

Observations for Climate: Global ocean temperature, salinity and circulation measured by the Argo Program

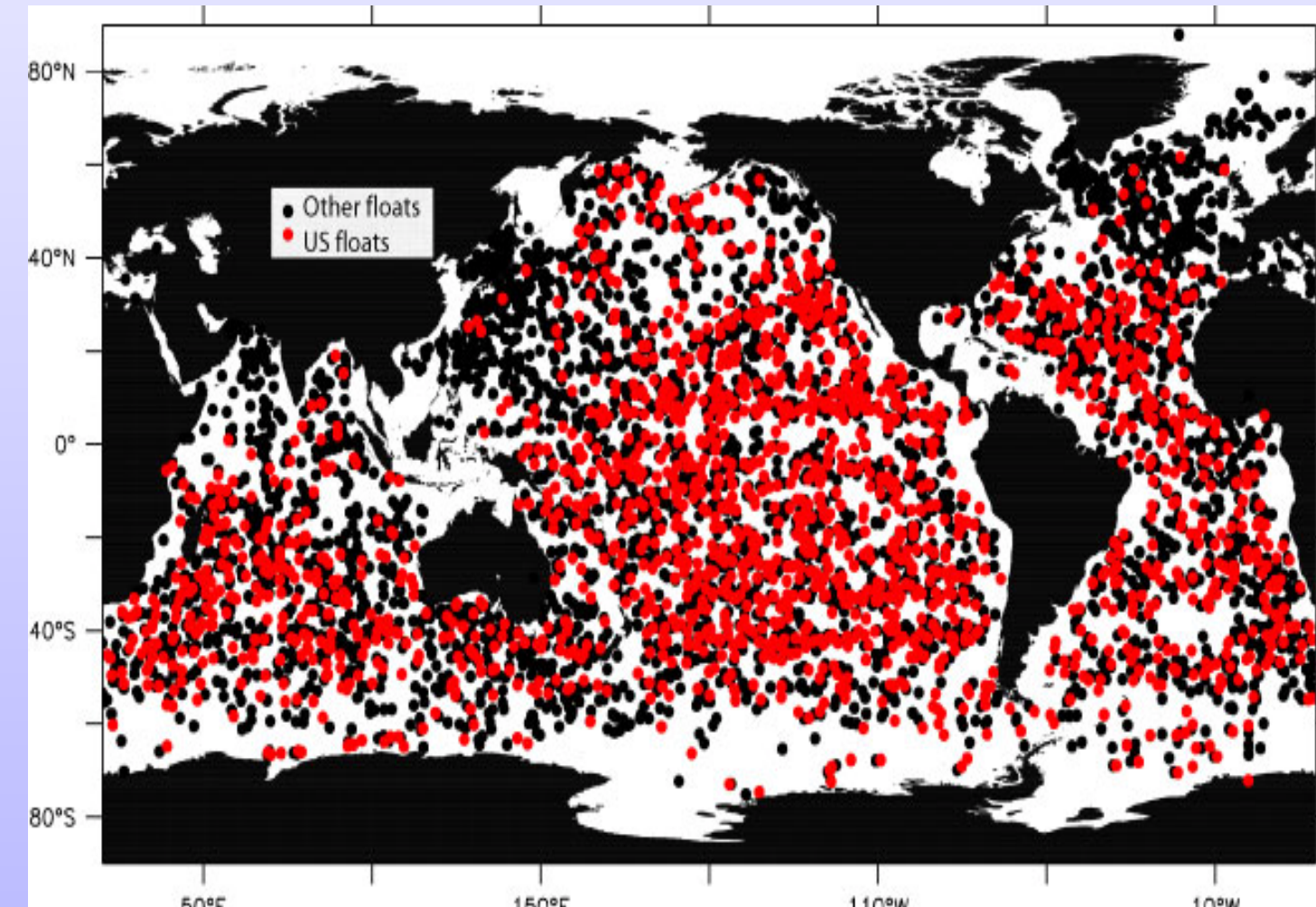
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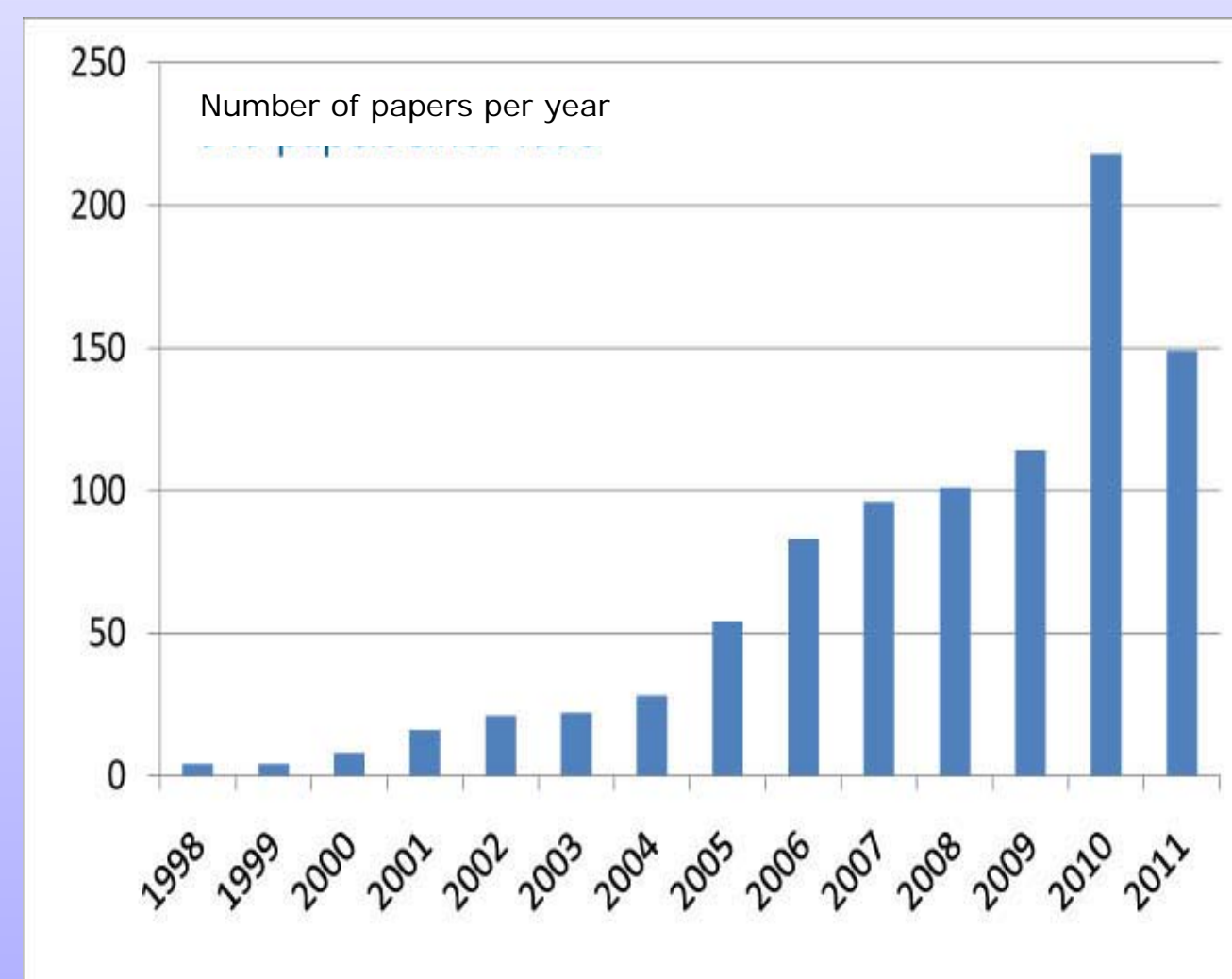
Introduction



