Recent Science Highlights from the SIO High Resolution XBT Network in the Indian and Pacific Oceans

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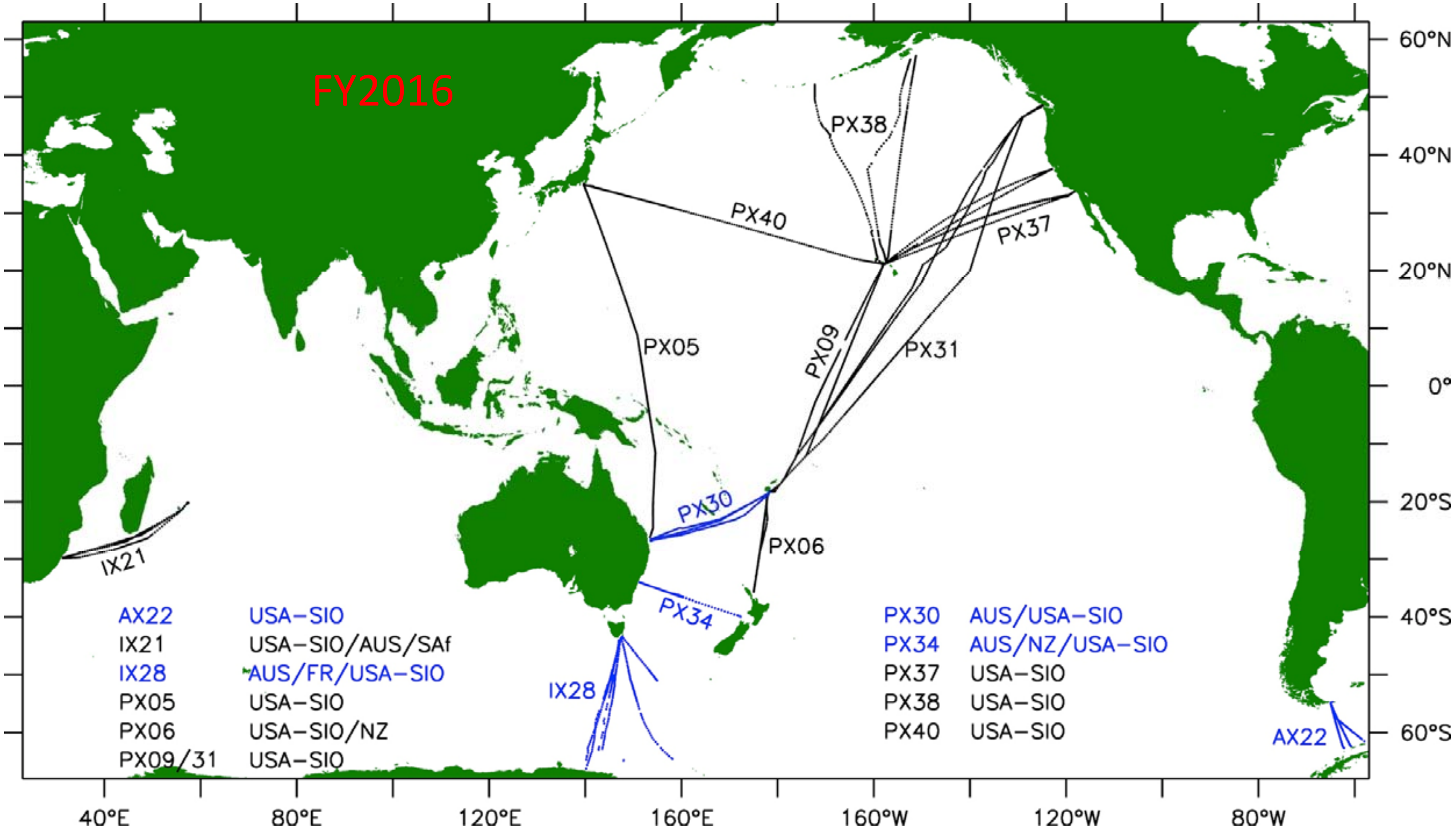
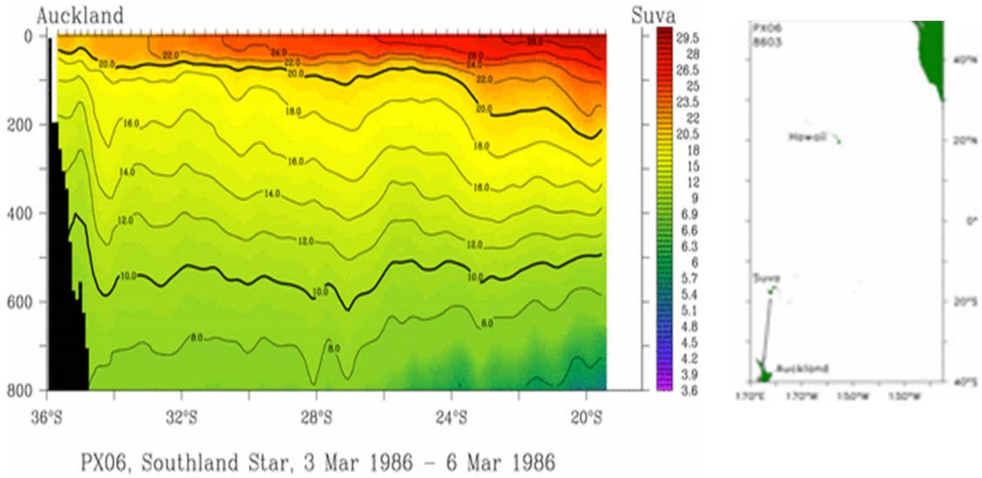
For information and data see http://www-hrx.ucsd.edu

The SIO HR-XBT Network: International Partnerships



- The SIO HR-XBT Network in the Pacific and Indian Ocean during FY2016.
- International partnerships: first-listed has primary responsibility.
- NOAA (Pacific-Indian Ocean) and NSF-OPP (AX22) (soon to incl. NOAA) funded
- Over 98% of XBT profiles (~5500) in FY2016 returned good data
- compatible with NOAA/SEAS system; distributed via GTS and NODC archives
- some lines initiated 1986-90s -> decades of continuous measurements

The SIO Network: 30 years of HRX Measurements!



- The HR-XBT Network began 30 years ago (Mar 1986) along PX06 Auckland to Suva!
- Dean Roemmich reminisces: “With no autolauncher at that time, Bruce Cornuelle and I both went along to stand opposite watches. For the next few cruises, we had only one of us on board, a real exercise in sleep deprivation. Necessity is the mother of invention, so the first generation of autolaunchers was quickly devised, with paper clips, string, and electric motors to pull the pin. Thank goodness for the autolauncher version 2”
- The ocean temperature measuring XBT may be expendable but its data is priceless!

