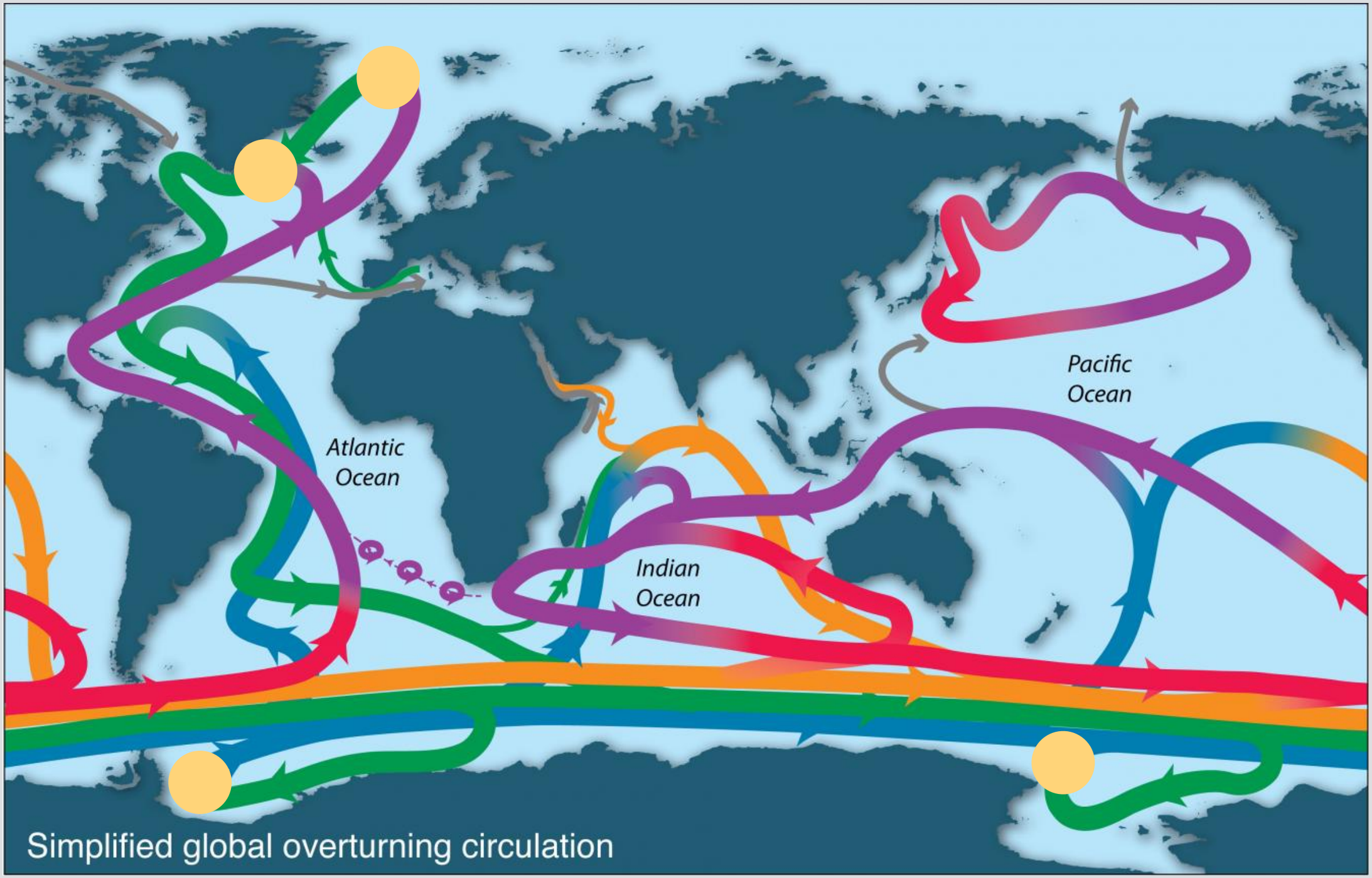
Exploring Ocean Circulation

Jordan Landers

Thinkful Capstone | September 2018

Ocean Circulation

Overview of Currents

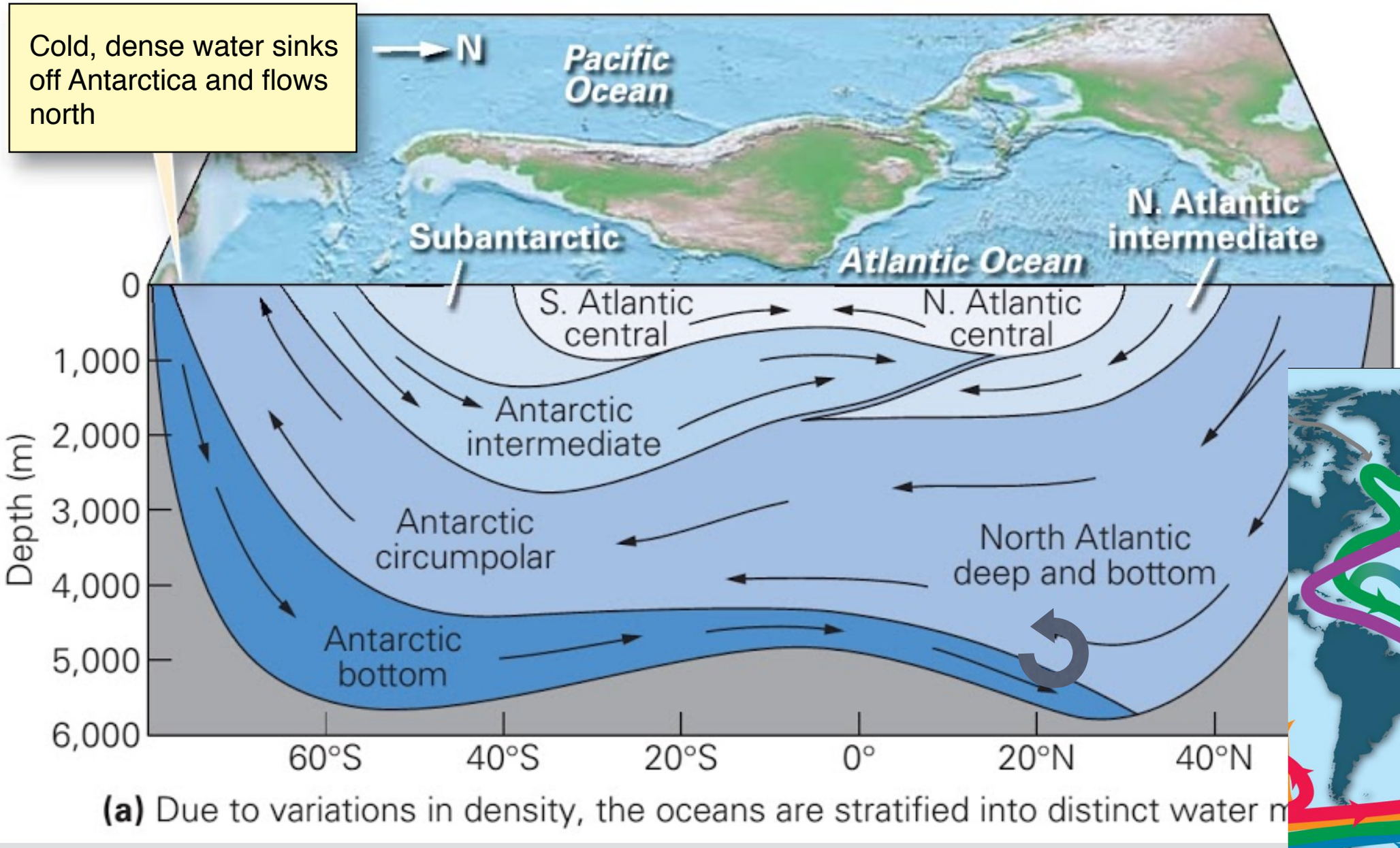


https://phys.org/news/2016-06-wind-blown-antarctic-sea-ice-ocean.html

