An Indian Deep Water upwelling pathway along the southern coast of Australia

Veronica Tamsitt (vtamsitt@ucsd.edu), Lynne Talley; Scripps Institution of Oceanography, La Jolla, CA, 92093

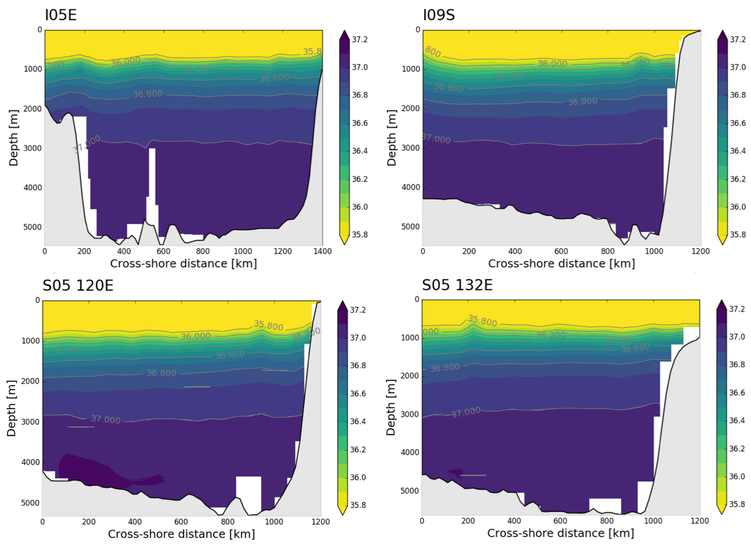
Introduction

- Deep water upwelling in the Southern Ocean travels southward from the Atlantic, Indian and Pacific via Deep Western Boundary Currents and pathways along the eastern boundary of each basin (Tamsitt et al. 2017).
- The upwelling Indian and Pacific Deep Waters bring carbon and nutrient-rich water to the sea surface.
- Although limited observational evidence for the eastern Indian pathway exists (Hufford et al. 1997, Schodlok et al. 1997, Sloyan et al. 2006), the characteristics and dynamics are not well established

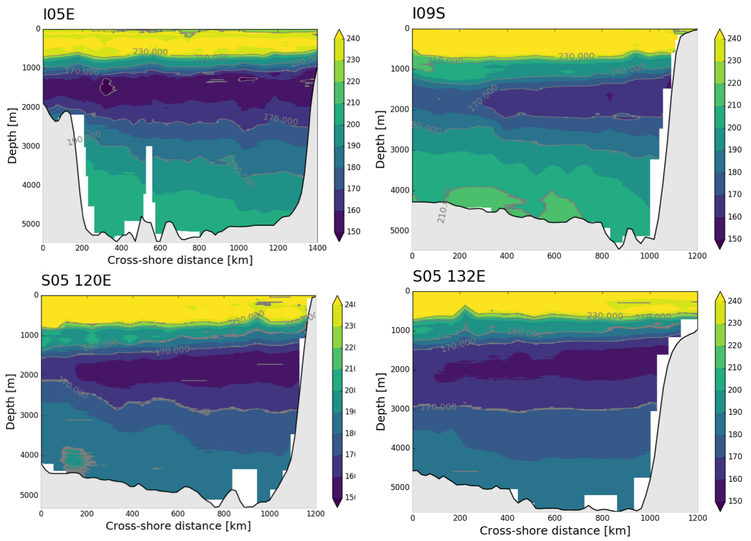
Goal: Describe the Indian Deep Water pathway south of Australia and investigate the underlying dynamics

1. What are the characteristics and transport of this deep water pathway?
2. What drives this pathway and in particular what role do eddies and topography play in driving this pathway?

