

Unearthing the forgotten record of glacier change in southeast Greenland

Michael A. Cooper^{1*}, P. Lewińska², J.A. Dowdeswell³, E.R. Hancock², W.A.P. Smith² and D.M. Rippin¹

¹Environment and Geography, University of York, York, UK.

²Department of Computer Science, University of York, York, UK.

³Scott Polar Research Institute, University of Cambridge, Cambridge, UK.



*michael.cooper@york.ac.uk



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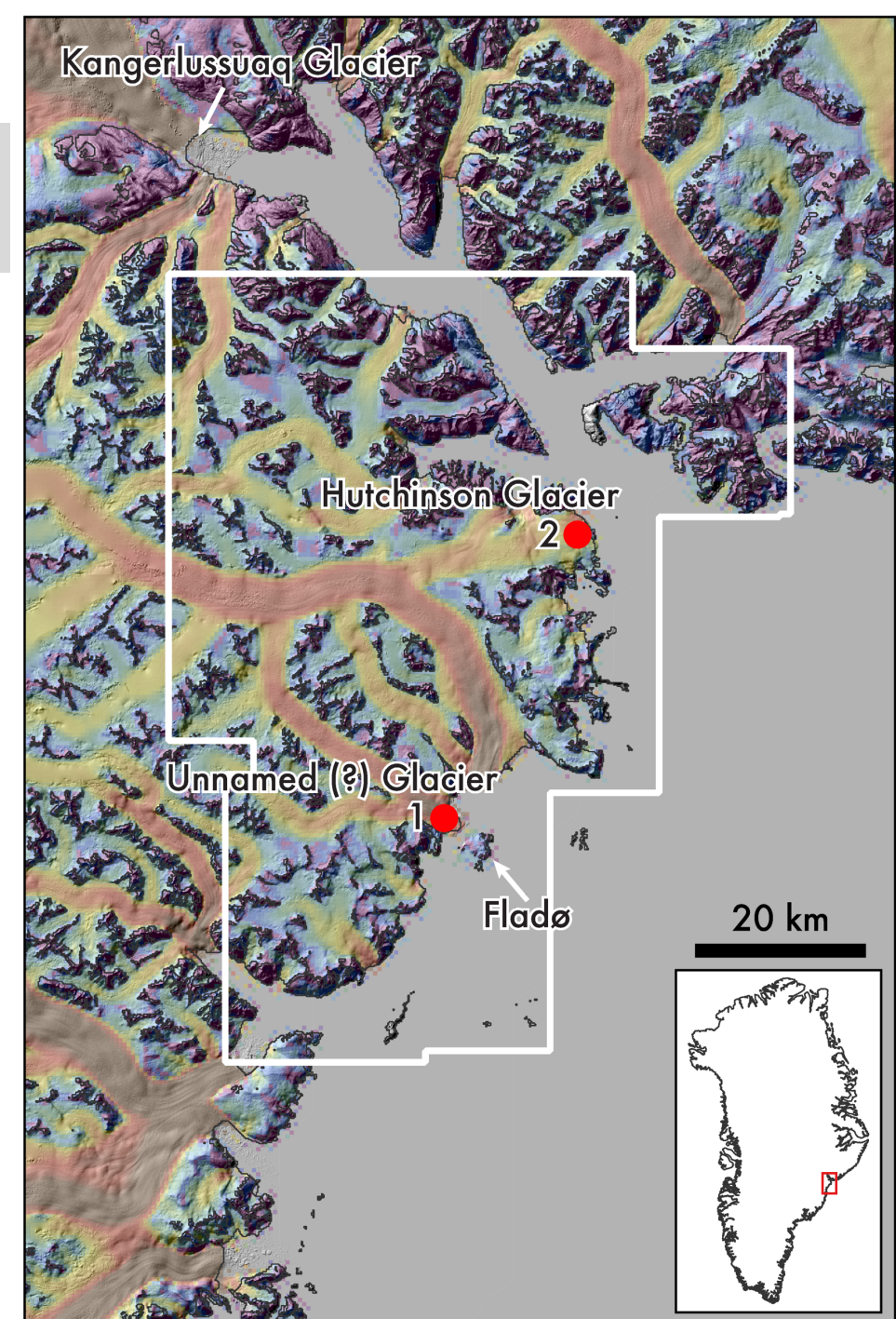
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Background