The SIO HR-XBT Network: Science Objectives

- examine annual cycle, interannual variability & long-term mean of T, V_g and transport
- long-time repeat sections to separate temporal from spatial variability
- identify permanent boundary currents & fronts &eddies
- provides information on boundary currents that complements other in situ and remotely sensed components of the observing
- provide in situ data for testing ocean and ocean-atmosphere models

<u>Primary Uses:</u>

- Education
  - 10 PhD theses completed
- Research
  - statistical data analyses;
  - data assimilation models
  - operational ocean models

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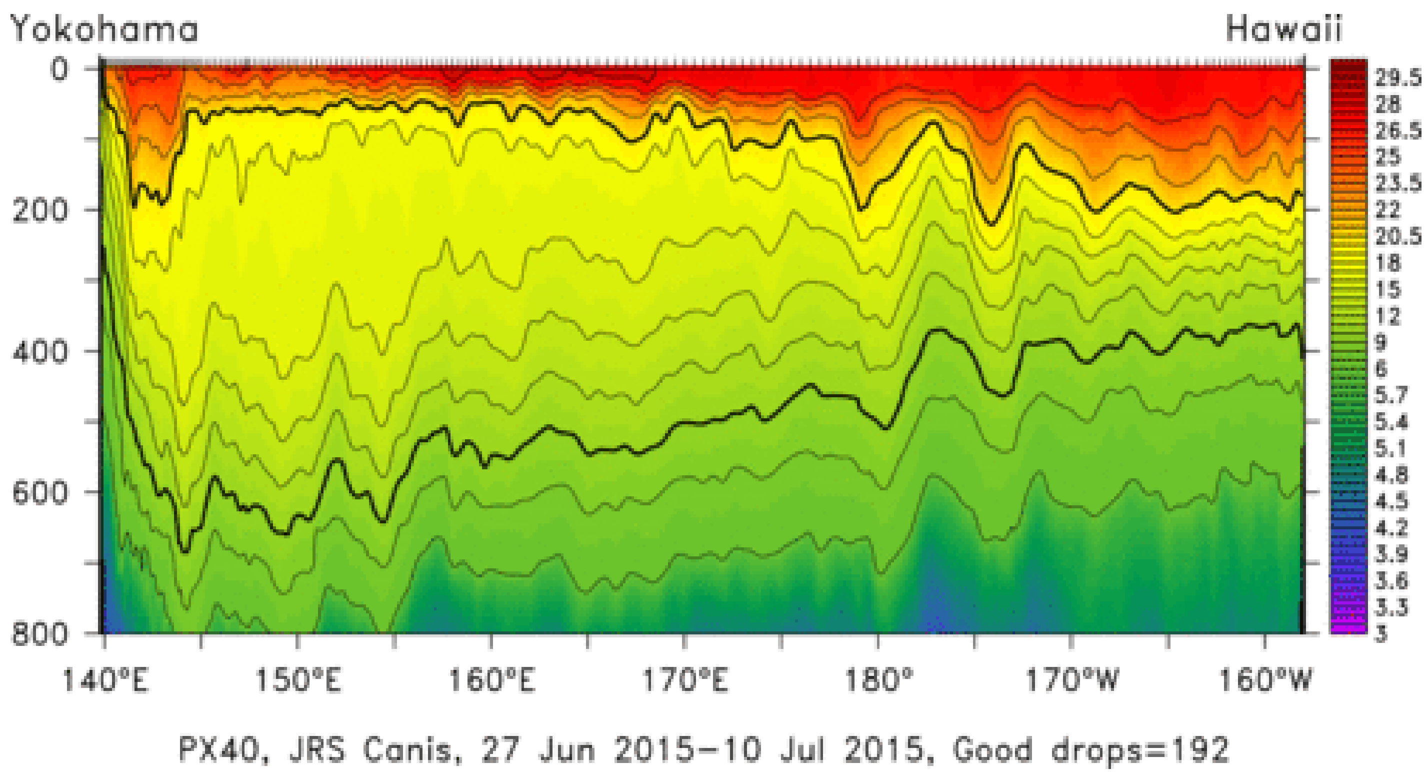


Boundary, surface and subsurface currents

XBT transects are sampling:

Western Boundary Currents:

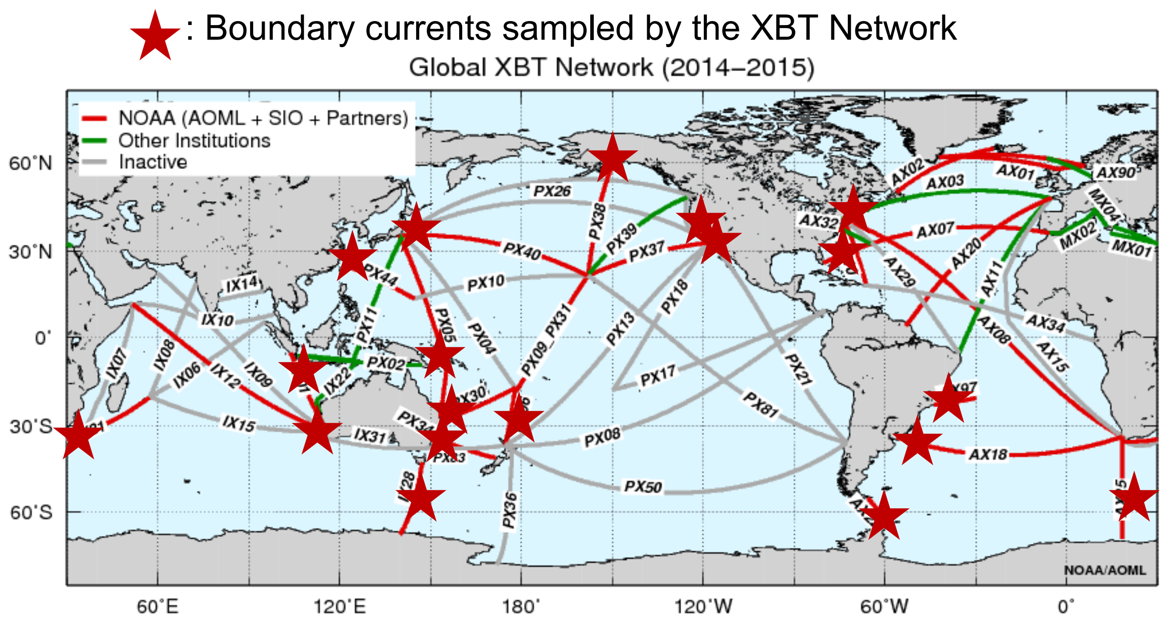
Kuroshio (3 transects)
Gulf Stream (3 transects)
Agulhas Current, rings
Brazil Current, rings (2 transects)
East Australian Current (2 transects)
East Auckland Current and Tasman Outflow

Eastern boundary currents: California Current,
Alaska Current, Leeuwin Current, …