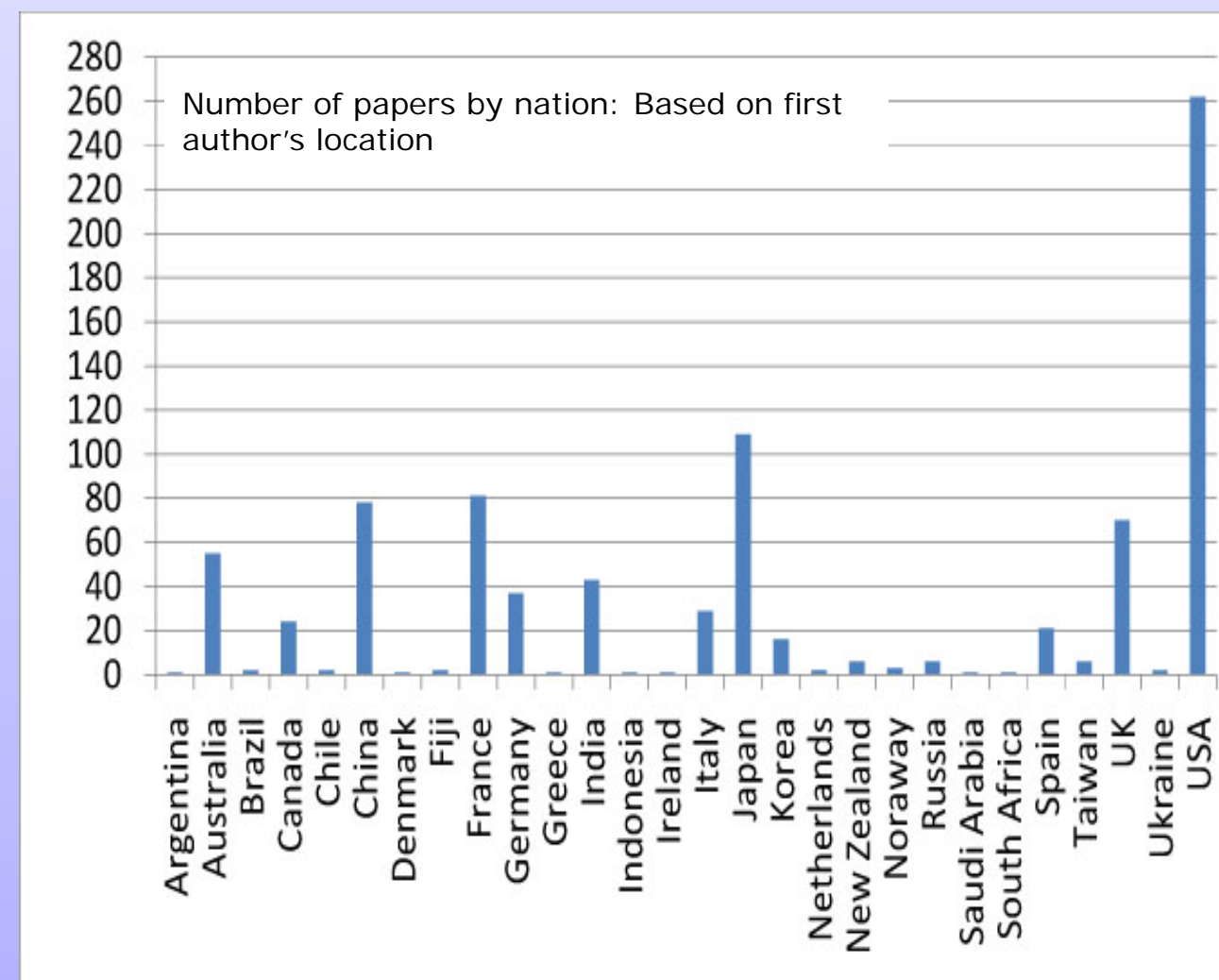
3307 active floats, 1709 active US floats

The Argo Program is transforming large-scale oceanography by implementing and sustaining systematic global ocean observations. Global coverage with Argo profiling floats was achieved in 2004 and the target of 3,000 active floats has been maintained continuously since 2007. Argo provides free and unrestricted access to its 100,000 temperature/salinity profiles every year through an innovative data management system, delivering near real-time data in less than 24 hours and high-quality data for climate research in delayed-mode. Argo has observed the mean state of the ocean with unprecedented accuracy, while providing the first global views of time variability in the subsurface ocean. The Argo array is a subsurface counterpart and a complement for satellite missions observing sea surface height, ocean wind-forcing, ocean mass, and sea surface temperature and salinity. Its global coverage enables integration of the ocean observing system – repeat hydrographic and XBT transects, moorings and time-series stations, surface drifters, and air-sea flux measurements – together with the satellite measurements of the sea surface, for a dynamically complete description of the physical state of the oceans.