- **Glaciers and ice sheets are key indicators of changing climate**
 - documenting widespread retreat, and mass loss in recent decades;
 - yet, uncertainties remain regarding longer-term trends, rates of change, and response to variation in climate variables.
- **The widespread, continuous monitoring of ice masses has been possible since the 'satellite era' (post-1972);**
 - **prior to this, however, only more disparate records of glacial change exist** (as collated by the World Glacier Monitoring Service), and few of these records extend before the 1980s (coinciding with the launch of NASA's Landsat programme).
- **Archived expedition, reconnaissance, and field photographs may hold the potential to 'back-extend' satellite records and improve understanding:**
 - pertinent measures of glacial change (i.e. extent [frontal position], and surface elevation) depicted over multiple timesteps can be used to establish more long-term (> 50 year) trends.
 - **Computer vision techniques** (such as Structure from Motion [SfM], in this study) **can prove instrumental in extracting such glaciological metrics, and 3-D models, from these 2-D photographs.**

Study snapshot

- Aerial imagery from two time-steps (1931 & 1983) over a portion of southeastern Greenland was acquired*;
- Structure from Motion (SfM) was used to extract a 3D point cloud using repeat 2D scenes for this region:
 - allowing SfM algorithm to estimate the focal length, altitude, and distance between frames.
- Georectification was applied using stationary ground controls points (GCPs) from a baseline DEM
 - baseline: ArcticDEM (mosaic tiles at 2m resolution);
 - negligible weathering (or change) in stationary (bare rock) points was assumed.
- High resolution DEMs were produced at each timestep at a posting resolution of 10 m.
 - *For the purposes of *#shareEGU* this presentation will only focus on the creation and analysis of data covering the Hutchinson Glacier region (outlined & labelled, right).



