# Sediment Supply to the Arctic Coastal Zone

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## Research Questions and Objective

Changes in the polar system due to changing global climate are both rapid and dramatic. 'Polar change' is one of the main themes of the International Polar Year 2007-2008. Changing Northern Hemisphere temperatures, thinning of the sea-ice, and melting of the glaciers have all been recently reported.

### The main research question:

### How is the sediment supply to the Arctic coastal system influenced by changing climate?

Accurate understanding of the effects of climate change on river sediment fluxes is needed to predict changes in the biological productivity of the Arctic coastal ecosystem, which is extremely vulnerable to changes in sediment and associated nutrient supply.
The responses are complex; will increased glacier melting and increasing precipitation result in increased water and sediment discharge? Or will the decrease of glacier area result in decreased sediment production? Does the sediment transport capacity of the river systems decrease with decreasing glacial meltwater? And how much sediment is stored in the glacio-fluvial floodplains and how long does it lag in the basin before it reaches the coast? We need to unravel these complexities in the direction and timing of the system responses to perturbations, only then can we make predictions of the sediment and nutrient supply to the ocean.

### Objective: built a numerical process model.

We aim to develop a process-based model linking parameters routinely predicted by glacier dynamics models, such as glacier dimensions and basal sliding speed, to a climate-driven sediment flux prediction model. For the first time, this framework would make it possible to make quantitative predictions of river sediment fluxes to the coast under a number of changing climate and glacial conditions. The framework allows assessment of rapidly melting glaciers, or disappearance of glaciers; all in unique basins with different area, relief, and climatic conditions.

### Modeling needs field validation

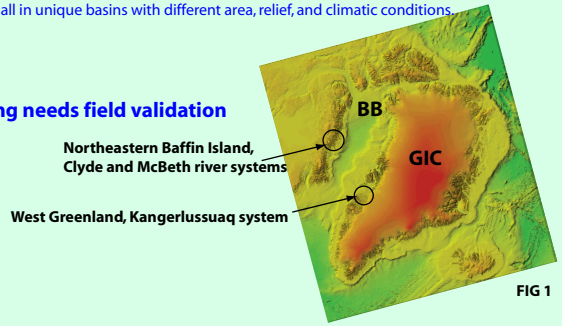


FIG 1

Kangerlussuaq river system drains the active Greenland Ice Cap (GIC). This system is the base-case for model validation of short-term climate changes and effects on glacier and sedimentary system. To get an understanding of the longer-term response we will study Clyde and McBeth river system on Baffin Island. McBeth river is decoupled from the last remnant of the Laurentide Ice Sheet, the Barnes Ice cap and allows a source-to-sink sediment supply reconstruction since the last deglaciation.

## Hydrological Model ( ~100 yr)

HydroTrend is a climate-driven hydrological model that predicts time-series of daily discharge and sediment load at the river mouth, based on drainage basin characteristics, glacier characteristics and local climate (precipitation and temperature).
As an example, we use a Digital Elevation Model of the Canadian Topographic Survey to delineate the contributing basin to Clyde river on Baffin Island (FIG 1). The drainage basin is ~2526 km$^2$, Clyde river is about 66km long and drains the SE part of the Barnes Ice Cap.
The maximum elevation in the drainage basin is 1450m and the estimated glacier equilibrium line is 1000m. Daily temperature and precipitation data have been measured at the town of Clyde River. Mean annual T is -12°C, average monthly temperatures are above 0°C in June, July and August and mean annual P is 21cm.