Low latitude WBCs: Solomon Sea,
Indonesian Throughflow

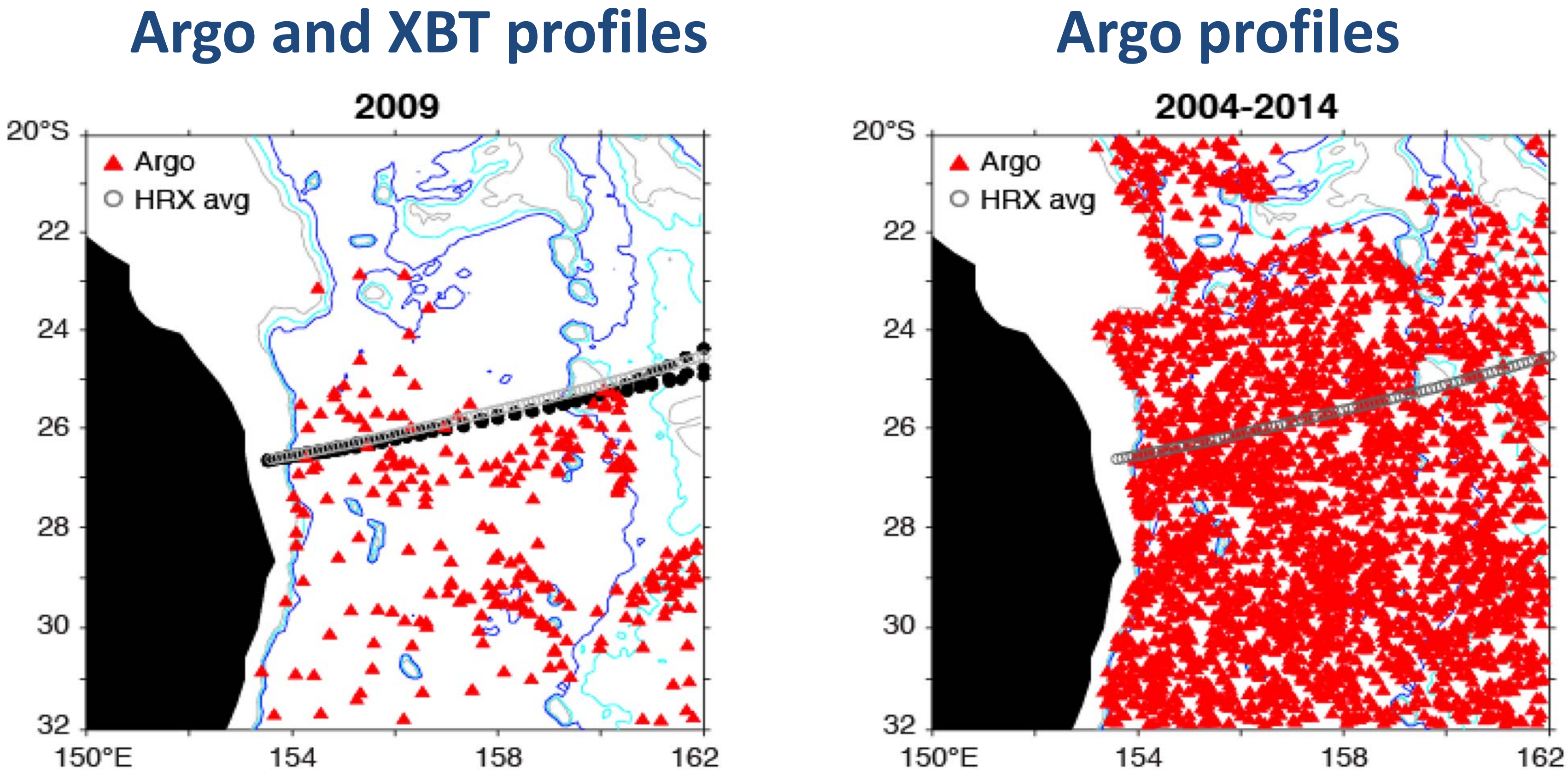
High latitude: Antarctic Circumpolar Current (3 transects)

Equatorial System: NECC, NEUC



- BCs are narrow, meandering, deep reaching jets
- Observational arrays of WBCs are expensive and sparse in time and space
- An integrated ocean observing BC system requires a combination of area-mode (e.g. Argo) and line-mode (e.g. HRX and/or glider and/or altimeter) sampling.
- Multiple transects across one current provide critical information on spatial changes in the structure

Estimating the velocity and transport of Western Boundary Currents systems using Altimetry, XBT, and Argo: A Case study of the East Australian Current (EAC)

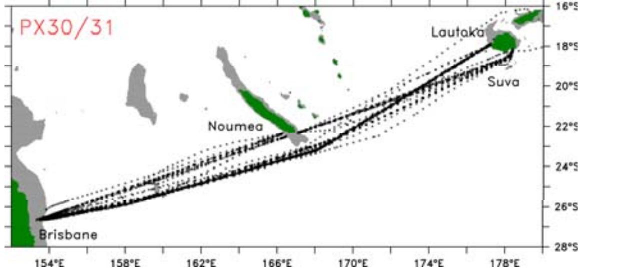


Depth contours are 1000 m (gray), 1500 m (light blue), and 2000 m (dark blue)

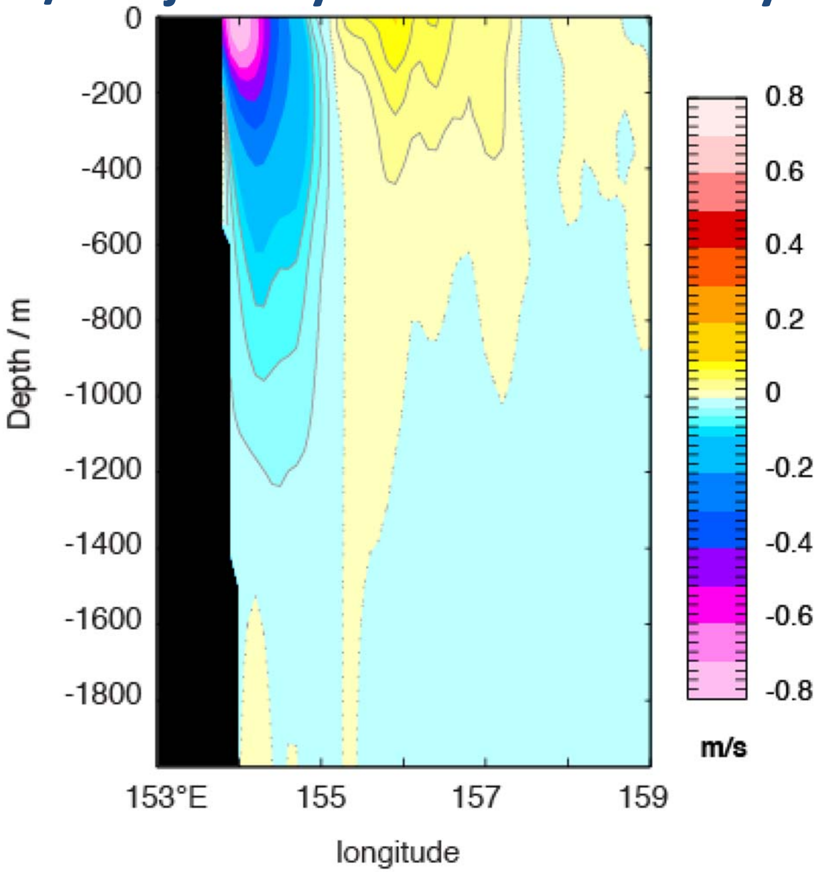
Argo has many profiles in WBC regions, but **HRX transects obtain much denser coverage**.
HRX sampling **extends further shoreward** than Argo (in shallow region & strong EAC shear).

N. Zilberman, D. Roemmich, and S. Gille (in preparation)

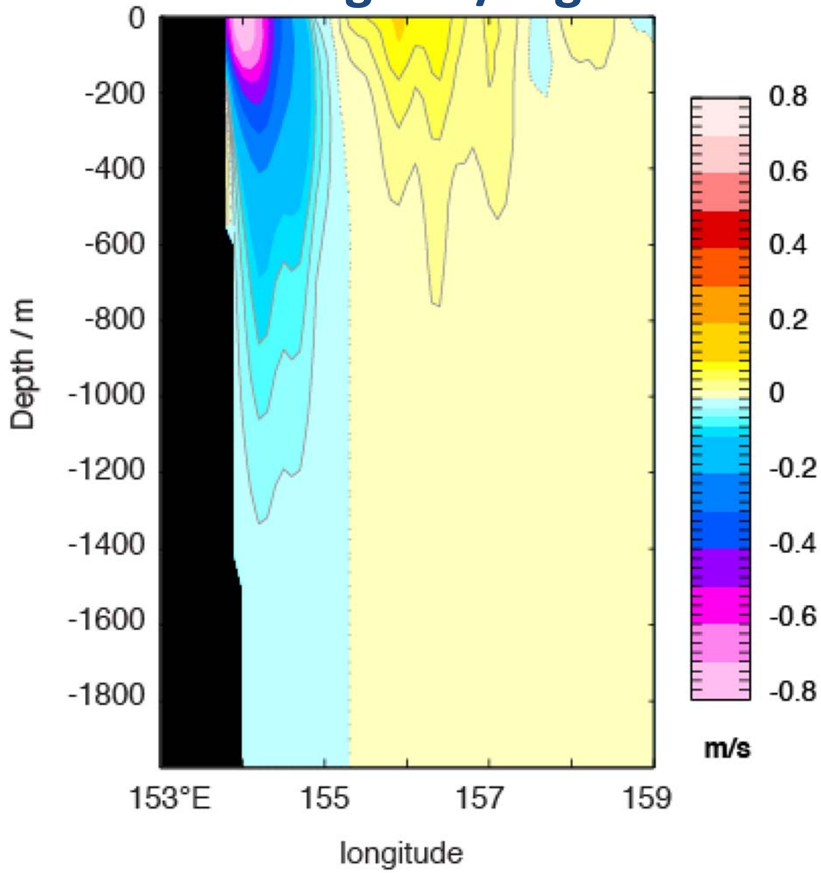
Geostrophic velocity and transport using XBT/Argo near Brisbane



