GO-SHIP Science Results

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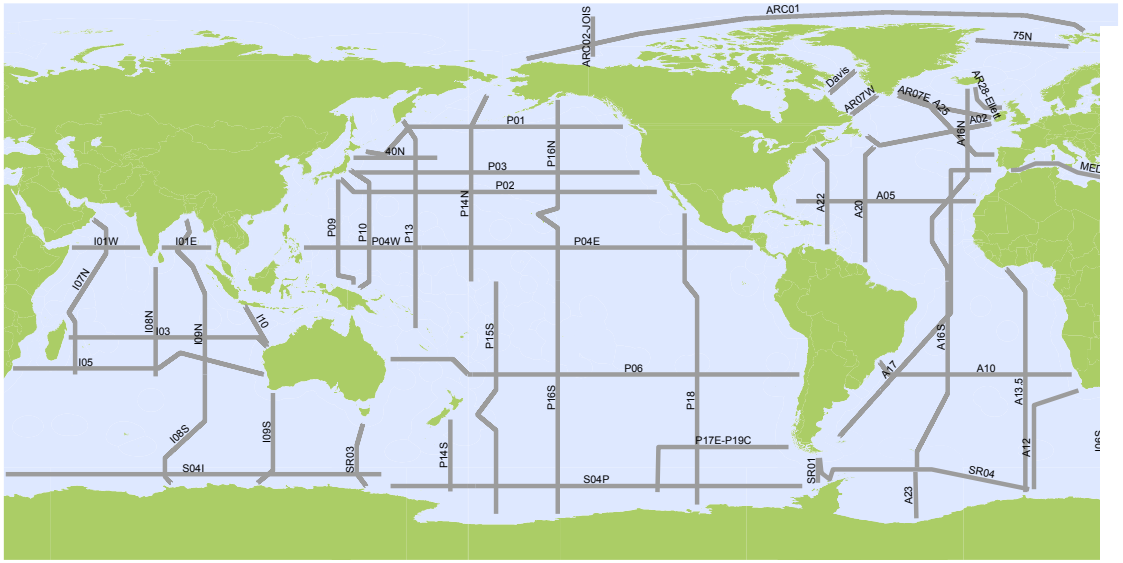
What is U.S. GO-SHIP?

- Global Ocean Ship-based Hydrographic Investigations Program
- Under GCOS/GOOS and Global Ocean Acidification network internationally
- Contributes to WCRP and IOCCP internationally
- In the US, under US CLIVAR and OCB (Ocean Carbon and Biogeochemistry, part of USCCSP (US Climate Change Science Program))
- Grew out of WOCE in the late 80's / 90's
- Rigorous data policies and data management
- International: GO-SHIP Executive Committee http://www.go-ship.org
- U.S.: Repeat Hydrography Oversight Committee http://ushydro.ucsd.edu

- (presentation material given to us by L. Talley and R. Wanninkhof)

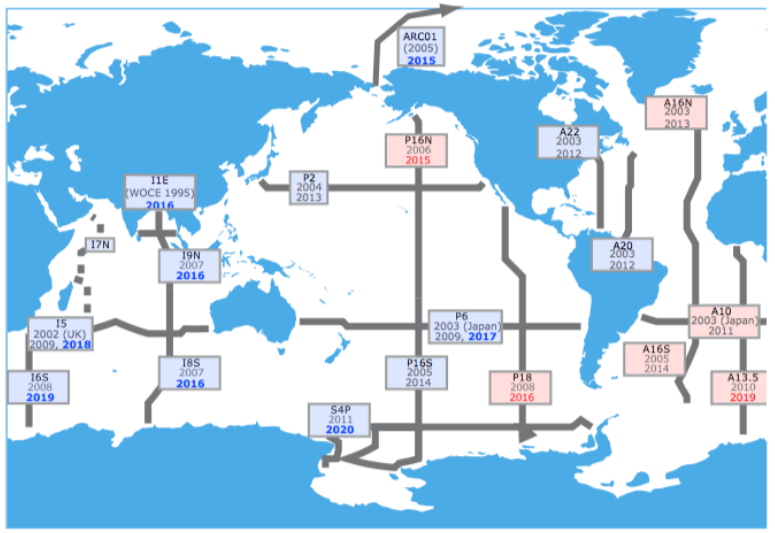
GO-SHIP Goals

- Document the large-scale ocean water property distributions to the ocean bottom, their changes, and drivers of those changes,
- Determine the distributions and controls of natural and anthropogenic carbon (both organic and inorganic),
- Determine ocean ventilation and circulation pathways and variability using chemical tracers



