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Only skin deep? Linking sea surface temperatures with sub-surface continental shelf and fjord ocean variability near Helheim Glacier, Greenland

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The Greenland ice sheet (GIS) contributes one-quarter of global sea level rise each year and one-third of its mass loss occurs at outlet glaciers. Melting at the ice-ocean boundary through interactions with relatively warm ocean water is one mechanism for this loss. In situ ocean measurements serve as the predominant method for studying these harsh and remote fjord environments, but have only been acquired within the last decade in most Greenland fjords. Since many outlet glaciers began to accelerate and retreat before that period, the lack of earlier measurements requires us to rely on an understanding of contemporary fjord processes and inference of past conditions to evaluate the ocean's role in observed glacier change. Satellite-derived sea surface temperatures (SST) may hold clues to fjord heat content and ice-ocean interactions spanning before rapid change began at the turn of the century, but they have been historically underutilized around Greenland.

In this study, we explore the utility of SSTs using Sermilik Fjord near Helheim Glacier as a case study. Within Sermilik Fjord and on the inner continental shelf, warm Atlantic Water (AW) flows below 150-250m with cold, fresh Polar Water above, while AW resides from the surface to depths below 600m outside of the shelf break. Little is known about the water mass interactions between, or the mechanisms linking AW offshore to the fjord. To investigate these problems, we derive SSTs from the MODIS Level 3 gridded SST product, exploring changes in water mass temperatures and transport within the Helheim system from 2000 to present. The SSTs reveal a permanent, but variable, bifurcation of AW throughout the water column that transports heat onto the continental shelf along bathymetric troughs toward Sermilik Fjord. Peak SSTs and maxima in the extent of the bifurcation occur on the shelf in 2003 and 2010, and have experienced an upward trend since a low in 2012. In contrast, we observe a general cooling of AW offshore since 2012, suggesting that AW source temperature may not be the most important driver of the variability of waters on the shelf that ultimately feed the fjords. Comparing the SSTs to wind events and sub-surface ocean temperatures, we find that winter shelf SSTs closely correlate with deep water temperatures near the fjord mouth and variability may have linkages with the winds. Our work suggests SSTs can provide new insight into ocean variability that can better inform our understanding of the drivers of glacier change.