

# XBT Science Team: Updates and Recommendations

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On behalf of the XBT Science Team

Special thanks to: Gustavo Goni, Janet Sprintall, Marlos Goes, and Francis Bringas

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# EXpendable BathyThermographs (XBTs)

- XBTs measure water temperature profiles from the sea surface to a maximum depth of 850 m.
- On average, approximately 20,000 XBTs are deployed per year.
- XBTs have been historically deployed by navies, research vessels, and merchant ships.
- The countries that provide the largest contributions to this program are the United States, Australia, France, South Africa, Brazil, Germany, Italy, and Japan.



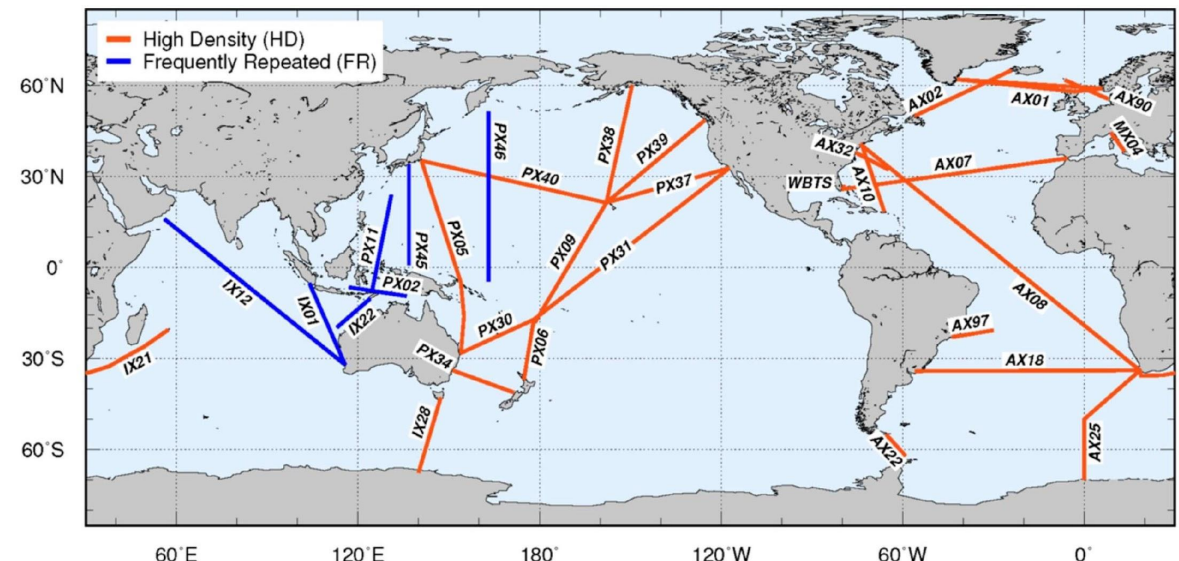
An EXpendable BathyThermograph (XBT) with its probe inside a canister (top). On the right is an exploded view of the XBT.



# Global XBT Network

XBTs are deployed in two spatial modes:

- **High-density/resolution mode (10-50 km):** aimed at obtaining high spatial resolution in a single realization to resolve the spatial structure of mesoscale eddies, fronts, and boundary currents. (Four or more repetitions per year)
- **Frequently Repeated mode (100-150 km):** aimed at obtaining repeat surveys along those transects where there is high temporal variability. (Twelve or more repetitions per year)



# Global XBT Network Highlights

Collaborating

~10

Countries

Maintaining

~30

Transects

Monitoring

~20

Ocean Currents

Providing

>30

Years of continuous  
record

Contributing

~100

Publications/year

[www-hrx.ucsd.edu](http://www-hrx.ucsd.edu)

[www.aoml.noaa.gov/phod/hdenxbt/index.php](http://www.aoml.noaa.gov/phod/hdenxbt/index.php)

[www.aoml.noaa.gov/phod/goos/bib/index.php](http://www.aoml.noaa.gov/phod/goos/bib/index.php)

[www.aoml.noaa.gov/phod/goos/xbtscience/index.php](http://www.aoml.noaa.gov/phod/goos/xbtscience/index.php)

*XBT deployments across the shelf into the Gulf Stream started in 1977 (50+ years!)*

# Contributions of Global XBT Network to Science

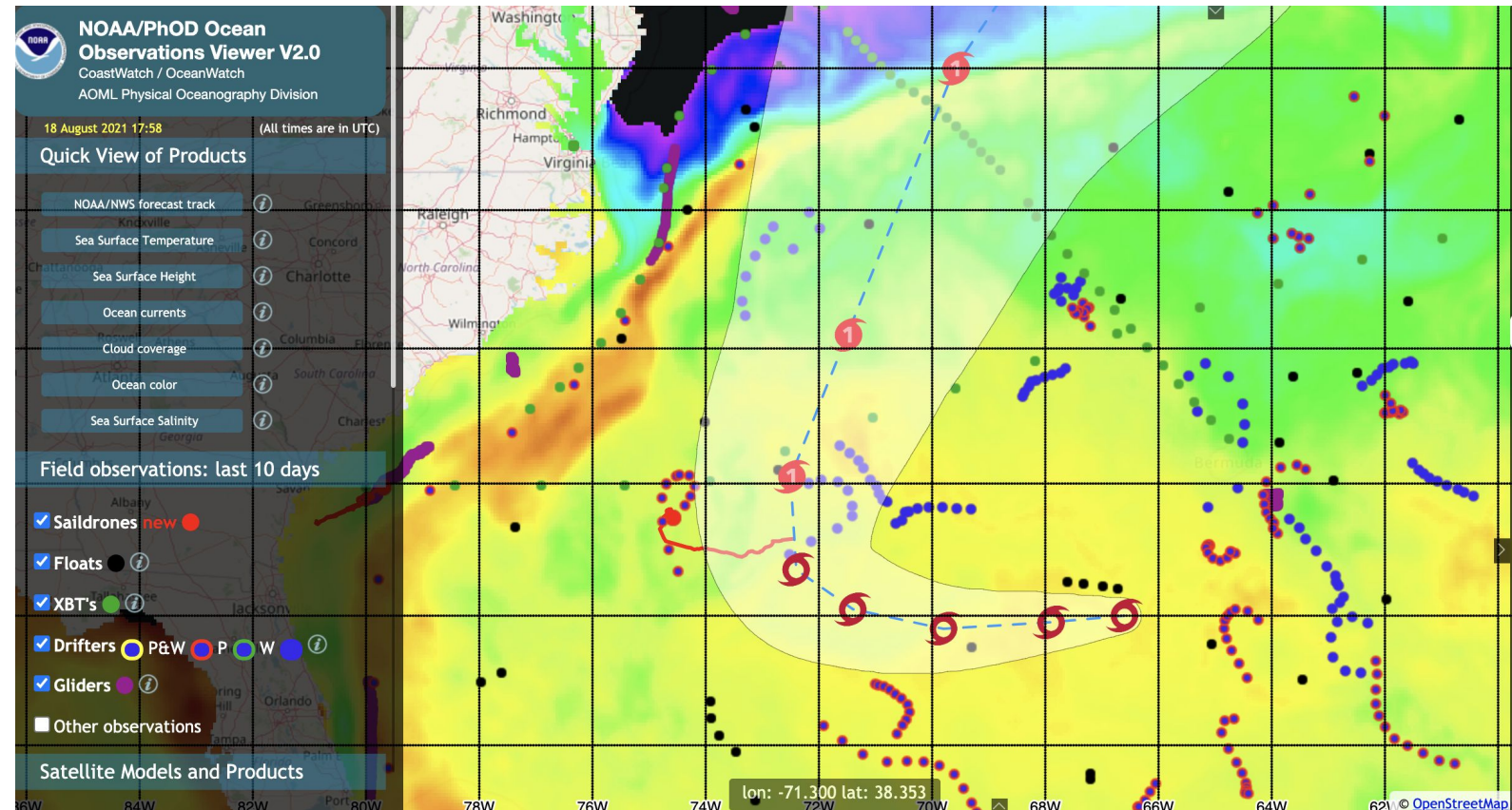
- Monitor the state and spatial and temporal variability of key surface and subsurface ocean currents and boundary currents, including their transport;
- Provide upper ocean thermal profile observations to estimate global and regional Ocean Heat Content (OHC) in areas undersampled by other observational platforms (such as boundary currents);
- Monitor the state and variability of the Meridional Heat Transport (MHT) and Meridional Overturning Circulation (MOC) across ocean basins;
- Study impact of oceanic variability, monitored by XBTs together with other observational platforms, on climate and weather;
- Initialize and validate Ocean Forecasting Systems;
- Provide constraints through data assimilation for ocean reanalysis hindcasts; and
- Education including numerous PhD theses and postdoc support



