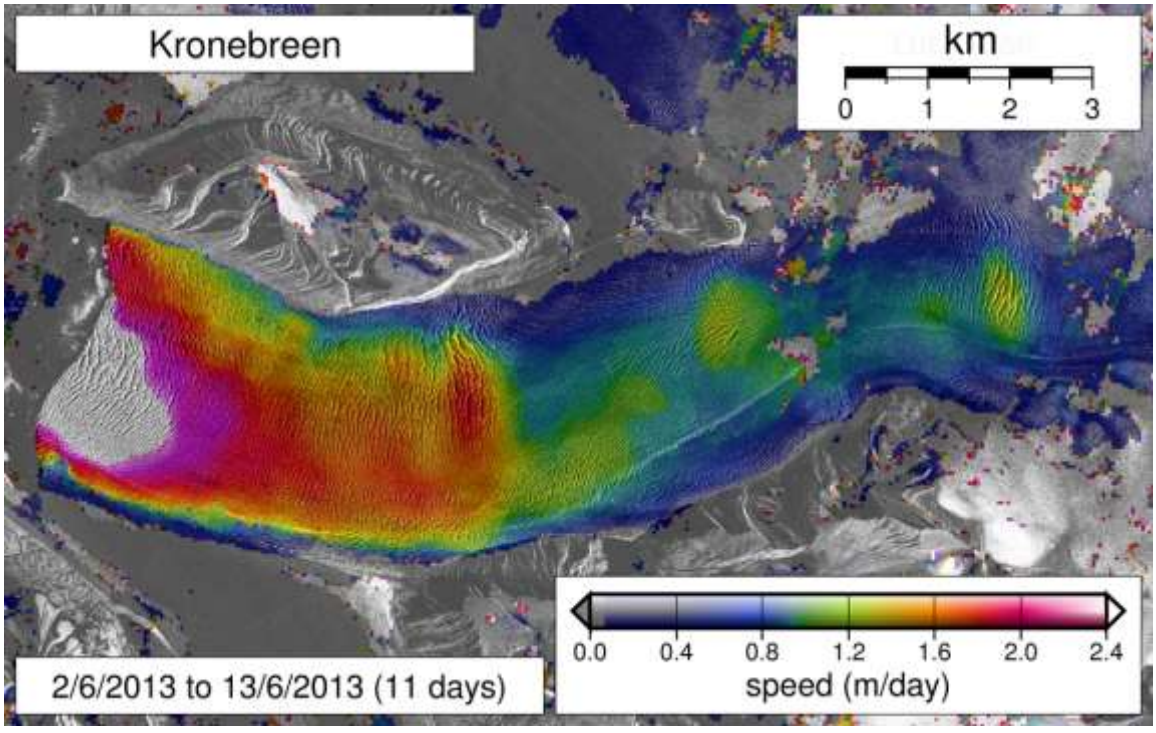
Calving and Surging in Svalbard (CASS)

Svalbard Science Forum funded Workshop

Utrecht, Netherlands
October 18 and 19, 2015

Final Report



Introduction

Calving and surging are both complex dynamic phenomena that exert strong controls of the flux of ice into the oceans. Calving - the breakaway of icebergs from glaciers into the sea - is a major source of uncertainty in projections of future sea-level change. Surges are dramatic speed-ups of glacier flow resulting from switches in conditions at the glacier bed. Svalbard is an excellent natural laboratory for studying both of these poorly under-stood phenomena. The archipelago contains one of the richest clusters of surging glaciers on Earth, and recent investigations have revealed a wide variety of dynamic glacier behaviors, including rapid advances and retreats out of synch with climatic and oceanic forcing.

An SSF-funded Workshop on Calving and Surging in Svalbard (CASS) was organized to bring together key researchers and early-career scientists to:

- Review recent and ongoing research into calving and surging glaciers
- Identify research challenges and opportunities, including innovative instrumentation and data sources
- Developing new conceptual and theoretical frameworks
- Encourage transfer of technology and expertise.

Wahlenbergbreen in 2007, prior to its surge

The Workshop was held in the NH Hotel, Utrecht, Netherlands on 18-19 October 2014. Invitations were extended to over 40 researchers and students working on calving and surging glaciers in Svalbard. Twenty six were able to attend, representing all the major research groups working on calving and surging in Svalbard. The participants included full-time academic staff (9); Post-doctoral

researchers (8); PhD students (8), and one Masters student. Unfortunately, it was not possible to achieve a gender balance, with 18 male and 8 female participants.

In addition, Tomas Johanesson (Icelandic Meteorological Office) represented the Nordic Centre of Excellence project SVALI (Stability and Variations of Arctic Land Ice), and Karoline Baelum represented SSF.