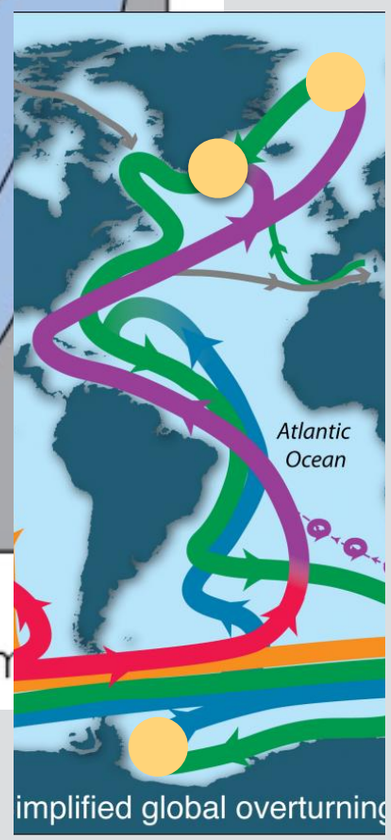
Ocean Circulation... by the slice

Watermass Geometry

Cold, dense water sinks off Antarctica and flows north



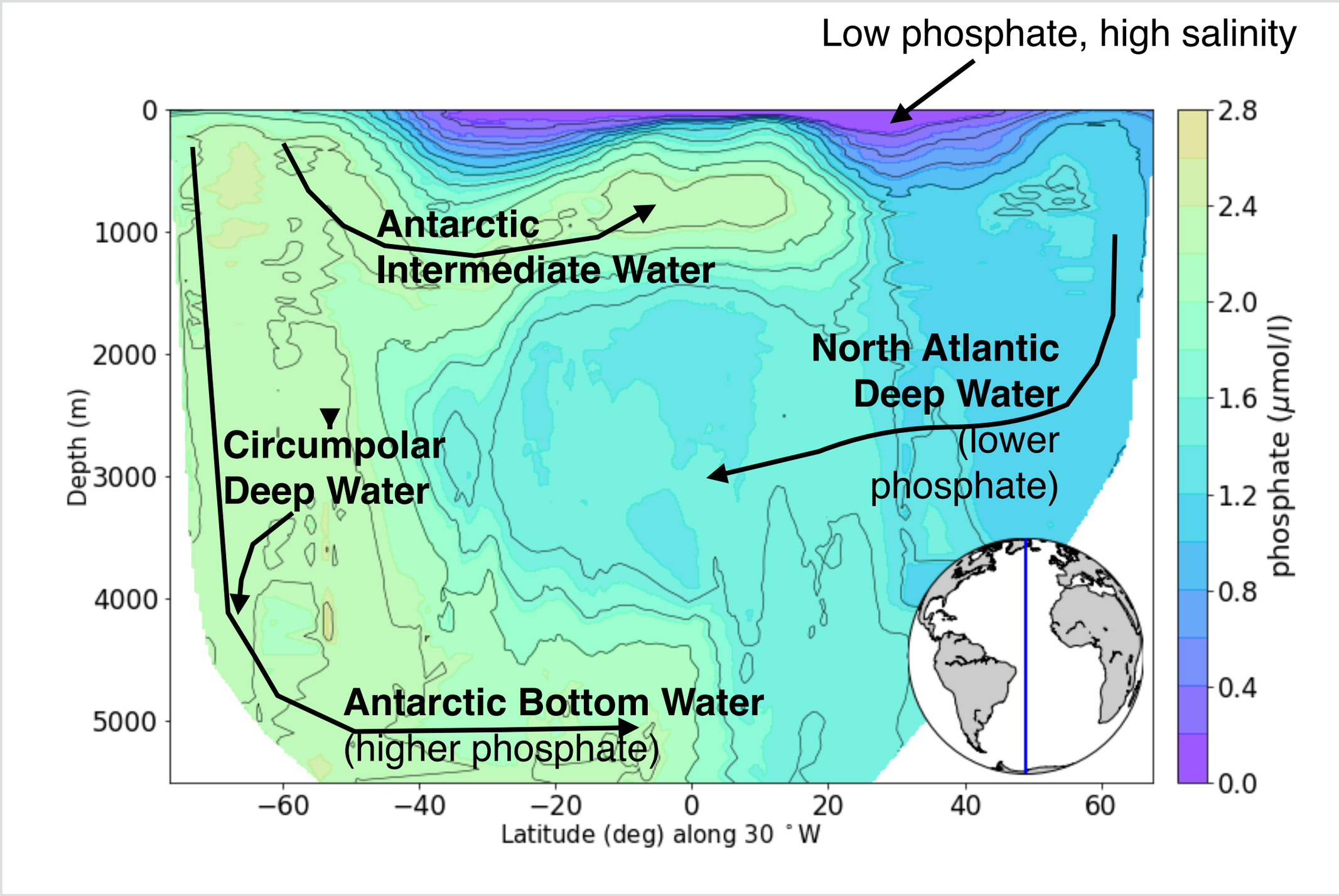
(a) Due to variations in density, the oceans are stratified into distinct water m



