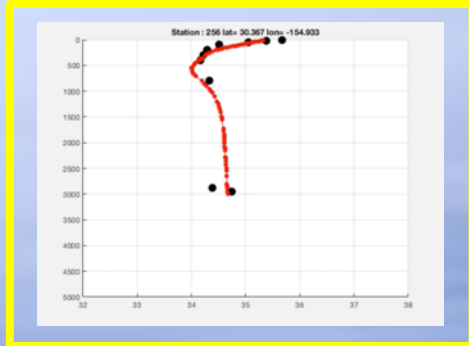
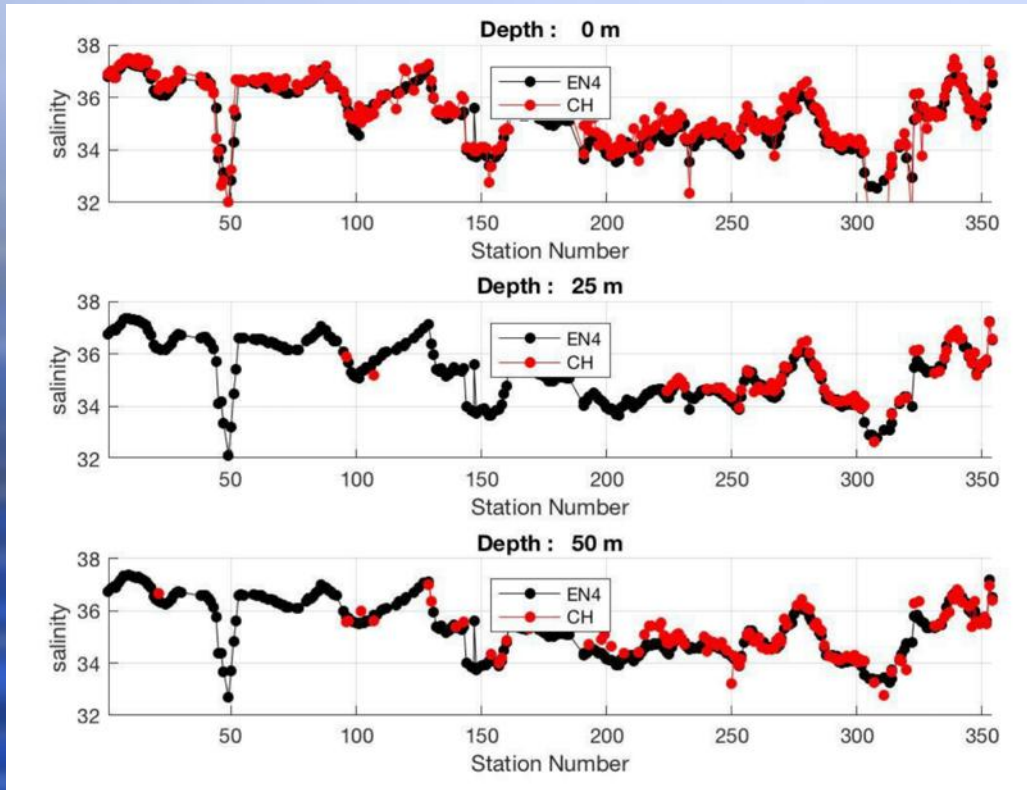


Value in old “less than perfect” data



Argo minus Challenger 1870 temperatures

.... and salinity



In summary

- We have made enormous strides in collecting TS data
- From 1870 – 1960 the methods used changed little
- The pace has quickened especially since 1990 (WOCE)
- This has only partly been due to adopting generic technologies
- Innovation and perseverance have been essential
- Argo is invaluable – but its survival is not guaranteed
- Historical data have value for detection of ocean changes

