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Forced Changes in the Arctic Freshwater Budget Emerge in the Early 21st Century

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Arctic liquid freshwater (FW) storage has shown a large increase over the past decades, posing the question: Is the Arctic FW budget already showing clear signs of anthropogenic climate change, or are the observed changes the result of multi-decadal variability? Using large ensemble simulations from the Community Earth System model (CESM), we show that the observed change in liquid and solid Arctic FW storage is likely already driven by the changing climate. Generally, the emergence of forced changes in Arctic FW fluxes occurs earlier for oceanic fluxes than for atmospheric or land fluxes. Nares Strait liquid FW flux is the first to show emergence outside the range of background variability in the model, with this change potentially already occurring, followed by Davis Strait. Other FW fluxes have likely started to shift but have not yet emerged into a completely different regime. By re-sampling the model simulations, we find that the already changing nature of many FW budget terms over the short (~maximum 25 years) observational period can delay detection of shift and emergence from observations. Future emissions reductions have the potential to avoid the emergence of some FW fluxes beyond the background variability, in particular for runoff and Fram Strait solid FW export. However, under both low and high warming scenarios, all FW fluxes show changes, just not always completely outside the background variability as simulated by the CESM. Overall, this study provides an example of how large ensembles can be used to diagnose forced changes in short observational timeseries.