1. Introduction

The circulation in Greenland's glacial fjords influences the rate of submarine melting at the face of the Greenland Ice Sheet's outlet glaciers. Here we use real-time, hourly position data from expendable GPS units deployed on large icebergs (~500 meter diameter) in Sermilik Fjord, SE Greenland to track fjord circulation. We observe and quantify the motions of these icebergs moving through three distinct regions: the ice mélange, main fjord, and continental shelf. Future work will constrain the freshwater input due to iceberg melt based on iceberg-derived residence time calculations and ambient water properties.

2. Setting and Instrumentation

Our study site is Sermilik Fjord, SE Greenland, which connects Helheim Glacier to Irminger Sea, and has been the site of several recent hydrographic and glaciological field campaigns.²

- **Sermilik Fjord**: ~900 m deep at mouth, shoaling to 600 m; Two-layer system: cooler, fresher Polar Water overlying warmer, saltier Atlantic-origin water; Pycnocline at 200-300 m, deepens in winter
- **Helheim Glacier**: Calvings ~50 km² yr⁻¹; grounding line at 600 m; ~10 km ice mélange in front of glacier terminus

**GPS Trackers**

- Axonn AXTracker units, with custom machined tripods
- Transmit hourly GPS fix over Globalstar network
- Position error < 20 m
- Helicopter-deployed: 5 trackers in September 2012, 5 in August 2013

3. Iceberg Movement

Variations in iceberg movement are linked to the mechanisms that control circulation in each distinct region, shown below.

**Ice Mélange**

- Variations in iceberg movement are linked to the mechanisms that control circulation in the ice mélange region.
- Icebergs moving through the ice mélange region exhibit large fluctuations in velocity, which may be due to changes in the underlying water properties or atmospheric forcing.

**Fjord**

- Icebergs moving through the main fjord region exhibit more consistent velocities, likely due to the more homogeneous water properties in this region.
- The direction of iceberg movement is strongly influenced by the direction of the wind, with icebergs moving in the direction of the prevailing wind.

**Shelf**

- Icebergs moving through the continental shelf region exhibit the highest velocities, likely due to the presence of strong along-shelf currents.
- The direction of iceberg movement is less influenced by the wind in this region, with icebergs moving along the shelf edge.

4. Shelf Wind-Driven Circulation

Circulation in Sermilik Fjord has been shown to be controlled primarily by along-shelf winds, with variability due to strong barrier wind events.

**Barrier Winds**

- Strong, northeasterly barrier wind events along the East Greenland coast during winter months³
- Iceberg velocity flow switches direction to out-fjord as winds relax, indicating a response of the upper Polar Water layer.

5. Impacts

- Low-cost, expendable GPS iceberg 'drifters' can successfully track fjord circulation on hourly timescales.
- Iceberg residence times in Sermilik Fjord average 72 days after exiting the ice mélange, with velocity variability on tidal and synoptic timescales.
- Using existing melt parameterizations, iceberg dimensions and size distributions, and observed residence times, we can calculate estimates of freshwater input in the fjord by icebergs.

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References


Figure 1. Top: Study site with Helheim Glacier, Sermilik Fjord, and the town of Tasiilaq highlighted; Bottom: Deployed GPS tracker and tripod.

Figure 2. 2012 Iceberg deployment locations, tracks, and coastal bathymetry. Stars indicate deployment locations; boxes indicate last transmitted locations.

Figure 3. 2013 iceberg tracks with improved deployments in the ice mélange.

Figure 4. In the ice mélange, icebergs move away from the terminus at a steady 3.5-4.5 mm s⁻¹ (350-450 m d⁻¹). Strong, concurrent events dramatically accelerate the icebergs and displace them up to 8 km d⁻¹. We interpret these events as increased ice mélange mobility from either large calving events or strong glacial katabatic winds. Once they escape from the mélange border, icebergs accelerate and transition to the fjord circulation regime.

Figure 5. Velocity data from tracker UO2, shown in green in Fig. 2, typical of the main fjord region. Semidiurnal tides with amplitudes of 2 cm s⁻¹ are superimposed on multi-day periods of net inward or outward motion.

Figure 6. Once icebergs escape the fjord, they move southeastward at much higher speeds than in the fjord and mélange regions, with velocities suggesting entrainment in the East Greenland Coastal Current. Periods of no motion are assumed to indicate grounding of the iceberg on shallow shelf bathymetry (see Fig. 2). The data end when communication with the GPS unit is lost, most likely due to iceberg breakup or capsizing.