Absolute velocity using XBT/Argo w/ trajectory-based ref velocity



Velocity relative to 2000 m using XBT/Argo



Argo trajectories show differences in less negative velocities in EAC and in offshore circulation compared to XBT/Argo velocity at 2000 m.
Trajectories “feel” the equatorward undercurrent observed in Mata et al. (2000).

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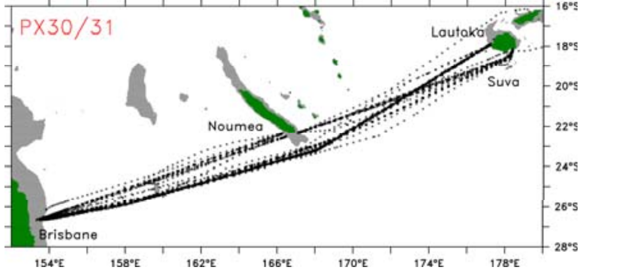
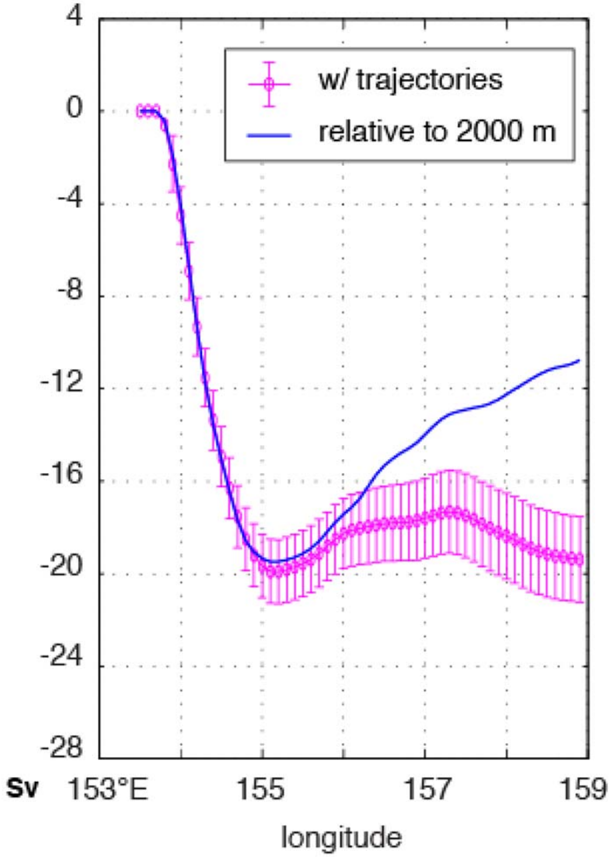
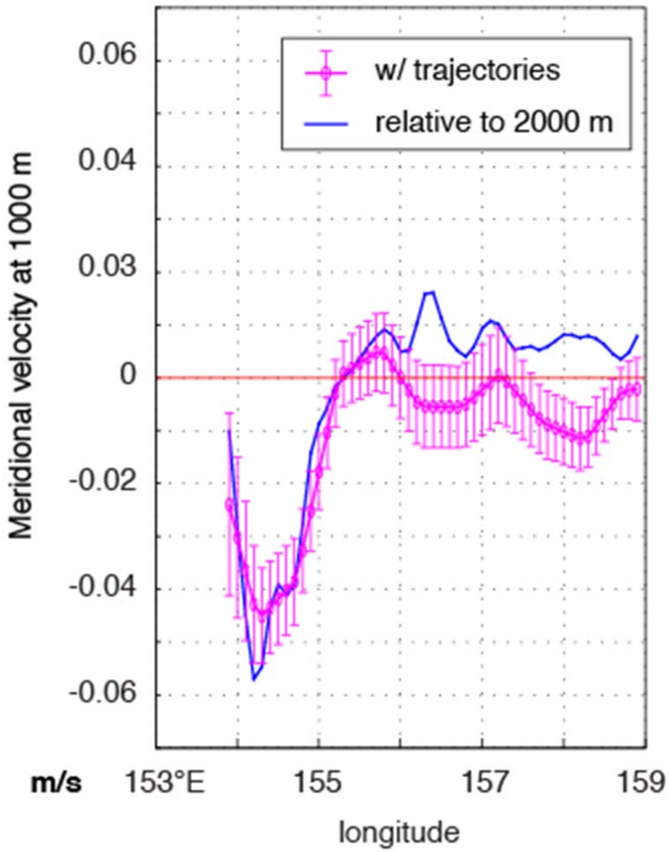


