Impact of Temperature- and Salinity-driven Convection on Ocean Circulation: Insights from Direct Numerical Simulations

Catherine Vreugdenhil*[1,2], Bahman Ghasemi[1], Bishakhdatta Gayen[1,2], and Taimoor Sohail[1]

[1]University of Melbourne – Australia
[2]Australian Centre for Excellence in Antarctic Science – Australia

Abstract

The Atlantic Meridional Overturning Circulation (AMOC) plays a crucial role in the global climate system by transporting heat, salt, and nutrients across ocean basins. The AMOC sees strong temperature-driven deep convection in the northern regions, which feeds into the large-scale meridional overturning circulation, akin to a horizontal convection set-up. However, there are also effects from salinity differences at the top surface of the ocean, which can drive localised freshening and double-diffusive effects. In a changing climate, the salinity-driven effects are hypothesised to intensify, and so there is much interest in whether the AMOC may slow or even shut down due to these changes in buoyancy forcing and deep convection. In this study, we use direct numerical simulations of a laboratory-scale model of the North Atlantic Ocean to examine how changes in surface salinity and temperature forcing influence large-scale ocean circulation. By varying the relative impacts of salinity and temperature, we find that the intensifying salinity forcing slows the AMOC by weakening deep convection and shifting the subtropical gyre southward. This slowdown reduces northward heat and salt transport, leading to warming and salinification in the northern subtropics and cooling in subpolar regions. Future climate projections indicate that the salinity forcing may become increasingly significant, and our results suggest that this will further slow the AMOC. These findings are helpful for improving large-scale ocean models and advancing our understanding of temperature-salinity convection mechanisms in global ocean circulation.

*Speaker