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Sea ice in the glacial North Atlantic: coupled model intercomparison and sensitivity study of climate impacts

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Sea ice displacements are thought to play an important role in the abrupt Dansgaard-Oeschger (D-O) cycles recorded in Greenland ice cores and other Northern Hemisphere paloeclimate archives during the last glacial period. This model study investigates the characteristics and climate impacts of North Atlantic sea ice in glacial (LGM) simulations to provide insight into its involvement in D-O cycles. The coupled models participating in PMIP2 produce annual mean Northern Hemisphere sea ice areas from 6–10 $\times 10^{12}$ m^2 with mean Arctic ice thicknesses from 5.2–16 m. All simulations have sea ice concentrations close to 100% year round in the Arctic Basin, but show considerable differences in the low-concentration ($<$50%) regions of the western North Atlantic and western North Pacific. Focusing on one of these models, CCSM3, sea ice variability is concentrated in the winter season with large year to year differences in the ice cover of the Nordic Seas and western North Atlantic. Experiments performed with an atmospheric general circulation model indicate that Greenland surface climate is more sensitive to Nordic Seas ice perturbations than to western North Atlantic ice perturbations. Nordic Seas ice retreat causes 10C of winter warming and a 50% increase in snow accumulation at Greenland Summit, in qualitative agreement with observations of the cold-to-warm (stadial-to-interstadial) transitions of D-O cycles; concomitant ice retreat in the western North Atlantic has little additional effect. The results suggest that winter sea ice displacements in the Nordic Seas are important for creating the observed climate signals associated with D-O cycles in the Greenland ice cores.