**Detecting rapid changes and tipping points in the abyssal ocean circulation**

The deep ocean circulation plays a fundamental role in Earth’s climate, as it cycles and sequesters vast quantities of carbon, heat, oxygen and nutrients throughout the global ocean for as long as millennia (Talley, 2013). Recently, it has been proposed, based on a numerical simulation of the ocean (Li et al., 2023), that the accelerated melting of Antarctica associated with anthropogenic climate change may be disrupting the abyssal ocean circulation <https://www.theguardian.com/science/2023/may/25/slowing-ocean-current-caused-by-melting-antarctic-ice-could-have-drastic-climate-impact-study-says>).. As the pace of Antarctic melting grows, the additional freshwater deposited on the Antarctic margins may be driving a decrease in the salinity and density of the local ocean waters, making them lighter and less prone to sink to the abyss. The ensuing slowdown of the abyssal ocean circulation would be expected to have a very substantial impact on the functioning of the climate system. However, such a slowdown is very challenging to detect from observations, for no direct measurements exist of the abyssal circulation’s rate.

In this project, the student team will be tasked with assessing whether an approach exists to robustly detect rapid changes in the abyssal ocean circulation from easily measurable ocean surface variables (such as sea level, sea surface temperature, or sea surface salinity), which can potentially be observed from satellites. For this purpose*, we would like you to start working with a numerical model of the ocean circulation to find a way – using machine learning (see e.g., Solodoch et al., 2023) – to quantify the temporal evolution of the abyssal ocean circulation from ocean surface variables.* Subsequently, the team will use the output of the numerical simulation featured in Li et al. (2023), which motivated the proposition of an abyssal ocean circulation slowdown.

**References:**

Talley (2013)

Purkey & Johnson (2010)

Li et al. (2023)

Solodoch et al. (2023)

Talley et al. (2011), Descriptive Physical Oceanography.

**Data and methodology:**

To start with, we would like to work with the following model, which has already been analysed with ML tools, and try their methodology and reproduce some of their key results:

Solodoch et al. (2023) ocean model data - https://ecco-group.org

Solodoch et al. (2023) ML code - https://zenodo.org/records/7016247

Subsequently, we would like you to examine Li et al.’s (2023) simulation, which will be made available in due course.

**Project supervision and support:**

Dr. Laura Cimoli (DAMTP) and Prof. Alberto Naveira Garabato (University of Southampton) – project supervisors

Josh Lanham and Kate Oglethorpe (Earth Sciences) – project mentors