http://geologylearn.blogspot.com/2015/12/ocean-waters-and-currents.html

Eyeballing Contours Approach

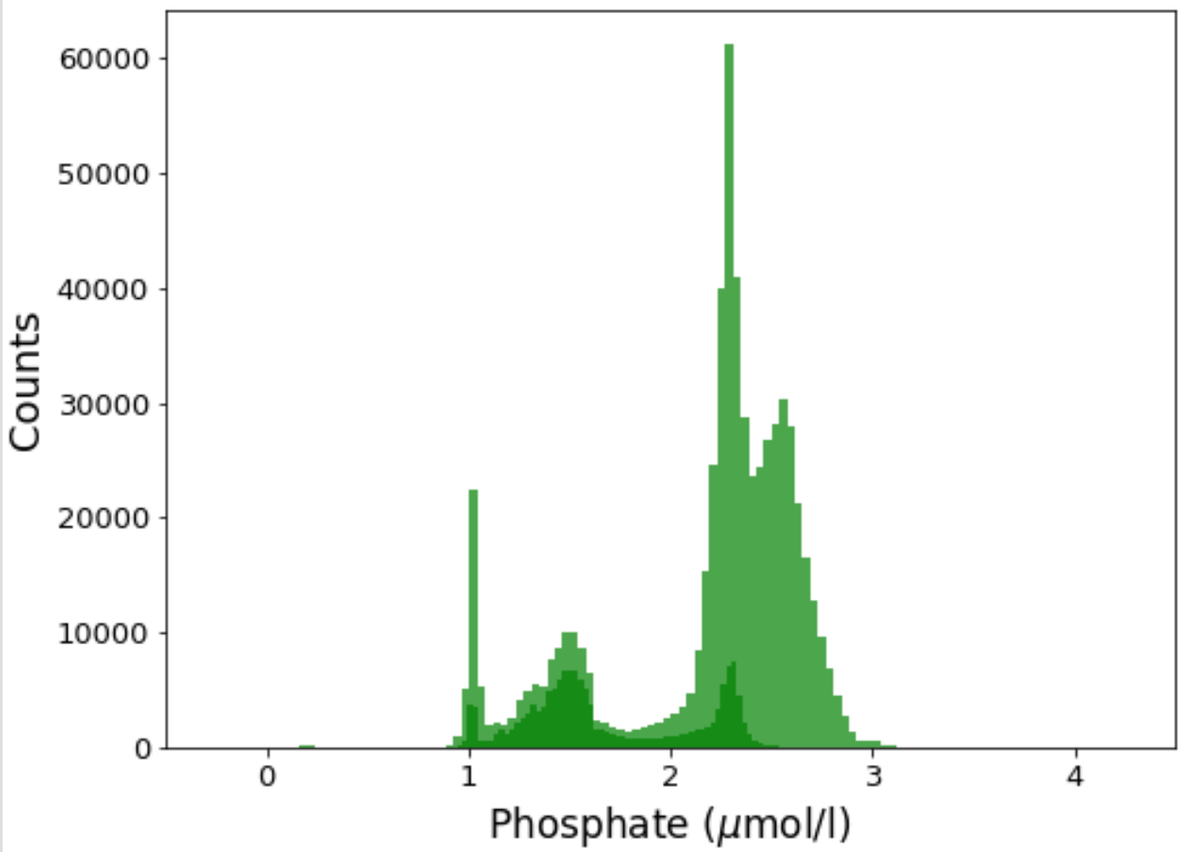
Popular practice for identifying water masses

