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Nudging the Arctic Ocean to quantify sea ice feedbacks

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With Arctic summer sea ice potentially disappearing halfway through this century, the surface albedo and insulating effects of Arctic sea ice will decrease considerably. The ongoing Arctic sea ice retreat also affects the strength of the Planck, lapse-rate, cloud and surface albedo feedbacks together with changes in the heat exchange between the ocean and the atmosphere, but their combined effect on climate sensitivity has not been quantified. This study presents an estimate of all Arctic sea ice related climate feedbacks combined. We use a new method to keep Arctic sea ice at its present day (PD) distribution under a changing climate in a 50-year CO_2 doubling simulation, using a fully coupled global climate model (EC-Earth V2.3). We nudge the Arctic Ocean to the (monthly-dependent) year 2000 mean temperature and minimum salinity fields on a mask representing PD sea ice cover. We are able to preserve about 95% of the PD mean March and 77% of the September PD Arctic sea ice extent by applying this method. Using simulations with and without nudging, we estimate the climate response associated with Arctic sea ice changes. The Arctic sea ice feedback (globally) equals 0.28 ± 0.15 Wm^{-2} K^{-1}. The total sea ice feedback thus amplifies the climate response for a doubling of CO_2, in line with earlier findings. Our estimate of the Arctic sea ice feedback agrees reasonably well with earlier CMIP5 global climate feedback estimates and shows that the Arctic sea ice exerts a considerable effect on the Arctic and global climate sensitivity.