Deep water pathway in observations

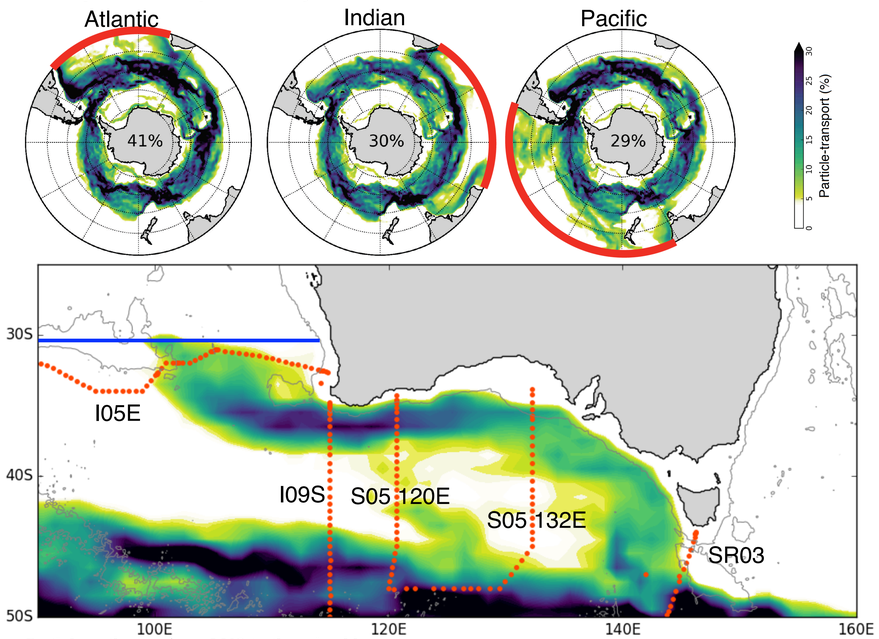


Density sections from hydrography. Potential density (kg/m^3; referenced to 2000 m) from CTD sections extending away from the Australian coast (right) from west to east.

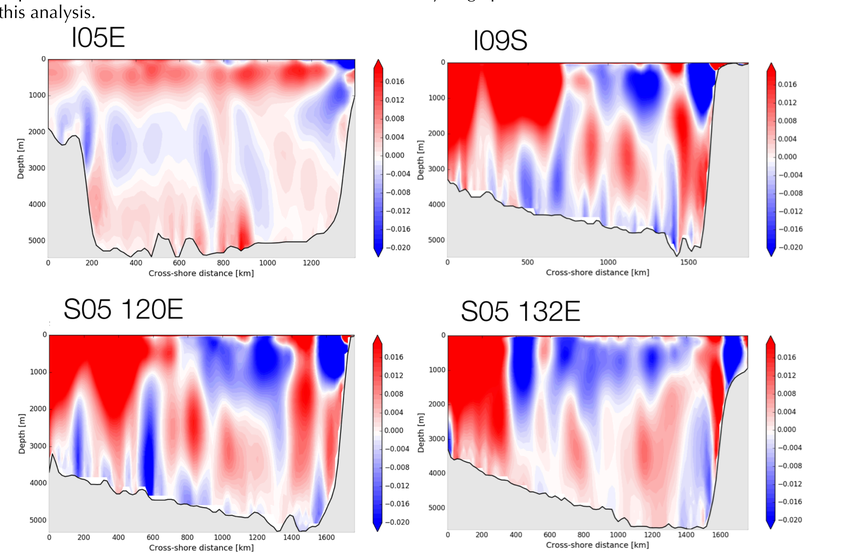


Oxygen sections from hydrography. Oxygen concentration (µmol /kg) from sections extending away from the Australian coast (right) from west to east showing a low-oxygen deep water signal extending away from the continental slope.

