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How much did the North American ice sheet contribute to Meltwater Pulse 1a?

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Constraining the source of Meltwater Pulse 1a (MWP1a), a sea level rise of 12 to 22 m in less than 350 years, 14.6 ka (Deschamps et al., 2012) is important for understanding mechanisms of rapid ice melt and the links with abrupt climate change. The North American ice sheet could have been a major contributor to this event due to the abrupt Northern Hemisphere Bølling warming at 14.7 ka and the collapse of the ice saddle between the Cordilleran and Laurentide ice sheets which caused accelerated melt (Gregoire et al., 2012). Here, we combine modelling of the North American ice sheet with observational constraints of ice extent evolution and sea level change to evaluate how and how much the North American ice sheet could have contributed to MWP1a. We drive an ice sheet model offline with transient climate experiments of the last deglaciation (21-7 ka) performed with two General Circulation Models (CCSM3 and FAMOUS) and run perturbed physics ensembles of ice sheet model experiments to take into account both climate and ice sheet model uncertainties. By ruling out experiments which do not match the evolution of ice extent and volume through the deglaciation (21-7 ka), we determine the range of plausible sea level rise associated with MWP1a. The North American ice sheet produces a sea level rise of 3-6 m in 350 years in response to the Bølling warming and 7-10 m over the same duration due to the ice saddle collapse during the separation of the Cordilleran and Laurentide ice sheets. Although not seen in our experiments, it is possible that the Bølling abrupt warming triggered the saddle collapse, in which case the meltwater flux would have been substantially amplified.