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Investigating connections between local-remote atmospheric variability and Greenland outlet glacier behavior

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The outlet glaciers along the margins of the Greenland Ice Sheet (GrIS) exhibit a range of behaviors, which are crucial for understanding GrIS mass changes from a dynamical point of view. However, the drivers of this behavior are still poorly understood. Arguments (counter-arguments) have been made for a strong (weak) local oceanic influence on marine terminating outlet glaciers while decadal-scale drivers linked to fluctuations in the Ice sheet itself and the North Atlantic ocean (e.g. Atlantic Multidecadal Variability) have also been posited as drivers. Recently there have also been studies linking (e.g. seasonal to interannual) atmospheric variability, synoptic activity and the Ice Sheet variability. But these studies typically investigate atmospheric links to the large-scale behavior of the Ice Sheet itself and do not go down to the scale of the outlet glaciers. Conversely, investigations of the outlet glaciers often do not include potential links to non-local atmospheric dynamics. Here the authors attempt to bridge the gap and investigate the relationship between atmospheric variability across a range of scales and the behavior of three outlet glaciers on Greenland's southeast coast over a 33-year period (1980-2012). The glaciers – Helheim, Midgard and Fenris – are near Tasiilaq, are marine terminating and exhibit varying degree of connection to the GrIS. ERA-Interim reanalysis, sea-ice data and glacier observations are used for the investigation. Long records of mass balance are unavailable for these glaciers and front position is employed as a measure of glacier atmosphere interactions across multiple scales, as it exhibits robust relationships to atmospheric variability on time scales of seasons to many years, with the strongest relationships seen at seasonal – interannual time scales. The authors do not make the argument that front position is a suitable proxy for mass balance, only that it is indicative of the role of local and remote atmospheric/climate dynamics in glacier behavior. Our study suggests a strong relationship between large-scale tropospheric circulation patterns, such as the so-called Greenland Blocking Index (GBI), and glacier front position. This relationship is seen in the wintertime (summertime) circulation influence on spring (fall) front position. Dynamically, a physical pathway is illustrated via canonical correlation analyses and composites of low-mid level winds, which show strong southerly advection into the region when the GBI is positive. There are also potential links between local and remote diabatic heating in the atmospheric column, SSTs, sea-ice concentration and front position. Whether there are physical pathways connecting remote surface processes, such as heating along western Greenland is not yet clear. Causality is always difficult to infer in reanalysis-based studies but physical intuition and theory provide multiple lines of evidence, which suggest a substantial influence of large-scale atmospheric dynamics at the margins of the GrIS. Improving our understanding of these physical connections will be crucial, as we know the outlet glaciers will respond under rapidly changing climate conditions.