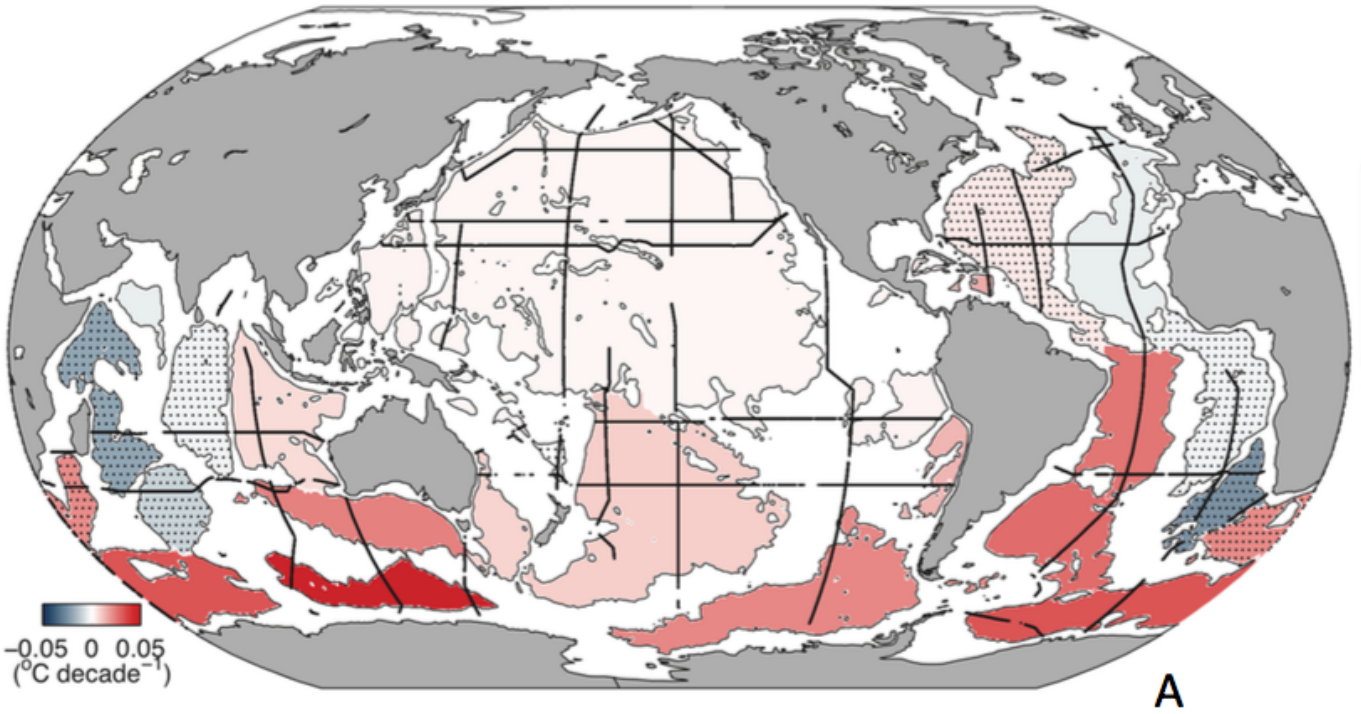
GO-SHIP 2012-2023 Survey (53 Lines)

Status April 2015



- Approximately decadal repeat surveys
  - First decadal survey after WOCE (2002-2012) was 97% completed.
- Stations to ocean bottom, highest measurement accuracies.
- Requirements for types of observations
  - Profiles: CTD, oxygen, nutrients, DIC, alkalinity, pH, CFCs, velocity
  - Underway: surface T/S, pCO_2, met. observations
- Requirements for data reporting that is rapid in the context of CTD/ chemistry/velocity profiling.
- 21 US cruises since 2003