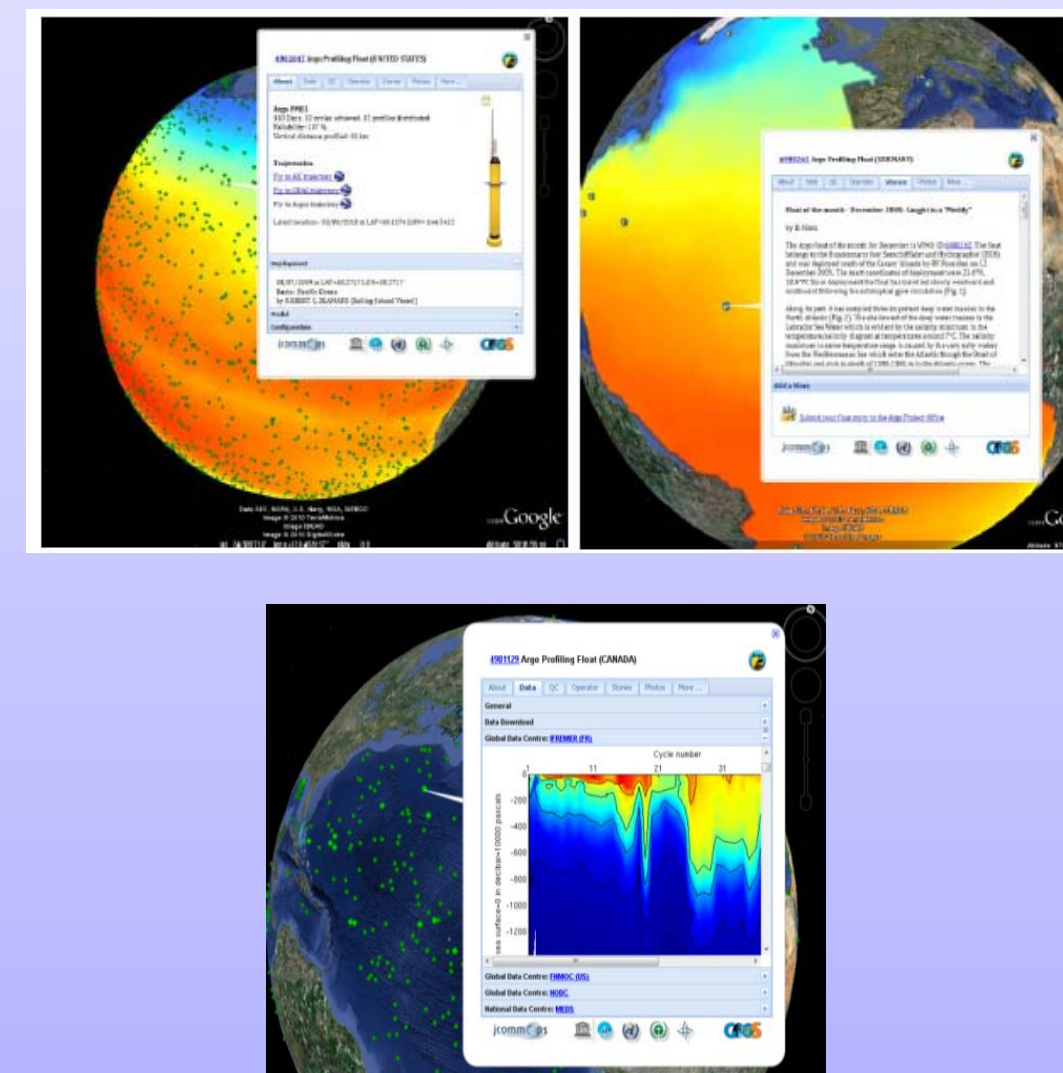
Applications of Argo data



Applications of Argo data include basic research, operational analysis and forecasting, and education/outreach. Basic research using Argo data has grown rapidly to over 200 publications in 2010 alone, on topics including water mass properties and formation, air-sea interaction, ocean circulation, mesoscale eddies, ocean dynamics, and intra-seasonal to multi-decadal ocean variability. Argo is the core subsurface dataset for global ocean data assimilation modeling, used by modeling centers around the world in ocean reanalyses and for initializing seasonal-to-decadal prediction. Finally, the use of Argo in secondary and tertiary education is growing rapidly, as students anywhere in the world can now explore the global oceans from their desktop.



Outreach



A new Argo layer has been developed for Google Earth showcasing Argo floats, data from the entire array and stories on a subset of floats. Popup balloons for individual floats and overlay maps of temperature, salinity, and dynamic height are available
<http://argo.commops.org/argo.kml>

International Argo

Argo is implemented by a multi-national partnership, with over 30 nations contributing floats, logistics, and data management in oceanography's most internationally collaborative effort ever. U.S. Argo plays major roles in the partnership, ensuring global coverage, developing advanced float and sensor technologies, and sharing leadership roles with international partners in data management and program coordination.