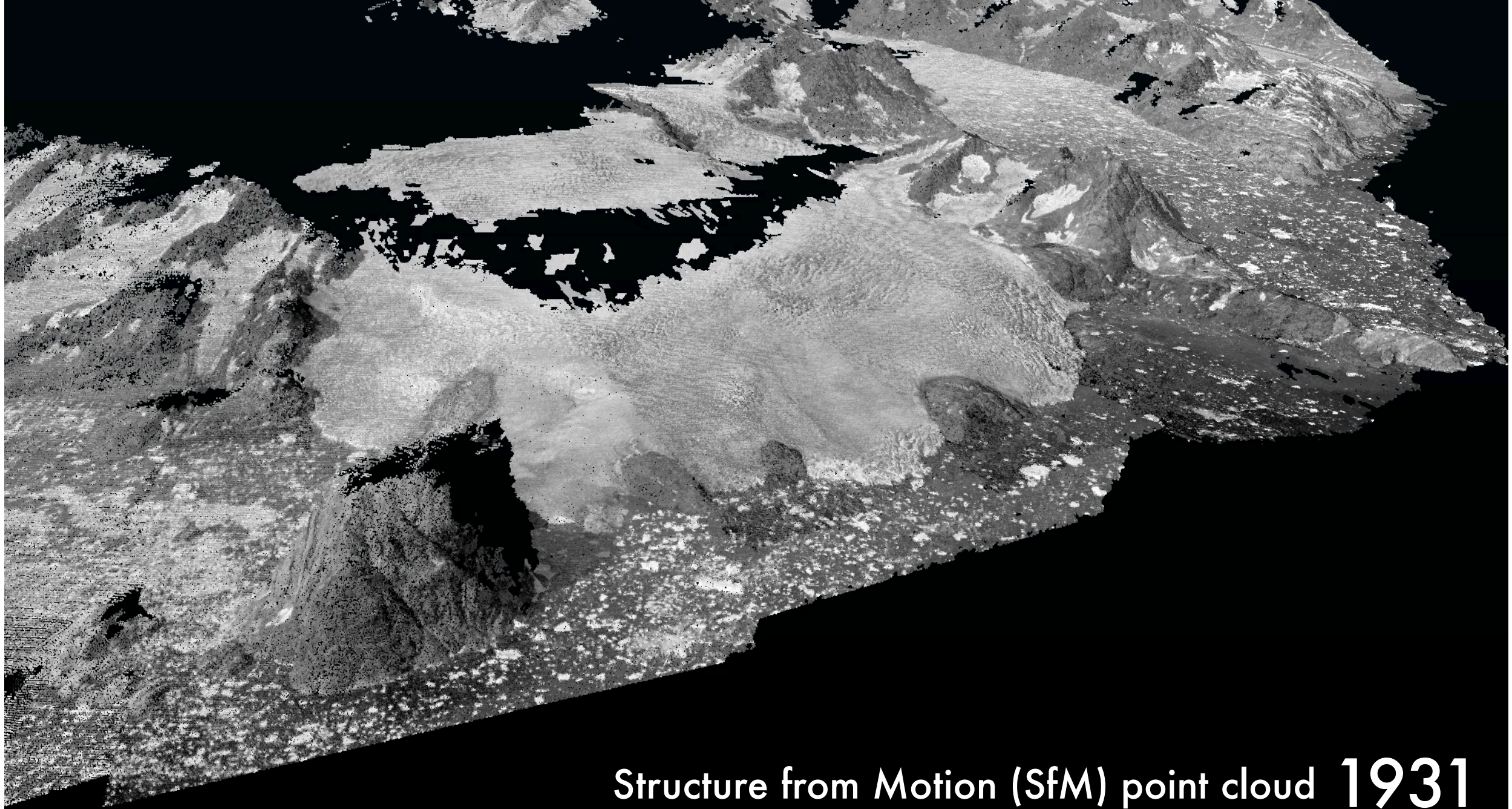
Examples of archival inputs