0-2000 m geostrophic transport using XBT/Argo

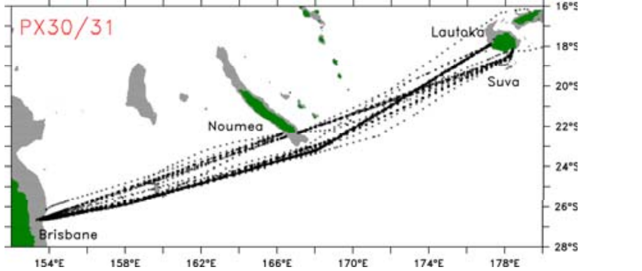


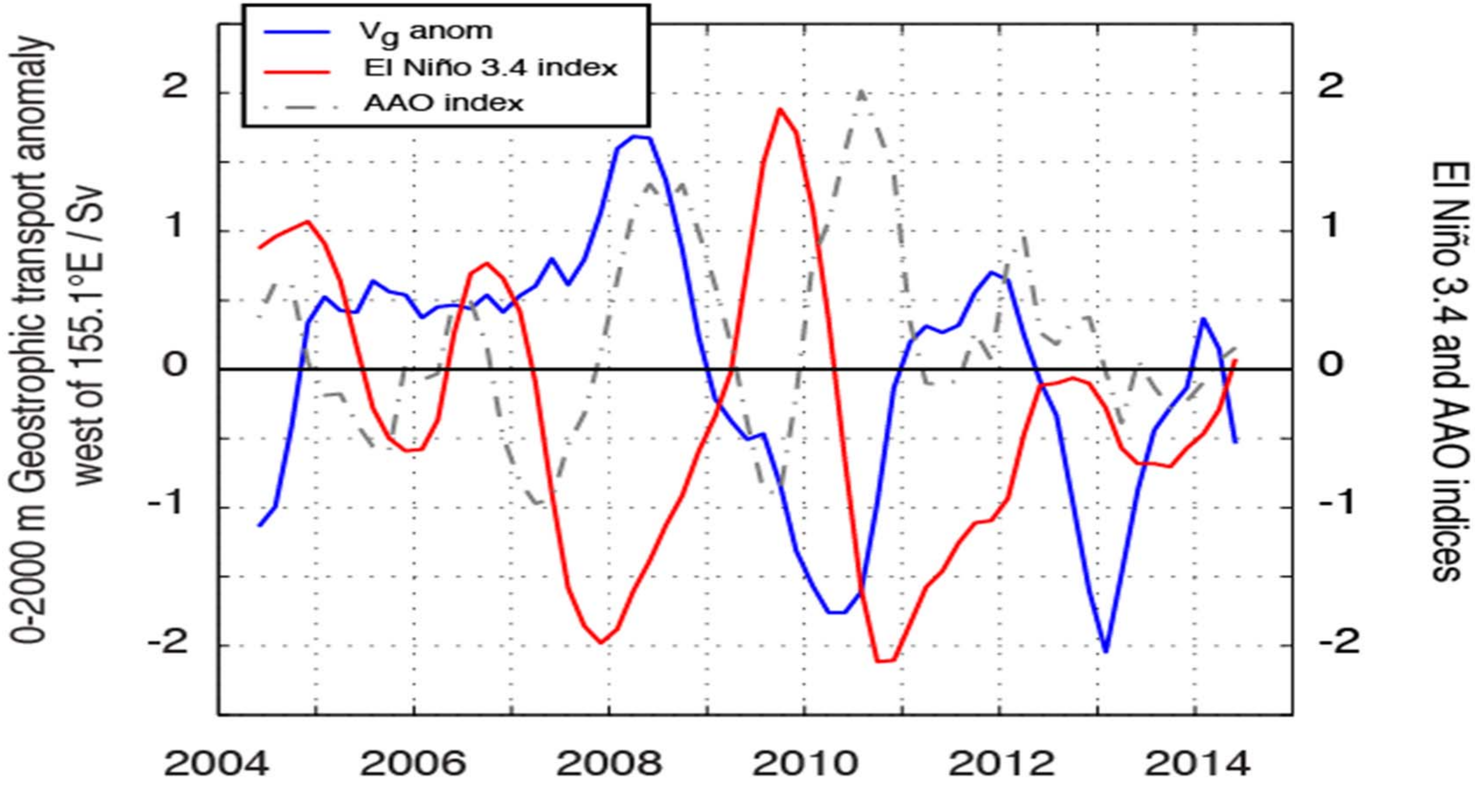
Velocity at 1000 m depth



0-2000 m EAC transport west of 155.1°E using XBT/Argo w/ ref velocity from trajectories is 19.9 Sv (0.4 Sv higher than using a level of no motion at 2000 m), consistent with moored observations by Sloyan et al., (2015).

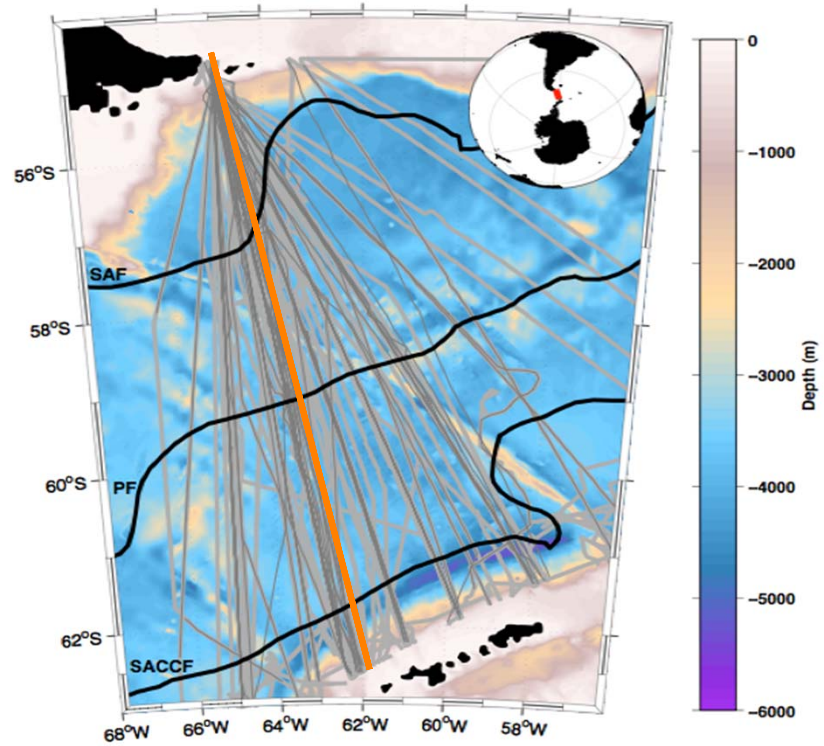
Time variability of EAC transport using XBT, Argo, and altimetry





0-2000 m geostrophic transport west of 155.1°E computed with XBT/Argo/altimetry data shows ± 1.0 Sv variability at interannual time scales. ENSO signature seen in EAC transport anomalies is more evident during strongest El Niño (2009) and La Niña (2008) events.

AX22: Provides the only year-round transect air-sea data in the Southern Ocean



Middle Transect Sampled 70 times

Year-round *ARSV L.M. Gould*

• 1996: High-resolution XBT (PI: Sprintall)
- 6-12 km spacing (70 XBTs)
- 6-8 transects/year
- 122 temperature transects to date

• 2001: XCTD Sampling (Sprintall)
- 25-50 km spacing (12 XCTDs)

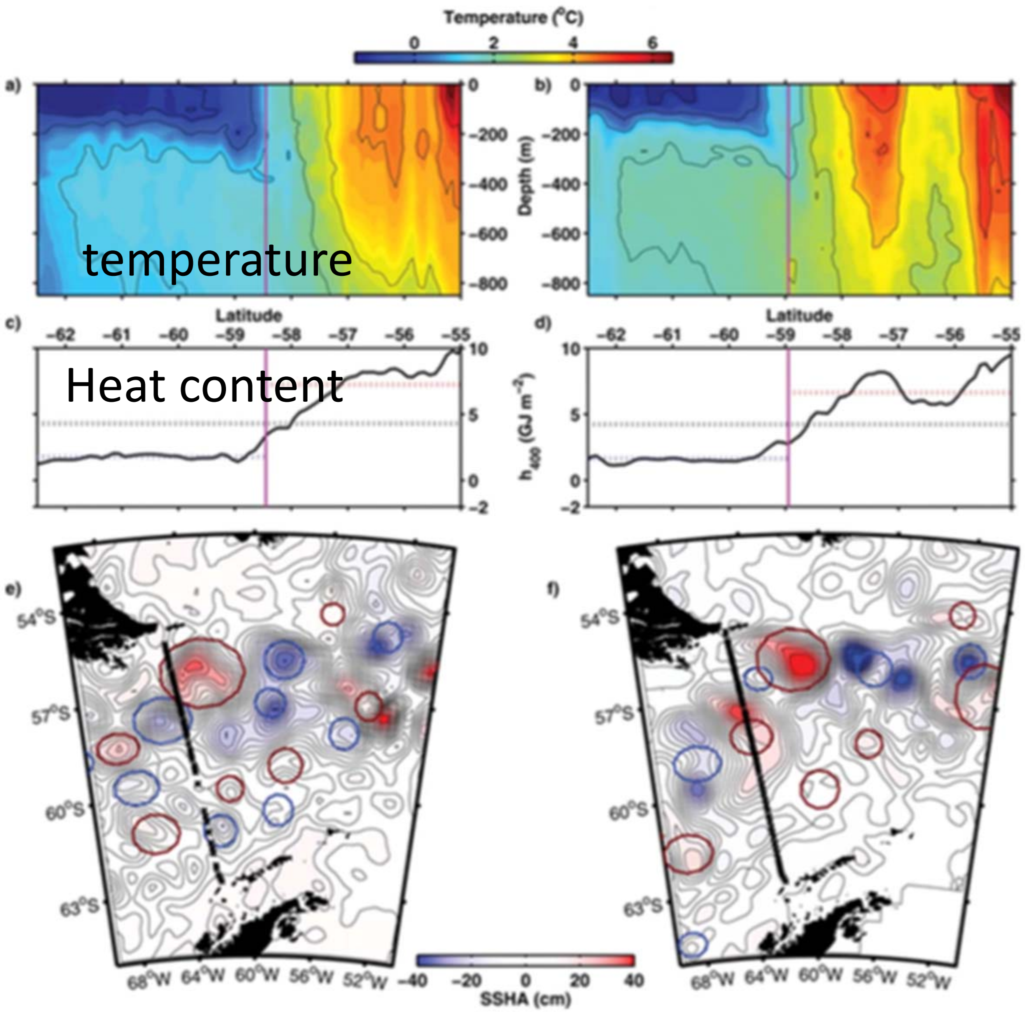
• 1999: ADCP Velocity (PI: Chereskin)
- NB150 (296 transects)
- OS38 (since 2004: 169 transects)

