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The effect of tides on sea ice, temperature and salinity fields in the Arctic Ocean on multi-decadal scales.

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The effects of tides on the hydrographical fields and sea-ice on multi-decadal timescales (from 1978-2007) has been examined using a newly developed Arctic Ocean NEMO-shelf–ice coupled model of moderate (10-15km) resolution, which explicitly simulates tides and processes in the benthic boundary layer. The model realistically reproduces the tides, which can be extremely strong on the Arctic shelf, with amplitudes reaching 4.4m in the Hudson Strait, 2-3m in the White Sea and above 1m in the Canadian Archipelago. It also accurately predicts the sea ice volume trends over this period, when compared with PIOMAS results, and demonstrates a stronger reduction in ice volume (by ∼15%) and extent (by ∼5%) in comparison with simulations without tides. By including tides in the Arctic simulation we find: (i) a decrease in ice thickness from 0.1 to 1m in Central Arctic, and up to 2m in the Canadian Archipelago; (ii) ice melting and thinning is accompanied by an increase in average surface salinity by 2PSU and changes of river freshwater pathways; (iii) cooling of the upper 300m of the Arctic Ocean in comparison with non-tidal simulations. We hypothesize that tidal mixing and advection support the supply of heat from warm Atlantic waters through the strongly stratified halocline layer. It has been found that tidal effects on the water mass structure are regionally localised, but subsequent can be transported across the entire basin. We discuss the following physical mechanisms for tidal influence: (a) increased vertical mixing near the bottom layer and on the ice-ocean interface; (b) opening and closing of leads in the sea ice in summer time altering the solar radiation flux to water below, thus affecting the ocean heat content and amount of ice melt ; (c) opening and closing of leads in the sea ice during winter leading to an increase the heat loss from the ocean to atmosphere, with subsequent ice production and brine rejection; (d) increased mixing in the pycnocline and at the base of mixed layer due to shear induced by clockwise rotating component of M2 and S2 currents; (e) intensive bottom Ekman pumping, generated by tidal benthic shear stresses over the rough bottom topography, leading to the entrainment of warmer waters to the mixed layer as warmer and saltier Atlantic Waters are pushed to the surface.