Participants
(Students indicated in italics)

Adrian Luckman (University of Swansea, UK)
Alastair Everett (University of Swansea, UK)
Andreas Köhler (University of Oslo)
Ankit Pramanik (Norsk Polarinstittut, Norway)
Chris Borstad (University Centre in Svalbard)
Chris Nuth (University of Oslo)
Dorothée Vallot (Uppsala University)
Douglas Benn (University Centre in Svalbard)
Faezeh Nick (University Centre in Svalbard)
Harold Lovell (Queen Mary, University of London, UK)
Heidi Sevestre (University Centre in Svalbard)
Ian Rutt (University of Swansea, UK)
Jacek Jania (U. Silesia, Poland)
Jack Kohler (Norsk Polarinstittut, Norway)
Jakub Malecki (Institute of Geoecology and Geoinformation, Poznań, Poland)
James Lea (University of Stockholm)
Malgorzata Blaszczyk (U. Silesia, Poland)
Martin O'Leary (University of Swansea, UK)
Martina Schäffer (Finnish Meteorological Institute)
Nick Hulton (University of Edinburgh, UK: UNIS)
Owen King (University of Leeds, UK)
Penny How (University of Edinburgh, UK: UNIS)
Silje Smith-Johnsen (University Centre in Svalbard, University of Bergen)
Tavi Murray (University of Swansea, UK)
Thorben Dunse (University of Oslo)
Tim James (University of Swansea, UK)

Karoline Baelum (Svalbard Science Forum)
Tomas Johanesson (Iceland Meteorological Office, on behalf of SVALI)

Meeting program

The two-day meeting consisted of 1.5 days of presentations by participants, followed by half a day of discussion. The presentations were organized into four sessions centered on major research themes: 1) Surging glaciers; 2) Calving observations; 3) Kronebreen; and 4) Models of glacier dynamics and calving. Each participant was allocated 15 minutes of presentation time; some presenters chose to pool their time to make a longer joint presentation.

Saturday

start	end	Session	Name	Talk title
9:00	9:30	INTRO	Doug Benn	Intro
9:30	10:00	SURGES	Heidi Sevestre	Surging glaciers in Svalbard
10:00	10:15		Andreas Köhler	Seismic signature of Nathorstbreen surge
10:15	10:30		Owen King	Surge of Comfortlessbreen
10:30	11:00	COFFEE		
11:00	11:30		Thorben Dunse & Jon Ove Hagen	Basin 3 surge
11:30	12:00		Jacek Jania & Malgorzata Blaszczyk	Surges in the Hornsund area
12:00	12:15		Jakub Malecki	TBA
12:15	12:30		Harold Lovell	Surge landsystems
12:30	13:00		**All**	**SURGE DISCUSSION**
13:00	14:00	LUNCH		
14:00	14:15	CALVING	Adrian Luckman	Svalbard calving driven by melt undercutting
14:15	14:30		Alastair Everett	Calving and meltwater plumes
14:30	14:45		Tavi Murray	Calving at floating termini
14:45	15:00		Tim James	Photogrammetric observations of tidewater glaciers
15:00	15:15		Chris Borstad	New rate-weakening constitutive relationship for damage evolution
15:15	15:30		**ALL**	**CALVING DISCUSSION**
15:30	16:00	COFFEE		
16:00	16:15	KRONEBREEN	Nick Hulton	CRIOS project
16:15	16:30		Penny Howe	CRIOS project
16:30	17:00		Silje Smith-Johnsen	CRIOS project

Sunday

start	end	Session	Name	Talk title
9:00	9:15	KRONEBREEN 2	Jack Kohler	Kronebreen/Holtedahlfonna mass balance, velocity, calving
9:15	9:30		Ward van Pelt	Kronebreen/Holtedahlfonna runoff modeling
9:30	9:45		Chris Nuth	TBA
9:45	10:00		**All**	**KRONEBREEN DISCUSSION**
10:00	10:15	MODELING	Ian Rutt & Martin O'Leary	Hydrology modeling
10:15	10:30		Faezeh Nick	Calving models
11:00	11:45		Martine Schäffer & Dorothée Vallot	Calving models
11:45	12:00		James Lea	Calving in ice sheet models
12:00	12:15		**All**	**CALVING MODEL DISCUSSION**
12:15	12:30		Jack Kohler	Kongsfjord tidewater glacier project
12:30	13:00		**All**	**DISCUSSION**
13:00	14:00	LUNCH		
14:00	14:15		Karoline Baelum	Svalbard Science Forum
14:15	15:30		**All**	**DISCUSSION**
15:30	16:00	COFFEE		
16:00	17:00		**All**	**DISCUSSION**