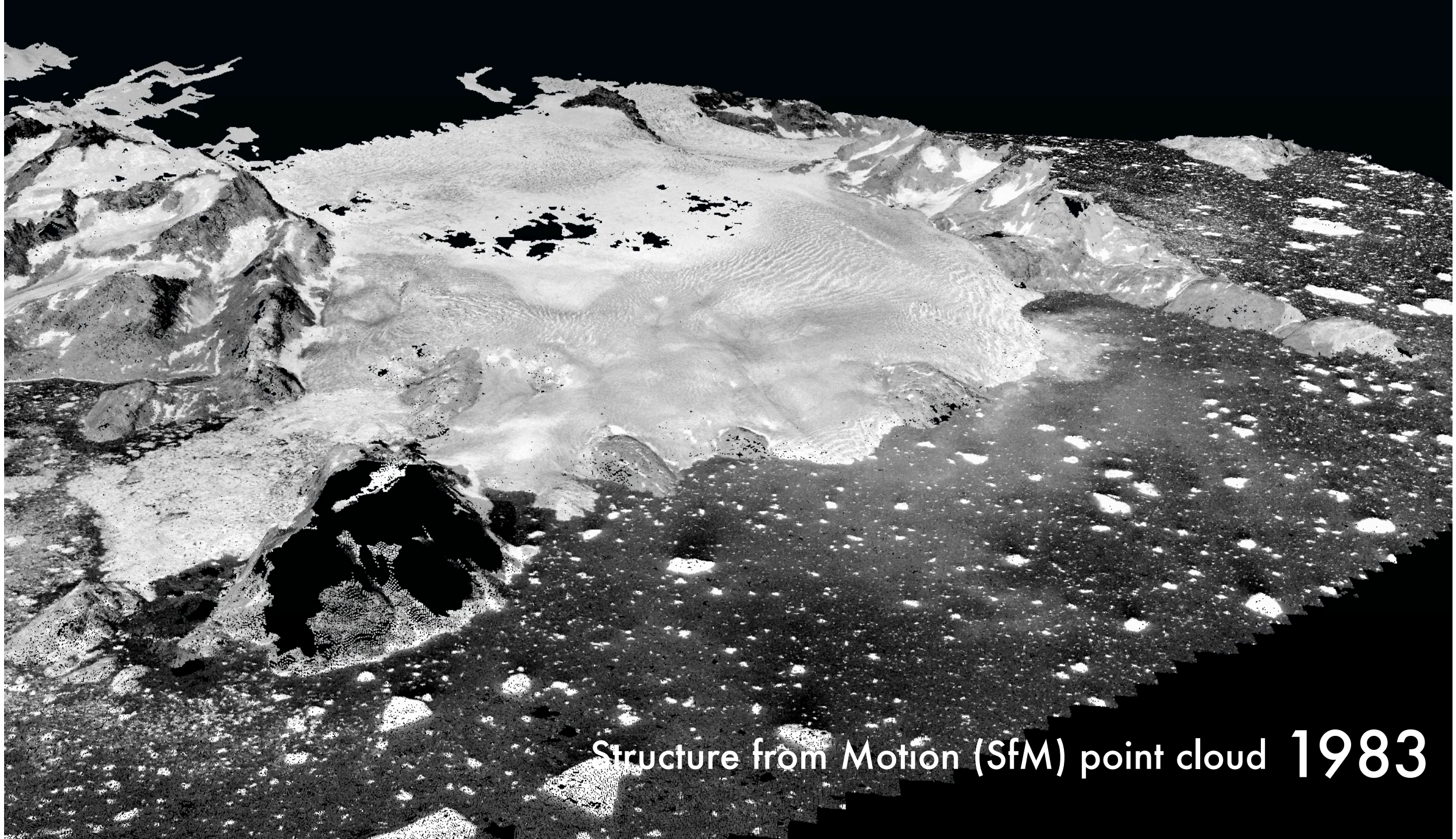
British Arctic Air Route Expedition (BAARE), 1930—31*