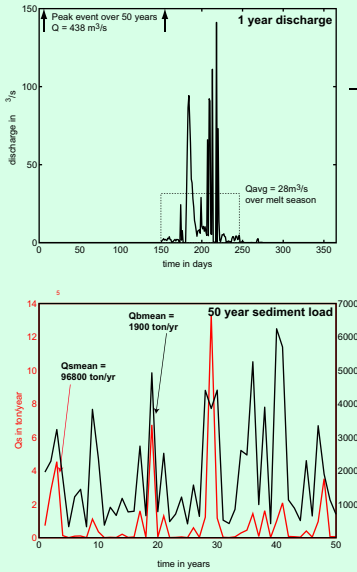


Figure 2 Hydrological model predictions for an example river on NE Baffin

Q, Qs, Qb (t) daily predictions at river mouth

Simulations point to relatively stable, small river system.....

### Short-term sediment fluxes: deglaciated system

HydroTrend predicts highly variable, but relatively low seasonal discharge and sediment load at the river mouth for the deglaciated Arctic rivers on Baffin Island.
We suspect that twofold river classification can be made; ice-cap influenced vs. mountain glacier influenced, where the latter systems will carry the bulk of the sediment loads reaching the Arctic coast.

## Longterm reconstructions (5 kyr)

We mapped the elevation of main river terraces at Clyde River mouth from the coast to about 10km landinward, where the channel becomes bounded by bedrock (FIG. 3).
The deglaciation of Clyde Fjord has been reconstructed by Briner et al., 2003 based on C14 and cosmogenic dating of erratics. Shells and organic matter samples have been dated and related t sedimentary section in the delta deposits close to the present fjord head. The withdrawal of the main ice flows from the fjordhead area occurred between roughly 8000 C14 yrs (very close to the fjord head) and 6600 C14 yrs more land inward. The emergence curve of Clyde Fjord is still rather uncertain, because the dated marine shells are not definitely tied to a certain sea level.
Assuming that terrace levels are tied to sea level we superimposed the terrace heights onto the emergence curve to estimate their ages. GIS analysis of the mapped terraces provides us with surface areas of each terrace; based on that terrace volumes have been estimated and combined with the age estimates we can compare sedimentation rates in the fluvio-deltaic plain (Fig 3c).

There is a distinct increase in sedimentation just after the retreat of the Barnes Ice Cap out of the present-day fluvio-deltaic area (upto ~100,000. m$^3$/yr). Sedimentation rates in the fluvial domain over the Late Holocene are very low (2850 m$^3$/yr). If this rates is placed into the framework of the present-day river simulations, we have to conclude that storage of sediment in the floodplain is relatively limited (~3%) over the Late Holocene.

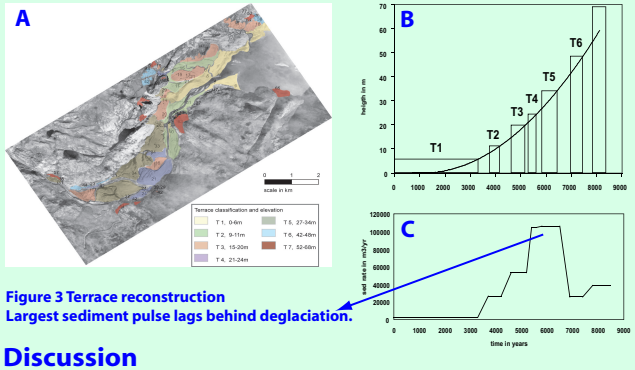


Figure 3 Terrace reconstruction
Largest sediment pulse lags behind deglaciation.

## Discussion

The comparison between the modern NE Baffin river, the quiet Late Holocene and the deposition during ice retreat indicates that the proximity of the ice margin is a strong factor determining the sediment flux. The period of proximity of the melting glacial edge shows the highest sedimentation rates. When the river channel is well-developed and incised due to isostatic rebound, sediment is hardly stored in the floodplain any more. The system is 'shut-off'.
This implies that 2D sedimentation models that do not include a floodplain module could still be usefull for giving sediment predictions under changing climate scenarios for the river systems draining a present-day ice-cap. A twofold river classification can be made; ice-cap influenced vs. mountain glacier influenced. For ungauged basins numerical models form a tool to predict water and sediment fluxes under changing climatic conditions.