Using Noble Gases to Distinguish Glacial Freshwater Sources from Greenland

Nicholas Beaird, Physical Oceanography Department
Fiamma Straneo, Physical Oceanography Department
William Jenkins, Marine Chemistry and Geochemistry

Proposed Work

The Greenland Ice Sheet is losing mass at unprecedented rates. This excess fresh water is causing sea level to rise while also freshening the North Atlantic, which can impact the global ocean circulation and climate. Understanding ongoing, and predicting future, changes in Greenland is therefore important to societies worldwide. One key question in understanding glacier behavior, and hence ice sheet mass loss, is differentiating mass that is lost from surface melting (e.g. by a warming atmosphere) from that lost to submarine melting (e.g. by a warming ocean). This issue is also critical to determining the rate and distribution of meltwater input into the ocean. Yet distinguishing these two kinds of meltwater from glaciological measurements is virtually impossible: submarine melting occurs under ice shelves or at margins of calving glaciers. Traditional oceanographic methods are also insufficient to make the distinction. Instead, we proposed to develop a new method to distinguish these two kinds of meltwater from ocean measurements downstream. The idea is that if we can estimate the relative fraction of the two meltwater sources in the ocean waters around Greenland - we can eventually reconstruct their different discharge rates.

Figure 1: Noble gas samples were taken using 10 L Niskin bottles and sealed on board using the cold welding technique developed by the W. Jenkins in the Isotope Geochemistry Facility.

Noble gases have been shown to be effective tools for distinguishing different flavors of glacial meltwater in Antarctica. Noble gases are such great tracers because they are inert (i.e. don't change due to biological or chemical interaction) and the signature of the gases trapped in bubbles in glacial ice is very strong relative to the background ocean. They allow us to quantify the distribution of meltwater in the coastal environment as well as identify the ways in which ocean waters are transformed by interactions with the ice sheet. This study extended a method that has employed noble gases in the Antarctic, and made the first of these type of measurements around Greenland – where warmer air temperatures create a significantly different suite of ice-ocean interaction processes relative to Antarctica.

Results from the field

Funds from the Ocean and Climate Change Institute allowed us to collect and analyze noble gas samples from Atasund, a fjord in West Greenland where two glaciers, Kangilerngata and Eqip Sermia, terminate [Figure 2]. The sample collection took advantage of a cruise funded by the Advanced Climate Dynamics Summer School.

