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The importance of oceanic forcing on Arctic sea ice variability

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Recent observational and modeling studies suggest that the increasing duration and area of open water during the melt season allows significant accumulation of solar energy in the upper ocean, extending below the shallow summer mixed layer. In addition, summer Pacific water provides another source of increasingly warmer water above the halocline entering the western Arctic basin from the Chukchi shelves. While the upper mixed layer cools during the fall and removes all its heat back to the atmosphere before freezing, the heat accumulated below he mixed layer is not readily removed and may continue into the winter. The absolute magnitude and long term variability of the upper ocean heat storage and fluxes are not well known from observations and are typically poorly represented in models. This heat may reduce sea ice growth in winter or increase under-ice ablation during summer, especially in regions where physical processes, such as mesoscale eddies, topographically controlled local flow and shelf break upwelling, can allow sufficient vertical mixing and heat entrainment into the mixed layer.

We hypothesize that the excess oceanic heat that has accumulated during recent summers due to increased solar insulation and oceanic heat convergence is a critical initial factor in preconditioning the sea ice cover before the melt season and reducing ice concentration and thickness in the western Arctic Ocean onwards the following year. To test this hypothesis we analyze and synthesize limited observational data and numerical model results on the upper ocean and sea ice conditions in the Beaufort Sea. Observational data include ice-tethered profilers (ITPs) and co-located ice mass-balance buoys (IMBs). Numerical results from two models are used, an eddy-permitting ($\sim$9km) and an eddy-resolving ($\sim$2km) pan-Arctic coupled ice-ocean model configurations. Based on observational data we find that entrainment events driven by mesoscale eddies may locally be a significant contributor to sea ice melt or a limiting factor for ice growth in winter. Model results are used to get a quantitative measure and spatial distribution of mesoscale eddy activities in the western Arctic. Gains in the eddy-resolving model due to its explicit representation of local Rossby radius of deformation (of order 10km or less) are evaluated. It is found that a significant portion of the total variance of sea ice thickness in the western Arctic Ocean can be explained by the oceanic heat that has accumulated below the mixed layer in the recent times. We argue that understanding of such processes and feedbacks affecting the ice-ocean interface is critical to advance Arctic climate prediction.