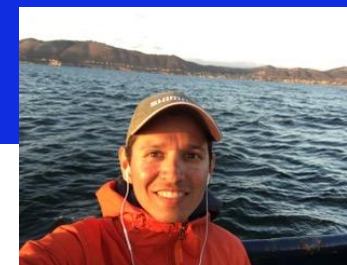
# Activities and Challenges During FY2020 and FY2021

- Due to COVID impact on shipping and travel restrictions for ship-riders, some boundary transects now done by ships crew in low resolution
- In partnership with cargo vessel companies, AOML began conducting continental shelf measurements of temperature profiles using XBTs along transects between the northeast US and Florida, provide temperature observations in regions with waters that are undersampled and that are known to contribute to hurricane intensity changes
- Simultaneous meteorological and oceanographic observations in the North Atlantic Ocean.

Ocean observations during August 8 – August 18, 2021, ahead of TS Henri



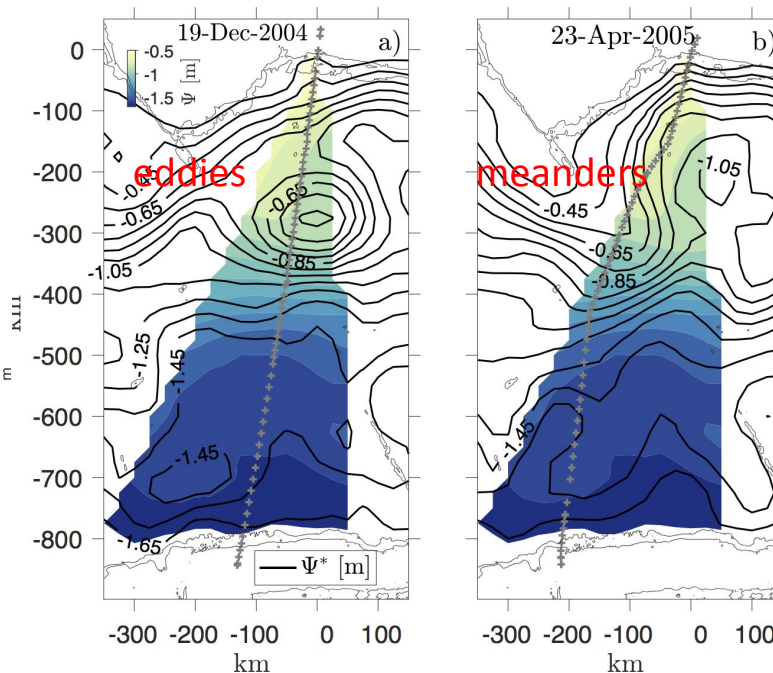
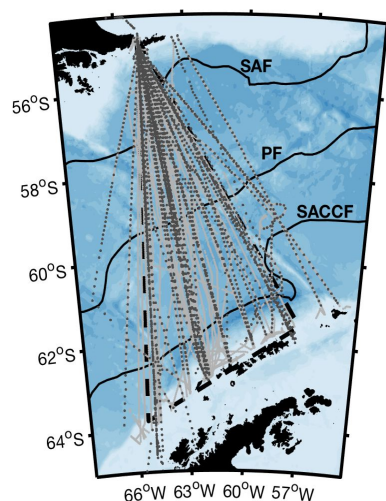
# Science: Derived Eddy Heat Fluxes



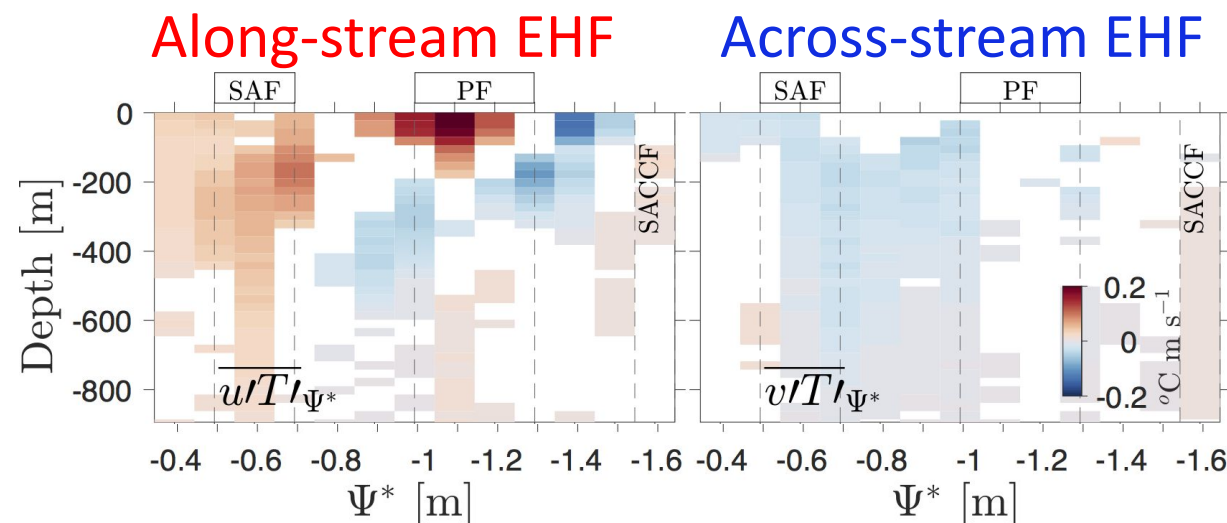
- SIO Ph.D. Student Manuel O. Gutierrez-Villanueva

The [20+ year-round time series of simultaneous sADCP velocity and XBT](#) measurements in Drake Passage enable computation of directly observed estimates of eddy heat fluxes

XBT transects . . .  
sADCP transects . . .