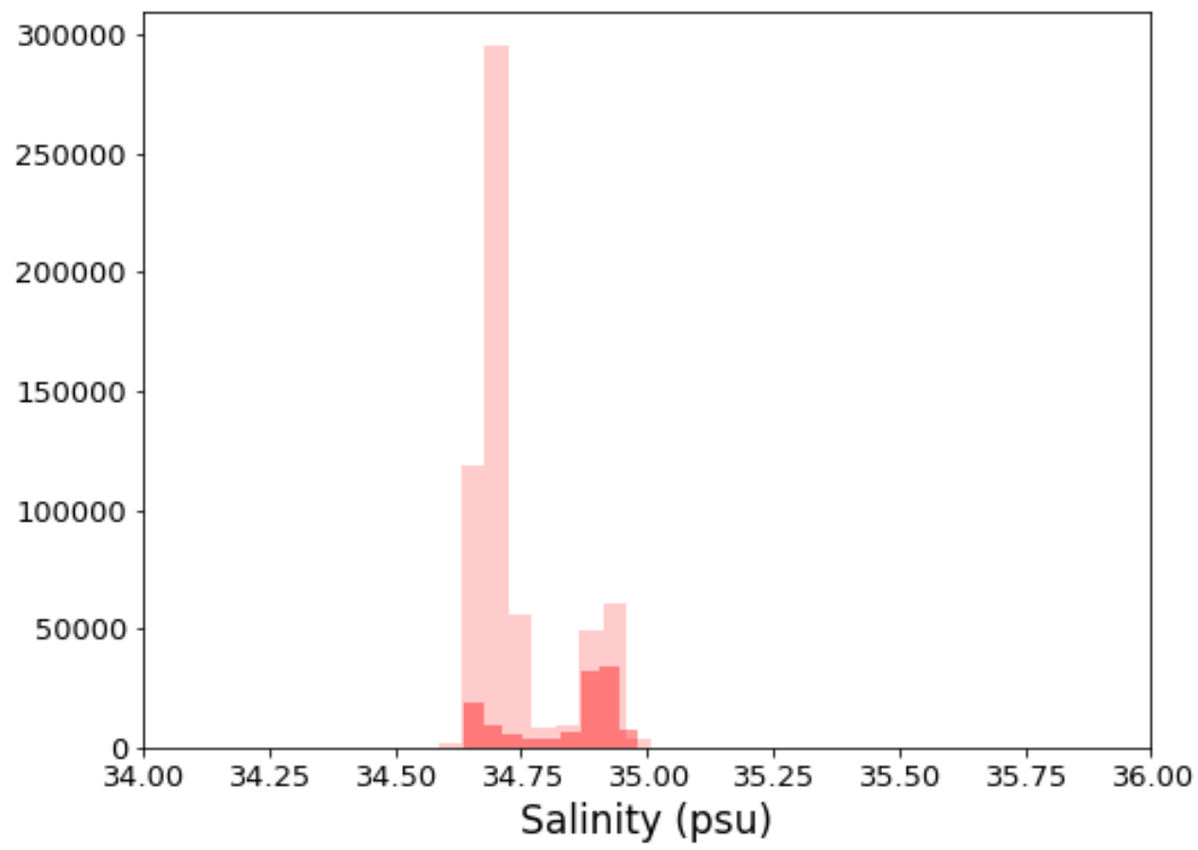


Deep Ocean Tracer Distributions

Popular practice for identifying water masses

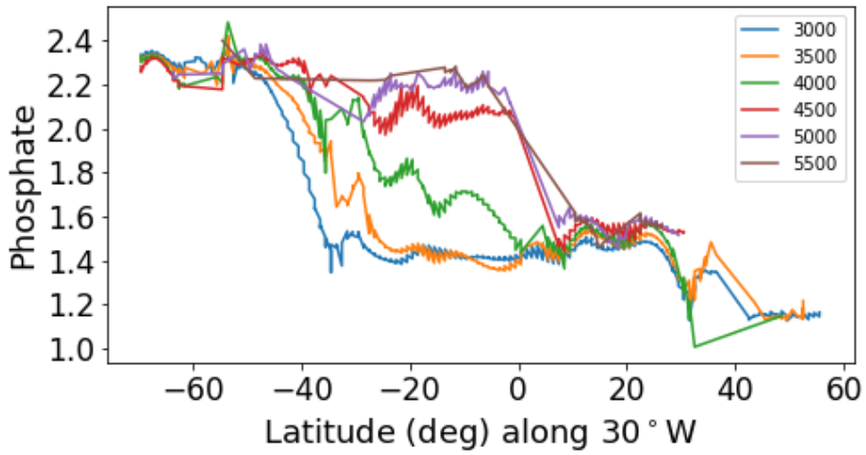
Atlantic basin below 2,500 m (dark), global ocean below 2,500 m (light)

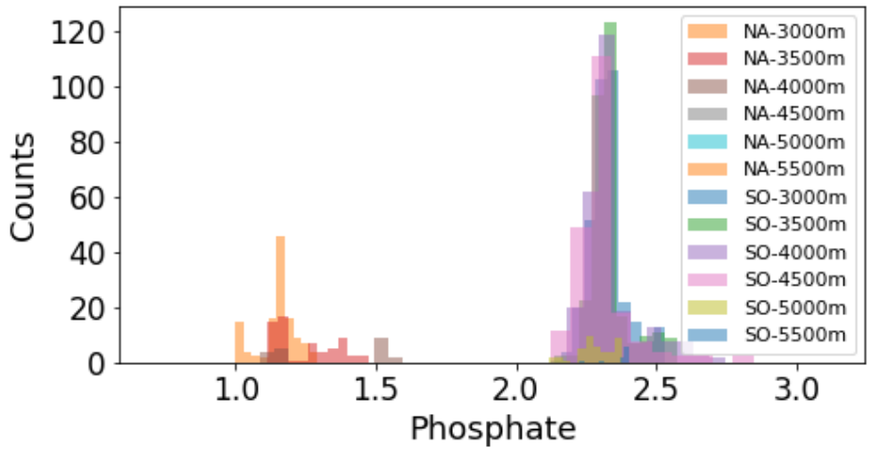


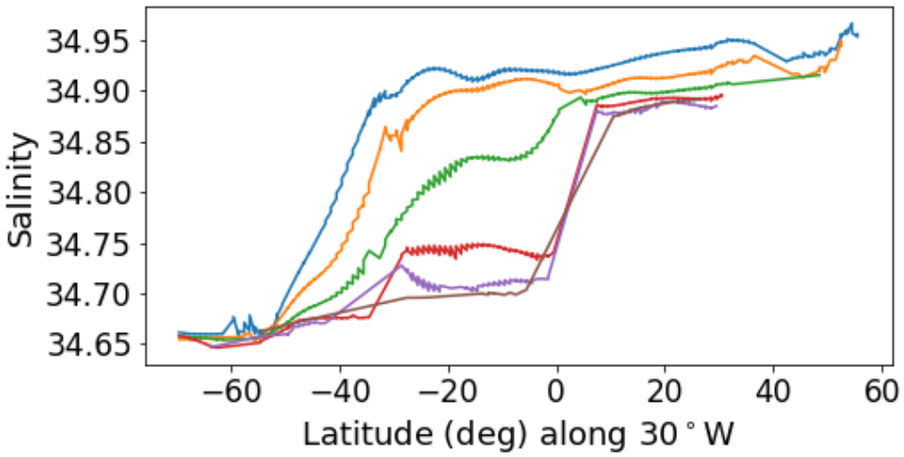


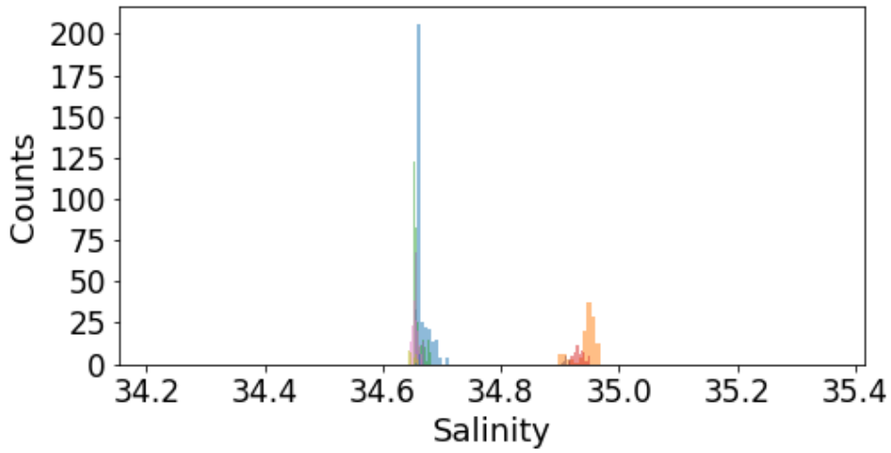
- ***Salinity***: global ocean > 2,500 m is within the range of values observed in the Atlantic Ocean
- ***Phosphate***: global ocean > 2,500 m is only partially bounded by values observed in the Atlantic Ocean

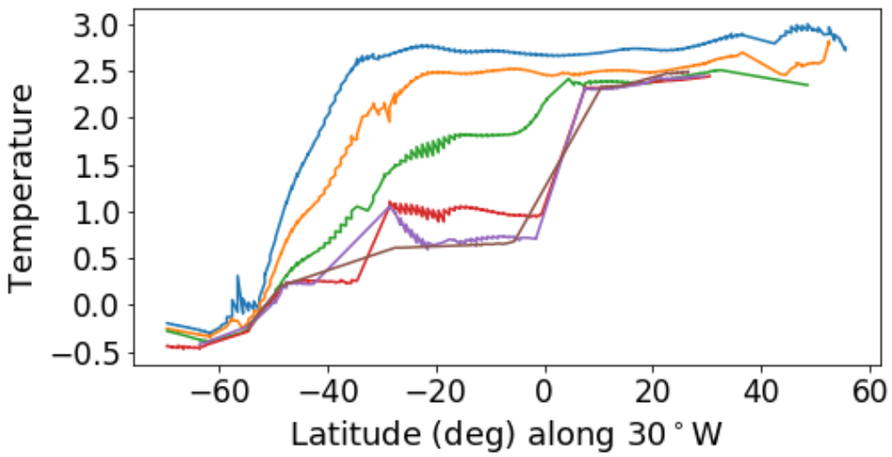
NADW AND AABW, STATISTICALLY DIFFERENT?