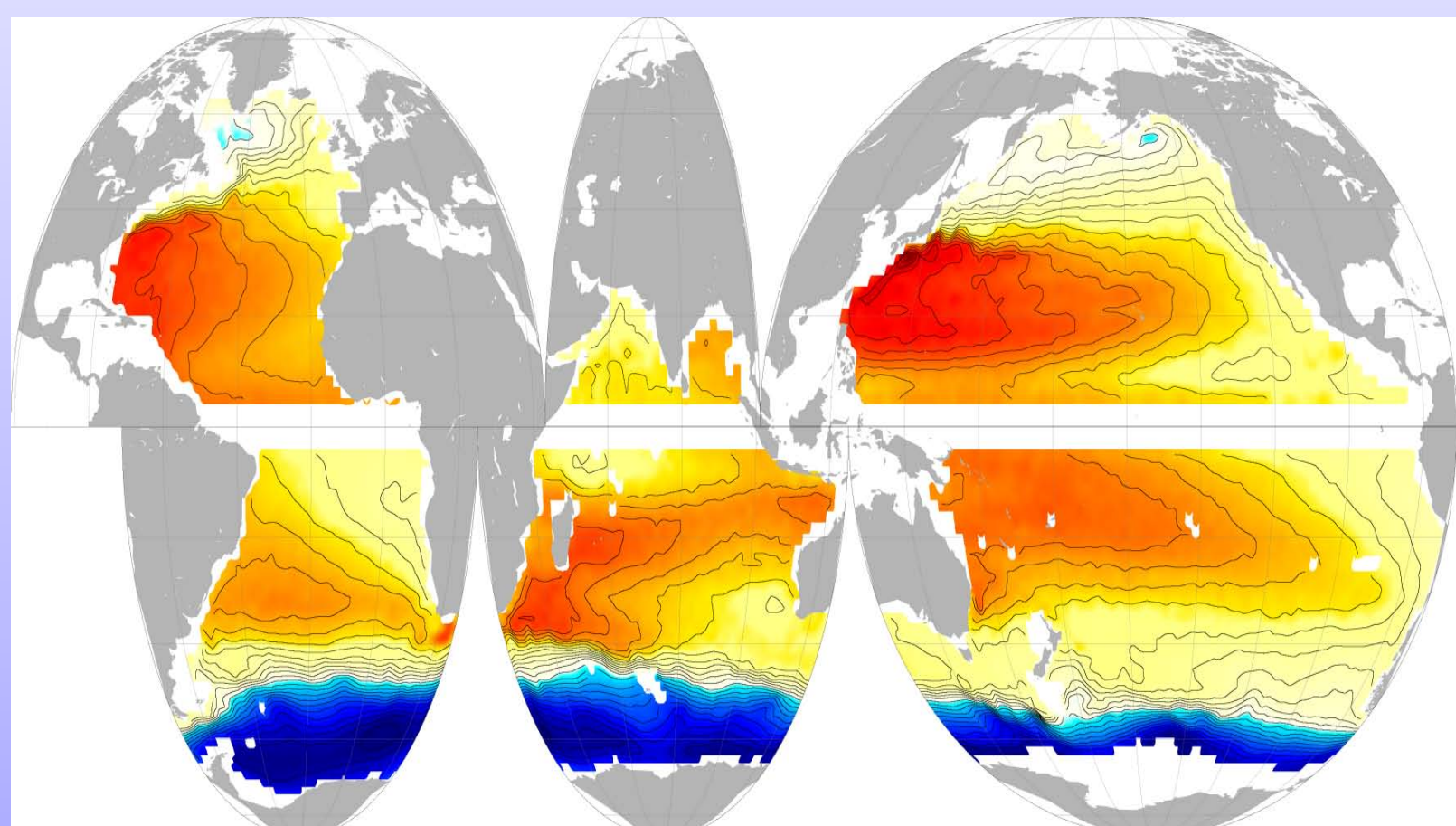


For instance, US, Australia, and New Zealand Argo groups cooperate to deploy floats around the globe using a 28-m research vessel, R/V Kaharoa. The ship, belonging to New Zealand's National Institute of Water and Atmospheric research, has deployed 850 floats in remote parts of the ocean seldom visited by vessels of any kind.

