Thermohaline Staircases in a Changing Arctic Ocean

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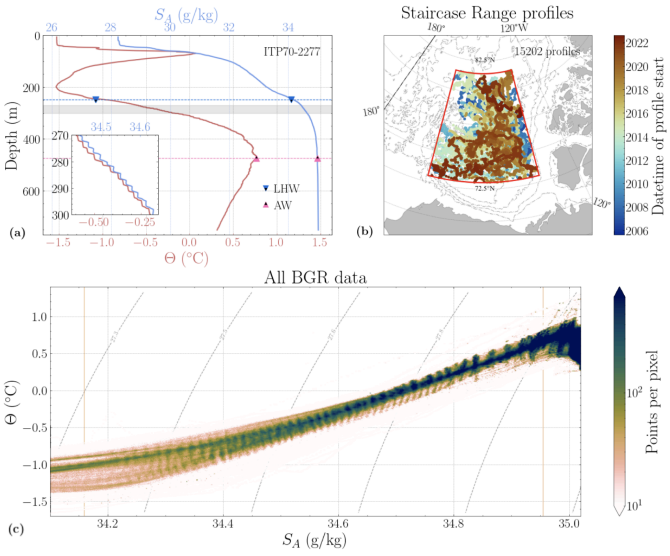
Under the surface of the Arctic Ocean, warm salty water from the North Atlantic Ocean subducts below the cold fresh surface waters of the Arctic Ocean. In seawater, heat diffuses a hundred times faster than salt which, in this environment, leads to an unbalanced system. The unstable temperature gradient competes with the stabilizing salinity gradient, creating unstable conditions that can lead to the emergence of a coherent structure called a thermohaline staircase, where each 'step' is made up of a relatively cool, fresh layer over a warmer, saltier layer separated by a thin interface.

The Atlantic water layer could deliver enough heat to melt all of the Arctic sea ice, were it transported to the surface. Processes controlling vertical heat flux in this area of the world are not well understood, but thermohaline staircases have been identified as playing an important role. Despite the significance of these structures, the underlying physics is not well understood, is not well captured by any current theory for macroscopic heat transport, and their response to a rapidly changing Arctic Ocean is unclear.

We recently made significant headway in this area by developing a method to track individual staircase steps across the Canada Basin over nearly two decades (Schee et al., 2024, 2026). Our results indicate a surprising level of staircase stability and unintuitive changes to the vertical heat flux. This project aims to expand on our work by adapting the layer tracking method to examine staircases in the Eurasian Basin and investigating the extent to which linear theory (Schmitt 1981, Johnson and Kearny, 2009) might be able to explain these interesting results.



Requirements: You are comfortable programming in Python and have some understanding of partial differential equations. Knowledge of fluid dynamics will be helpful but is not expected prior to the start of the project. We expect no knowledge of Arctic oceanography from you.

Bibliography:

Schee MG, Rosenblum E, Lilly JM, Grisouard N. (2026) Decadal coherence of Arctic thermohaline staricases. https://essopenarchive.org/users/1016377/articles/1376669-decadal-coherence-of-arctic-thermohaline-staircases

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