Title of the project

The Liestøl Symposium: Integrating field measurements, remote sensing, and models of Svalbard glacier mass balance

Description of the project

The primary aim of this symposium was to bring together researchers from the international groups studying Svalbard glacier mass balance. We sought to 1) promote better collaboration and cooperation between these groups, and 2) integrate the field studies with glacier and regional climate modelling efforts.

The workshop was named in honor of the pioneering Norwegian glaciologist Olav Liestøl (1916-2002), who initiated mass balance measurements in Svalbard in the 1950s, including the two annual long-term programs at Austre Brøggerbreen and Midtre Lovénbreen, near Ny-Ålesund, which were started in 1966 and 1967, respectively. Both measurement programs are still running today, and are among the longest continuously measured High Arctic mass balance time series still going. In autumn 2017, the record from Austre Brøggerbreen will be 50 years old.

Project leader

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Motivation for the workshop

Mass loss from the world's glaciers, that is, all ice bodies apart from the ice sheets of Greenland and Antarctica, is one of the main contributors to current sea level rise (Gardner et al., 2013). To help close the sea level rise budget, rates of mass loss need to be estimated in all glaciated regions in the world (Gardner et al., 2013). Furthermore, freshwater output from glaciers is an important component in the global hydrological cycle.

Svalbard is ca. 60% glacier-covered (König et al, 2014), comprising ~10% of the total Arctic glacier area. The current overall mass balance for Svalbard glaciers is negative, based on satellite measurements (Wouters et al, 2008; Moholdt et al, 2010; Nuth et al, 2010), and Svalbard glaciers are clearly shrinking. With the predicted further Arctic warming (Collins et al 2013; Førland et al. 2011), Svalbard glaciers are expected to continue retreating (Lang et al. 2015).

The annual net surface mass balance represents the average amount of snow and ice lost or gained on a glacier surface during the course of a year. Glacier mass balance is typically measured twice yearly, once at the end of the winter to estimate the winter accumulation, and again at the end of the summer to find the net melt. Summer temperature has the strongest influence on Svalbard glacier mass loss (Van Pelt et al., 2012), and decadal-scale Arctic summer warming has led to increasing rates of mass loss (Kohler et al, 2007). An additional important mass balance component in Svalbard is the dynamic loss at the front of "tidewater" glaciers, that is, glaciers that terminate in seawater. In terms of glacier area, more than 60% of all glacier fronts end at a calving front (Błaszczyk et al. 2009), such that a significant portion of the total ice mass lost in Svalbard occurs via calving. Warmer ocean water around Svalbard and overall atmospheric warming has led to retreat of Svalbard's tidewater glaciers, and additional mass loss term.

Measuring mass balance in the field is expensive, and therefore spatially limited. On Svalbard, glaciers with mass balance observations are mostly located along the western coast (Hagen and Liestøl, 1990). However, field-based mass balance programs do not exist solely to provide data for one particular glacier. These data are instead crucial for gaining a better understanding of the regional situation, either through

aggregation with other similar measurements, or by combining direct observations, satellite data, and surface mass balance models.

Surface mass balance models, forced either by meteorological observations or output from regional climate models, evaluate the surface energy balance to determine surface temperature and melt production. The most complete models couple the surface module to subsurface routines to account for the impact of water storage and refreezing on the mass and energy budgets.

Regional climate model data are important for describing spatial and temporal patterns of precipitation, while remote sensing assists in determining spatial patterns of precipitation, specifically snow distribution, as well as in determining frontal losses (e.g. frontal retreat, calving).

We sought support for a symposium to enhance further international and interdisciplinary cooperation on Svalbard mass balance, to discuss unresolved problems in the Svalbard field measurement programs, focusing on increased cooperation within research, and to increase coordination of activities to reduce costs and environmental impact. More importantly, we sought better communication between the field, remote sensing, and modeling communities.

By drawing upon the collective expertise of a diverse group of experienced researchers, the symposium aimed to forge more long-lasting contacts to enhance the interdisciplinary collaboration portfolio of the group, encourage transfer of knowledge and expertise within Norway and internationally.

Results

We had initially proposed to hold the symposium in the Fram Centre in late October or early November 2017. The budget provided was for rental of the meeting space, and for food and refreshments. A separate proposal to the Norwegian Research Council to provide support for travel and accommodations was not funded. Accordingly, we decided to move the location to Oslo, to lower the travel costs for the mostly international partners anticipated to participate. Furthermore, the opportunity arose to tie in the Symposium with the Svalbard Science Conference (SCC), which was held at Fornebu Nov. 6-8. This tie-in gave the possibility for a higher rate of participation by interested Svalbard scientists; there were 70 registered participants in the Symposium (see list below), and many more from other scientific disciplines who wandered in for specific talks.