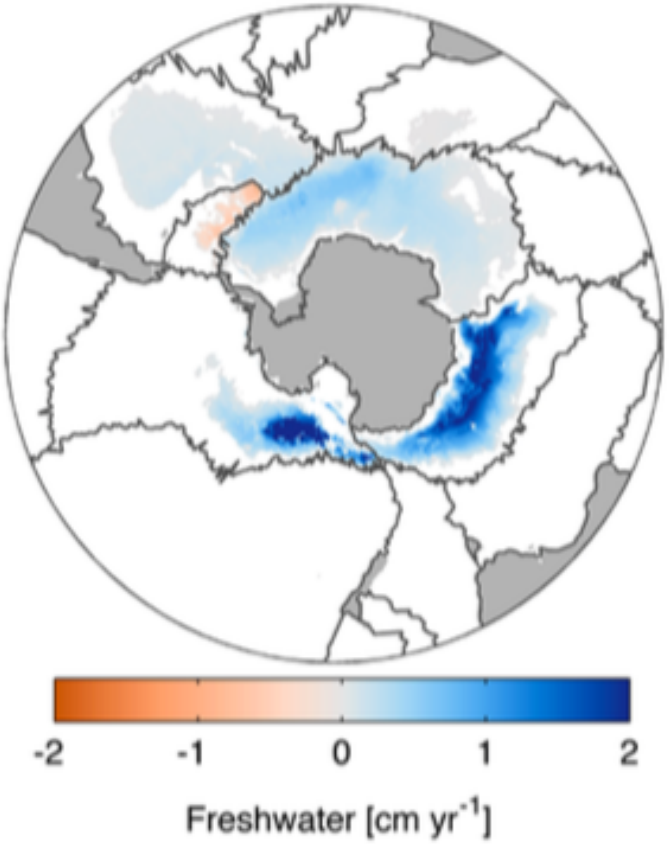
GO-SHIP science highlights



Rate of temperature change below 4000 m from repeat hydrography. Stippled areas are where change is not significant.