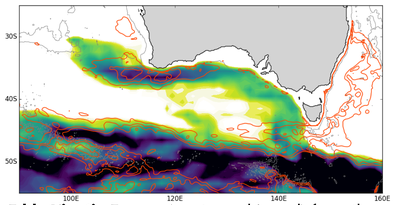
Deep water pathway in SOSE



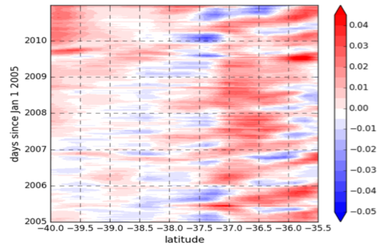
Particle pathways from 30°S to the mixed layer.
Maps of the percent of total Indian upwelling particle-transport visiting each 1° latitude x 1° longitude grid column at some time during the 200 year experiment from release at 30°S and before reaching the surface mixed layer. The top three panels show pathways from the Atlantic, Indian and Pacific and the lower panel shows a zoomed in map of the eastern Indian pathway. On the lower panel the blue line shows the location of particle release and red dots indicate the location of hydrographic station CTD and bottle data used in this analysis.



Velocities from the Southern Ocean State Estimate. 2005-2010 time-averaged meridional (top left) and zonal (all others) velocities along hydrographic section locations. A southward/eastward deep water flow extends from 1500 m – 4000 m along the Australian continental slope.



Eddy Kinetic Energy (contoured in red) from the Southern Ocean State Estimate showing high eddy activity along the Indian deep water pathway around the southwest tip of Australia. This is similar to the eddy train in the Southeastern Atlantic overlying a North Atlantic Deep Water pathway (Van Sebille et al. 2012).



Zonal velocity time series (Hovmöller diagram) from SOSE 2005-2010 five-day averaged output along the meridional I09S section in the Indian Deep Water density range. Strong eastward velocities (red) on the eastern edge of the section are intermittent.

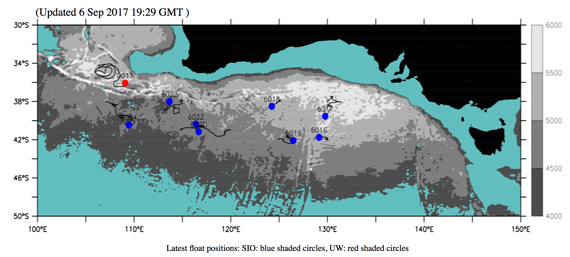
Conclusions

- Modeled Lagrangian trajectories show a pathway connecting Indian Deep Water to the Southern Ocean via the southern coast of Australia which is consistent with hydrographic property distributions that show the low oxygen, high nutrient signature of Indian Deep Water
- A westward eddy train similar to the Agulhas ring configuration in the South Atlantic suggests that eddies may be important for driving the dynamics

Future work

- More detailed observational synthesis, possibly including deep Argo float data from new pilot array
- Further analysis of Lagrangian pathways and transports in SOSE
- Look at dynamics with Potential Vorticity budget in SOSE (or higher resolution model)
- Explore interaction with the northward flowing abyssal Antarctic Bottom Water pathway

Deep Argo Float Locations: Southeast Indian Pilot Array



Map of trajectories and current locations of Deep Argo floats deployed in the Australian Basin as part of the Southeast Indian Pilot Array in October 2016 (http://sio-argo.ucsd.edu/).

Model and Lagrangian Experiment

The Southern Ocean State Estimate (SOSE) is a ⅛° resolution, eddy permitting general circulation model that is constrained to available data (Mazloff et al. 2010). More information and the latest SOSE solution is available at **http://sose.ucsd.edu.**

Lagrangian experiment (detailed description in Tamsitt et al. 2017):

- Offline particle tracking model Octopus (https://github.com/jinbow/Octopus) using SOSE daily averaged velocities for years 2005-2010
- > 1.2 million total particles released every 30 days for 6 years at 30S in each basin, from 1000 - 3500 m and tracked for 200 years
- Only including particles with initial southward transport, that remain south of 30°S
- Particles defined as upwelled when they enter the mixed layer
- Pathways are transport-weighted by tagging each particle with the initial volume transport at its release location at 30°S

References

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Acknowledgments

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