Revealing the Southeast Greenland physical environment to enhance biological knowledge

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Abstract

Southeastern Greenland (SEG) provides a complex habitat area consisting of dozens of deep fjords that connect land-based ice with the open ocean. Within these fjords, glacial ice mixes with sea ice and intricate topography can create niche local conditions. This area is important for a number of species, including polar bears, and better understanding of both land ice and floating glacial ice as biological habitat motivates the need to study the physical environment itself. Studying SEG, however, posed a variety of challenges, including difficult access for in-situ work or instrument deployment, cloudy conditions that can obscure optical satellite instruments, and steep, complex terrain that can complicate identification of surface conditions. Here, we discuss our work to leverage several remote sensing products to determine the geospatial patterns of landfast sea ice and solid glacial ice during 2015-2019 in five SEG fjords with high polar bear use. We further connect these data with measurements of solid glacial ice discharge and glacial and terrestrial freshwater flux across SEG. The landfast sea ice season in our focus fjords is quite short, extending on average only ˜2-4 months, and including substantial variability. Because of the fjord connections to marine-terminating glaciers, however, solid glacial ice creates a potential alternative ice platform on the fjord surfaces that can complement the short sea ice season. Challenges remain in automating this type of surface classification, and we discuss how our manual digitization work can be leveraged to support other ongoing efforts to create machine learning surface identification algorithms.

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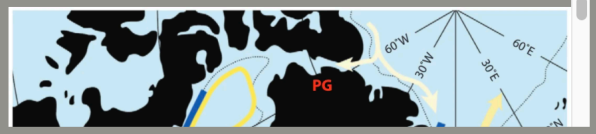
Southeast Greenland (SEG) is important habitat and a unique cryosphere zone.



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Satellites + hand-digitization reveal distinct ice types.

Digitizing Fjord Fast Ice

To more fully understand the physical characteristics of Southeast Greenland (SEG), we used satellite imagery to measure the spatial and temporal distribution of ice within fjords and determine the length of the "ice-cover season". Polar bears rely on fast ice platforms to support their lifestyle and the length of the frozen season is assumed to be related to the health of the polar bear population in SEG.

We sought to distinguish fast ice (FI) from pack ice (PI), glacial melange (GM) and open water (OW) [Figure 2]. To analyze landfast sea ice, we combined data extracted from imagery via the Operational Land Imager (OLI) onboard the USGS Landsat 8 satellite with data extracted from images captured by the MODIS (Moderate Resolution Imaging Spectroradiometer) instruments aboard the NASA Aqua and Terra satellites.

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Glacial ice extends the ice-cover season.

Fjord ice-cover can provide an important platform for marine mammal activities. With our carefully digitized fast ice and glacial ice datasets we are able to look at how glacial ice may alter the fjord ice-cover season.

Figure 4. Polar bears on glacial ice. Photograph demonstrating polar bears' use of glacial ice. Photo credit Kristin Laidre

Fjord ice-cover across the seasons

While landfast ice exhibits seasonal cycles, ice of glacial origin is introduced into fjords by active, marine-terminating glaciers throughout the year.

The multi-panel figure below show fast ice and glacial ice presence, including area and percent coverage for fast ice (solid lines) and glacial ice (dashed lines - denoting presence of type 2 and type 3 glacial ice) in five SEG fjords during 2015-2019. Using a threshold of 15% areal fast ice coverage (horizontal dashed grey line), the days on which the fast-ice area rises above or drops below the threshold are marked (black dots). The duration of the fast-ice season, when the area of fast ice exceeds the threshold, is indicated at the bottom of the figure by the

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Glacial ice and melt make SEG fjords diverse freshwater mixing zones.

The ice sheet and glacier landscape not only alters the solid ice character of the fjord surface, but also influences the output and circulation of freshwater.

Glacial ice calved as icebergs into the fjord and glacial meltwater provide freshwater input to the fjord, albeit with different input locations and timing.

- Glacial ice (icebergs, growlers, and bergy bits) is calved into the fjord year-round and can add fresh meltwater to the fjord both far from the shore and at a variety of depths. The timing and location fo

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An icy future?

Polar Bears Use the Unique Ice Surface

Our investigation of the SEG physical environment is in part motivated by interest in its character as a polar bear habitat. Our findings that glacial ice can extend the ice-cover season suggest that glacial ice provides a critical element of SEG polar bear habitat. While we have not yet fully combined our SEG physical environment evaluation with the full suite of 2015-2020 polar bear location data, preliminary results point to the potential value of glacial ice as a primary polar bear habitat.

Looking at the example Anitorup fjord, we combine heatmaps of fast ice and glacial ice presence with polar bear location data (Figure 13). Recall that the fast ice in this fjord is present during roughly February through May (with mean annual duration of 82 days). In contrast, glacial ice is present, especially near the head of the fjord, throughout the calendar

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