(Danish Geodata Agency [held by GEUS])



Structure from Motion (SfM) point cloud 1931



Structure from Motion (SfM) point cloud 1983

Validation of 1931 SfM PC production from camera and flight information

WILLIAMSON
TYPE P. 14
HAND-HELD
CAMERA
5 in. by 4 in.
To take Plates or Films. Multi-Speed Focal Plane Shutter.
Lens : Ross Xpres 8½ in. F/4.5.

Watkins was able to take photographs of about 150 miles of coast-line. These were obliques taken at 10,000 feet, and as no mechanical charge was used, Watkins was kept very busy during the flight. When it was decided to stay in the fjord for four or five days our Eskimo pilot, who had forgotten to bring his sleeping-bag (at least, that was the excuse), decided to go back and fetch it in

9217 feet

7 in.

Both aircraft had *coupé* heads, exhaust-heated cockpits, and extra fuel tanks giving an endurance of about seven and a half hours, or approximately 560–600 miles in still air.

120 km/h

1.8 – 4.4 km

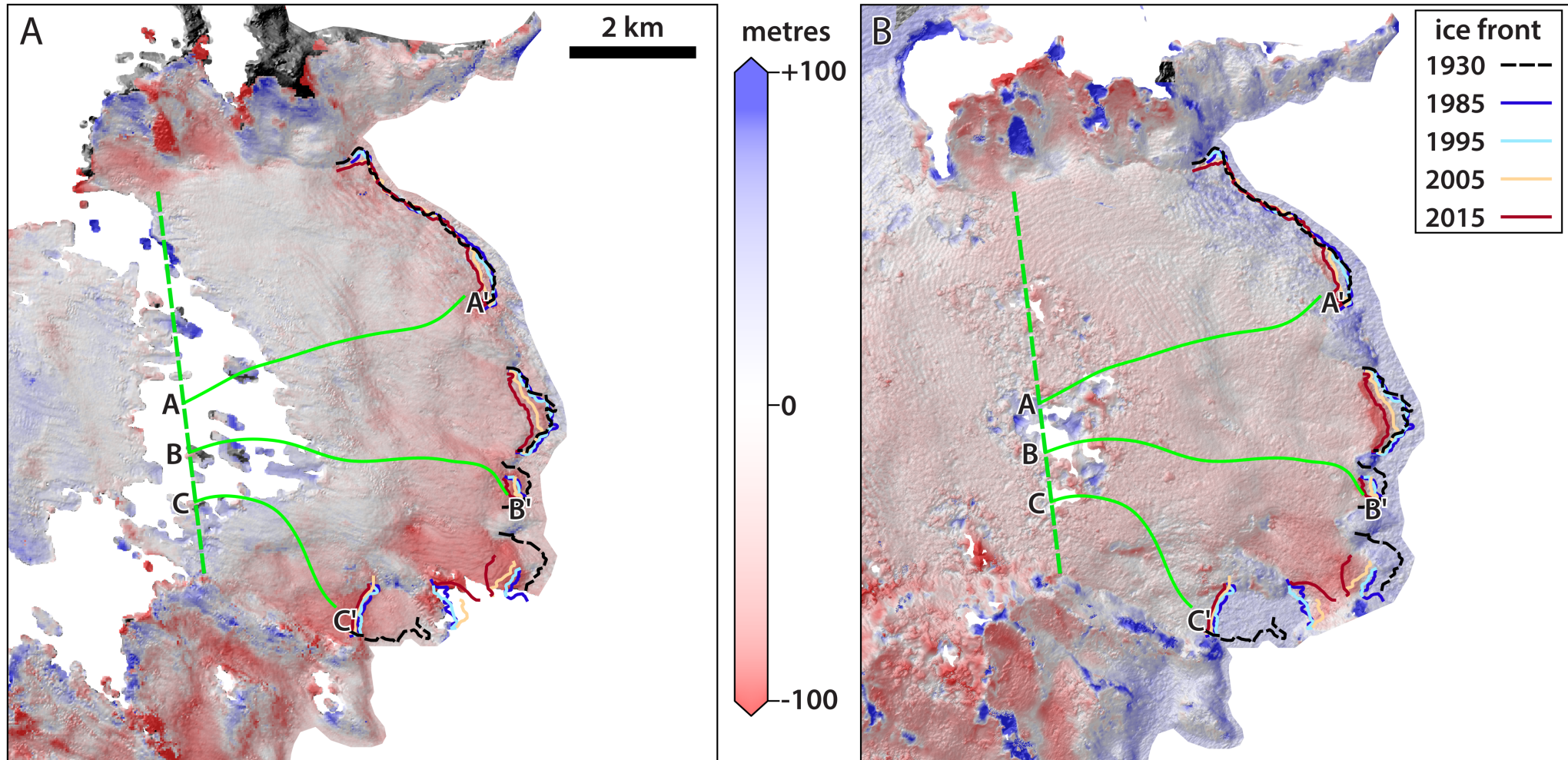
1 – 4.9 km

veyors. I have been doing the photographing. It is necessary to take a photograph every thirty seconds for at least thirty seconds. The thirty seconds do not leave much time for changing the

30s – 146s between frames

ried out in the morning. The camera was set up for 18 hours 20 minutes, were photographic, 450 plates were exposed, covering the whole coast in lat. 66° 05' N. up to and including Kangerdlugsuak. The camera was set up in Sermilik Fjord and Angmagssalik.

