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Assessing internal variability of climate variables as a driving force for ice sheet model simulations

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Rising sea level poses a major risk to human societies and coastal habitats and ice sheet melt is a major contributor to sea level rise. Thus, understanding uncertainty of forcing and variability within the climate system affecting ice sheet melt is essential for assessing its long-term risk. The predictability of polar climate is limited by uncertainties in the given forcing, the climate model response to this forcing, and the internal variability arising from feedbacks within the fully coupled climate system. Among those sources of uncertainty, the impact of internal variability on ice sheet changes has not yet been robustly assessed. Here we estimate how internal variability affects ice sheet projections using climate fields simulated from 50-member Community Earth System Model (CESM) experiment with different initial conditions (Sriver et al., 2015) to force the three-dimensional ice sheet model developed by Pollard and DeConto (2012). We find that some ensemble members show asymmetric trend of 2m air temperature variability over Greenland, which leads to different ice sheet responses. Our ice sheet model results indicate that using climate forcing fields of the CESM ensemble mean can significantly underestimate ice sheet melt compared to the melt using individual climate forcing fields from the 50 member ensemble. In addition, the internal variability solely due to unforced variability from the fully coupled CESM can cause about 15mm sea level contribution differences in 2100 compared to present day. As the Arctic region becomes warmer, the role of internal variability is critical given the complex nonlinear interactions between surface temperature and ice sheet. Our results demonstrate that internal variability from coupled atmosphere-ocean general circulation model can affect ice sheet simulations. This highlights the urgent need to reassess associated uncertainties of projecting ice sheet loss in the next few centuries to obtain robust estimates of contribution of ice sheet melt to sea-level rise.