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Atlantic water intrusions linked to NAO modulate Greenland Ice Sheet discharge dynamics

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Major outlet glaciers in the Greenland Ice Sheet have experienced rapid fluctuations in speed and discharge over the last decade. The triggering mechanism of abrupt speed-up events is not firmly established, but synchronous occurrences and numerical simulations of response dynamics suggest an oceanographic cause. Here, we show that warm Atlantic water was present inside Kangerdlugssuaq Fjord, East Greenland, a few months before the sudden retreat of Kangerdlugssuaq Glacier in 2004. Using temperature and salinity from the ¼ degree NEMO ocean model and hydrographic data collected in previous years, we show that inflow of warm, saline Atlantic water to the East Greenland continental shelf may be a seasonal mechanism and that the extent and coastal proximity of Atlantic water intrusions may be governed by the North Atlantic Oscillation (NAO). To investigate the possible impact of these intrusions, we developed an automated procedure for identifying calving margins from MODIS data (2000-2008), allowing for the delineation of calving margins in 100,000+ images of East Greenland. This region-wide assessment of glacier fluctuations showed rapid retreat by an average of 2.9 km over 2001 to 2005 for the glaciers exposed to Atlantic water intrusions opposed to average retreat of just 0.3 km for glaciers unaffected by such inflows. The modeled extent of Atlantic water intrusions and the mapped extent of rapid glacier change are consistent with the recent attribution of sustained mass losses in southeast Greenland to increased discharge. Although our data suggest that NAO impacts on ice sheet discharge could be large, they also show that the influence is geographically confined.