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Arctic circulation regimes and Greenland freshwater in the sub-Arctic seas

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Between 1948 and 1996, wind-driven components of ice drift and surface ocean currents experienced a well pronounced decadal variability alternating between anticyclonic and cyclonic circulation regimes. During cyclonic regimes, low sea level atmospheric pressure dominated over the Arctic Ocean driving sea ice and the upper ocean clockwise; the Arctic atmosphere was relatively warm and humid and freshwater flux from the Arctic Ocean toward the sub-Arctic seas was intensified. During anticylonic circulation regimes, high sea level pressure dominated over the Arctic driving sea ice and ocean counter-clockwise; the atmosphere was cold and dry and the freshwater flux from the Arctic to the sub-Arctic seas was reduced. Since 1997, however, the Arctic system has been dominated by a 17-year anticyclonic circulation regime with a set of environmental parameters that are atypical for these regimes. Of essential importance is to discern the causes and consequences of the apparent break-down in the natural decadal variability of the Arctic climate system, and specifically: Why has the well-pronounced decadal variability observed in the 20th century been replaced by relatively weak interannual changes under anticyclonic circulation regime conditions in the 21st century? We speculate that before the 2000s, the freshwater and heat exchanges between the Arctic Ocean and the North Atlantic were self-regulated and their interactions were realized via decadal climate oscillations. In the 21st century, this near-decadal variability has been interrupted as a result of an additional freshwater source associated with Greenland ice sheet melt. We hypothesize that the excess freshwater flux from Greenland has reduced deep convection in the sub-Arctic seas, resulting in the cessation of decadal oscillations in Arctic climate regimes. In order to test this hypothesis, numerical experiments with a set of FAMOS (Forum for Arctic Modeling & Observational Synthesis) ice-ocean coupled models have been conducted. In these experiments, Greenland freshwater is tracked by passive tracers being constantly released along the Greenland coast. The experiments demonstrate propagation pathways and time scales of freshening signal within the sub-Arctic seas.