*Mean (mapped ADCP velocity) and synoptic streamlines (SSH anomaly)*



*Along-stream EHF peaks in SAF and PF.*

*Across-stream EHF is largest poleward in SAF, but is continuously poleward from the SAF through the PFZ, tapering to insignificant in the PF.*

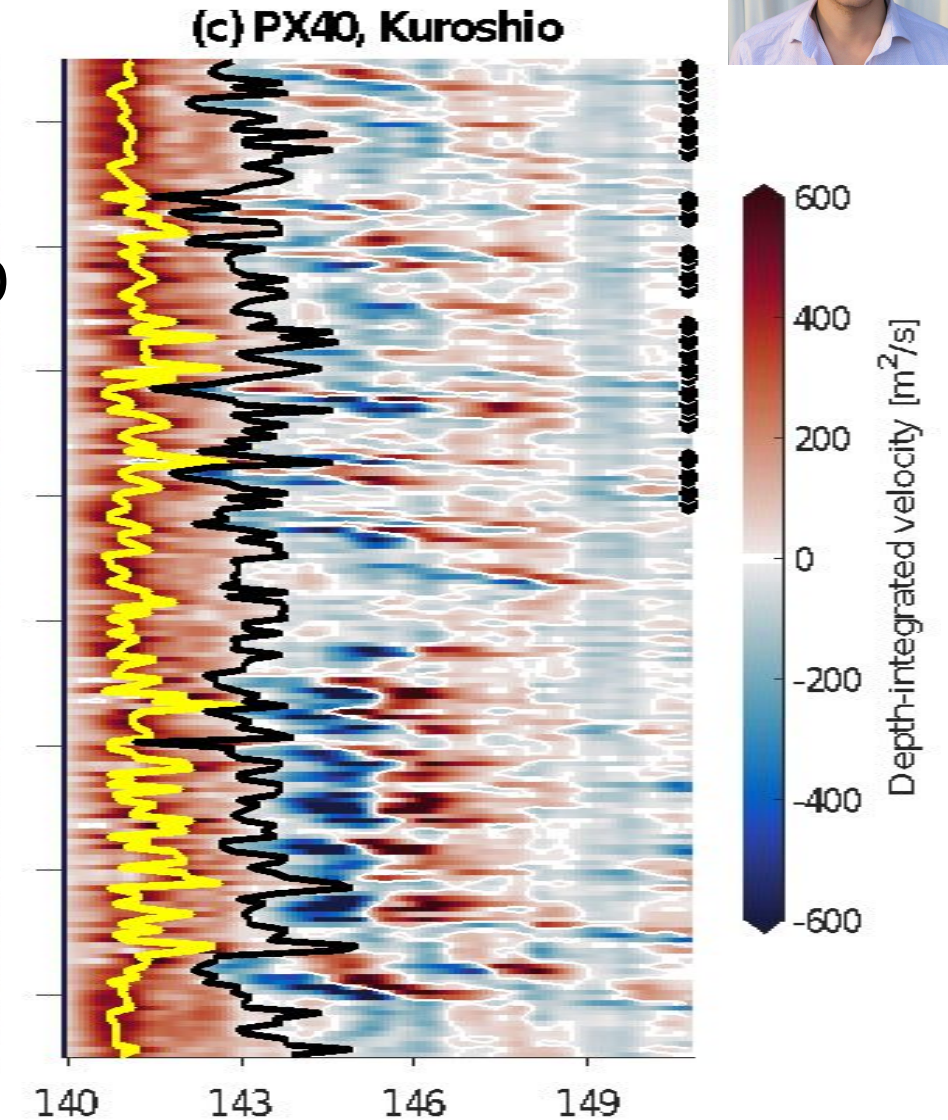
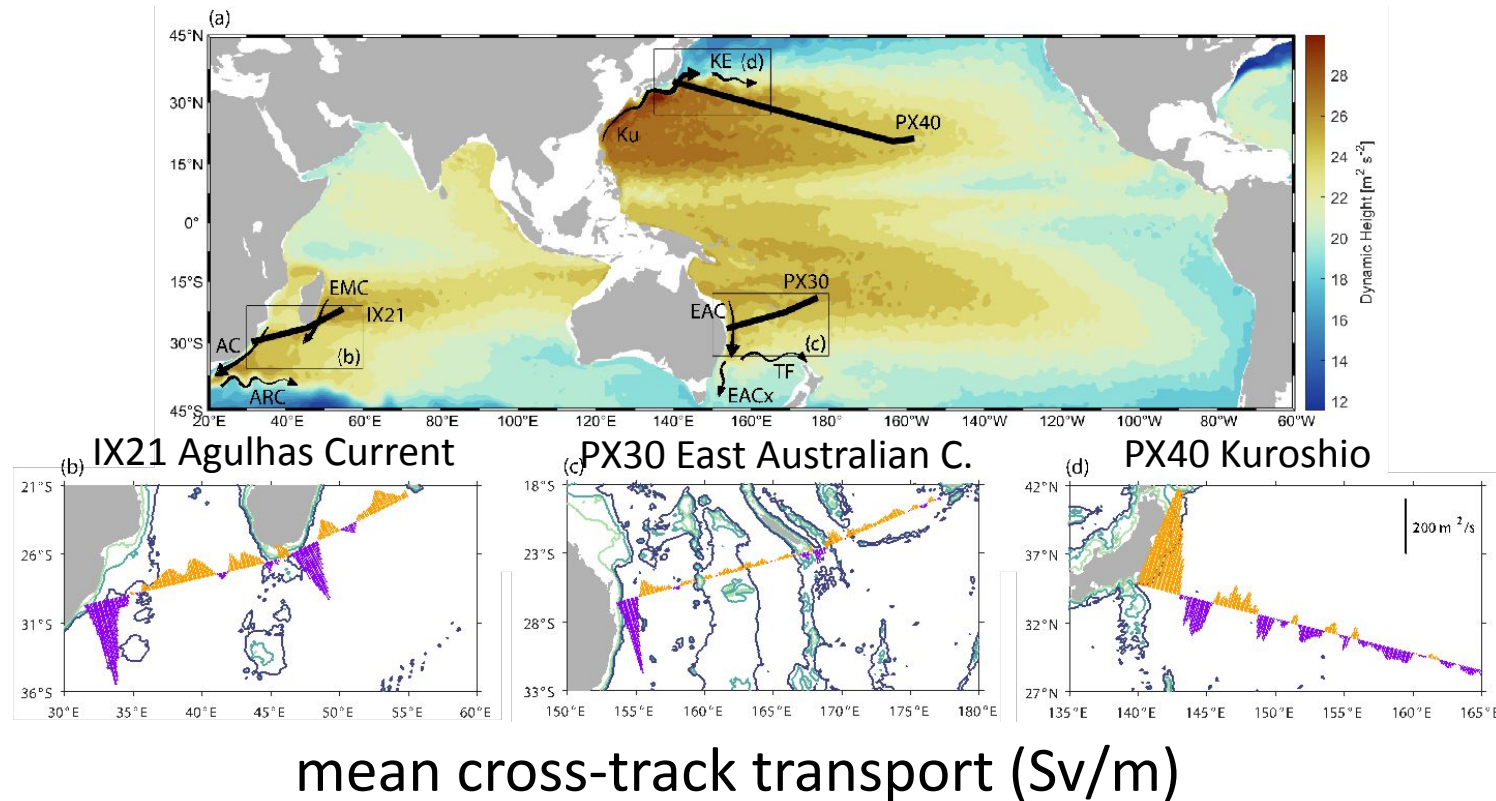