• 2002: Surface water pCO_2 (PI: Sweeney)
- >1 million measurements
- discrete TCO_2, nutrients, $\delta^{13}C$ of TCO_2 and bottle salinity

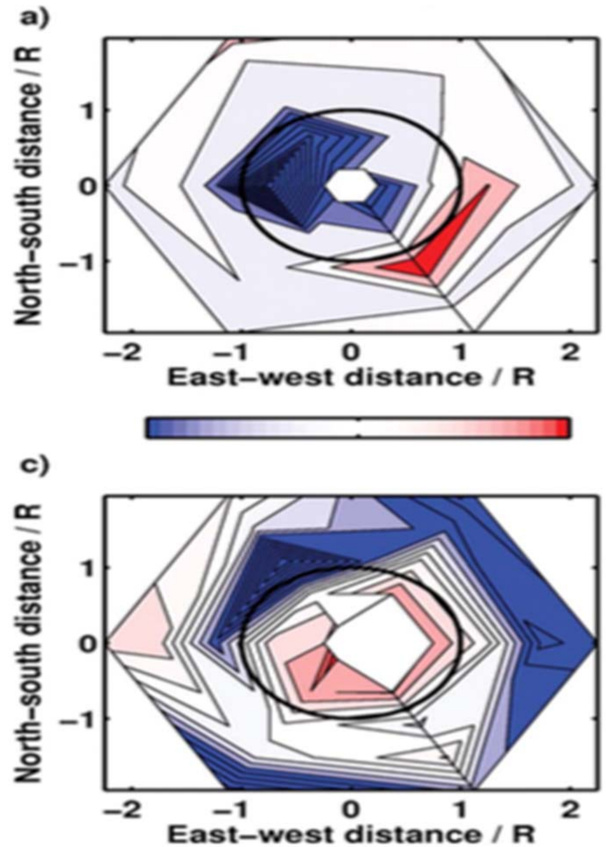
• 2012: Atmospheric O_2 and CO_2 (PI: Stevens)

• Meteorological system and TSG (SAMOS)

Eddy Variability in Drake Passage



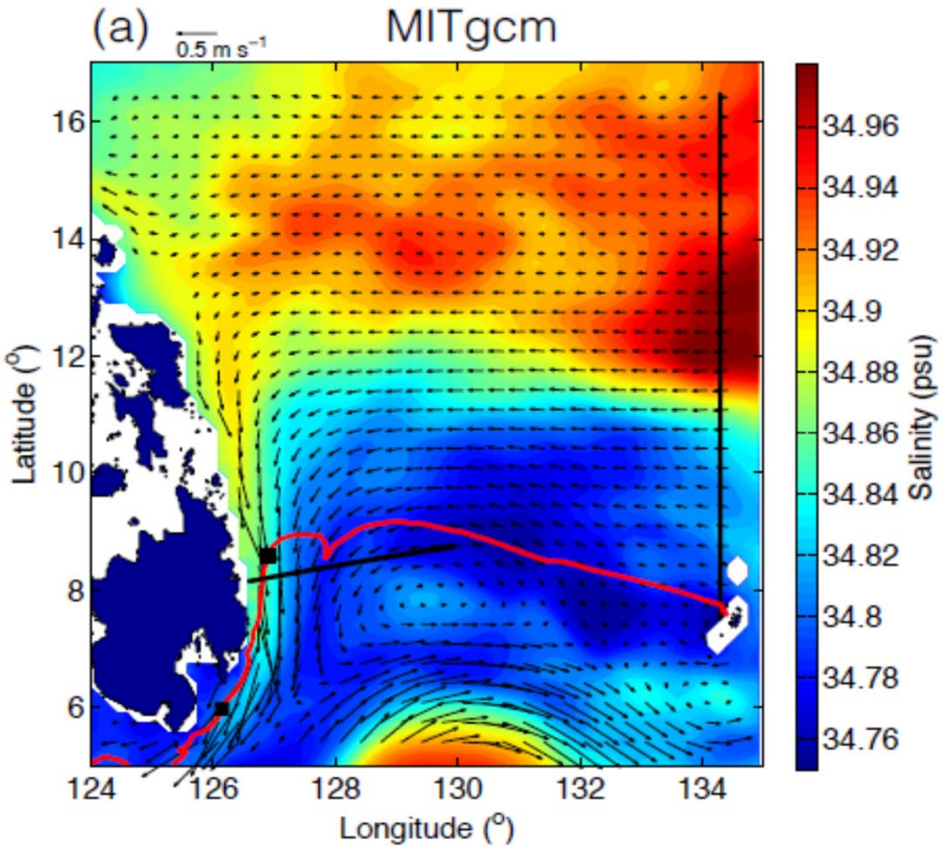
- Anomalous 0-400 m Heat Content in a composite cyclonic (cold-core) eddy (top) and anti-cyclonic (warm-core) eddy (bottom).
- Note asymmetry of heat content (also found for Chl-a and potentially gas uptake).



Daily sea surface height anomaly and locations of XBT casts (black x), and cyclonic (blue) and anticyclonic (red) eddies

Stephenson, G.R, S.T. Gille and J. Sprintall, *J. Geophys. Res.*, 2014

Data Assimilation Models: Estimating the circulation in the northwestern Pacific using HR-XBT, Argo, and altimetry