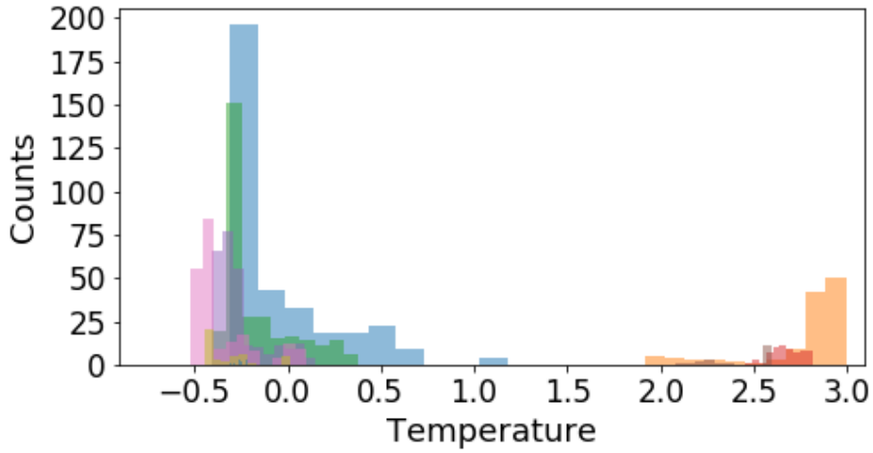




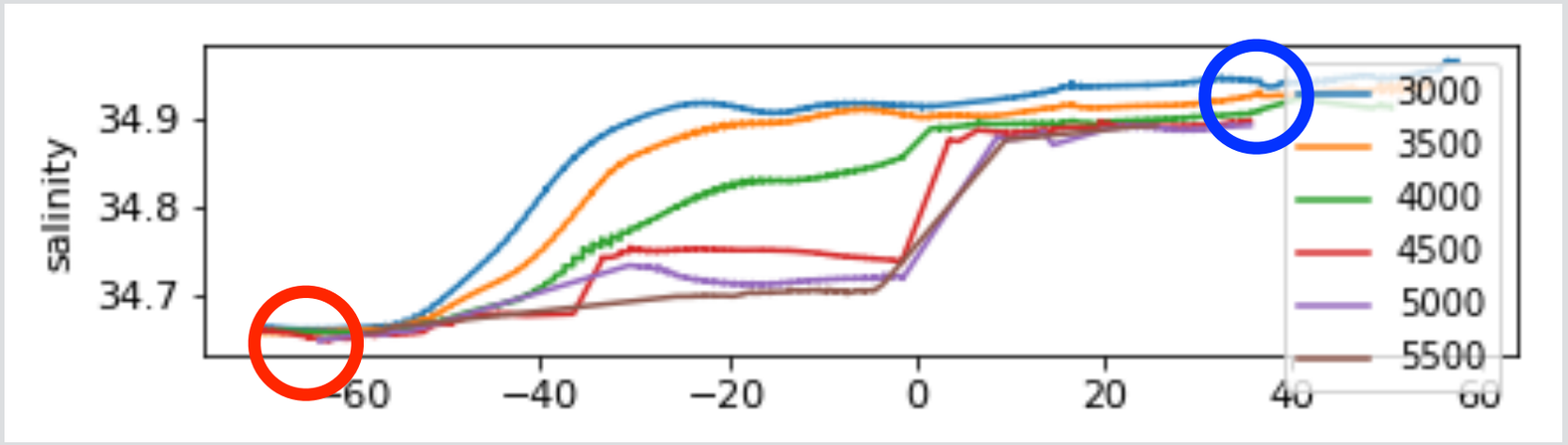








Two End-member Mixing Model



Slight depth dependence of North Atlantic Deep Water end-member

Minimal depth dependence of Antarctic Bottom Water end-member

NADW @3000m
=> 34.95 psu

AABW @3000m
=> 34.65 psu

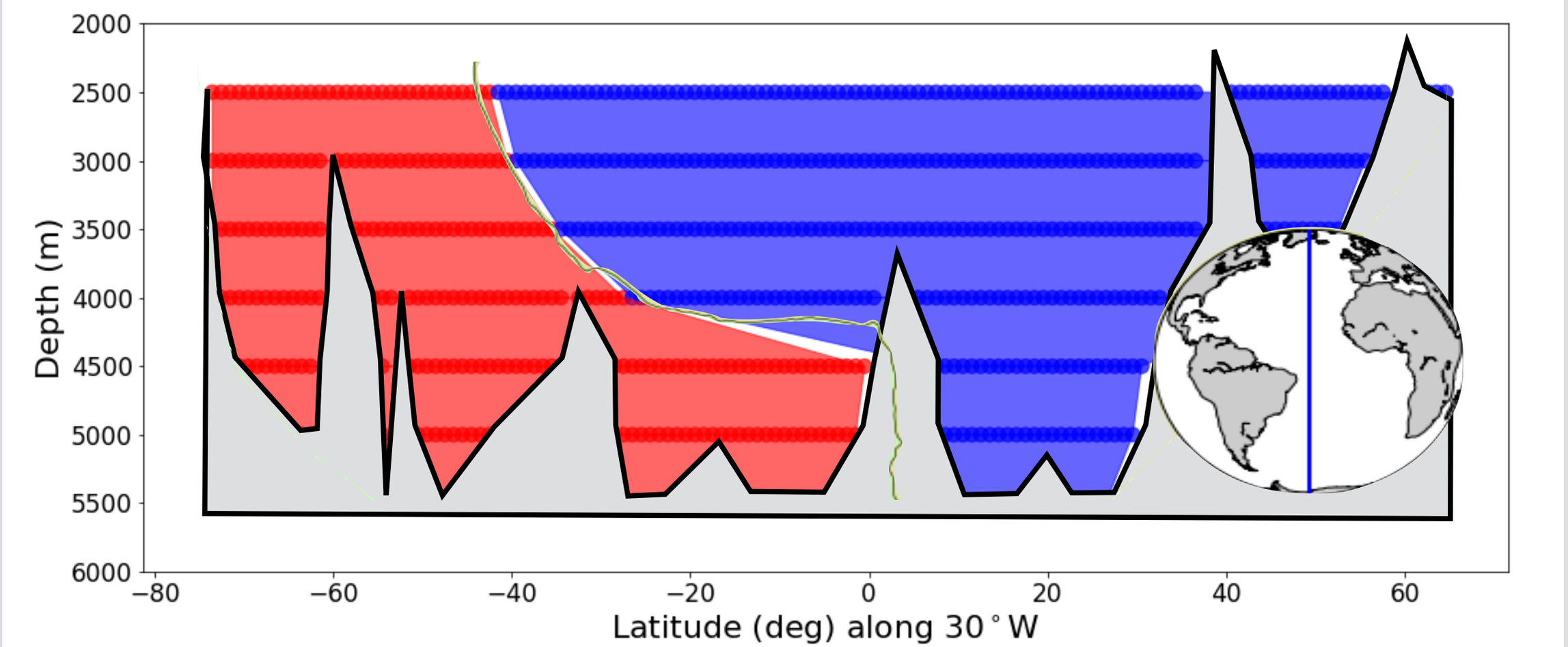
$$\%AABW\ (salinity_{AABW}) + \%NADW\ (salinity_{NADW}) = salinity_{parcel}$$