# Science: Variability in Western Boundary Currents

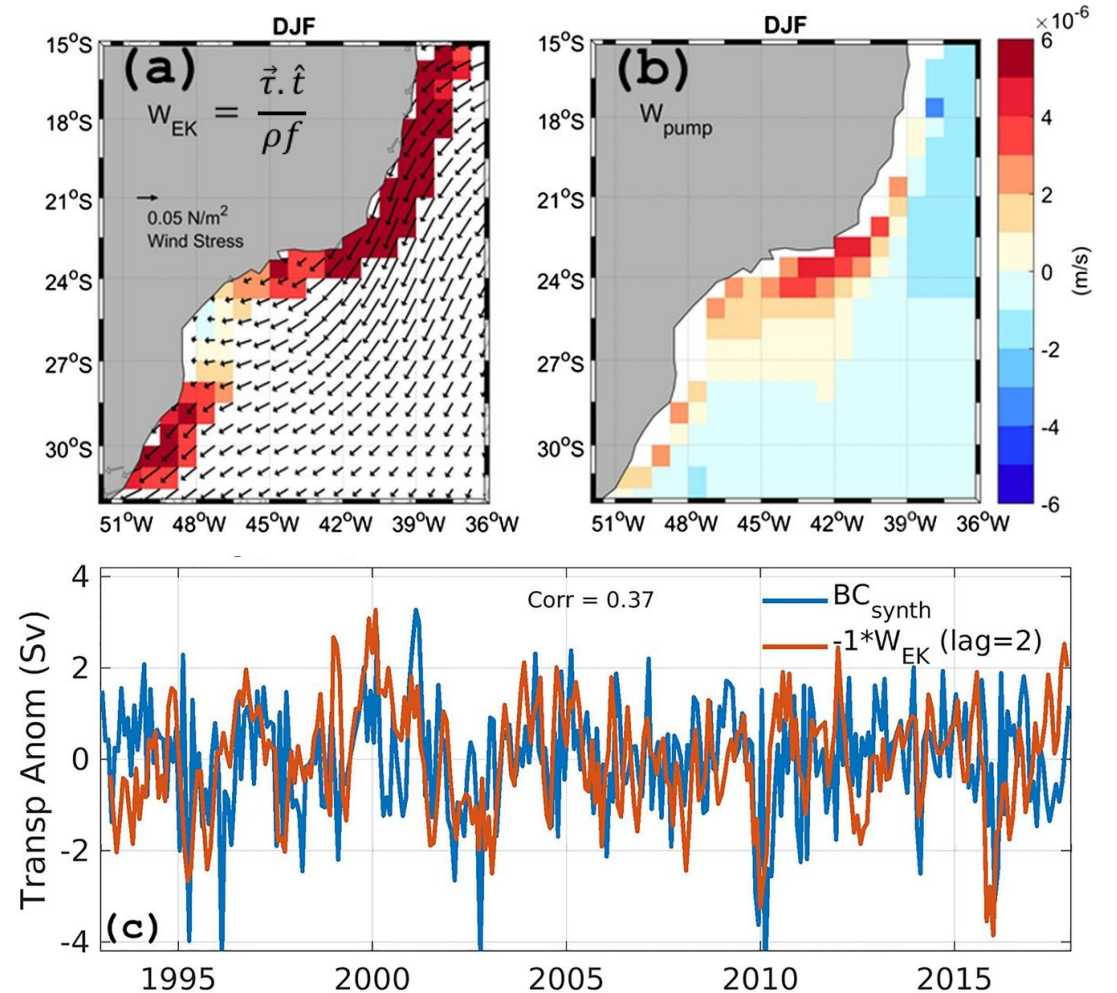
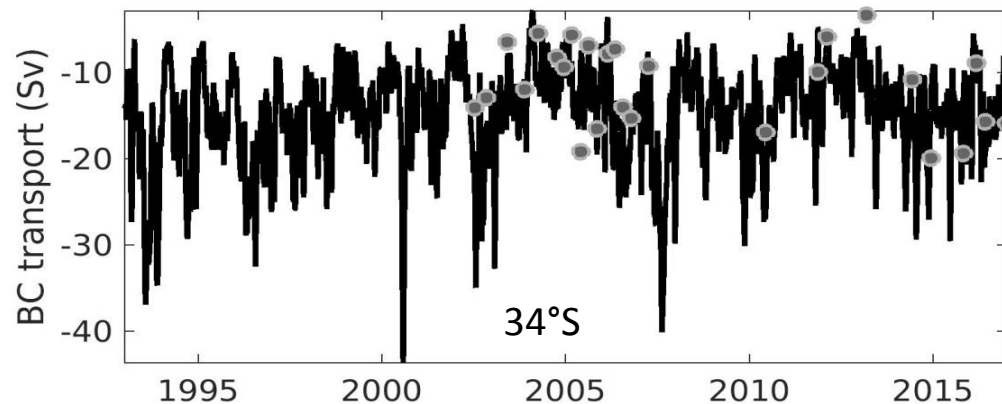
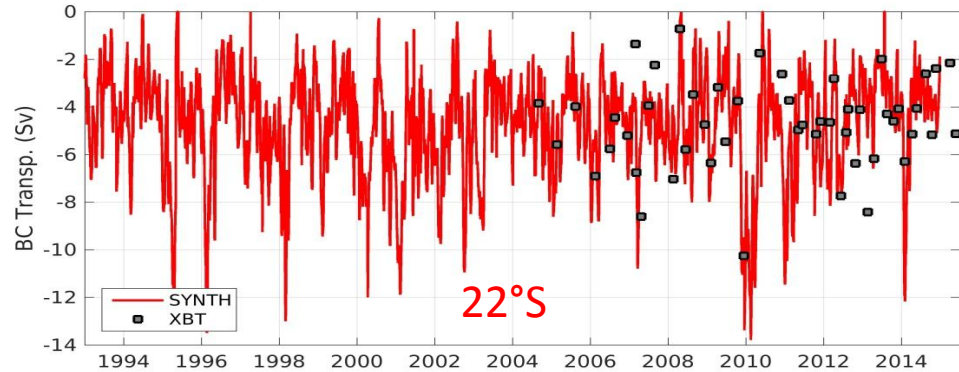
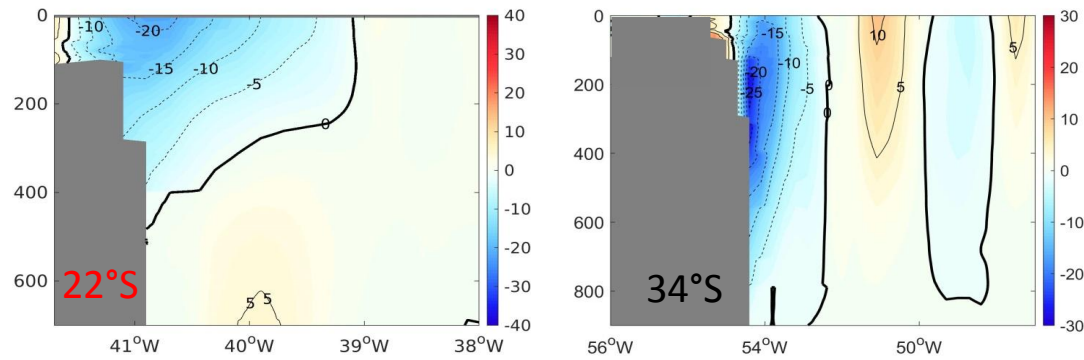


