The Changing Double Diffusion Properties in the Beaufort Sea

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Key Points:

- Beaufort Gyre's diffusive-convective staircase demonstrates long-term changing trend in properties
- Temporal evolution of the staircase is closely related to the changing background water-mass structure in the Beaufort Sea

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Abstract

In the Beaufort Sea, relatively cold and fresh Pacific winter water layer overlays warmer and saltier Atlantic Water layer, resulting in a depth range where vertical stratification is propitious to double diffusion, characterized by a step-like thermohaline structure (staircase). Using observations between 2004 and 2023 from the Ice-Tethered Profilers, we document the temporal evolution of the staircase during the past two decades. We find that, these staircases, while remaining their existence, exhibit a transition towards thinner layers and smaller interfaces temperature jump, which propagates eastward in the Beaufort Gyre. The evolution pattern of the staircase coincides with the variability of background water-mass. These results may have implications for vertical heat transport from the Atlantic Water layer to the surface with the potential to melt Arctic sea-ice, and give insight into the recent state transition of Beaufort Gyre at small scale.

Plain Language Summary

In the Arctic Ocean, near the depth of about 250 m in the Beaufort Sea, the sea water becomes warmer and saltier with increasing depth. In such a background, the properties of the seawater (e.g., temperature and salinity) tend to alternate vertically between thin layers (interfaces, ca. 0.1-1 m thick) with sharp variations and thick, well-mixed layers (ca. 1-10 m thick); such a structure exhibits a step-like structure (staircase) in the vertical profile, and is often thought to be associated with a mechanism known as double diffusion. The heat from the deep Arctic Ocean may be transferred upwards through this staircase to sea ice at the surface, leading to consequences such as melting of the sea ice, and is thus relevant to the future of our planet. Therefore, it is necessary to investigate the changes in this staircase structure, for a better understanding of and reaction to climate change. By analyzing Arctic Ocean observations over the past two decades, we find that the nature of these staircases has changed significantly in recent years, and that these changes are closely related to changes in the wider environment of the Arctic Ocean. This work provides a timely and important reference for understanding the ongoing changes in the Arctic Ocean and predicting changes in the future.

1 Introduction

Double-diffusive convective (DDC) is a kind of instability mechanism, which may happen in the ocean when the temperature and salinity gradients are both up (down), in which case ...

2 Data and Methods

2.1 Observational Data

The data analyzed here ...

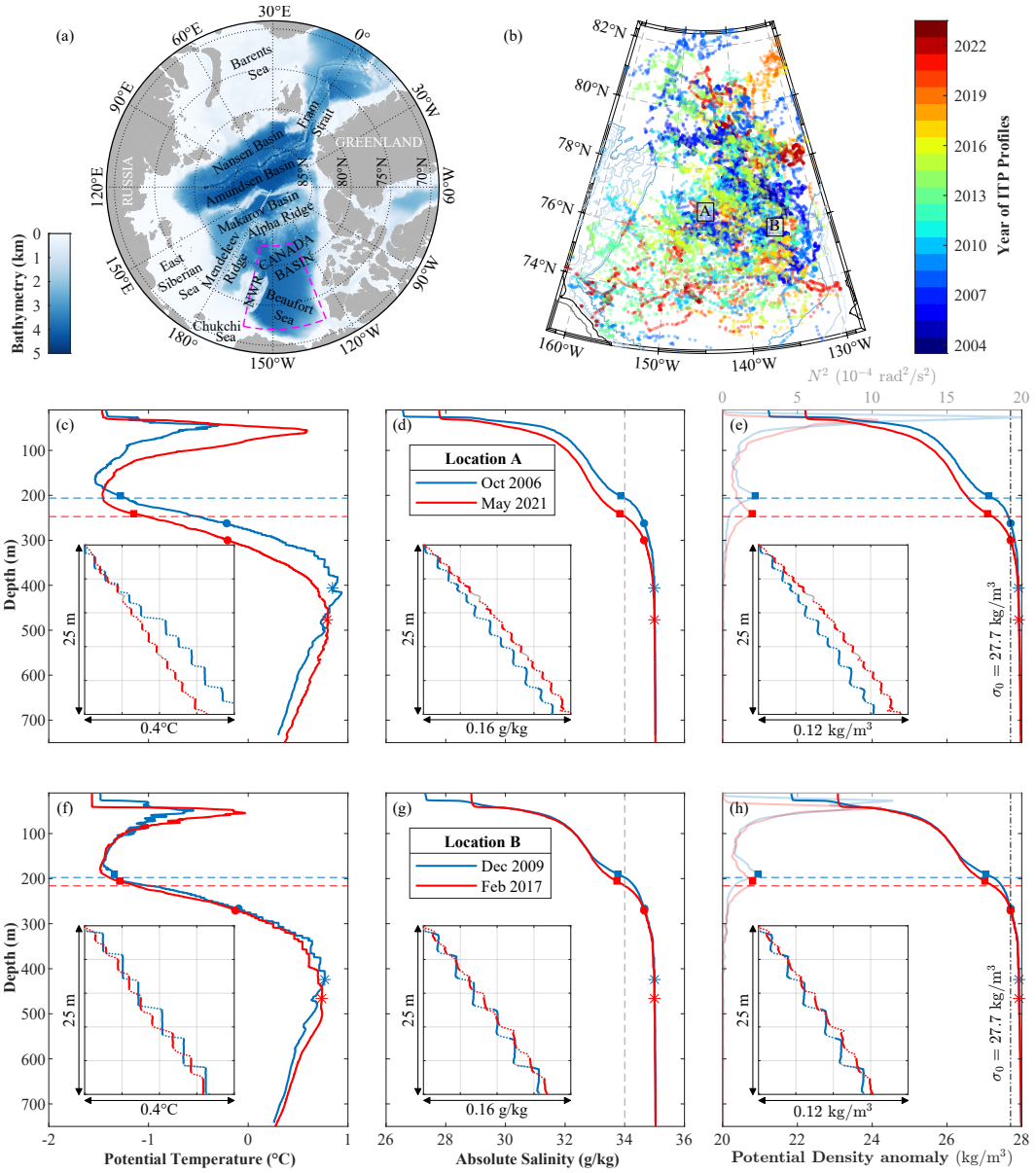

Figure 1. Observations of the diffusive staircase in the Beaufort Sea.

Data Availability Statement

The Ice-Tethered Profiler data were collected and made available by the Ice-Tethered Profiler Program (Krishfield et al., 2008; Toole et al., 2011) based at the Woods Hole Oceanographic Institution (`https://www.whoi.edu/itp`). The bathymetry data used in the study are from the International Bathymetric Chart of the Arctic Ocean version 4.2 (Jakobsson et al., 2020) (`https://www.gebco.net/data_and_products/gridded_bathymetry_data/arctic_ocean/`).

References

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