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New insight from CryoSat-2 sea ice thickness for sea ice modelling

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Estimates of Arctic sea ice thickness are available from the CryoSat-2 radar altimetry mission during the ice growth seasons since 2010. We derive the sub-grid scale ice thickness distribution (ITD) with respect to 5 ice thickness categories used e.g. in the sea ice component CICE of HadGEM3 climate simulations: (1) ice thickness $h < 60$ cm, (2) 60 cm $< h <$ 1.4 m, (3) 1.4 m $< h <$ 2.4m, (4) 2.4 m $< h <$ 3.6 m, (5) $h >$ 3.6 m. This allows us both to verify the simulated cycle of ice thickness and to initialize the ITD in stand-alone simulations with the sea ice model CICE. We find that a default CICE simulation strongly underestimates the ice thickness, in spite of doing a reasonable job regarding the inter-annual variability of summer sea ice extent. We can identity the underestimation of winter ice growth being responsible and show that increasing the ice conductive flux for lower temperatures (Bubbly brine scheme) and that accounting for the loss of drifting snow results in the simulated sea ice growth being more realistic and generally improves the model simulation. Sensitivity studies provide insight on the role of the conductive heat flux (depending on ice thickness) versus importance of warmer winter air temperatures, the importance of the autumn ice thickness distribution on winter growth and summer extent, the relative importance of atmospheric forcing components on ice evolution, and the relative importance of positive and negative feedback processes.