SIO Ph.D. Student Mitchell Chandler

Sustained HR-XBT, Argo, and altimetry observations are combined to examine variability in subtropical WBCs. e.g. Kuroshio: decadal changes related to PDO and long-term transport decrease



# Science: Variability in Western Boundary Currents

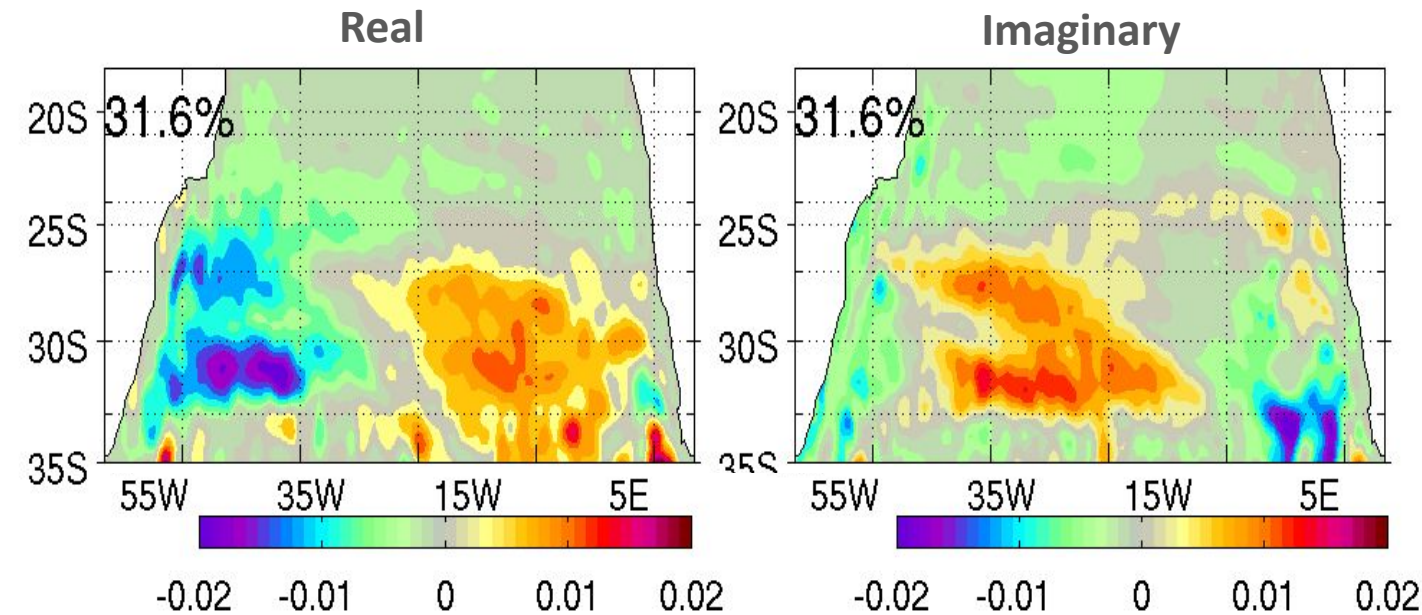


Significant correlation between Brazil Current transport and local coastal upwelling dominated by Ekman divergence ( $W_{EK}$ ).

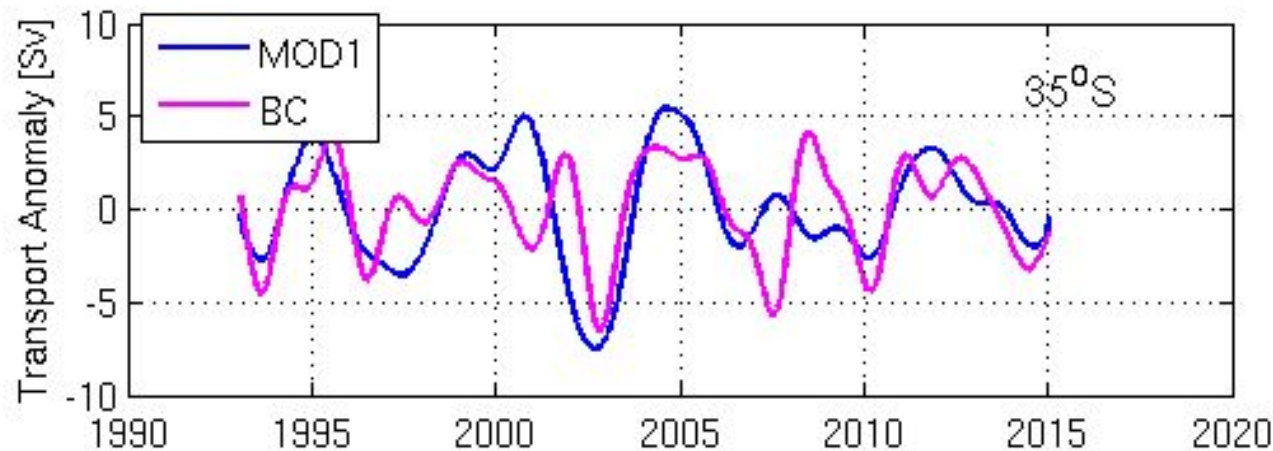
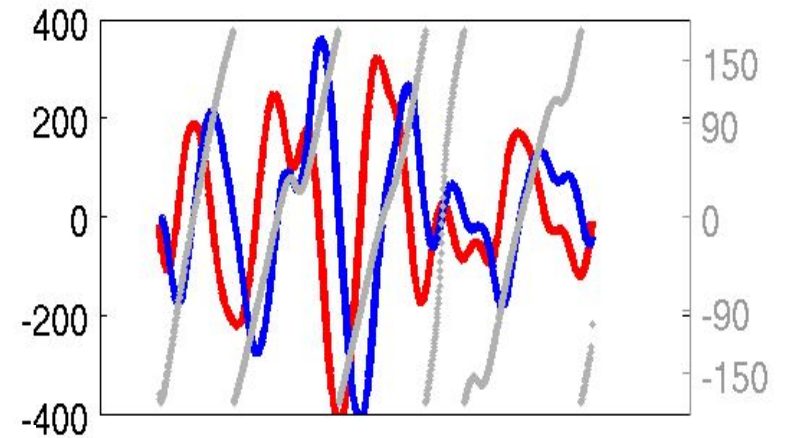