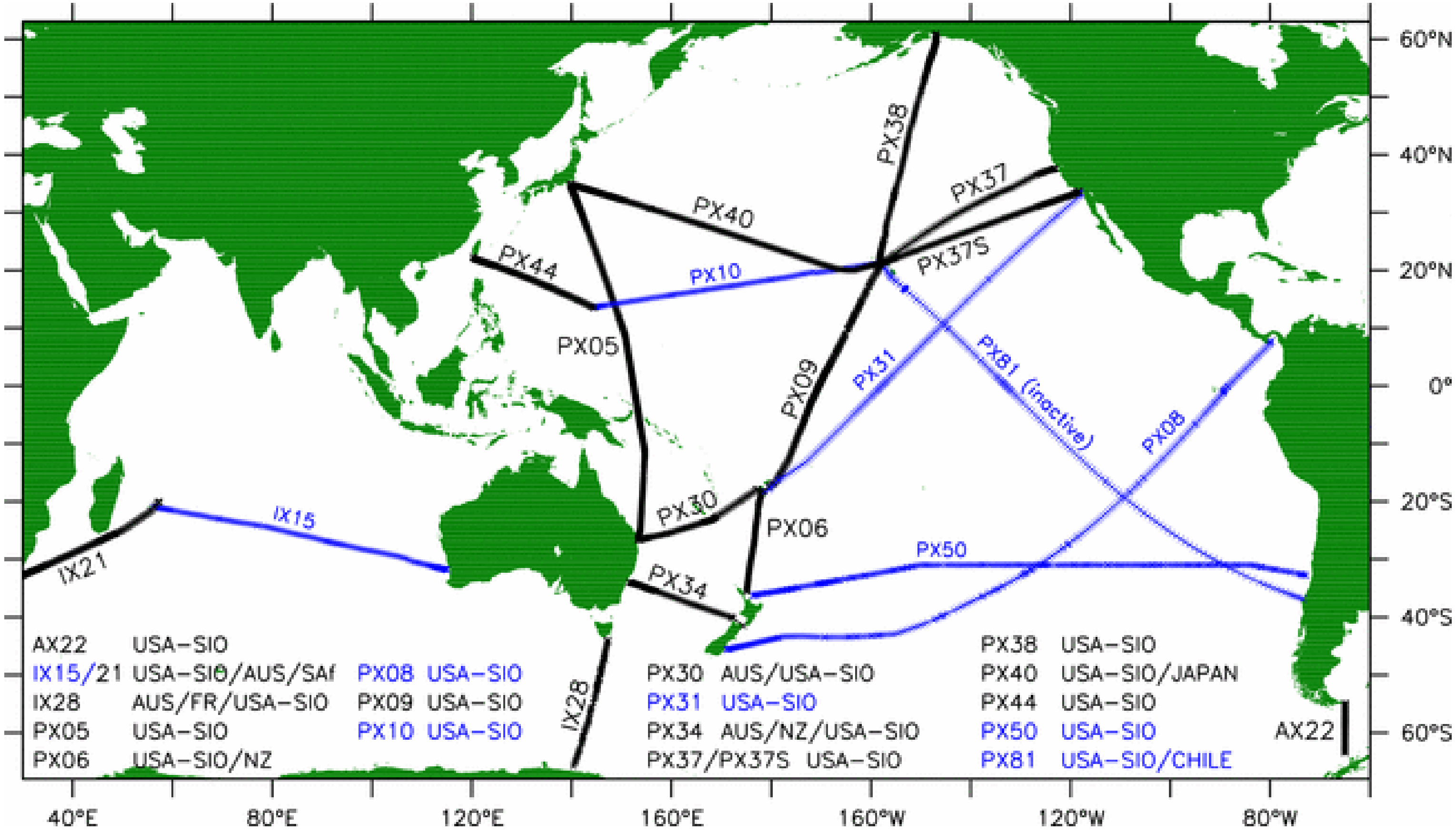


Advection of North Pacific Tropical Water shown on a horizontal map of velocity (arrows) and salinity (color) averaged over potential density range 23.5 to 24 kgm^{-3} from the MITgcm for April 2011, timed to match the time of glider sampling denoted by the red line

- Estimating the Circulation and Climate of the Ocean (ECCO) state estimation constructed from the HR-XBT, Argo, altimeter, and glider data
- Goal to understand the West Pacific circulation near the Philippines and of the dynamics and connectivity of the Kuroshio and Mindanao western boundary currents

(B.D. Cornuelle)

SIO HRX: Future Status and Plans



- Major challenge remains transient nature and routing changes of the commercial shipping industry.
    - PX44 kaput – not scientifically good for Kuroshio, offline
    - PX05 dry-dock in Nov 2016, then ship resumes NZ-Chile (PX50) – YAY!
- Our priority is to sustain the long time-series transects, particularly those including boundary currents

Conclusions

The HRX network unique contribution is in providing regularly repeating temperature, geostrophic velocity and transport estimates that span ocean basins from boundary to boundary

The HRX network increases the value of the combined observing system (Argo, air-sea fluxes, repeat hydrography, ADCP, pCO_2 etc.): through repeat, high resolution measurements in boundary currents, eddies and fronts

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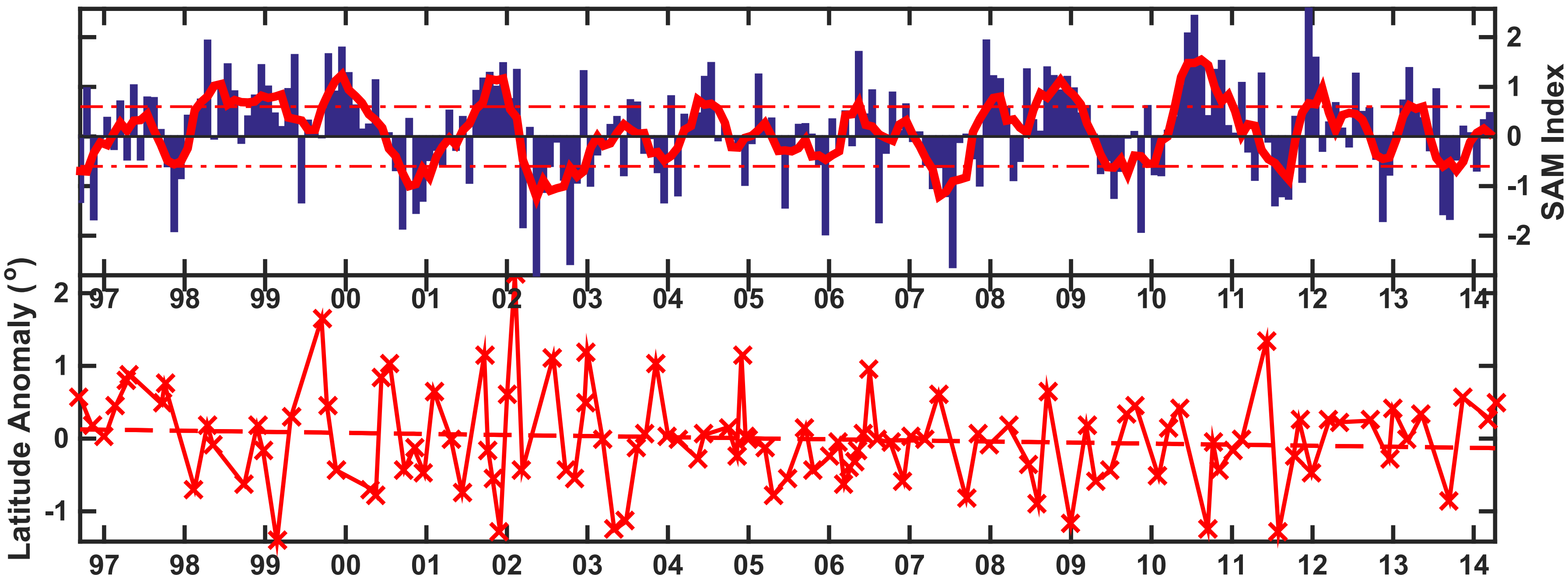
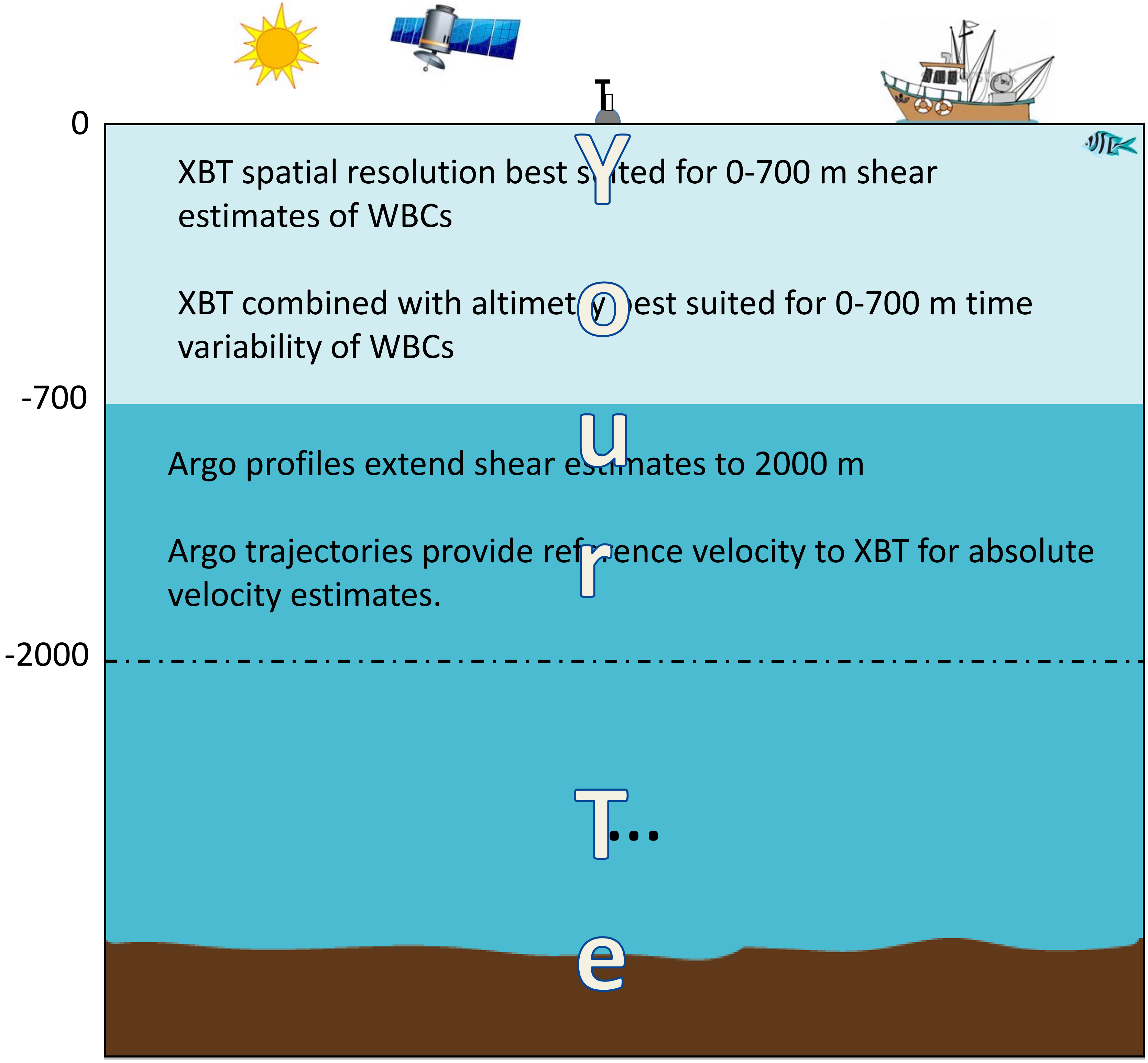
Shifting fronts in response to shifting winds