Argo and climate research

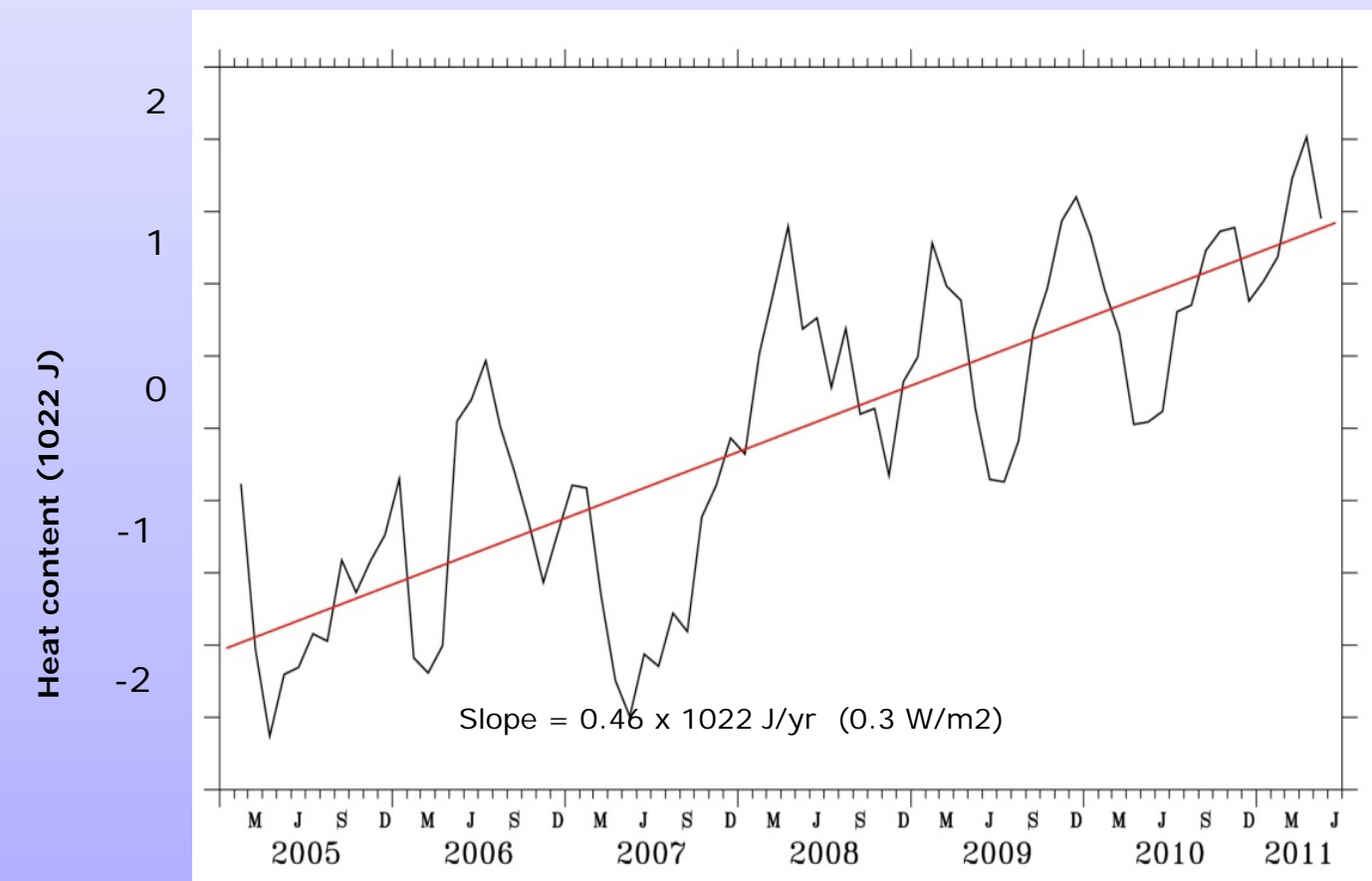
As the global observing system for the subsurface ocean, Argo enables research across a wide range of spatial and temporal scales.

Mean ocean circulation



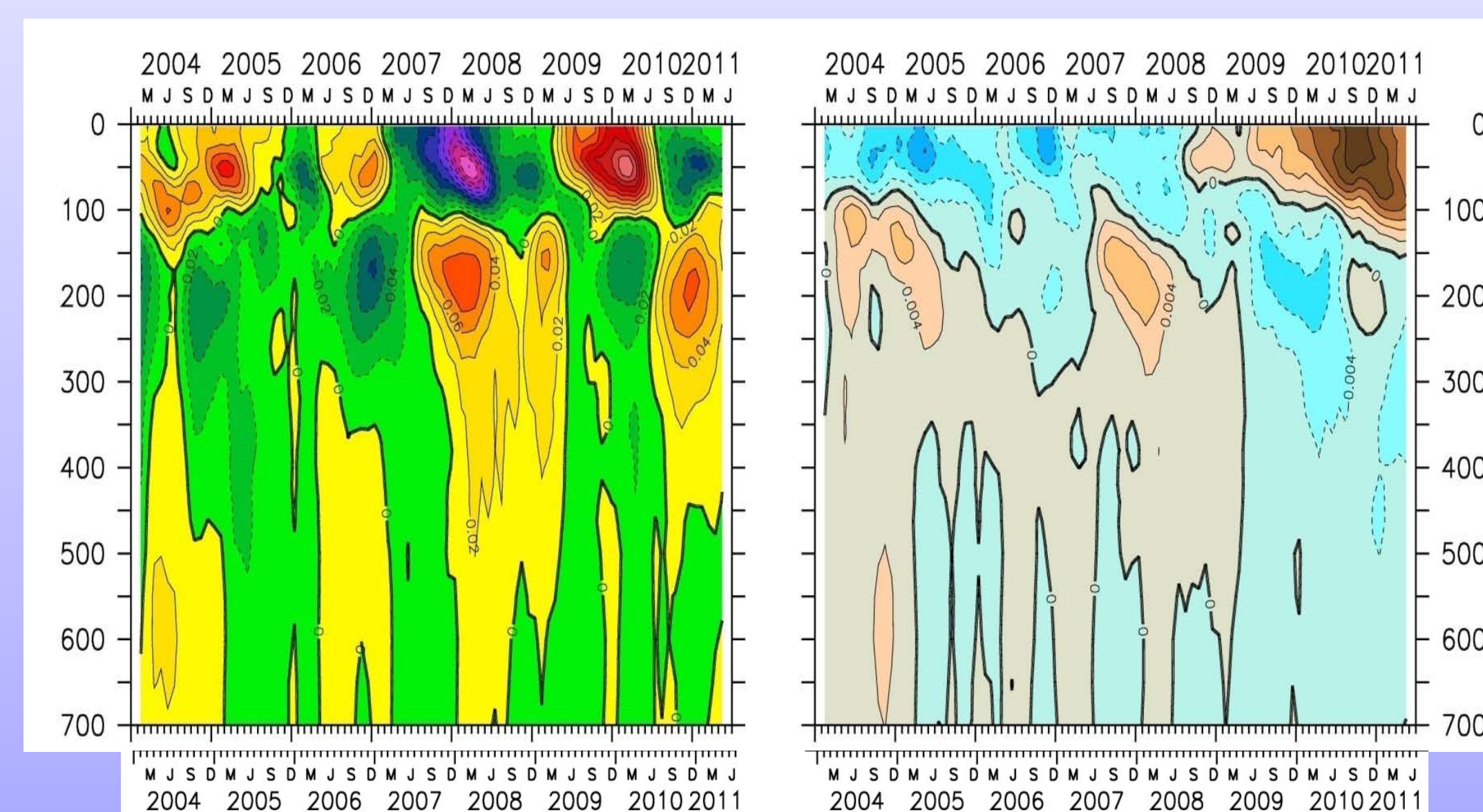
Absolute geostrophic pressure field at 5 db based on combined Argo trajectory and profile data. $Cl = 10 \text{ dyn cm}$. (From: Gray and Riser, 2011, in prep)

