EGU24-3811, updated on 15 Mar 2024
https://doi.org/10.5194/egusphere-egu24-3811
EGU General Assembly 2024

Impact of ocean vertical mixing parametrization on sea ice properties using NEMO-SI3 model in the Arctic Ocean

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In recent decades, global climate change has strongly affected the Arctic region, leading to a rapid decline in sea ice extent. This decline affects the interactions between sea ice, the atmosphere, and the ocean, driven by complex thermodynamic and dynamical processes. The Arctic mixed layer (ML), located in the upper ocean, plays a key role in regulating the interactions between the deep ocean, sea ice, and the atmosphere. This region is strongly affected by exchanges of mass (such as freshwater and saltwater fluxes) and momentum driven by various forces like ocean currents, tides, waves, and winds. Here, we study the ad-hoc vertical turbulent kinetic energy (TKE) mixing scheme within the NEMO-SI3 model. Specifically, we focus on the influence of surface and internal wave breaking in sea ice-covered regions. The critical parameters are the fraction of surface TKE that penetrates below the ML, the nature of the exponential TKE penetration decrease beneath the ML, and the damping effect on Langmuir and surface wave breaking beneath the ice cover. We aim to assess how these parameters affect the ML and various sea ice properties.

Our findings reveal significant impacts on Arctic sea ice thickness under two scenarios: when ice cover does not affect wave dynamics and when the mixing process weakens. Stronger mixing leads to a deeper ML and reduced sea ice thickness by 30 to 40 centimeters, while weaker mixing results in a shallower ML and a moderate sea ice increase of 10 to 20 centimeters. Results also show that reduced sea ice models exhibit a larger volume of freshwater content in the ocean with consistent spatial patterns. Conversely, increased sea ice simulations reveal reduced freshwater content, although clear spatial patterns are not evident. Differences in upper ocean properties, particularly in ocean stratification, highlight the significant impact of strong sea ice attenuation in the mixing parametrization. These findings underscore the substantial influence of enhanced ocean mixing on the physical properties of ocean and sea ice.