Ice-marginal dynamics of Fjallsjökull, Iceland, in response to climate warming

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Background and rationale

Ice-marginal moraines represent valuable terrestrial archives of glacier dynamics, and moraines formed seasonally to annually at glacier margins allow detailed information relating to controls on ice-marginal dynamics to be gained. Investigations of moraine sequences can thus be used to extract glaciological data and construct long-term records of glacier-climate interactions, contextualising and extending observations of current glacier change.

This project aims to exploit the moraine record to examine Icelandic glacier dynamics in response to climate warming. Iceland is an important location for this type of investigation due its maritime, subarctic setting, which makes the glaciers highly sensitive to climate change. This BSG-funded research focused on Fjallsjökull, a major outlet of the Öræfajökull-Vatnajökull ice-cap complex, with the intention of pump-priming future research on Icelandic glacier dynamics.

Field research

The BSG Research Grant was used to support summer fieldwork in 2019. This field research involved (a) UAV surveys of the glacier margin and adjacent foreland, (b) RTK-GNSS surveying of ground control points, (c) geomorphological mapping, and (d) sedimentological investigations of the moraines.

Preliminary findings

Ice-marginal moraines on the Fjallsjökull foreland display crenulated or sawtooth planforms (Figure 1). The sedimentological analyses indicate they formed through pushing and/or squeezing of subglacial traction till, with the distinctive planforms of the moraines reflecting the operation of pushing and squeezing at a glacier margin heavily indented by radial crevasses.

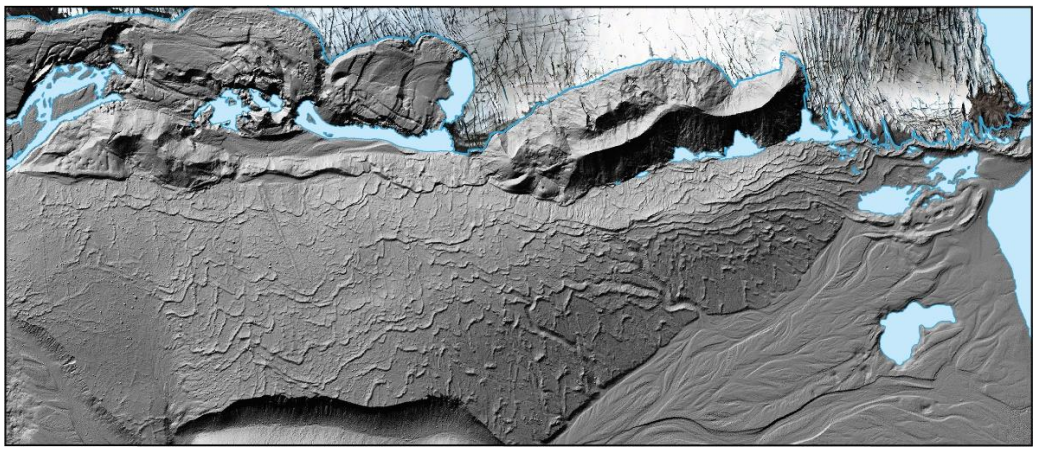

Figure 1. UAV-derived DEM showing an area of moraines near the Fjallsjökull margin. An orthophoto of the glacier is overlain on the DEM. Water bodies are masked by blue polygons.

Examination of remotely-sensed data reveals that push/squeeze moraines were produced on a sub-annual basis at Fjallsjökull between 2003 and 2012. Based on the sedimentological evidence, it is proposed that the sub-annual moraines record (a) minor winter re-advances (pushing) and (b) summer melt events (squeezing). In the latter case, moraines form purely through static loading of saturated till, with meltwater pulses to the bed leading to squeezing. Multiple melt events during summer ice-marginal retreat would result in sub-annual squeeze moraines. It is argued that the period of sub-annual moraine formation reflects a combination of poor drainage conditions (associated with retreat of Fjallsjökull into an overdeepening), large quantities of meltwater reaching the glacier bed, and strong recession during the summer. The period of sub-annual moraine formation coincides with a phase of pronounced positive temperate anomalies in Iceland. These temperatures likely exerted a key control through enhanced glacial meltwater production and glacier recession during the summer, leading to sub-annual moraine formation.