# Glacier Dynamics (Funk, retired)



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Ongoing Projects



## Dynamic changes of tidewater outlet glaciers: Bowdoin glacier, Northwest Greenland

Funk, Martin
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Tongue of Bowdoin Glacier, Northwest Greenland

The goal of this project is to quantify ice mass loss in northwestern Greenland and evaluate its impact on the arctic and global environments (e.g. sea level rise) in the context of the Arctic Climate Chang Research Project within the framework of the GRENE (Green Network of Excellence) Program.

The observed dramatic and rapid changes on tidewater glaciers in southern Greenland may propagate to the north in near future. Hence, the tidewater glaciers in this area are expected to start retreating rapidly in the coming years/decades thus allowing a monitoring and investigation of these changes starting from the early stage of rapid dynamic changes. This project is a collaborative effort combining in-situ measurements on a tidewater glacier and modeling work with scientists of Hokkaido University in Sapporo and ETH Zurich in order to obtain a more profound knowledge of the calving mechanisms and to make more reliable predictions of the retreat of tidewater glaciers possible.

This project will focus on iceberg calving of a tidewater glacier located at the northwestern coast of the Greenland Ice Sheet: Bowdoin glacier (77° 42' N; 68° 35' W). Bowdoin glacier is a grounded tidewater glacier approximately 10 km long and 3 km wide with an average surface slope of less than 1°. Along its center it is 250 m thick at the calving front, increasing to 350 m 6 km upstream. Its bed is 250 m below sea level along a 6 km centerline upstream the calving front. Its flow speed amounts 1.5 m/d close to the calving front, decreasing to 1 m/d 3 km upstream. The glacier surface experienced a thinning at a rate of 1.5 m/a since 2007. A rapid calving front retreat at a rate of 260 m/a was also observed since 2008, while no significant changes occurred during the previous 20 years. An interesting particularity of the glacier is that it is only little crevassed and accessible for field work very close to the calving front. This offers unique perspectives for crucial field experiments to investigate the calving process. In particular, we plan to record the following key information from immediately behind the calving front to 10 km glacier upstream:

Subglacial water pressure changes in boreholes
Internal ice deformation changes with tilt sensors at different depths
Englacial ice temperature profiles from the glacier bed to the surface
High resolution surface motion with GPS records
Seismological observations of the calving process

We plan to develop a numerical model for tidewater glaciers in which the crucial processes are implemented in a comprehensive way. These data will serve to validate the results obtained from the numerical simulations.

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| **Contact:** | **Funk, Martin, Prof. Dr.**<br>**Seguinot, Julien, Dr.**<br>**Walter, Fabian, Prof. Dr.**<br>**Bauder, Andreas, Dr.** |
| **Keywords:** | glacier dynamics, glacier calving, damage dynamics |
| **Funded by:** | SNF, Grant 200021_153179/1 |
| **Collaboration:** | **Dr. Shin Sugiyama** (University of Hokkaido, Sapporo) |

**Overview**

## Sun2Ice: Monitoring the fracturing of calving glaciers from solar-powered UAVs in polar regions

Jouvet Guillaume, Dr.
Funk, Martin, Prof. Dr.
Siegwart, Roland, Prof. Dr.
Oettershagen, Philipp
Stastny, Thomas

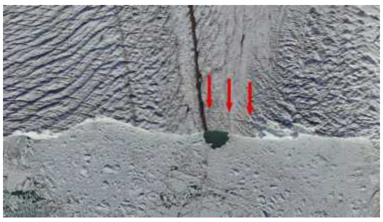
van Dongen, Eef
Hugentobler, Michael
Mantel, Thomas
Melzer, Amir
Weidmann, Yvo

The solar-powered AtlantikSolar UAV on the way to Bowdoin Glacier

Between Glaciology and Autonomous Systems, Sun2ice's ETHZ project aims to use a state-of-the-art, solar-powered Unmanned Aerial Vehicles (UAV), AtlantikSolar, for long surveys of glaciers located near the village of Qaanaaq (77° North), northwest Greenland. The "midnight sun" in polar regions offers unique conditions for perpetual solar-powered UAV flights. In Sun2Ice, this cutting-edge technology serves to monitor iceberg calving, a still poorly understood process which plays a major role in the sea-level rise.

The solar-powered AtlantikSolar UAV at take-off

The rapid retreat of ocean-terminating glaciers over the last decades has strongly contributed to the observed global sea-level rise. For the Greenland ice sheet, iceberg calving is responsible for approximately half of the ice ablation. Long-range UAVs as AtlantikSolar can provide a unique set of aerial images, leading to in-depth analysis of mechanical calving processes. Combining photogrammetry, feature-tracking, and ice flow modelling techniques, we can derive surface ice flow velocities at sub-crevasse resolution, and infer information about the crack vertical penetration and horizontal extension at several stages of the event. Sun2ice's focus is to model individual large-scale calving events driven by hydro-fractures. Such a modeling at the level of individual events is rare, but necessary, as the physical mechanisms triggering small- and large-scale events differ.



The survey of Bowdoin Glacier reveals a crack opening about to trigger a large-scale calving event

An accompanying objective of this project is the undertaking of the first-ever autonomous, energetically perpetual, and solar-powered flight of a UAV above or below the Arctic or Antarctic circles, respectively. The latest advances in photovoltaic technology have shed light on the immense potential of solar-powered manned and unmanned flying platforms. However, most platforms of this type are experimental and not primed for real-world application. This project aims to demonstrate a concrete example of the specialized utility of solar-powered UAVs. Here, the goal is to demonstrate the robustness and applicability of the AtlantikSolar platform, not only in new environmental settings, but in the context of a challenging, real-world science mission; a project requiring the combination of long-range and long-endurance performance, payload capacity, and human-machine inter-

actibility never before demonstrated on a system of this class.
For more information on this project, visit **www.sun2ice.ethz.ch**

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| **Contact:** | **Jouvet, Guillaume, Dr.**<br>**Stastny, Thomas**<br>**Funk, Martin, Prof. Dr.** |
| **Keywords:** | unmanned aerial vehicle, structure-from-motion, calving glacier, ice flow model |
| **Funded by:** | Sun2ice is an ETHZ project supported by the Dr. Alfred and Flora Spaetli Fund and the ETH Foundation, Grant ETH-12 16-2 |
| **Collaboration:** | **Prof. Roland Siegwart** (Autonomous Systems Laboratory) |

**Overview**

# Publications

**2019** **2018** **2017** **2016** **2015** **2014** **2013** **2012** **2011** **2010** **2009**
**2008** **2007** **2004**

## 2019

### Monitoring Greenland ice sheet buoyancy-driven calving discharge using glacial earthquakes

**Amandine Sergeant, Anne Mangeney, Vladislav A. Yastrebov, Fabian Walter, Jean-Paul Montagner, Olivier Castelnau, Eleonore Stutzmann, Pauline Bonnet, Velotioana Jean-Luc Ralaiarisoa, Suzanne Bevan and Adrian Luckman**

*Annals of Glaciology*, vol. 60: no. 79, pp. 75-95, Cambridge: Cambridge University Press, 2019.

**DOI: 10.1017/aog.2019.7** **Research Collection Abstract**

### Analysis of temporal and spatial variations in hydrometeorological elements in the Yarkant River Basin China

**Ren-juan Wei, Liang Peng, Chuan Liang, Christoph Haemmig, Matthias Huss, Zhen-xia Mu and Ying He**

*Journal of Water and Climate Change*, vol. 10: no. 1, pp. 167-180, London: IWA Publishing, 2019.

**DOI: 10.2166/wcc.2018.111** **Research Collection**

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## 2018