Rapid changes in advance–retreat (co)variability of Sermilik fjord glaciers, southeast Greenland

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Marine-terminating Greenland Ice Sheet outlet glaciers have recently been found to vary more rapidly than previously believed. Among the most dynamic are the outlet glaciers in southeast Greenland. Three major outlet glaciers – Helheim, Fenris and Midgård – terminate in the upper part of Sermilik fjord, the largest fjord system in southeast Greenland. Their close proximity, only 7–15 km apart from each other, suggests that the glaciers are under the same atmospheric and oceanic regime, and thereby may have a common response to variability in external forcing. The range of variability and the degree of co-variability between them is poorly known except for the past decade, as there are few studies of the long-term variability of glacier calving at high temporal resolution.

Here we present results from the most temporally well-sampled satellite record produced to-date for these glaciers, spanning 30+ years at monthly to seasonal resolution through the period, 1980–2012. These efforts are part of the SEALEV project at the Centre for Climate Dynamics at the Bjerknes Centre for Climate Research, Bergen, Norway. We identify approximately decadal sub-periods (1980–1991, 1992–2001 and 2002–present) when the three glaciers exhibit different advance–retreat (co)variability than in the other sub-periods, which are marked by rapid shifts. The early period from 1980–1991, which has been little studied previously, was highly dynamic despite no significant overall trend for Helheim and Fenris. This period was characterized by: (1) the largest seasonal cycle in advance–retreat, (2) advance–retreat patterns that were generally consistent between the three glaciers, and (3) individual years that were extremely dynamic, e.g., 1985/86, when Helheim advanced 6 km and then retreated 4.6 km in just two weeks, suggestive of possible surge-type behavior. The second period was more quiescent, with a low-amplitude seasonal cycle and no multiyear advances or retreats. The third period since 2001 is characterized by changes in behavior, including: (1) renewed seasonal variability, albeit half that observed in 1980–1991, (2) enhanced interannual/multiyear variability, including the well-known retreat of Helheim 2001–05, and (3) overall retreat for each of the three glaciers, though Midgård exhibits divergent behavior with an unabated recession through the entire period.

The possible reasons cause the rapid changes in glaciers behavior and sometimes coherent and sometimes incoherent behavior of the three glaciers, and the connection with climatic forcing are discussed.