# Science: Variability in Western Boundary Currents

SSH CEOF MOD1



Real and imaginary PCs and phase



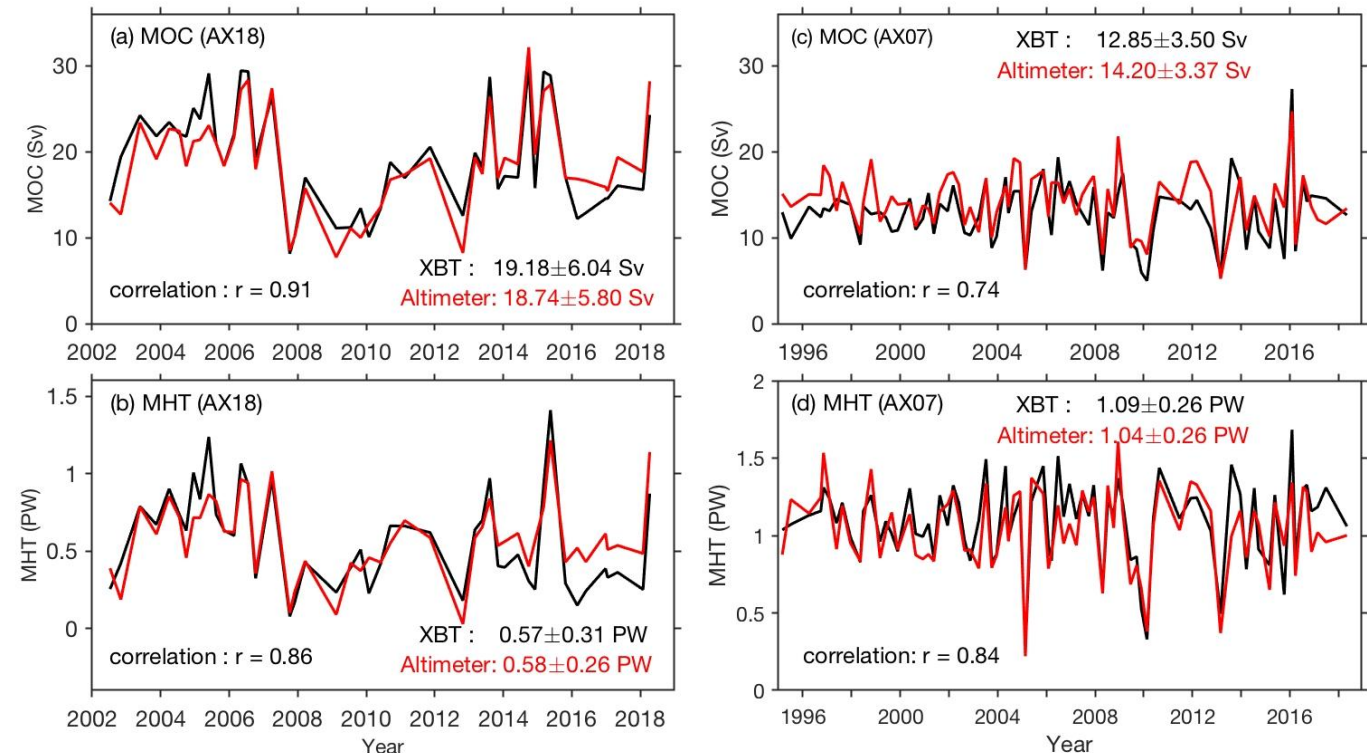
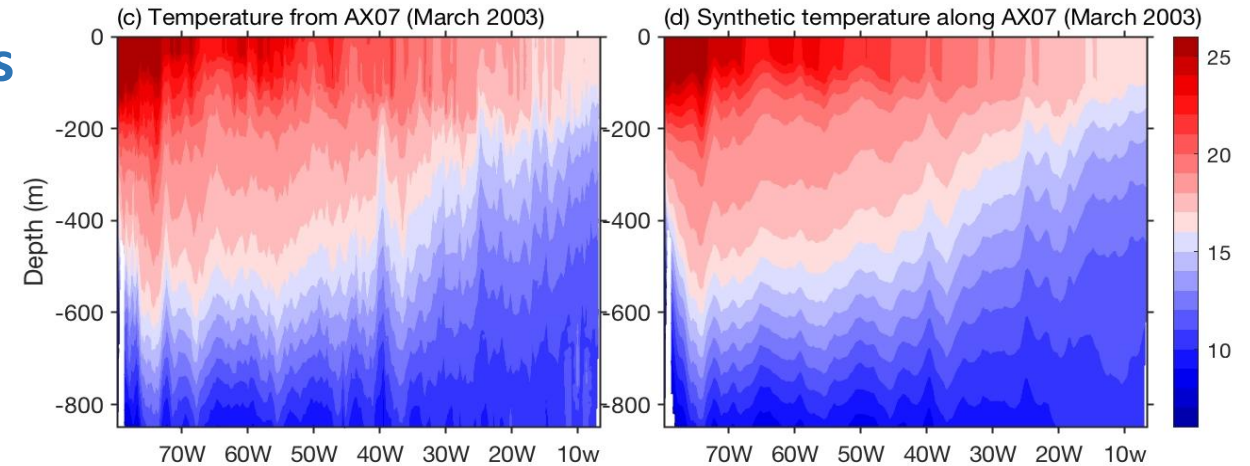
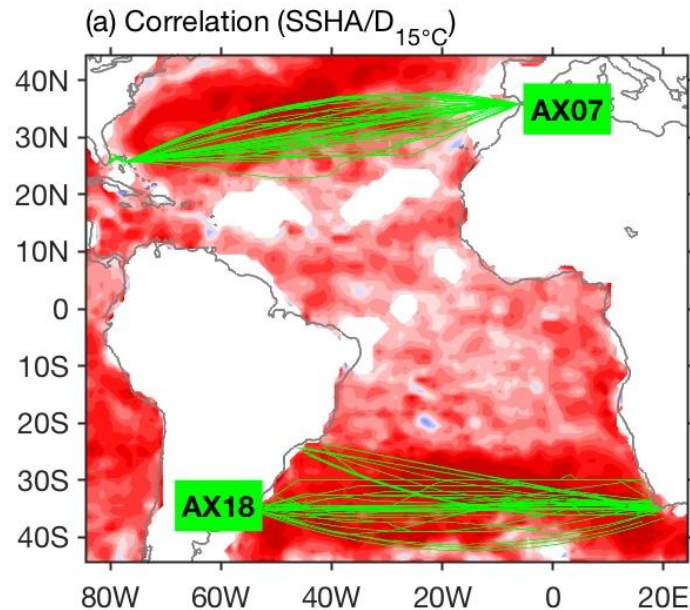
- The interannual variability of the Brazil Current between 25S and 35S is linked to the E-W propagating modes in the South Atlantic.
- The variability of the Brazil Current transport has been linked to regional rainfall patterns of southeast Brazil.

# Science: Meridional Overturning Circulation (MOC)

## MOC and Meridional Heat Transport Estimates from XBT and in-situ/Satellite Observations

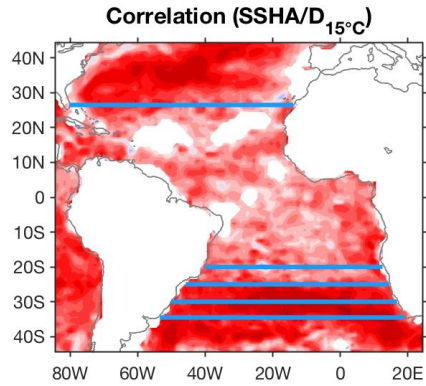
AOML has been maintaining two XBT (eXpendable BathThermograph) transects to monitor the upper limb of the AMOC,

- AX07 at 30°N since 1995, 108 total transects
- AX18 at 34.5°S since 2002, 55 total transects

