Characteristics, Recent Evolution, and Ongoing Retreat of Hunt Fjord Ice Shelf, Northern Greenland

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INTRODUCTION

Due to climate change, significant changes in the Arctic cryosphere have occurred. One feature in particular has been hit the hardest - Arctic ice shelves. These ice shelves are different than Antarctic ice shelves as they are not draining an ice sheet and form partially (or wholly) from multi-year sea ice (MYI).

Known Arctic ice shelves in Ellesmere Island have been deteriorating rapidly since the 1900s. There is one remaining ice shelf in Northern Greenland, Hunt Fjord Ice Shelf (HFIS). This is the story of HFIS (Figure 1)

DATA & METHODS

- Optical Imagery for analysis of physical characteristics of the ice shelf and their changes.
  - Landsat 8 off-nadir
  - MODIS
  - 1978 orthophotography
- DEMs for ice shelf thickness and tributary glacier thickness and grounding line changes.
  - ArcticDEM
  - 1978 DEM
- Altimetry Data for ice shelf thickness.
  - ICESat-1
  - ICESat-2
- Passive Microwave Data for sea ice concentrations and surface melt days.
  - SSMI/I-SSMIS

References

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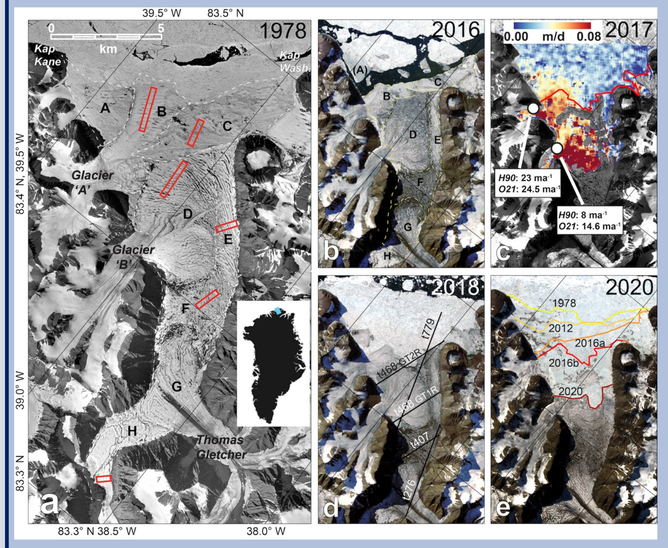


Figure 1. (a) Subscene of the late summer 1978 airphoto mosaic of HFIS region (Korsgaard et al., 2016a). Inset, outline of Greenland showing study location in blue. White dashed lines and bold letters show ice shelf textural regions linked to ice provenance. Red boxes show sampling areas for corrugation wavelength measurements. (b) July 17, 2016 off-nadir Landsat 8 image of HFIS with shelf texture regions and new ice front. (c) August 05, 2017 Landsat image with 2017-2018 image-pair-derived ice flow speed (color scale at top). Red line marks ice shelf front in 2017-18. White dots and text insets show ice flow speed comparisons for locations cited in Higgins, 1990 (*H90*) with this study (*O21*). (d) August 08 2018 Landsat 8 image with ICESat-2 tracks used in Figure 2. (e) July 12 2020 Landsat 8 image showing ice front retreat. All Landsat 8 images are Path 040 Row 245.

RESULTS

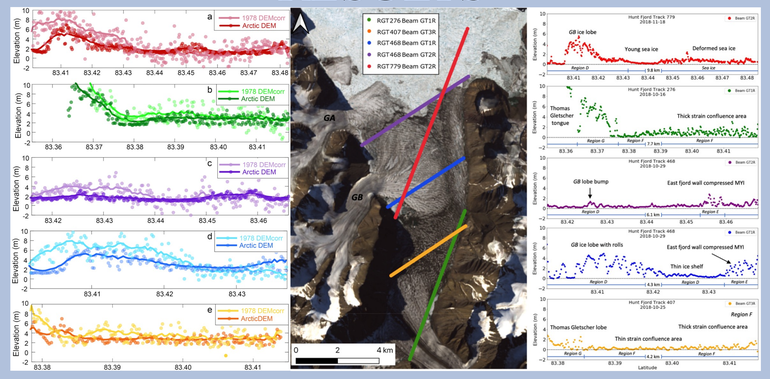


Figure 2. (a) ICESat2 tracks from 2018 plotted over the August 08, 2018 Landsat 8 image; (b) ICESat2 annotated profiles. GA and GB refer to unnamed Glacier 'A' and 'B' respectively. (c) Extracted ArcticDEM and 1978 DEM profiles along the same tracks as ICESat-2. The solid lines are smoothed local averages