Purkey and Johnson, 2010, Talley et al., 2015

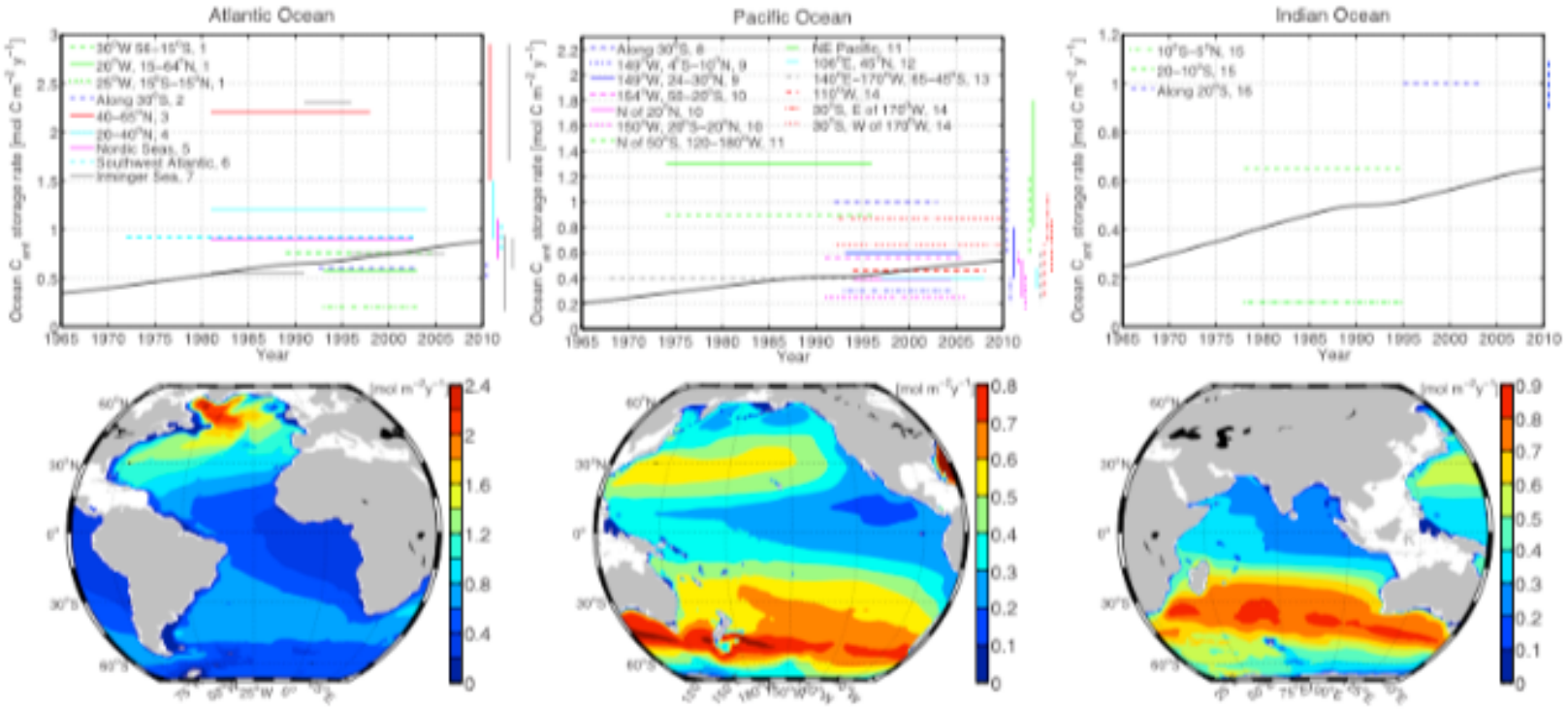
GO-SHIP science highlights



Rate of freshwater inventory change in the Southern Ocean below 0°C. This is a result of changes in AABW θ-S properties.

Purkey and Johnson, 2013

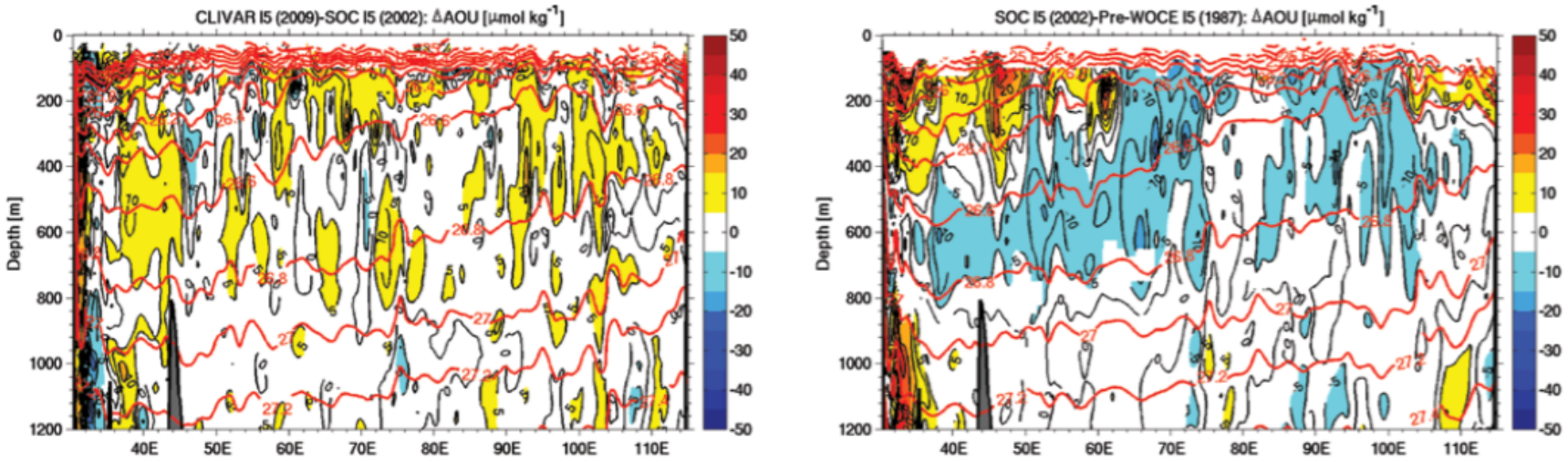
GO-SHIP science highlights



Anthropogenic CO_2 storage rate, in mol m^{-2} yr^{-1}.