%AABW > 50%: **Red**

%NADW > 50%: **Blue**

Q2: How far does Southern Ocean source water extend?

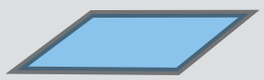
Two End-member Mixing Model



- ***Foreground***: each latitude-longitude-depth point is labelled as being either predominantly southern sourced (red) or northern sourced (blue) based on salinity data
- ***Background***: salinity contour plot (raw data)
- ***Gray Line***: Salinity contour; take note of close match to north/south split

Connectedness using t-test

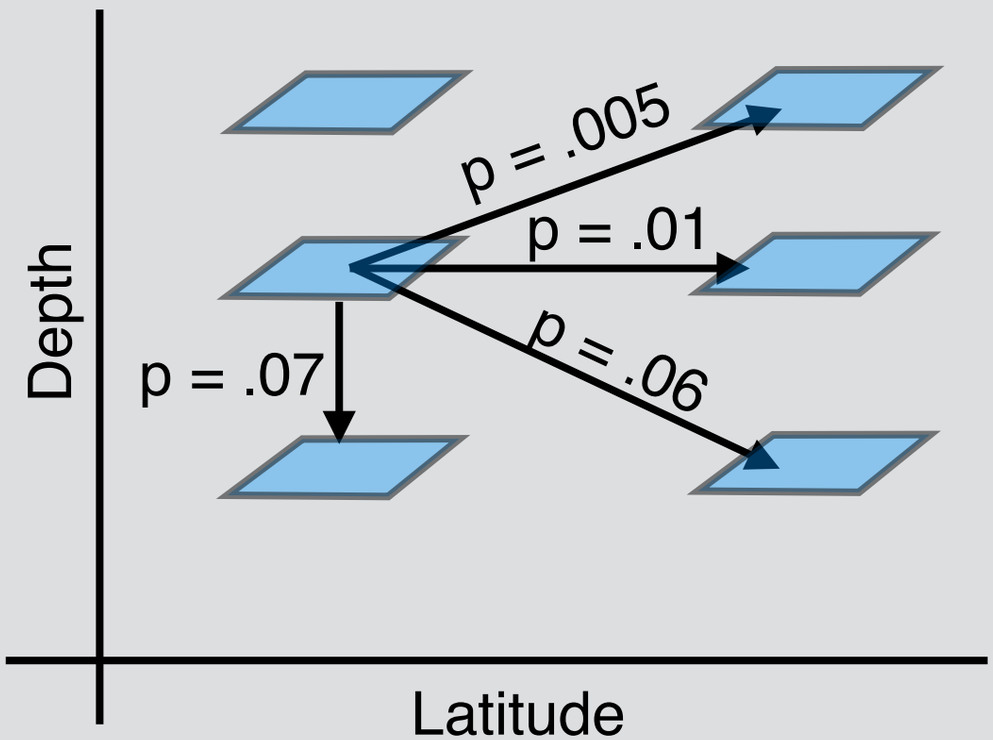
Where is the Atlantic Ocean is well mixed (vertically or horizontally)? First lets develop a way to think about “well-mixed” mathematically.

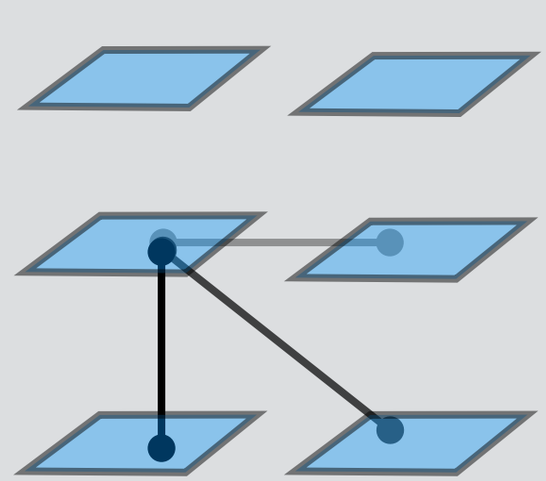


= Data inside 3x3 degree area at a particular depth:

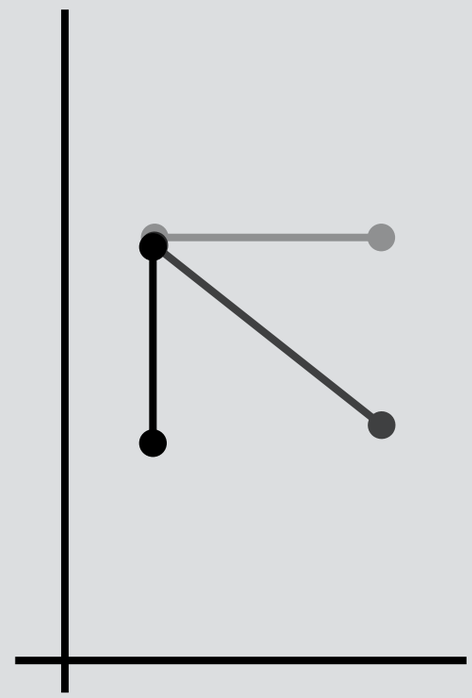
t-test

Connectedness





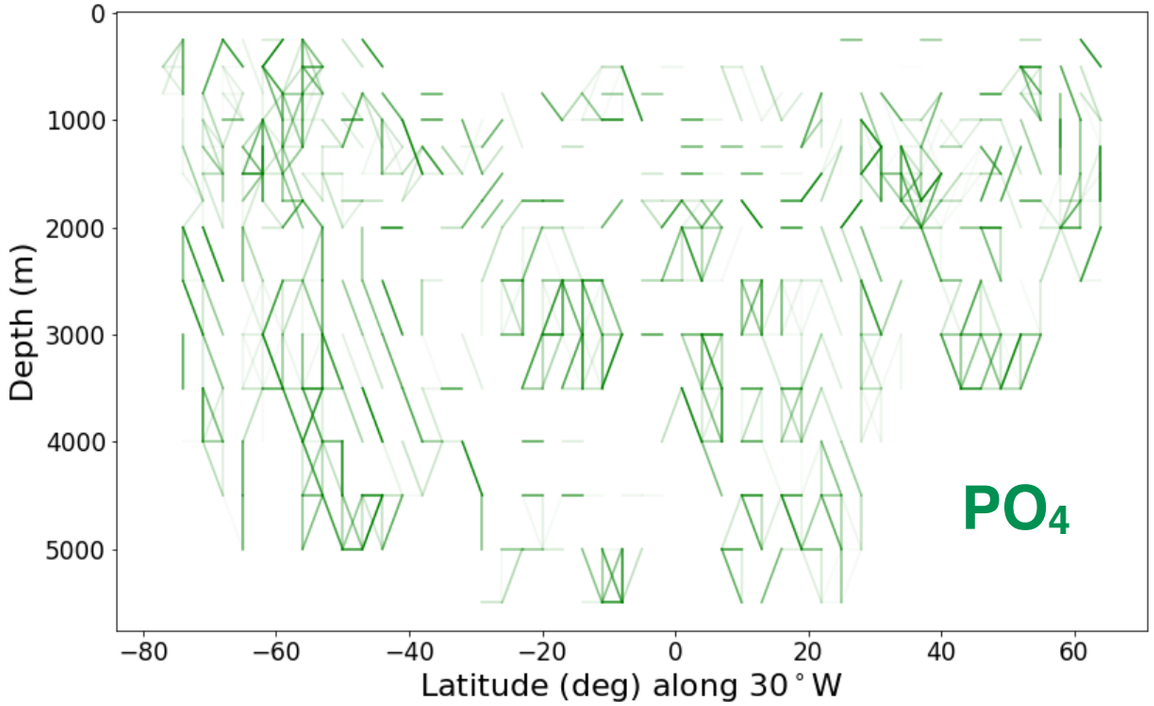
Light line: .01< p < .05
Heavy line: p > .05

