IAPETUS
doctoral training partnership

Interaction between proglacial lake development and Icelandic glacier dynamics (Ref IAP-16-33)

Newcastle University, Department of Geography
In partnership with Durham University, Department of Geography and British Geological Survey (CASE partner)

Supervisory Team	• **Dr. Rachel Carr (Newcastle University)** **http://www.ncl.ac.uk/gps/staff/profile/rachel.carr** • **Prof. Andy Russell (Newcastle University)** **http://www.ncl.ac.uk/gps/staff/profile/andy.russell** • **Dr. Emrys Phillips (British Geological Survey, Edinburgh: CASE partner)** **http://www.bgs.ac.uk/staff/profiles/1449.html**

Key Words	**Iceland, glacier retreat, proglacial lake, ice dynamics, hazards.**

Overview

Glaciers and ice caps are major contributors to global sea level rise and this is forecast to continue during the 21st Century. Consequently, understanding the mechanisms by which glaciers retreat and identifying the factors controlling ice losses are essential for accurate prediction of near-future sea level rise. A growing influence on ice loss is the expansion of proglacial lakes, which develop at the glacier margins as the ice retreats. As a consequence of climate warming, these lakes are currently expanding in many regions, including Iceland, the Himalaya and New Zealand. Here, they represent major natural hazards, with outburst floods threatening human life and causing severe and costly damage to infrastructure. Despite their expanding impact, the detailed interaction between proglacial lakes and their associated glaciers is not properly understood, which limits our capacity to accurately predict glacier loss and its associated hazards, as climate warms.

The formation of a proglacial lake markedly alters the conditions at the glacier terminus and allows the glacier to loose mass through calving of icebergs, in addition to surface melting. Iceberg calving is a key mass-loss mechanism for both lake- and marine-terminating glaciers, but the process and its triggers are not properly understood. A number of potential controls have been identified to date, including: lake level; lake properties (temperature, circulation); pre-existing weaknesses created by crevasses; surface melt inputs; and ice thinning. However, it is unclear which factor(s) dominate and how this may change over time, as proglacial lakes develop grow. Furthermore, it is uncertain how the interaction between a lake and a glacier evolves temporally and the types of feedbacks that might develop.

Iceland and Europe's largest ice cap, Vatnajökull, has a number of outlet glaciers with recently developed proglacial lakes (e.g. Skeiðarárjökull, Skaftafellsjökull, Fjallsjökull, Heinabergsjökull and Hoffellsjökull. Iceland is therefore an ideal location for investigating interactions between proglacial lakes and glacier dynamics. Icelandic glaciers have been highly responsive to climate change and have experienced negative mass balance and margin retreat for the past 20 years (*Björnsson et al., 2013*). During this time, proglacial lakes have expanded rapidly at the margins of its southern outlet glaciers (*Schomacker, 2010*) and have been identified as a cause of their variable response to climate change (*Hannesdóttir, et al., 2015)*, but this relationship is not properly understood, due to a lack of detailed data. Given that major ice loss is forecast to continue in the region during the 21st and 22nd centuries (*Björnsson* et al., 2013), it is vital to understand controls on ice loss from the region. This studentship will address the following key research questions:

1. How does proglacial lake development effect glacier dynamics, including surge behaviour?
2. How does the interaction between the proglacial lake and the glacier evolve over time?
3. What role do proglacial lakes play in the calving process?

Methodology

The project will use a combination of fieldwork, remote sensing and numerical modelling. The study will focus on the past 25 years, during which these glaciers have retreat rapidly, the ice cap has shown negative mass balance and the proglacial lakes have grown dramatically.

Fieldwork will be conducted in two, four-week long periods in 2017 and 2018, with the aim of quantifying the detailed, short-term interaction between the glacier calving front, the proglacial lake and the inland ice. This will be achieved through repeat surveys of the calving front, glacier surface and proglacial topography, using a combination of terrestrial time lapse photography, terrestrial laser scanning and dGPS. Lake temperature and level will be monitored using data loggers. The basal topography of the glacier may also be quantified, using radar surveys. Key meteorological and glaciological datasets will be identified during a two month placement at the University of Iceland and the Iceland Meteorological Office.

Remotely sensed data will be used to assess the relationship between proglacial lake development and glacier dynamics at annual to decadal timescales. Optical imagery (e.g. Landsat, ASTER) will be used to map changes in lake extent and glacier frontal position and to determine velocities using feature tracking. Furthermore, the imagery will be used to determine glacier structure and its evolution over time, in order to evaluate its relative importance in determining ice loss rates and calving patterns. A numerical modelling component may be included, in order to further investigate the impact of the proglacial lakes on glacier retreat and response to climate change.

Timeline

Year 1: Initial remote sensing analysis of glacier change. Field season 1.
Year 2: Analysis of field data, refinement of field methods and remote sensing analysis on basis of results. Field season 2.
Year 3: Complete processing and analysis of field and remotely sensed data.
Year 4: Integration of results and thesis writing.

Training & Skills

The student will receive training in relevant GIS techniques and software packages, including ArcGIS, ENVI and ERDAS imagine. They will be trained in field data collection techniques, such as operation of the Terrestrial Laser Scanner, dGPS and hydrometric equipment. In terms of health and safety training, the student will undertake out door first aid training and a 4 x 4 driving course.

References & Further Reading

Björnsson, H., F. Pálsson, S. Gudmundsson, E. Magnússon, G. Adalgeirsdóttir, T. Jóhannesson, E. Berthier, O. Sigurdsson, and T. Thorsteinsson. 2013. Contribution of Icelandic ice caps to sea level rise: Trends and variability since the Little Ice Age, Geophys. Res. Lett., 40, doi:10.1002/grl.50278

Hannesdóttir, H. Björnsson, H., Pálsson, F. Aðalgeirsdóttir, G. & Guðmundsson, S. 2015. Changes in the southeast Vatnajökull ice cap, Iceland, between 1890 and 2010. The Cryosphere 9, 565– 585.

Schomacker, A. 2010. Expansion of ice-marginal lakes at the Vatnajökull ice cap, Iceland, from 1999 to 2009. Geomorphology 119, 232-236.

Further Information

Dr Rachel Carr, Newcastle University
Email: rachel.carr@newcastle.ac.uk
Tel: +44 (0) 191 208 6436