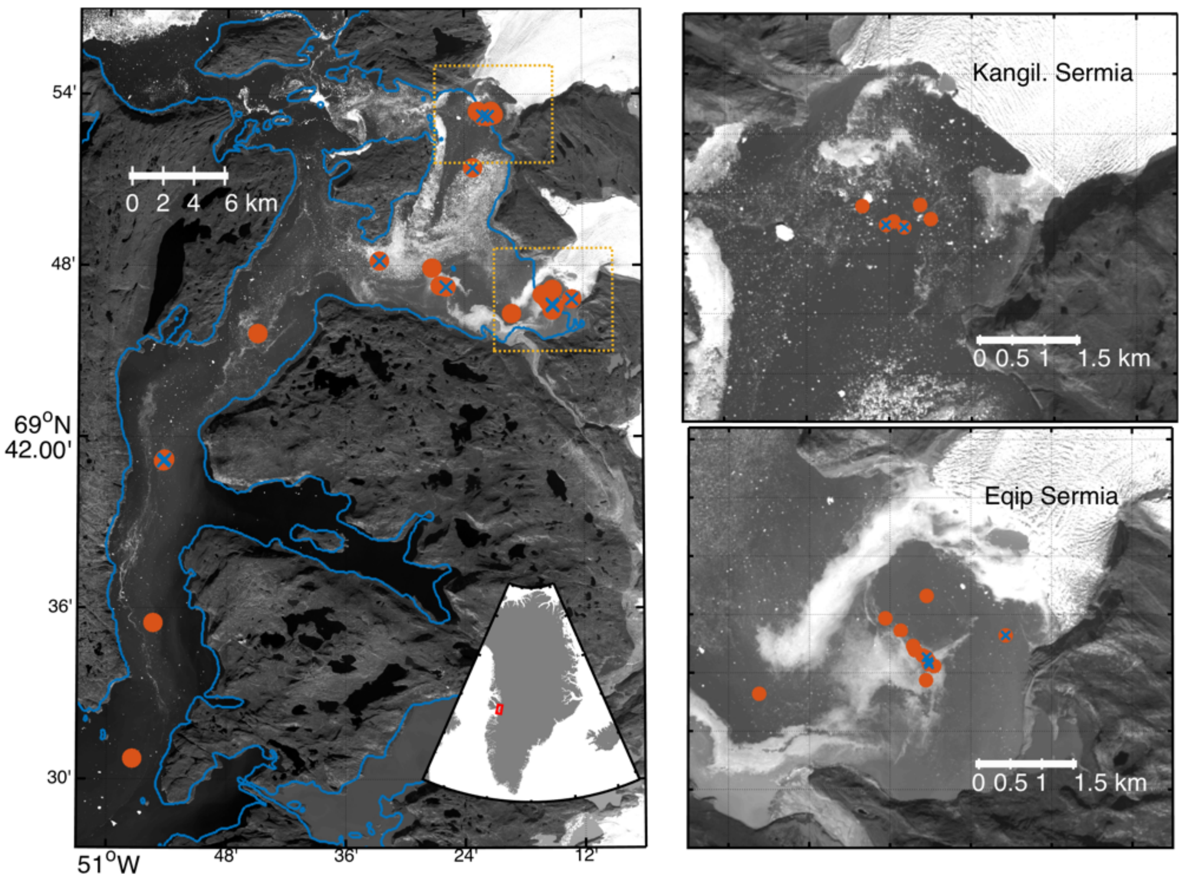

Figure 2: Landsat image of Atasund fjord, West Greenland in late August 2014 during the first Greenland noble gas field campaign. Orange dots indicate CTD stations, blue 'x' indication stations with noble gas measurements.

Analysis of the samples collected showed the expected strong signatures of glacial melt. We were able to disentangle the mixing and modification of oceanic and glacial sourced waters. For the first time we were able to unambiguously quantify the distribution of meltwaters in a Greenlandic proglacial fjord. We found that distinct plumes of meltwater equilibrate and spread at different depths in the fjord – a finding that has important consequences for how Greenland's freshwater influences the ocean. This behavior had been noted before but these are the first unambiguous evidence for it.

Distinct types of meltwater plumes at the ice-ocean interface were observed. We also found that small proglacial sills (likely old terminal moraines from advanced glacier positions) control the accessibility of the glacier face to the warmest water in the fjord, which, during our survey, was blocked from the ice edge.

The results from this OCCI funded survey were published in a short article in the broadly read journal Geophysical Research Letters (Beaird, Straneo, Jenkins, "Spreading of Greenland meltwaters in the ocean revealed by noble gases", GRL 2015). Additionally the success of the method lead us to propose a larger study in Sermilik Fjord, East Greenland. The proposal was funded by NSF for $600,000, and has lead to ongoing work understanding the freshwater linkages in Sermilik and impacts on the coastal physical oceanography and biogeochemistry [Figure 3].

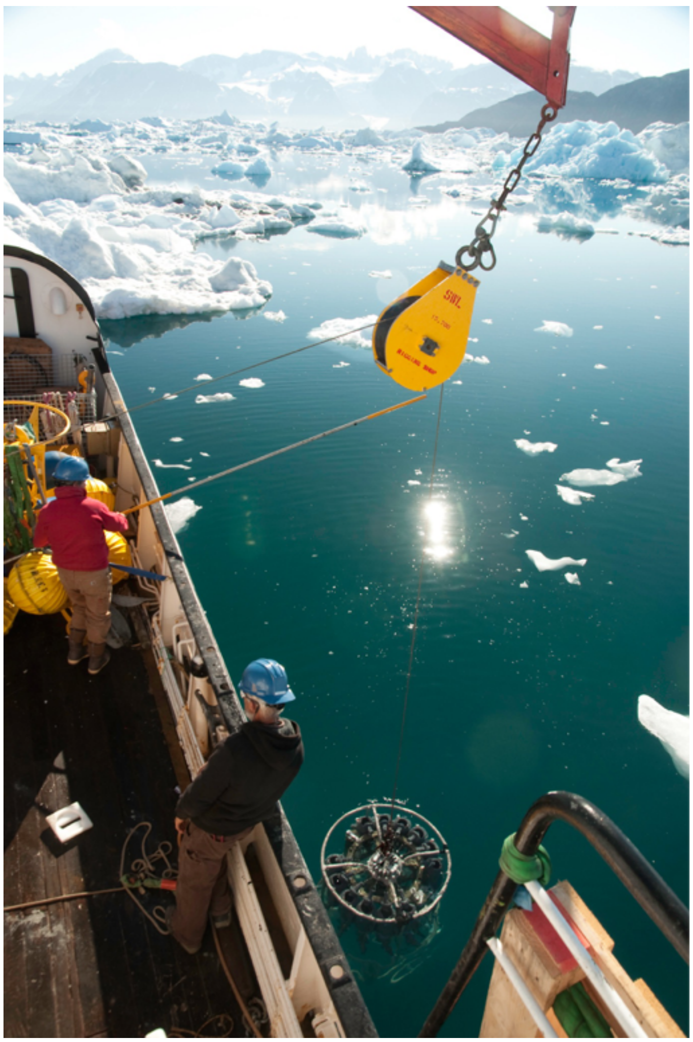

Figure 3: The CTD being lowered into Sermilik Fjord to obtain noble gas samples during an NSF funded study enabled by the measurements from the OCCI study.

The OCCI funding has produced a dataset that is one of the major components of the postdoctoral work of one of us (Beaird). Aside from being published in GRL, the work has been presented at five international conferences and at four university seminars. The new method has garnered considerable interest in the Greenland ice-ocean community and spurred numerous proposals to be used by other researchers.

We are grateful for the support from the Ocean and Climate Change Institute and believe that the funds have provided some very valuable scientific results.