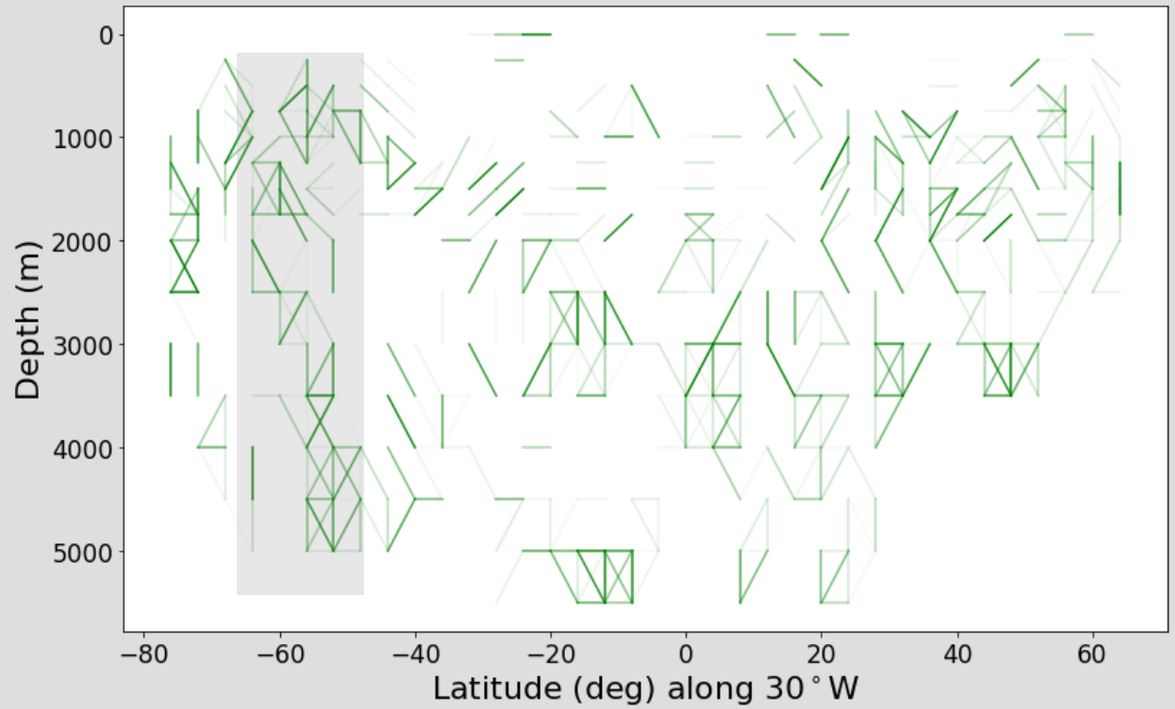


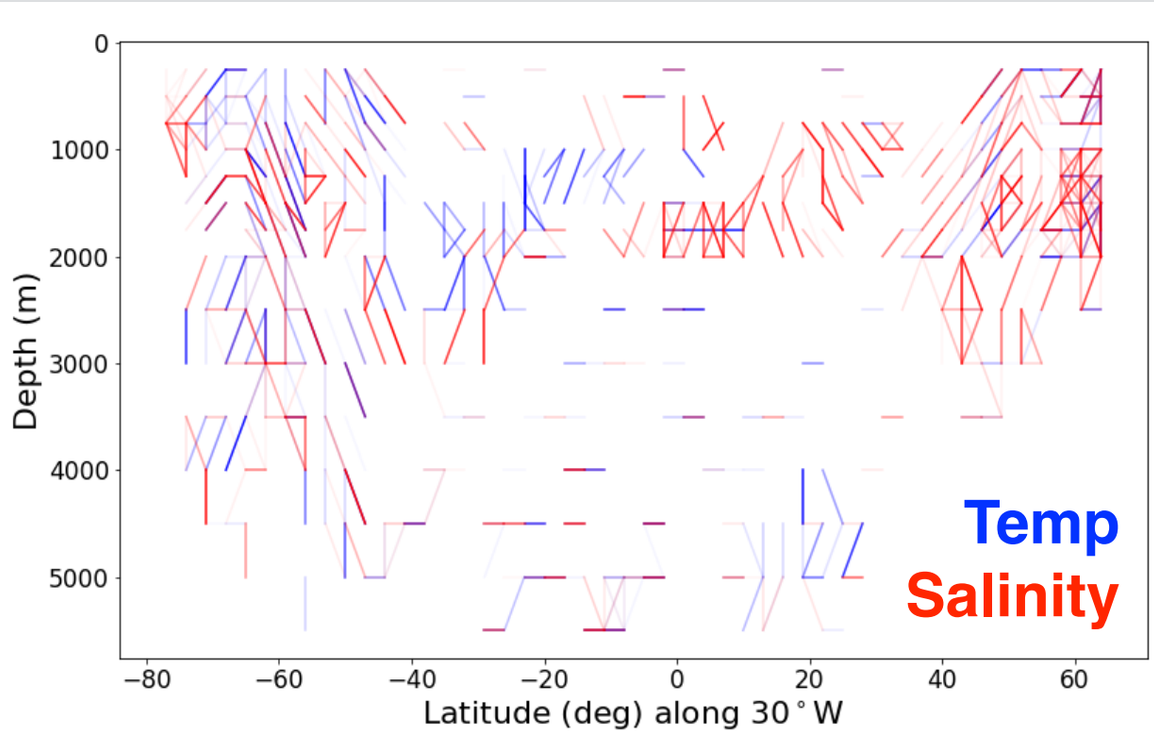
Final representation

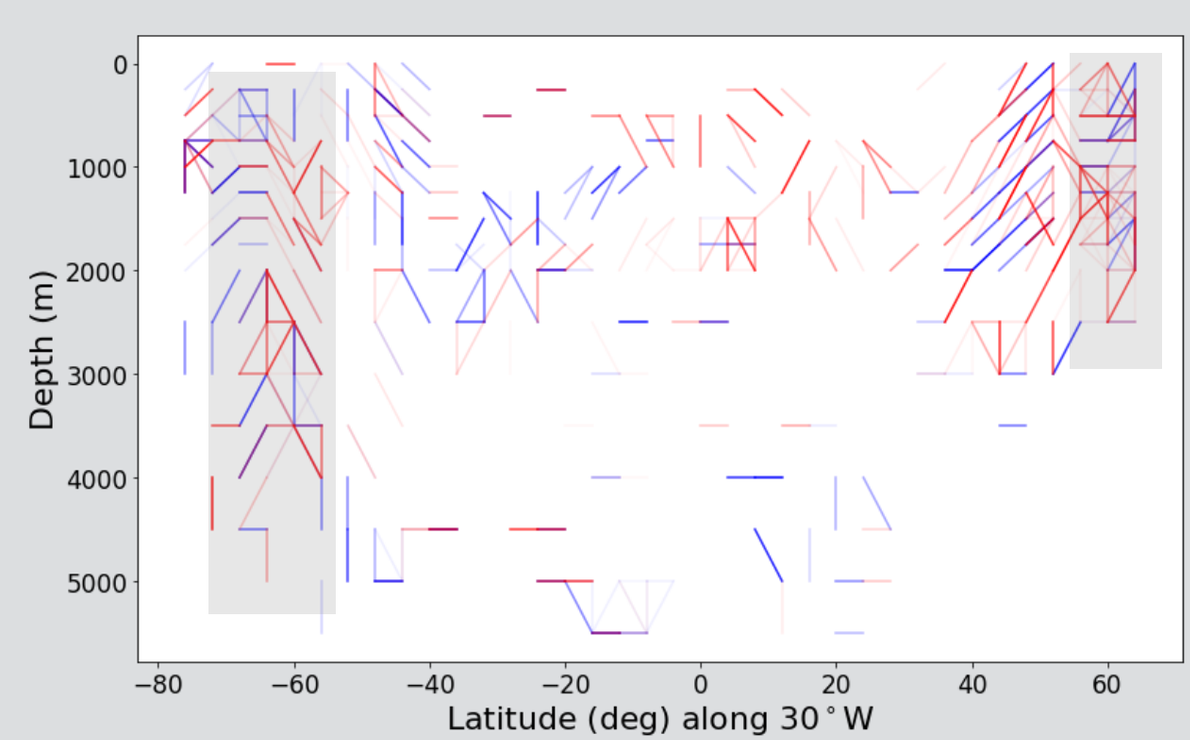
Q3: Can we trace water formation statistically?

Connectedness using t-test









What's next?

Stay tuned for new episodes…

Multiple tracers and clustering

- How can we use cluster analysis and multiple tracers to better define watermasses?
- What areas are classified differently depending on the combination of tracers used?
- Are those differences interpretable?

End-member analysis to trace flow trajectory

First extending the end-member analysis to latitude-longitude distributions but then to trace trajectories. The next level analysis is to acknowledge that the mix varies with longitude, and to analyze at various longitudes, tracing the distribution of the highest percentage of southern ocean source water as it moves north. Higher up in the water column, tracing a high and potentially characteristic fraction southern ocean source water might yield the pathway the water takes as it snakes its way from the Southern Ocean to the North Atlantic.

Role of non-mixing processes on tracer distribution

To understand the contribution by a given process, we need to know how much change is due to mixing; if we use a one dimensional mixing model for salinity and then repeat the process for phosphate, how different are the mixtures? statistically different?

References

Gotta stand on the shoulders of giants…

Figure References:

http://geologylearn.blogspot.com/2015/12/ocean-waters-and-currents.html
https://phys.org/news/2016-06-wind-blown-antarctic-sea-ice-ocean.html

World Ocean Atlas

Temperature: Locarnini, R. A., A. V. Mishonov, J. I. Antonov, T. P. Boyer, H. E. Garcia, O. K. Baranova, M. M. Zweng, C. R. Paver, J. R. Reagan, D. R. Johnson, M. Hamilton, and D. Seidov, 2013. World Ocean Atlas 2013, Volume 1: Temperature. S. Levitus, Ed., A. Mishonov Technical Ed.; NOAA Atlas NESDIS 73, 40 pp.

Salinity: Zweng, M.M, J.R. Reagan, J.I. Antonov, R.A. Locarnini, A.V. Mishonov, T.P. Boyer, H.E. Garcia, O.K. Baranova, D.R. Johnson, D.Seidov, M.M. Biddle, 2013. World Ocean Atlas 2013, Volume 2: Salinity. S. Levitus, Ed., A. Mishonov Technical Ed.; NOAA Atlas NESDIS 74, 39 pp.

Nutrients: Garcia, H. E., R. A. Locarnini, T. P. Boyer, J. I. Antonov, O.K. Baranova, M.M. Zweng, J.R. Reagan, D.R. Johnson, 2014. World Ocean Atlas 2013, Volume 4: Dissolved Inorganic Nutrients (phosphate, nitrate, silicate). S. Levitus, Ed., A. Mishonov Technical Ed.; NOAA Atlas NESDIS 76, 25 pp.