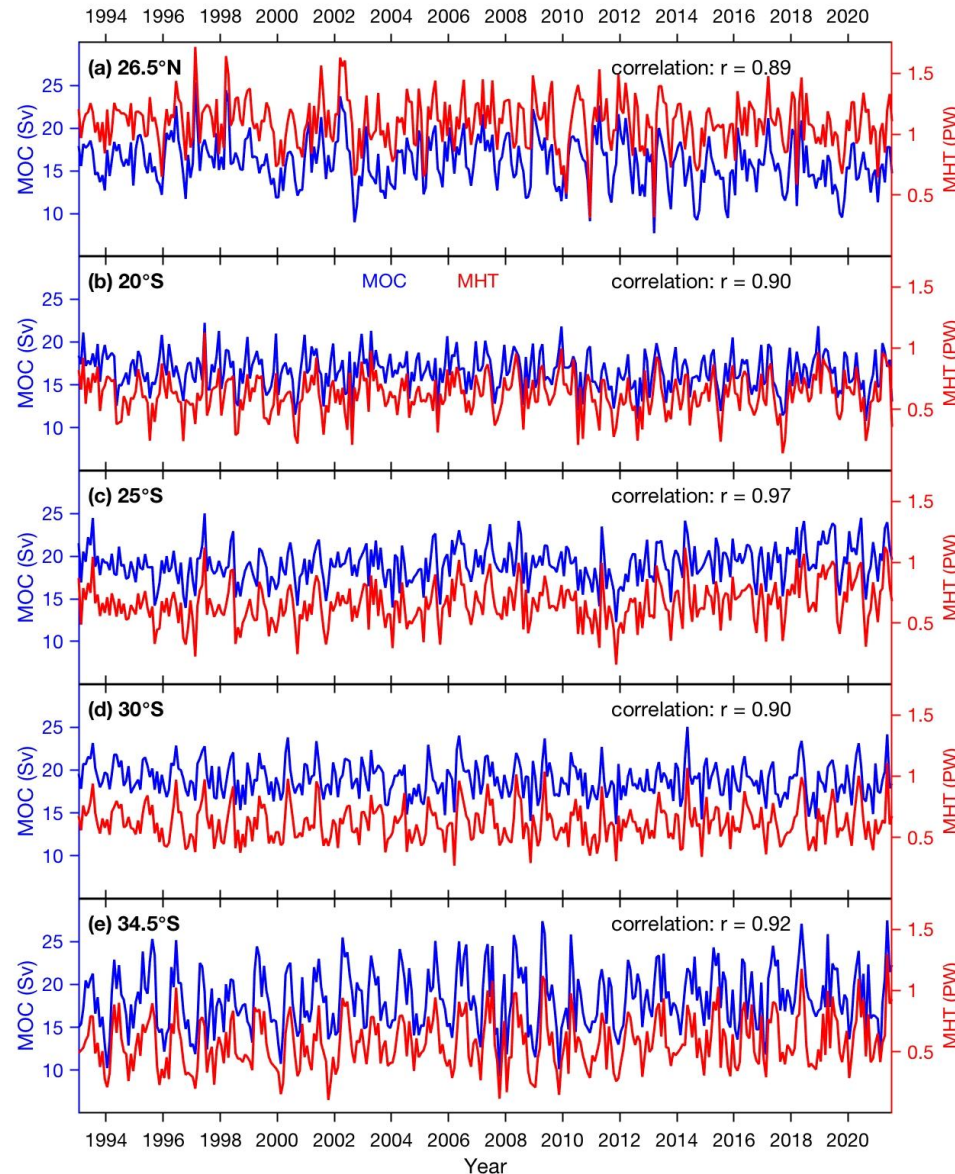




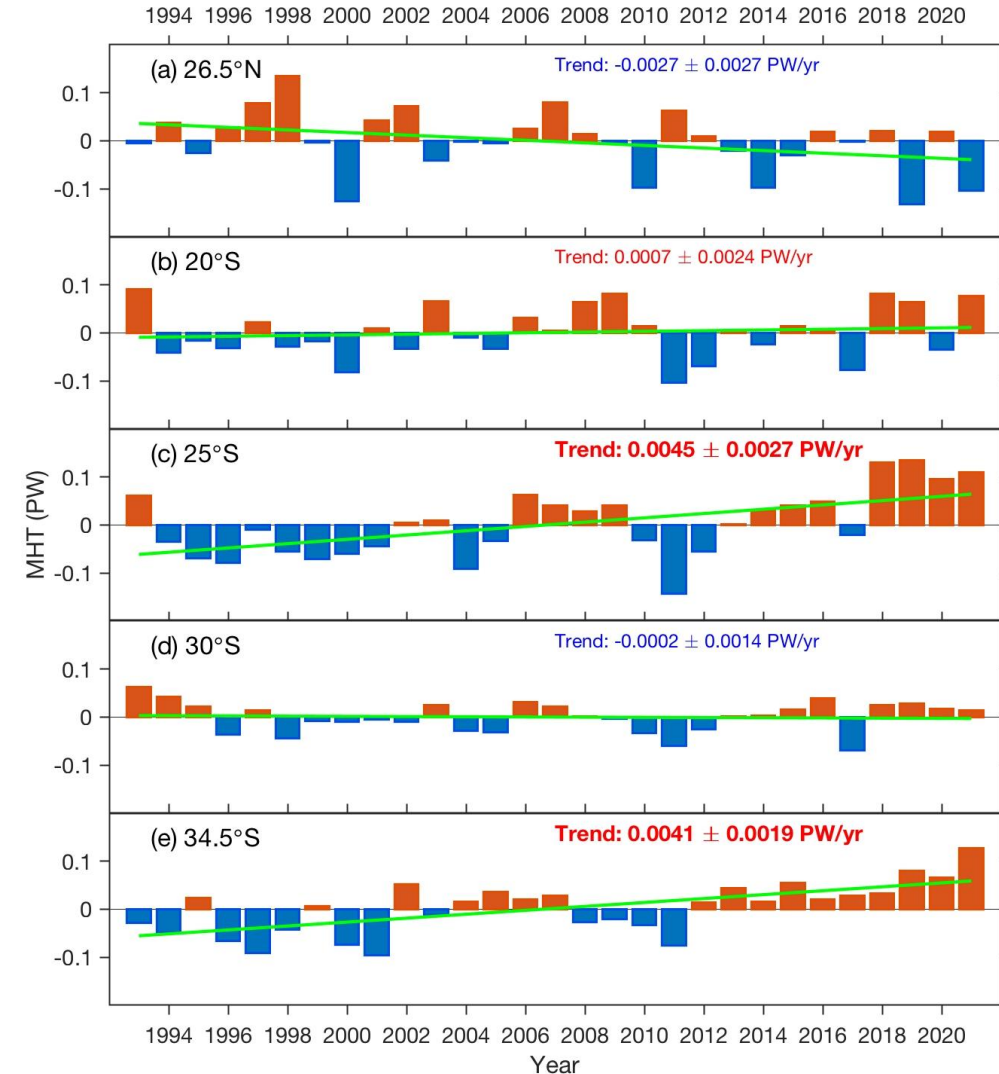
# Science: Meridional Overturning Circulation (MOC)



## Monthly Time Series (1993-present)



## MHT yearly anomalies



### Long-term trends:

- Decreasing trend at 26.5°N, but not significant
- Increasing trends in the South Atlantic at 25°S and 34.5°S.