Global change

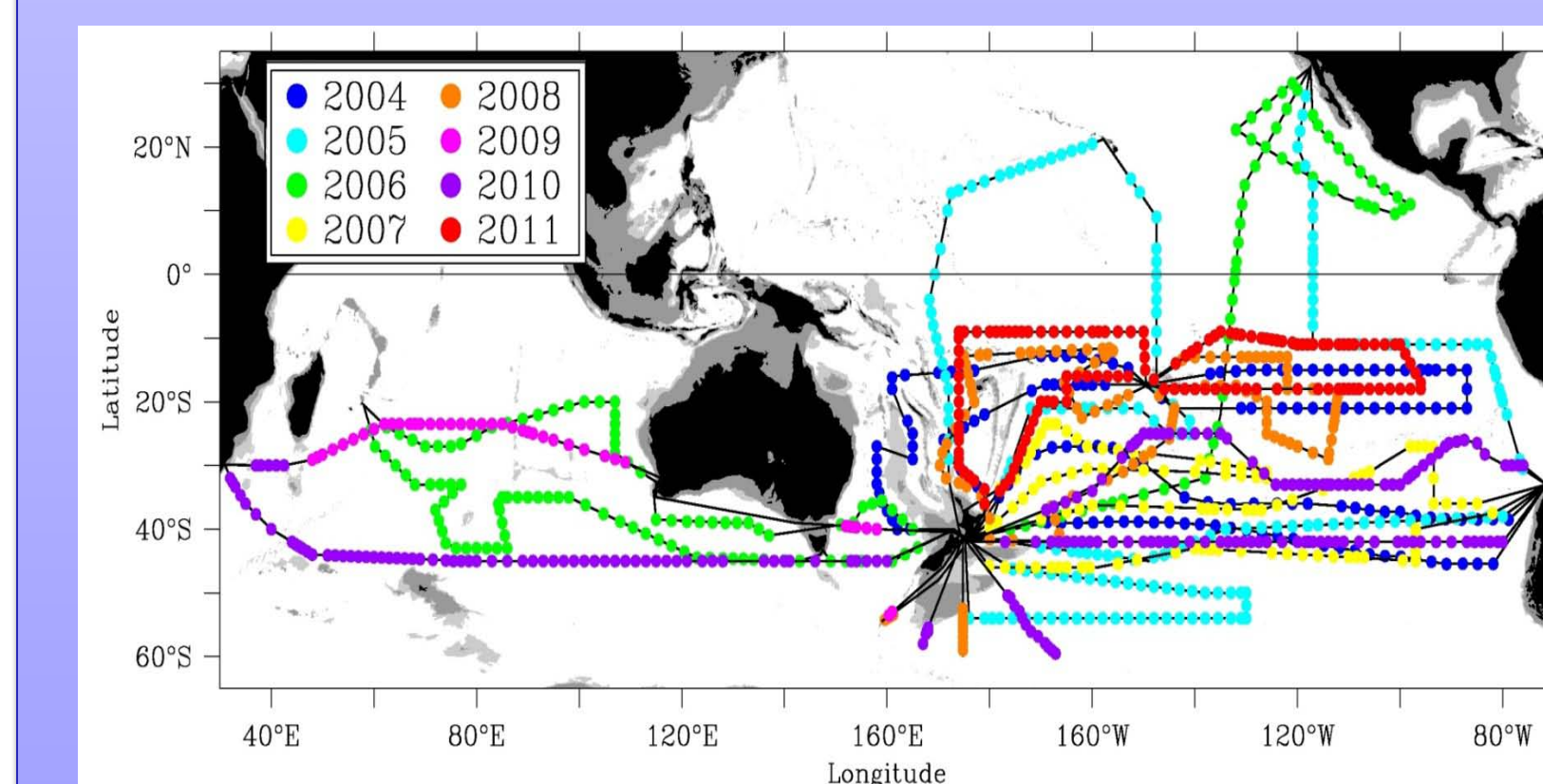


Anomaly in global ocean heat content, 0 – 2000 db; from Argo data interpolated as in Roemmich and Gilson (2009, Progress in Oceanography). The estimate is a preliminary one pending correction of pressure drift in Argo floats.

