**PROJECT GREENLAND 2008**

## Aim

The focus of this study was to infer the drainage structure of Russell glacier, Greenland, from diurnal investigations into proglacial hydraulics and hydrochemistry.

## Introduction

Fieldwork was carried out in proglacial system of Russell glacier, an outlet glacier from the polythermal Greenland ice sheet (GIS). Investigations of Greenlandic outlet glacier dynamics has not often been carried out as such a remote area was seen to be detached from the human sphere. However, relatively recent studies show the significance of the GIS to the global phenomenon of climate change (IPCC 2007) thus work on outlet glaciers is becoming more and more vital. Fieldwork centred round monitoring proglacial streams is relatively common practice in warm-based glaciers and have been used as templates for this study on Russell glacier in order to gain a better understanding of the hydrology for such a large polythermal catchment.

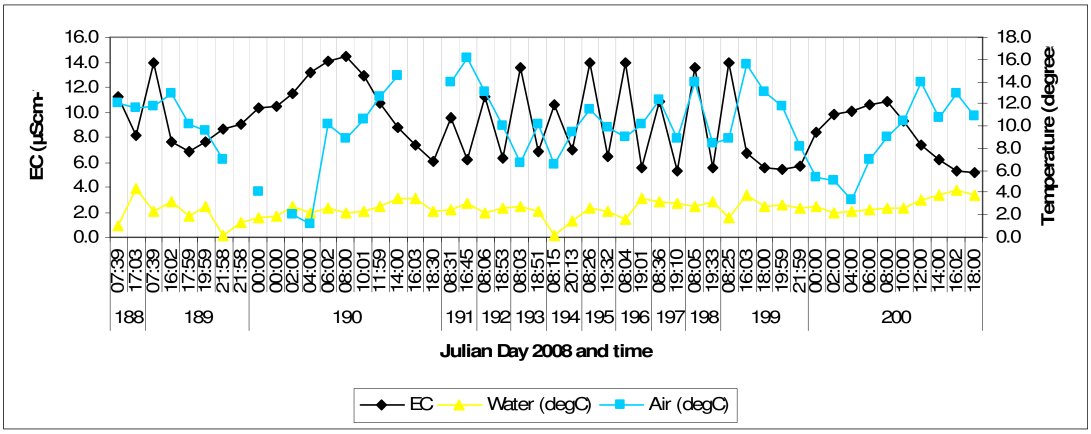
## Methodology

The fieldwork was carried out on the southeastern corner of Russell Glacier, before the proglacial stream braids. Russell Glacier is situated in west Greenland, around 25km north east of Kangerlussuaq. The site was chosen for logistical reasons

Sampling of the proglacial stream occurred twice a day, at approximate times of maximum and minimum discharges, for nine days; and every two hours for two twenty-four hour surveys, at the beginning and end of the fieldwork. At each sampling point, three sets of data were collected: hydraulics, hydrochemistry and contextual. Hydraulically, stage measurements were collected using a tape measure so that discharge data could be resolved from rating curves. Rating curves were defined through the use of dye-tracer experiments facilitated by a separate synchronizing study. For hydrochemistry, an electrical conductivity probe measured the bulk ionic content of proglacial waters and water samples were taken and filtered before being collected in two washed sample bottles: one for pH readings and the second for laboratory study. The analysis of water samples for individual ionic concentrations through a mass spectrometer is still to be completed by Bristol University. Every four days, a pH probe was calibrated before being used in water sample analysis. Contextually, water and air temperatures and weather and ice activity descriptions were taken at times of sampling,.

This type of data collection worked effectively although was limited by scale. Only diurnal relationships can be resolved. Also, the imprecise electrical conductivity probe added inaccuracy to bulk ionic concentrations. The use of a rating curve adds inaccuracies to data as discharges are interpolated within a given calibration range (Hubbard and Glasser 2005). Indeed, the rating curve only fits while the channel cross-section remains unchanged. Due to high discharge events eroding channel banks, two rating curves had to be defined for this 13-day field survey.

## Results




This graph shows the diurnal variations in electrical conductivity, showing the distinct peaks and troughs of ionic concentration for each day. Days 189-190 and 199-200 define the two 24-hour surveys. Highest bulk ion concentrations are reported in the morning, and minimum concentrations in the evening. Air and water temperatures tended to have an inverse relationship with electrical conductivity, showing low results of electrical conductivity at higher temperatures.

## Discussion

The results show interesting diurnal patterns of proglacial stream ionic content, relating to the diurnal variations in glacier hydrology. High ionic concentrations in the early mornings are attributed to low temperatures and low melt rates. Overnight, meltwater is stored within the glacier system and high rates of chemical weathering can take place. In the evening, high temperatures induce high melt rates throughout the day which flush water out the glacier system quickly and there is little time for chemical reactions. The importance of time stored within the glacial system to levels of ionic concentration is reflected in the inverse relationship derived from this study between discharge and electrical conductivity. Additionally, the pH of water samples was high when the electrical conductivity was high and pH was low if electrical conductivity was low. This is because as a result of the acidifying effect of $CO_2$ in meltwaters at night, the higher electrical conductivities of the early hours are also attributed to low levels of hydrogen and a high pH.

## Conclusion

Proglacial hydraulic and hydrochemistry results have shown how information can be inferred as to drainage routeways through a glacier. Low electrical conductivities suggest that Russell Glacier was not experiencing prolonged subglacial water storage at the time of field survey and water travelled through hydraulically effective drainage pathways characterised by large water fluxes, rapid transit speeds and contact with low concentrations of debris. The effects of a low melt-season are apparent: distributed routeways penetrating the subglacial system are more likely to be breached only at times of high melt.

The analysis of water samples for specific ions is still to be finished and will improve inferences as to Russell Glacier hydrological routeways. Some ionic species are principally derived from atmospheric aerosols whereas others are acquired from contact with reactive debris during subglacial flow.

The report enables a more comprehensive assessment of diurnal hydrology dynamics for Russell glacier that fits into wider glaciology research centred in Greenland on outlet glacier dynamics. However, the paper is yet to be contextualised within wider seasonal trends. Importantly, hydrology is key to glacier health and thus has connotations for global sea level rise. In addition, electrical conductivity and associated rates of chemical weathering have implications for sequestration of $CO_2$.

The study has not only enthused my interest in glaciology but also enabled a widening of my skills base through the development of independent study competence.

**Bibliography**

Hubbard, B. and Glasser, N. (2005) *Field Techniques in Glaciology and Glacial Geomorphology*. John Wiley & Sons: Chichester.

IPCC Fourth Assessment Synthesis Report (2007) Topic3. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_topic3.pdf

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Financial support was precisely adequate for the trip to cover costly flights; two nights accommodation in Copenhagen and one night in Kangerlussuaq before the return flight. Costs were also incurred for the analysis of water samples after the fieldwork; for food and fuel for central camp; and in equipment such as the high quality tent for withstanding relatively high winds.

**Itinerary**

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| Feb-July 2008 | Continuous reading; fieldwork planning; and fundraising activities |
| May | Preliminary discussion with dissertation supervisor |
| July | Undertake fieldwork:<br>- 4th Arrive at field site<br>- 5th Familiarisation with equipment<br>- 6th-17th Data collection<br>- 20th Leave site |
| Aug-Nov | Data analysis and interpretation |
| Sept | Second meeting with supervisor |
| Dec/Jan | Writing. |
| Jan 2009 | Draft to supervisor (one chapter or 1500 words) and third meeting |
| Feb | Re-working |
| March 19th | Deadline |