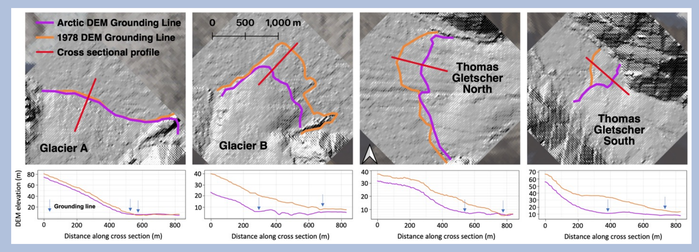


Figure 3. Grounding lines of the HFIS tributary glaciers determined by the distinct break in slope. The DEMs have been adjusted for the EGM2008 geoid and the 3.85 m bias. The background is the 1978 DEM hillshade extracted in 2.5 km boxes (Fig. 4).

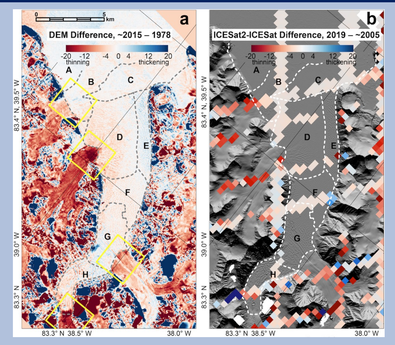
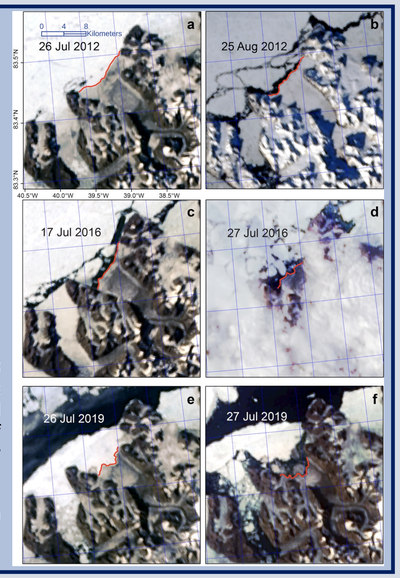


Figure 4 (above). (a) HFIS region of the ArcticDEM minus 1978 stereo airphoto-derived DEM. (b) Gridded ICESat2 elevations (from 2019 ICESat tracks) minus ICESat elevations extrapolated by adjustment of the Arctic DEM, overlain on a shaded relief image of the Arctic DEM. Yellow boxes are 2.5 km cells used for groundling line analysis (Figure 3).

Figure 5 (right). MODIS images of 2012, 2016, and 2019 calving events illustrating connection with limited fast ice loss.



CONCLUSIONS

- HFIS is like other Arctic-style ice shelves with corrugations and minimum thickness (Fig. 1a, b, and c).
- HFIS has several provenance regions, including tributary glaciers and MYI (Fig. 1b), with little change from 1978-2012.
- Starting in 2012 several calving events (Fig. 1 and Fig. 5) **reduced area by 42.5 km²** (~57%) (Fig. 1e).
- Ice shelf and tributary glaciers have **thinned** (Fig. 2 and 3), glacier **velocity nearly doubled** (Fig. 1c), and grounding lines **retreated** (likely due to warm Atlantic water; Fig. 4). Compression of ice shelf from surrounding sea ice resulted in fracturing and damage to the integrity of the shelf.
- Calvings occur during open-water periods at the ice shelf front; low sea ice concentrations offshore of HFIS prior to 2012 did not lead to calvings (Fig. 6).
- **Surface melt days have significantly increased**, likely being the main driver of ice shelf break-up (Fig. 6).

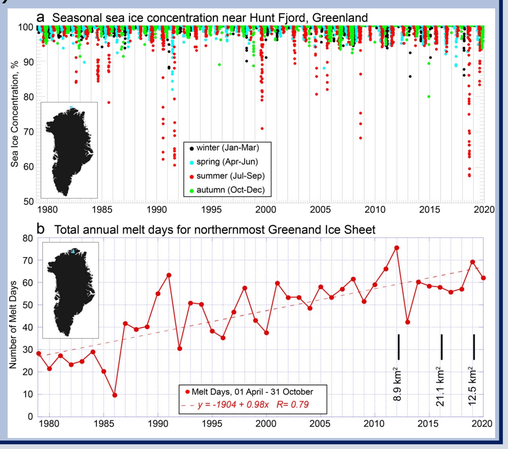


Figure 6. (a) Daily passive microwave-derived sea ice concentrations of a region immediately north of HF and the Greenland coast, versus year (b) Annual total melt days, 1978-2020, from passive microwave determination for the northernmost region of the Greenland Ice Sheet as indicated by the blue points in the inset map. Black lines and areas mark the end-of-season annual area losses (± 1 km²) for HFIS. No losses were evident in MODIS images relative to the 1978 airphoto mosaic prior to 2012.