Interannual variability

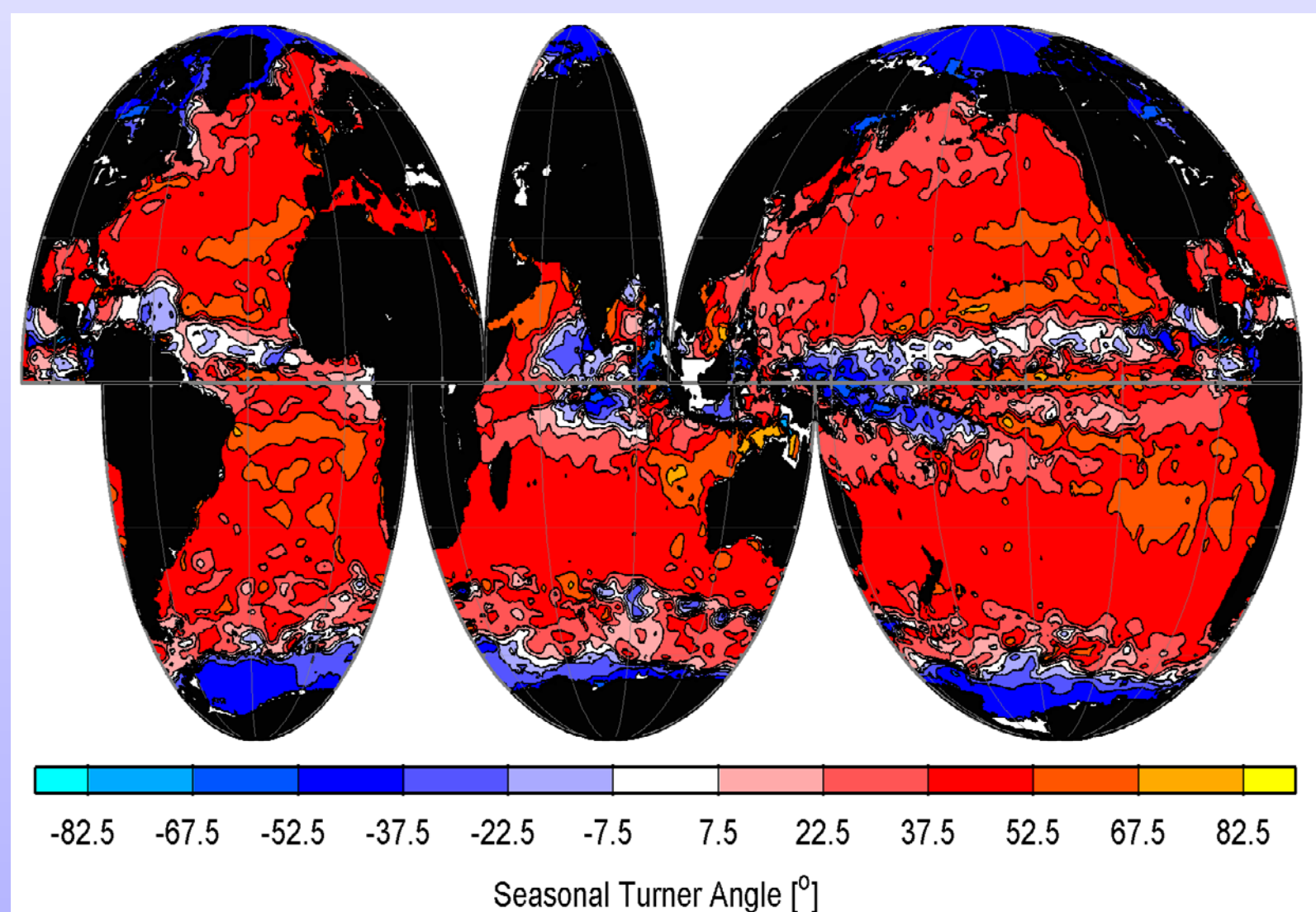


Globally-averaged T (left) and S (right), highlighting the ENSO anti-correlated variation of the surface layer (0 – 100 db) and the 100-500 db layer. (From: Roemmich and Gilson 2011, GRL)



Float deployments by R/V Kaharoa

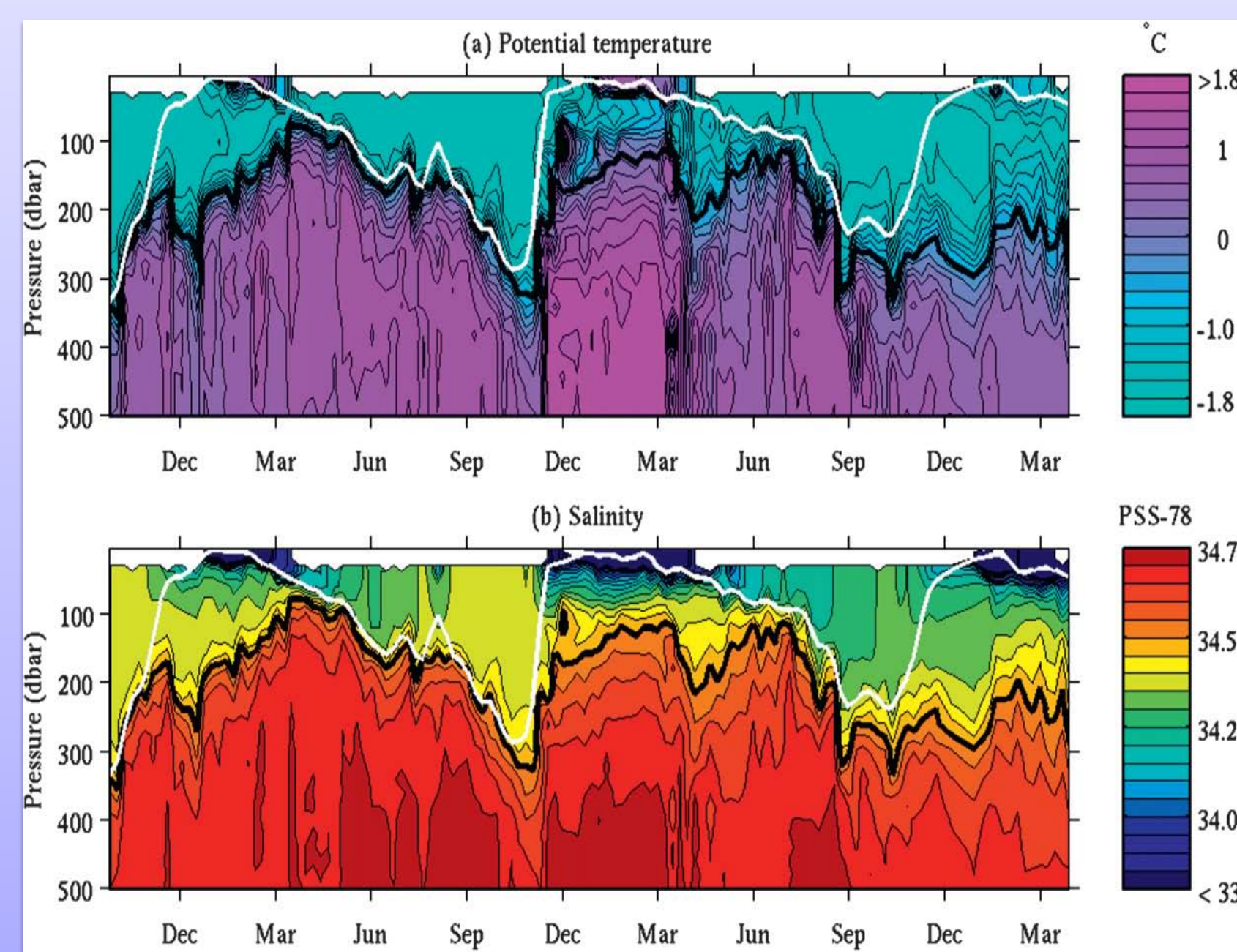
Seasonal cycle



The contribution of T and S to seasonal mixed layer density change is shown (From: Johnson, 2011 in prep) by the Turner angle, which is