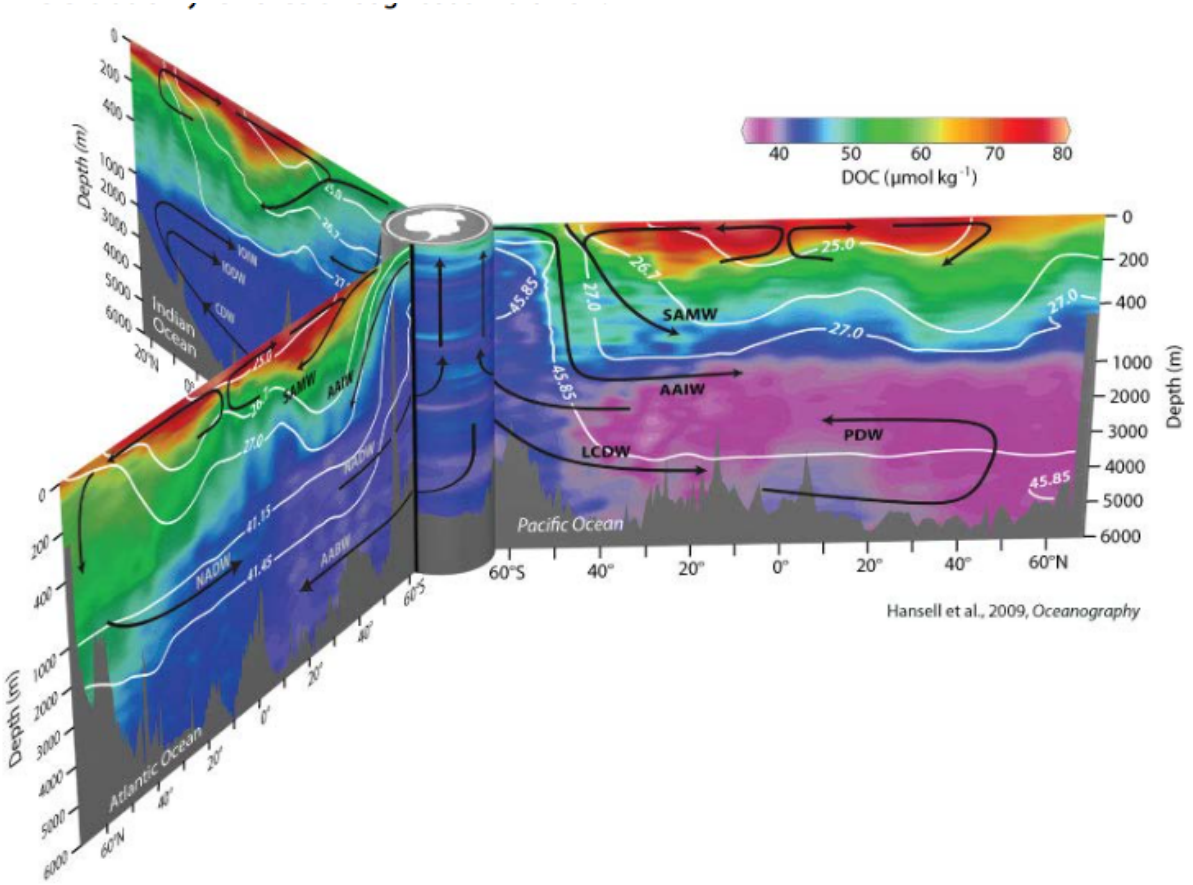
Khatiwala et al., 2013; Talley et al., 2015

GO-SHIP Science Highlights



Changes in AOU (Saturation-actual O_2 concentration) along 32°S in the Indian Ocean, 2009-2002 (left) and 2002-1987 (right). Left panel shows an increase in O_2 in the S. hemisphere thermocline, right panel shows a reverse in that trend (Mecking et al., 2012).

GO-SHIP Science Highlights



DOC Sections in the 3 major ocean basins along GO-SHIP sections. Also shown is the vertical and horizontal spreading of some named water masses (black) and isopycnals (white). Hansell et al., 2009 and Talley et al., 2015.

