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Quantifying mixing from standard observations: revisiting finescale parameterization in the Arctic Ocean

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Ocean mixing governs the vertical exchange of matter, heat and salt in the water column. In the Arctic Ocean, the vertical transport of heat due to turbulent mixing is ultimately coupled to the sea-ice cover, with immediate and far-reaching impacts on the climate and ecosystem. A detailed understanding and quantification of turbulent mixing is crucial to assess and predict the state of the changing Arctic Ocean. However, direct observations of turbulent mixing are complicated, expensive and sparse.

Finescale parameterization of turbulent energy dissipation allows for the quantification of mixing based on standard hydrographic observations such as velocity and density profiles. This method is based on the assumption that energy dissipation is achieved exclusively by cascading energy from large, observable scales to small scales by wave-to-wave interactions in the internal wave field, which in turn can be related to vertical diffusivity and hence turbulent fluxes. While the finescale parameterization is proved to be reliable at mid-latitudes, the Arctic Ocean internal wave field is distinct from the canonical mid-latitude spectrum and the applicability of the parameterization is not certain. Furthermore, in the historically quiescent Arctic, the application of finescale parameterization suffers from a generally low signal to noise ratio and processes violating the assumptions in the parameterization, such as double diffusion. During the year-long MOSAiC expedition, both standard observations as well as specialized microstructure measurements were carried out continuously. We analyse dissipation rate and stratification measurements (from an MSS90L profiler) and 8-m vertical resolution current measurements (from a 75 kHz RDI acoustic Doppler current profiler) in the depth range from 70 -198 m, in the absence of thermohaline staircases or double-diffusive intrusions. Although the range of dissipation measurements is limited and spans $1e^{-11}$ W kg^{-1} to $8.8e^{-7}$ W kg^{-1}, direct comparisons between in-situ observations of dissipation rate and finescale parameterization provide a detailed insight into the capabilities and limitations of this method in various meteorological, oceanographic and geographic conditions. The aim is to provide guidance in how far standard oceanographic observations may be utilized to quantify mixing in past, current and future states of the Arctic Ocean.