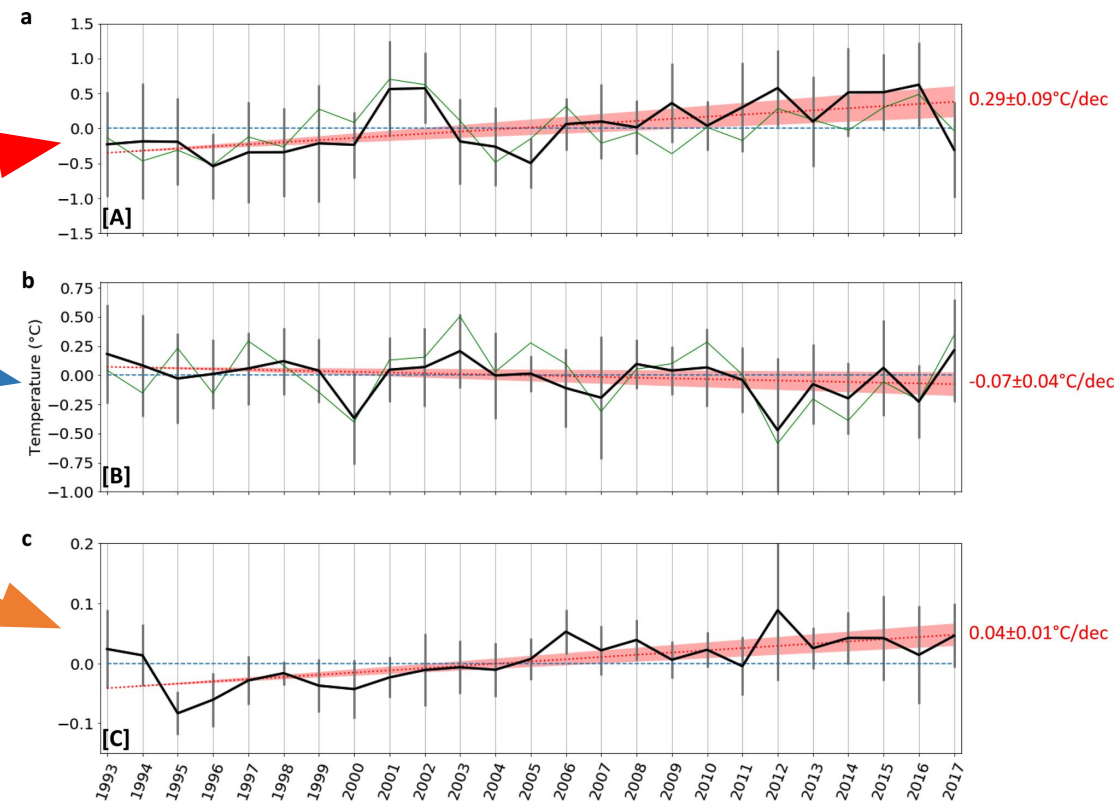
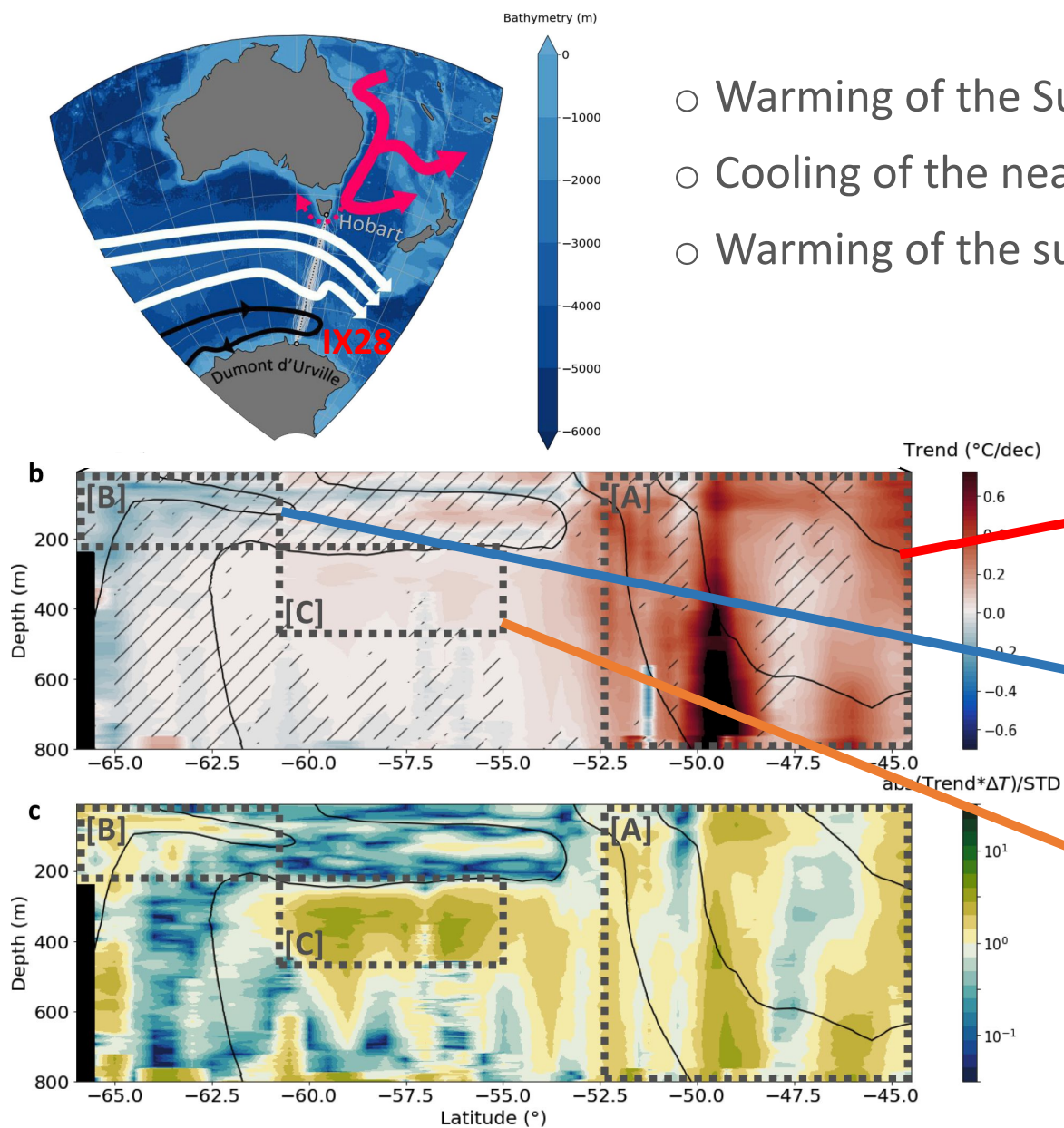
### For 2021:

- Negative anomaly at 26.5°N, -0.1 PW
- Positive anomalies in the South Atlantic, varies from 0.01 PW (30°S) to 0.13 PW (34.5°S).



# Science: Southern Ocean Temperature Trends

- Warming of the Subantarctic Waters ( $0.29 \pm 0.09$  °C per decade)
- Cooling of the near-surface Subpolar Waters ( $-0.07 \pm 0.04$  °C per decade)
- Warming of the subsurface Subpolar Deep Waters ( $0.04 \pm 0.01$  °C per decade)



# Recommendations:

- **Maintenance of long climate record**
- **Improvement of data quality**: allowing for better monitoring and analysis of climate change and variability
- **Simultaneous meteorological and oceanographic observations** to calculate surface heat and moisture fluxes, which are critical for weather and climate research.
- **Submesoscale (<10 km) ocean dynamics**: increasing spatial sampling along selected portions of XBT transects
- **Internal tides**: to help validate the altimetric internal tide observations, as well as ocean models including internal tides.
- **Applications for sea level change and hurricane studies**

**Thank You!**