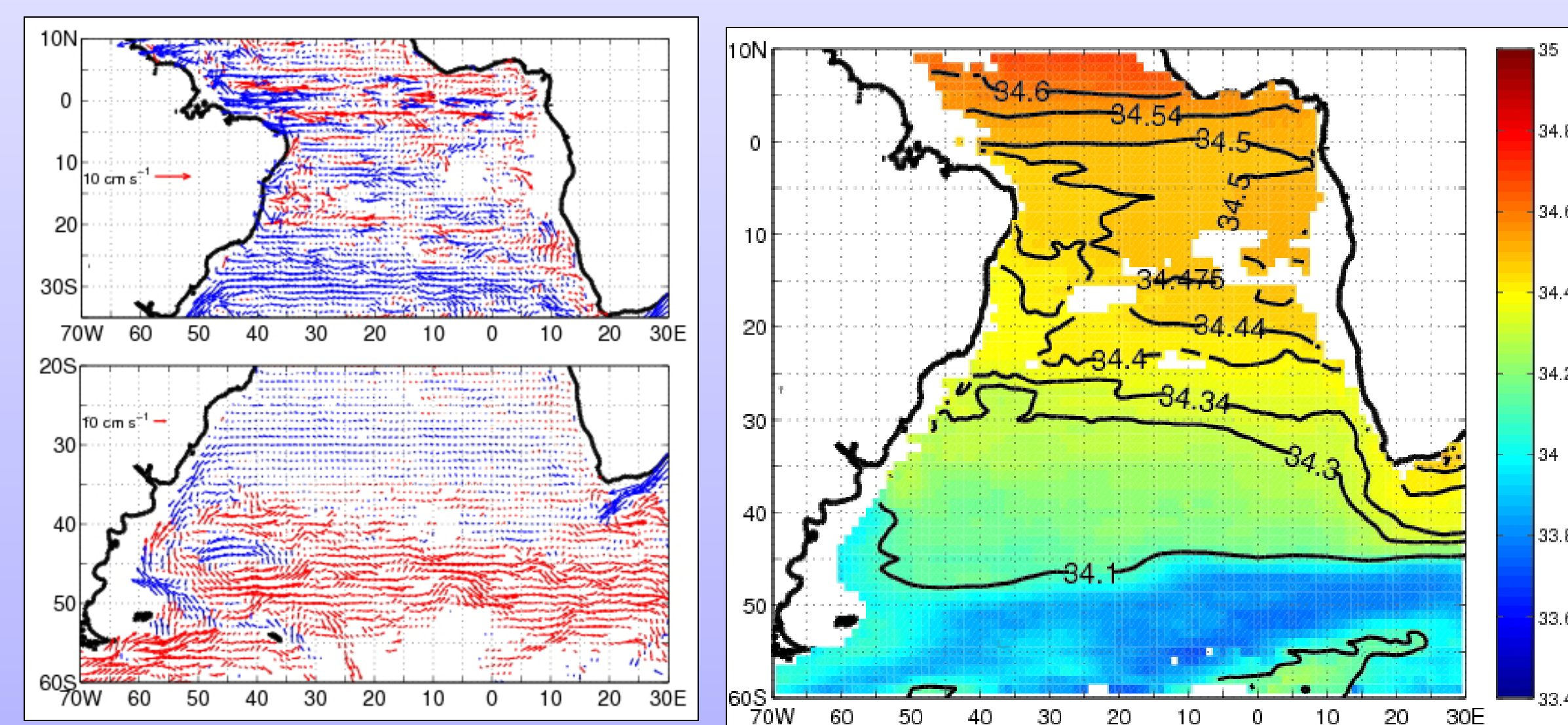
- 45° when T dominates
- -45° when S dominates
- 0° when T and S reinforce one another (equally) in density change.
- Values > 45° or < -45° indicate partially counteracting effects of T and S.

Argo under ice



Three-year time-series of Temperature and Salinity, from 0 to 500 db, obtained with an Argo float (WMO 290001) under seasonal ice off of Wilkes Land, East Antarctica. (From: Wong and Riser 2011, Journal of Physical Oceanography)

Spreading of the Atlantic Intermediate Water in the Atlantic



Mapping of the mean currents (red for eastward, blue for westward) reveals the main features of the circulation which is dominated by zonal currents in the interior and the boundary currents. The velocity field is used to show that the zonal transports of the eastward and westward branches depend significantly on the longitude. The joint analysis of velocity and salinity at the depth of the salinity minimum (800 to 1100dbar), associated with the AAIW provides additional information on the circulation in terms of the spreading of this watermass. (From: Schmid and Garzoli, 2009)

Future priorities

In the coming years, Argo will expand its sampling capabilities for better coverage in the high latitudes, marginal seas, and boundary current regions, and to include the deep ocean below 2000 m. Deep Argo floats are presently under development. Additional sensors, for dissolved oxygen, nutrients, pH, and bio-optical measurements will enable observations of the biogeochemical impacts of climate variability and change in the oceans. The Argo data system will continue to be a highest priority for producing a climate-quality dataset, and as at present, all Argo data will continue to be immediately and publicly available: <http://www.argo.net>.

Acknowledgments:

The Argo data were collected and made freely available by the International Argo Program and the national programs that contribute to it.
(<http://www.argo.ucsd.edu>)

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