DEMs of Difference for Hutchinson Glacier

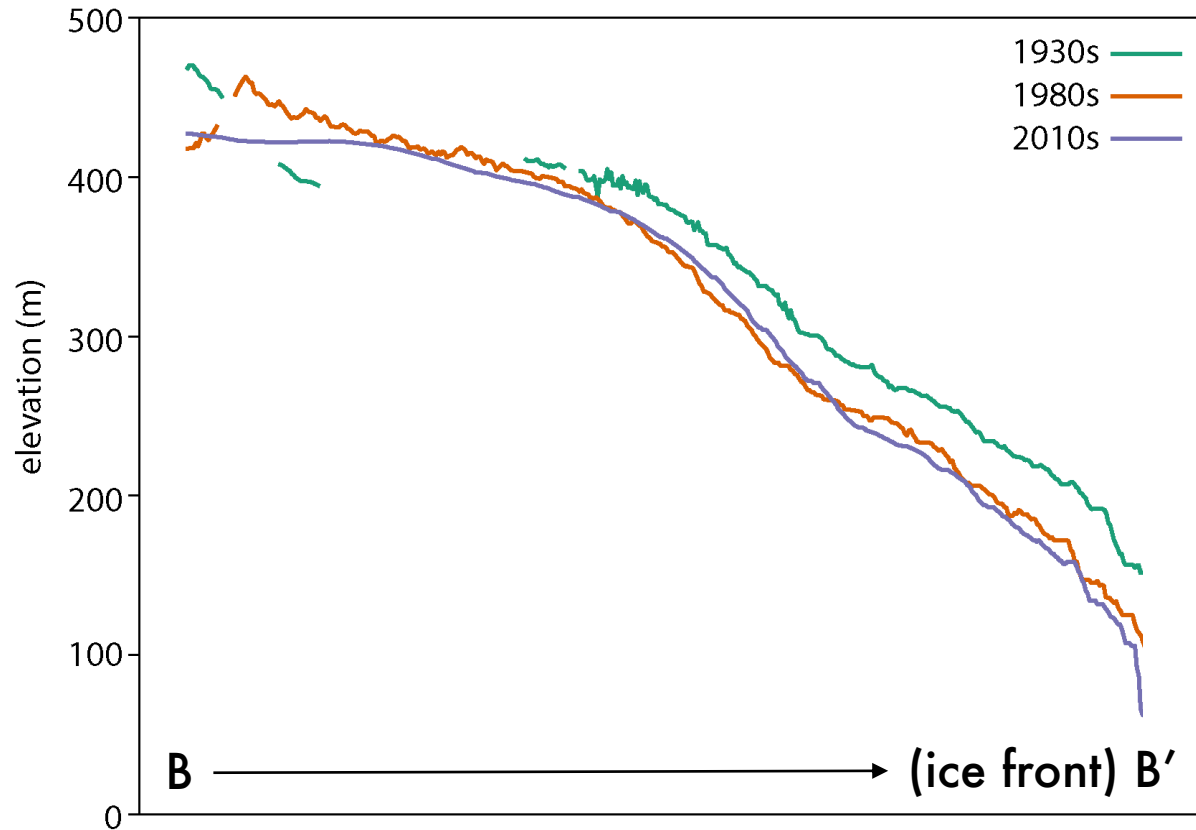


Elevation change 1930s–1980s

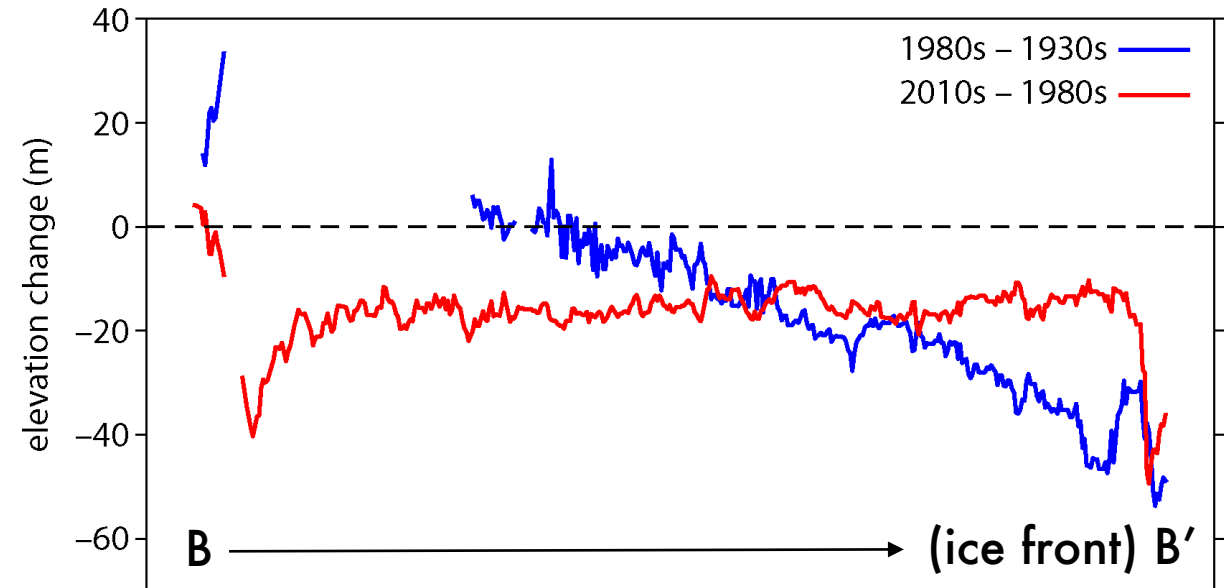
Elevation change 1980s–2010s

(profiles A, B, C are generated along contemporary flowlines)

Surface elevation change (profile B–B')



a) Extracted surface elevations along profile B–B' for generated DEMs for 1931, 1983 and the baseline ArcticDEM (average elevation 2010 to-date).



b) Elevation change (difference) between each time-step.

Early period shows marked lowering at glacier front, later period (between 1980s–2010s) shows more even distribution of throughout profile length.

Summary and future scope

- Using Structure from Motion, high resolution DEM snapshots can be extracted from archival photography to examine over 90 years of glacier change history in southeast Greenland;
- Whilst only one glacier has been presented here, we have covered a ca. 240,000 km length of coastline, extracting glaciological variables for ca. 20 outlet glaciers, providing insight into changing:
 - glacial extent (glacier front, and trimlines);
 - frontal characteristics (transition from marine- to land-terminating);
 - surface characteristics (hydrology, crevassing, etc.);
 - as well as, surface elevation – allowing the calculation of volumetric change since 1931.
- Available regional meteorological data (air temperature anomalies and sea surface temperature changes) will be incorporated to further assess trends between each timestep.
- Aside from repeat aerial photographs (with overlap) as used here, this project aims to make use of single shot photographs (with no overlap) for similar analysis using in-house computer vision techniques – this may extend to using Ponting's photographs from Scott's South Pole Expedition.