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Impact of atmospheric and oceanic form drag parameterization on simulations of Arctic sea ice

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Pressure ridges, keels, floe edges and melt pond edges all introduce discrete obstructions to the flow of the air or ocean over the ice, and are a source of form drag. For typical ice covers the form drag contribution to the total drag is of comparable or greater magnitude to the surface or skin drag. In current climate models form drag is only accounted for by tuning of the air-ice and air-ocean drag coefficients, i.e. by altering the roughness length in a surface drag parameterization. The existing approach of skin drag parameter tuning, while numerically convenient, is poorly constrained by observations and fails to describe correctly the physics associated with the air-ice and ocean-ice drag. Here we combine recent theoretical developments to deduce the total neutral form drag coefficients from the key parameters of the ice cover such as ice concentration, size and area of the ridges and keels, freeboard and floe draft and size of melt ponds. We incorporate the drag coefficients into the sea ice component of a climate model (the CICE model). This stage necessitates that the sea ice characteristics obtained locally from observations are mapped to the averaged sea ice quantities provided by the sea ice model at the larger grid cell length scale. We present results over the Arctic of a stand-alone version of the model and show the influence of the new drag parameterization on the motion and mass of the ice cover. The new parameterization allows the drag coefficients to be coupled to the sea ice state and therefore to evolve spatially and temporally. We test the predictions of the model against measured drag coefficients in several regions of the Arctic and find good agreement between model and observations.