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The impact on Arctic sea ice of increased ice-ocean drag caused by ocean internal waves

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The phenomenon of dead waters was first observed by Nansen in 1893 when navigating through polar waters; it is caused by the ship's hull inducing internal waves in the ocean that radiate momentum away from the ship, effectively increasing the ocean's drag on the ship.

The rough topography of the underside of sea ice also generates internal waves as sea ice drifts over the stratified ocean, increasing the total ice-ocean drag.

A parameterization of the impact of internal waves on momentum transfer at the sea ice-ocean interface has been developed and implemented in a sea ice model (CICE) for the first time. The parameterization comes from a previous study by McPhee, which we have adjusted to account for the presence of keels deeper than the mixed layer depth.

The extra ice-ocean drag from internal waves is stronger for shallow mixed layer depth and large density jump at the pycnocline, and is a function of the strength of the stratification beneath the ocean mixed layer and geometry of the ice interface. We consider the contribution to internal wave drag from both ridged and non-ridged ice. The increase of the ice-ocean drag transfer coefficient has consequences on the bottom melt and therefore on the sea ice state.

We present results from a coupled sea ice-ocean model (NEMO-CICE) where the internal wave drag has been implemented. Simulations were run from 1980 to 2016. We show results demonstrating the regional effect of internal wave drag on emergent Arctic sea ice characteristics such as thickness, motion, and deformation. In particular, we observe an increase in sea ice thickness in the Canadian Arctic due to an overall slow-down of the ice drift and decrease of the ice to ocean heat flux.