Understanding deep water formation in the Southern Ocean

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The continental shelf surrounding Antarctica is the source of the deepest waters in the global ocean. The extreme cold at high latitudes combined with sea ice formation increases the density of surface waters, causing them to become heavy and sink to the bottom. This drives global ocean circulations and extracts anthropogenic heat and CO2 from the atmosphere, as it is absorbed into sinking water masses.

Recent studies are showing that warming and freshening of Southern Ocean waters is reducing the quantity and rate of formation of Antarctic Bottom Water (Aoki et al., 2020; Menezes et al., 2017; Purkey et al., 2019), potentially leading to a slowdown of the global overturning circulation (Li et al., 2023) and reducing the capacity of the ocean to absorb excess anthropogenic heat and carbon. It is vital that we understand the processes through which deep water formation is changing so that we can accurately predict large-scale future knock-on effects.

The dynamics of the Southern Ocean are complex. The physical changes in each basin are driven by different mechanisms as the atmosphere, ocean and cryosphere interact in different ways. The aim of this project is to explore how water mass transformations, including deep water formation, vary at different locations around Antarctica and begin to understand how local dynamics might be impacting these changes. In this project, the student will investigate steric height signatures from pre-processed datasets of altimetry, gravimetry and in-situ observations, looking at changes in regions of deep water formation over multi-decadal timescales. The student would work with an existing python-based web app and/or Jupyter Notebooks, with opportunities to modify the codebase and work in a version-controlled environment in GitHub.

This project would be suitable for candidates from a wide range of backgrounds, including Maths, Physics, Computer Science and Environmental Sciences; knowledge of oceanography or the cryosphere is not essential.

Aoki, S., Katsumata, K., Hamaguchi, M., Noda, A., Kitade, Y., Shimada, K., Hirano, D., Simizu, D., Aoyama, Y., Doi, K., & Nogi, Y. (2020). Freshening of antarctic bottom water off cape Darnley, east Antarctica. Journal of Geophysical Research, C: Oceans, 125(8). https://doi.org/10.1029/2020jc016374

Li, Q., England, M. H., Hogg, A. M., Rintoul, S. R., & Morrison, A. K. (2023). Abyssal ocean overturning slowdown and warming driven by Antarctic meltwater. Nature, 615(7954), 841–847.

Menezes, V. V., Macdonald, A. M., & Schatzman, C. (2017). Accelerated freshening of Antarctic Bottom Water over the last decade in the Southern Indian Ocean. Science Advances, 3(1), e1601426.

Purkey, S. G., Johnson, G. C., Talley, L. D., Sloyan, B. M., Wijffels, S. E., Smethie, W., Mecking, S., & Katsumata, K. (2019). Unabated bottom water warming and freshening in the south pacific ocean. Journal of Geophysical Research, C: Oceans, 124(3), 1778–1794.