GO-SHIP Pluses

- Tight integration of physical oceanography and biogeochemistry
- Coordination with international governing bodies (GOOS, IOCCP)
- Highest standards for sampling accuracy
- Rapid dissemination of data and open data sharing policy
- Sampling of deep ocean
  - Changes in heat and freshwater content. CO_2 and transient tracer changes, etc.
- Reference data for calibration of autonomous sensors and models
- Platform with high quality reference data for experimental or 1-time programs (see next slide)
- U.S. leadership in fully international program

Example: P16S, austral fall 2014

Principal Investigators for US-Repeat Hydrography(GO-SHIP) P16S

Program	Affiliation*	Principal Investigator	email
CTDO/Rosette, Nutrients, O_2,	UCSD/SIO	Lynne Talley	ltalley@ucsd.edu
Salinity, Data Management	UCSD/SIO	James H. Swift	jswift@ucsd.edu
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ADCP , LADCP	U Hawaii	Eric Firing	efiring@soest.hawaii.edu
Chipod (T variance)	OSU OSU UCSD/SIO	Jonathan Nash James Moum Jennifer MacKinnon	nash@coas.oregonstate.edu moum@coas.oregonstate.edu jmackinnon@ucsd.edu
CFCs , SF_6, N_2O	U Washington	Mark Warner	mwarner@uw.edu
^3He , ^3H	LDEO	Peter Schlosser	schlosser@ldeo.columbia.edu
DIC (Total CO_2)	NOAA/PMEL	Richard Feely	Richard.A.Feely@noaa.gov
pH , Total Alkalinity	UCSD/SIO	Andrew Dickson	adickson@ucsd.edu
DOC , TDN	UCSB	Craig Carlson	carlson@lifesci.ucsb.edu
Radiocarbons (^{13}C , ^{14}C)	WHOI Princeton	Ann McNichol Robert Key	amcnichol@whoi.edu key@princeton.edu
$\partial^{15}N\text{-}NO_3$, $\partial^{18}O\text{-}NO_3$	Princeton	Daniel Sigman	sigman@princeton.edu
Dissolved Calcium	UCSD/SIO	Todd Martz	trmartz@ucsd.edu
$\partial^{30}Si$	Princeton	Greg de Souza	gfds@princeton.edu
Pigments HPLC	NASA	Joaquin Chaves Cedeño	joaquin.e.chavescedeno@nasa.gov
CDOM	NASA UCSB	Joaquin Chaves Cedeño Norm Nelson	joaquin.e.chavescedeno@nasa.gov norm.nelson@ucsb.edu
IOP Cage Hyperpro "Javelin"	NASA	Joaquin Chaves Cedeño	joaquin.e.chavescedeno@nasa.gov
Biogeochemical Floats	Pre-SOCCOM/UW MBARI	Stephen Riser Ken Johnson	riser@ocean.washington.edu johnson@mbari.org
Surface Drifters	GDP/NOAA/AOML	Shaun Dolk	shaun.dolk@noaa.gov
pCO_2 Underway Data	LDEO NOAA/AOML	Taro Takahashi Rik Wanninkhof	Takahashi@ldeo.columbia.edu rik.wanninkhof@noaa.gov
Ship's Underway Data	USAP USAP	Joe Tarnow Bryan Chambers	Joe.Tarnow.Contractor@usap.gov Bryan.Chambers.Contractor@nbp.usap.gov

*Affiliation abbreviations listed on page 11

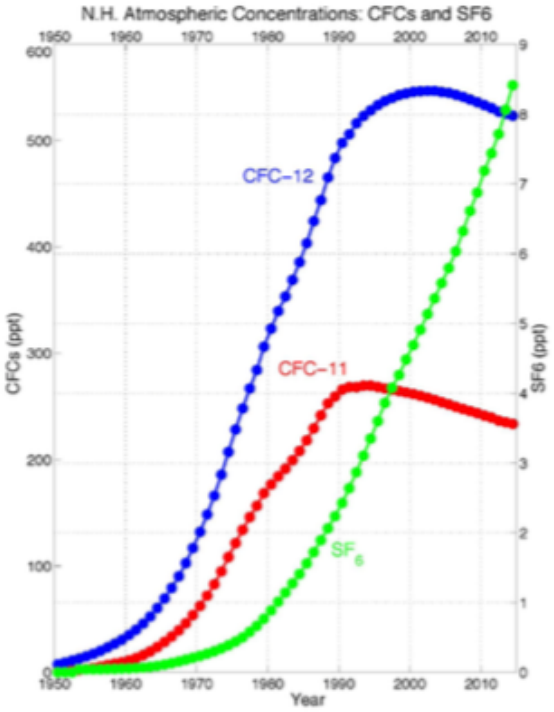
Future Objectives

- Reduce uncertainties in global heat, FW and sea level budgets, especially below 2000 m
- Determine distributions of natural and anthropogenic carbon
- Determine ventilation rates and circulation pathways using chemical tracers
- Determine variability and controls of water mass properties and ventilation
- Determine significance of biogeochemically and ecologically important properties on the interior carbon cycle
- Test and validate new methods for high-res physical and biogeochemical measurements on autonomous vehicles