- SAM index mostly trended positive, although this is interspersed with weak (e.g. 2003-2007; >2012) and strong (2008-2001) variability.
- Poleward shift and strengthening of the westerly winds -> location of the Polar Front in Drake Passage has shifted southward by ~38 km/decade (significant at 95%).
- However, the trend up until the end of 2011, was 58 km/decade, and has since slowly decreased to 30 km/decade.
- Are these changes are due to internal climate variability or longer term change?
- Examine impact of frontal shift on carbon variability

Sprintall (in preparation)


0
XBT spatial resolution best suited for 0-700 m shear estimates of WBCs
XBT combined with altimetry best suited for 0-700 m time variability of WBCs
-700
Argo profiles extend shear estimates to 2000 m
Argo trajectories provide reference velocity to XBT for absolute velocity estimates.
-2000
…

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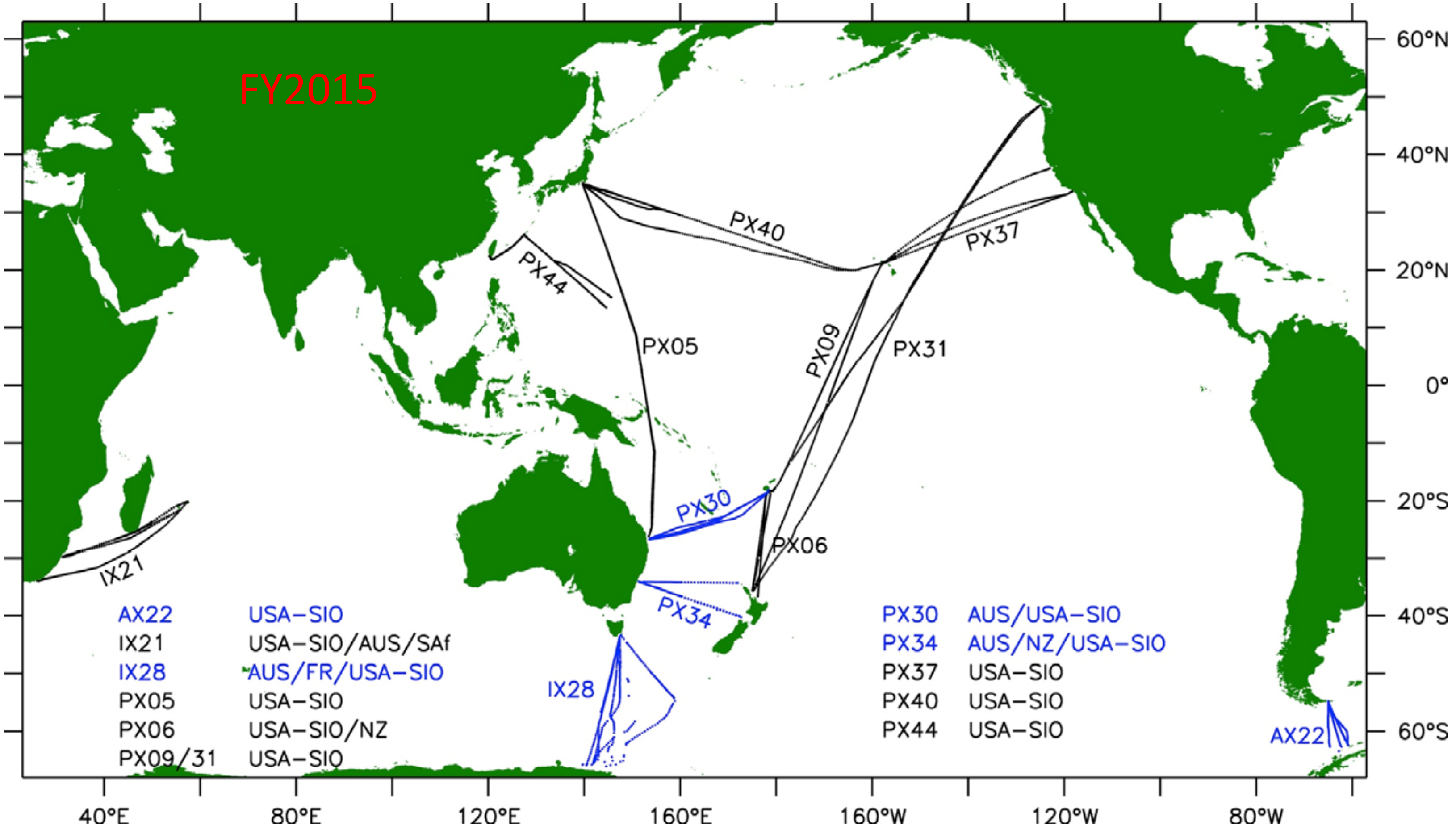

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