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A physical wave mixing parameterisation for the polar regions

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Breaking waves and waves propagating under sea ice cause mixing of the upper water column. Present mixing schemes in ocean models take this into account through surface roughness. Sea surface roughness in the polar regions depends on significant wave height and sea ice bottom roughness. Nevertheless, surface roughness is commonly parameterised using significant wave height of wind waves, calculated from local wind speed, ignoring the effect of sea ice. Here, we present results from global simulations using modelled surface roughness instead, which accounts for the roughness of sea ice itself, as well as the effect of swell and wind waves. The simulations use the NEMO ocean model coupled to the CICE sea ice model in a global 1-degree configuration, with wave information from the ECWAM model of the European Centre for Medium-Range Weather Forecasts (ECMWF). The new mixing formulation modifies vertical heat fluxes to and from the sea ice, which in turn affect sea ice concentration and ice thickness in both Polar Regions. In the Southern Ocean there is an increased meridional gradient in ice thickness with the new scheme. The sea ice concentration shows a dipole pattern change with decreasing concentration in the Weddell and Ross seas and increases in the Bellingshausen and Amundsen seas and in the Indian sector of the Southern Ocean. We also examine the mixed layer depth changes. With the new mixing scheme the mixed layer depth bias under sea ice in the Arctic in spring is improved. In the Southern Ocean mixed layer depth under ice decreases year round. These results highlight the sensitivity of high latitude ocean simulations to the choice of mixing scheme and suggest potential impacts on biogeochemistry and carbon uptake in future projections of the climate and Earth system. For the study we acknowledge support from the NERC Grant NE/R000654/1 'Towards a Marginal Sea Ice Cover' and the EU FP7 Project 'Ships and waves reaching Polar Regions (SWARP), grant agreement 607476. We also acknowledge funding from the NERC Programme "The North Atlantic Climate System Integrated Study (ACSIS)" NE/N018044/1.