Feely et al (2014) p. 33

Issues

- Wide temporal sampling
- Expense of large hydrographic vessels and long lines
- Decreasing signal strength of bomb radiocarbon and CFCs (SF_6 replacing CFCs)
- Are snapshots useful?

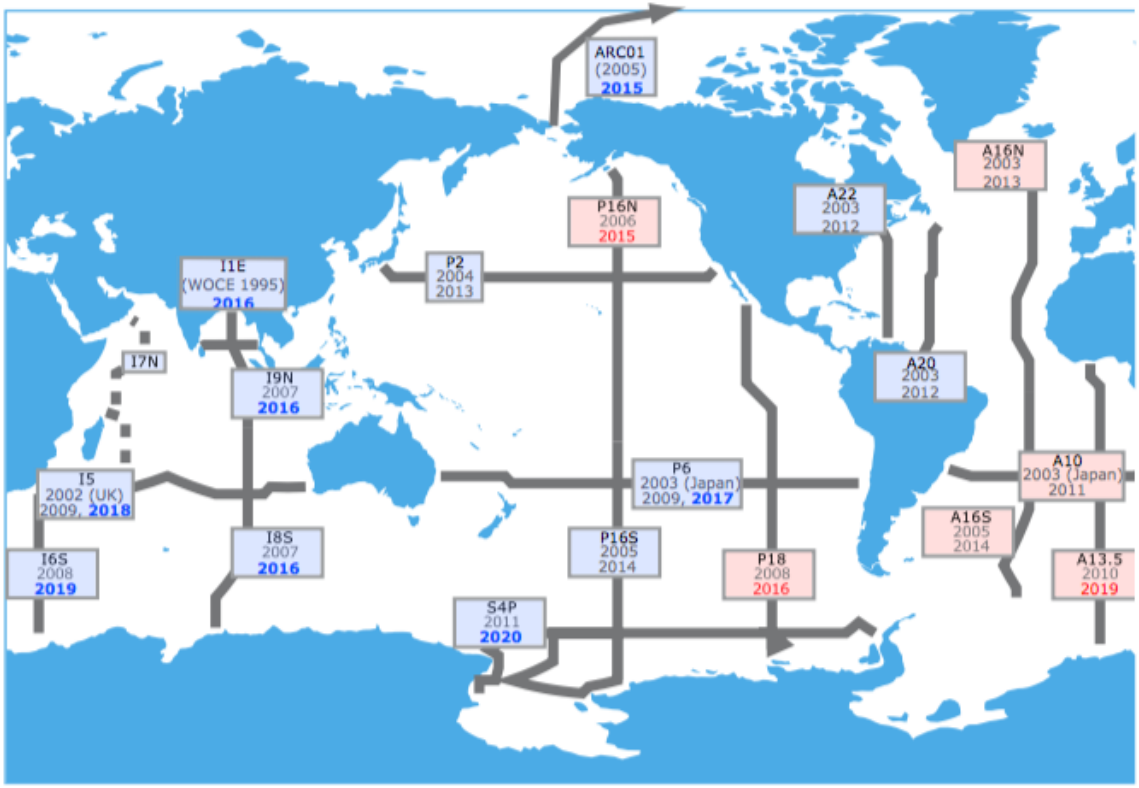


Atmospheric concentration of CFCs & SF6, northern hemisphere

Needs

- Clear organizational relationship between US-CLIVAR, UC OCB, and US GO-SHIP
- Guidance about how to make their data more accessible and used by the community
- Any measurements that GO-SHIP is not making that they should/could?
- Formal external program review at the national or international level?

What's next?



Blue and red text shows planned lines and year for the US element of GO-SHIP