Summary of talks

Surges

Benn and **Sevestre** summarized data on recent and ongoing surges in Svalbard. Many events have been captured in a comprehensive program of TerraSAR-X image acquisitions, including surges of the tidewater glaciers Aavatsmarkbreen and Wahlenbergbreen, and the terrestrial glaciers Penckbreen and Morsnevbreen. A new enthalpy cylcing model was presented, which has the potential to explain diverse surging behaviour within a single framework. **Köhler** presented an analysis of seismic signals from Svalbard glaciers, obtained from the permanent seismic stations at Hornsund, Ny-Ålesund and Longyearbyen. Most signals originate from calving events and have a strong seasonal cycle. An unusual swarm of events emanated from Nathorstbreen in early 2009, reflecting catastrophic ice failure and surge onset. **King** discussed the 2008-2010 surge of Comfortlessbreen, and reconstructed its development from structural glaciology. **Dunse** gave a detailed presentation about the ongoing surge in Basin 3, Austfonna. Data on this major surge include velocity records from multiple GPS units and satellite image analysis. Development of the surge was strongly influenced by surface water reaching the glacier interior via crevasses and consequent cryo-hydrologic warming. **Jania** and **Blaszczyk** reviewed recent surges in the Hornsund area, and discussed the influence of fjord topography on surge evolution. **Malecki** presented geometric and mass balance data from Horbyebreen, which is currently in quiescence following a probable surge. **Lovell** reviewed conceptual models of land-system formation by surging glaciers using a range of new examples from Svalbard.

Calving observations

Luckman presented an analysis of TerraSAR-X data from 3 Svalbard glaciers, and demonstrated a strong correlation between calving rates and fjord water temperature. This indicates that melt undercutting is the dominant calving mechanism in the archipelago. This calving process is thought to be strongly linked to fjord water mixing by meltwater plumes, which was the subject of the next paper by **Everett. Murray** then presented a detailed and comprehensive dataset from Helheim Glacier, Greenland, providing unequivocal evidence for the buoyant calving mechanism. **James** discussed development of photogrammetric techniques, and their application to calving glaciers. Finally, **Borstad** discussed new methods of determining damage evolution on calving glaciers from analysis of velocity data.

Fig1. Time-lapse camera installed above Kronebreen

Kronebreen

Hulton, How and **Smith-Johnsen** presented results of the ConocoPhillips Lundin funded project CRIOS (Calving Rates and Impact on Sea Level). Study of calving and dynamics of Kronebreen forms a major part of this project. The dataset includes velocities and calving rates derived from satellite images and time-lapse photography, and borehole water pressures. Detailed data on the dynamics of Kronebreen were also presented by **Kohler, van Pelt** and **Nuth**, including velocity records, and modeled meltwater production and runoff.

Models of Dynamics and Calving

O'Leary and **Rutt** outlined a simple model of glacier hydrology, and presented some preliminary results. Progress in applying calving models was reported by

Nick. **Schäfer** showed impressive models results that explore how thermodynamic processes affect the flow behaviour of outlet glaciers of Vestfonna. **Vallot** used inversion techniques to model glacier force balance, and investigate the relationship between water input and glacier dynamics. Finally, **Lea** presented some new developments and applications of calving models.

Summary of Discussion

The presentations clearly demonstrated that a large body of research is being conducted into calving and surging glaciers in Svalbard, and that this work is at the forefront of an important branch of glaciology. This provided a stimulating starting point for the Discussion session on the final afternoon.

Grant proposals in development were presented by **Kohler** (TIGRIF: TIdewater Glacier Retreat Impact on Fjord circulation and ecosystems), and **Malecki** (thermal evolution of glaciers in Dicksonland). The role of *Svalbard Science Forum* in funding and supporting research was then presented by **Baelum**.

Most of the Discussion session was devoted to identifying research priorities and areas of potential collaboration and cooperation. The following key issues were highlighted. There is a pressing need to:

- test models of surging, particularly the new enthalpy cycling concept
- develop a better understanding of calving processes, including melt undercutting and buoyant calving mechanisms
- understand the links between glacier hydrology, basal friction, and ice velocity
- develop numerical models of ice dynamics and calving, to promote deeper understanding of the underlying mechanisms and improve predictive capability.

Recommendations

One the basis of these discussions, we would make the following recommendations:

- Observation programs should be continued on a number of key target glaciers, including Kronebreen, Hansbreen and Tunabreen. These programs should include well established techniques, as well as experimentation with new technologies and approaches.
- We need to continue making detailed observations of calving events, to better understand the range of processes operating at Svalbard glacier margins.
- Better knowledge of calving processes is required for making risk assessments of iceberg calving, which is important for the development of rigorous safety protocols for tour companies.
- We need to promote greater integration between glaciological and oceanographic data collection, to better understand mass and energy exchanges at the ice-ocean interface.

Fig. 2 Visiting Sveabreen by small boat

Action points

- Continue programs of time-lapse photography of calving glacier fronts
- Develop grant proposals to study and monitor the calving process.
- More outreach: movies based on time-lapse imagery (e.g. YouTube) are powerful tools for illustrating.

Budget

NH Hotel conference and accommodation:	NOK 91,383
Workshop dinner, travel expenses, and administration:	NOK 180,000