The Liestøl Symposium opened with a plenum talk by the PI to the SCC giving an overview of glaciological activities in Svalbard, with extended plugs for talks in the Liestøl Symposium. After a short break, the Symposium then started in the late morning of Nov 8th, and continued on to the next day. The talks in the Symposium took us from the early days of field measurement of surface mass balance at Midre Lovénbreen, Austre Brøggerbreen and Finsterwalderbreen, through modern modelling and remote sensing techniques, into literally uncharted waters. The speakers highlighted the breadth of contemporary glaciological research in Svalbard, and its links with biological, oceanographic, atmospheric, terrestrial and geodetic research.

Field-based mass balance monitoring continues around the settlements of Ny Ålesund and Barentsburg, in Hornsund, and on Lomonosovfonna and Austfonna. It has been combined with monitoring of glacier dynamics and the calving process, which are thought to be as important to the mass balance of the archipelago as surface processes. Established methods, such as stake measurements, AWS observations, and GPS and GPR transects, are being supplemented by seismic monitoring, geodetic measurements, terrestrial lidar and radar scanning, and surveying by drones. Photogrammetry and sediment coring are helping to place these contemporary observations in a longer-term perspective. Modelling is being used to

expand mass balance estimates in time and space, to focus on individual glaciological processes, and to investigate the effects of glacier change on the wider environment. Interdisciplinary studies focus on the links between glaciology, biology and oceanography, including the effect of glacial meltwater on the marine food web, and clues about glacier behaviour from seafloor and submerged calving front mapping.

In all, ice loss is widespread in Svalbard, with calving glaciers losing mass more rapidly than land-terminating glaciers, though larger, high elevation ice caps further from the influence of the West Spitsbergen Current are closer to balance. The loss of firn pore space and the deposition of black carbon may drive a large decrease in surface mass balance and an increase in sea level rise contribution in the future. The archipelago - with its diverse ice masses, established logistics and developing integrated research infrastructure - constitutes a natural laboratory for studying processes that are likely to be important for the future of the wider Arctic cryosphere, as well as an ideal location for training the next generation of polar scientists.

The difficult to document aim of the Symposium was to not only bring together bring together researchers from the international groups studying Svalbard glacier mass balance, but to better integrate their activities. Social interactions promoted in coffee breaks and collective dining allowed for a high degree of such interaction, and participants can likely attest to a number of data swaps and promises of future collaboration that arose directly as a result of the Symposium.

Schedule

Wednesday, Nov. 8		
10:40-10:50	Jack Kohler	*Introduction*
10:50-11:20	Olav Orheim	*The start of Norwegian glaciological research on Svalbard*
11:20-11:40	Jon Ove Hagen	*The history of direct mass balance time series in Spitsbergen, Svalbard.*
11:40-12:00	Thomas Vikhamar Schuler	*Current status of Svalbard glacier mass balance and needs for future assessments*
12:00-13:00	**Lunch**	
13:00-13:20	Kjetil S. Aas	*Coupled Atmosphere – Climatic Mass Balance Modeling of Svalbard Glaciers*
13:20-13:40	Ward van Pelt	*A high-resolution dataset of climatic mass balance, snow conditions and runoff in Svalbard between 1957 and 2017*
13:40-14:00	Halfdan P. Kierulf	*Geodetic measurements at Svalbard. Implications for glaciology and solid Earth sciences*
14:00-14:20	Marie-Andrée Dumais	*Sub-ice topography of Nordaustlandet, Svalbard derived from potential field modelling*
14:20-14:40	Julian Podgórski	*Detection of Svalbard glaciers on satellite imagery with subpixel accuracy*
14:40-15:00	Jack Kohler	*MODIS albedo products used to detect ELA on Svalbard glaciers*
15:00-15:30	**Coffee**	
15:30-15:50	Andreas Köhler	*Monitoring the cryosphere on Svalbard using environmental seismology*
15:50-16:10	Christopher Nuth	*The CalvingSEIS project: Glacier dynamic ice loss quantified through seismic eyes*
16:10-16:30	Andrey Fedorov	*Seismic and infrasonic monitoring of glacier destruction*
16:30-16:45	**Poster introductions**	
	Marta Majerska	*Spatial and temporal variability of ablation based on the Waldemar Glacier (Kaffiøyra, Svalbard)*
	Gleb Tarasov	*Mass balance observation of Aldegonda Glacier and West Grønfjord Glacier, West Svalbard*
	Ashley Morris	*Calibration and validation of interferometric synthetic aperture radar altimetry for mass balance estimation in Svalbard – preliminary*
	Bas Altena	*Glacier front detection through mass continuity and remote sensing*
	Kristian Breili	*Geodetic constraints on ice-mass changes on Svalbard*
	Pierre-Marie Lefeuvre	*Characterising size and frequency of calving events based on high temporal time-lapse and automatic image processing*
	Marco Doveri	*Isotopic signatures, physical-chemical features and flow rates of glacial drainages in the Ny-Ålesund area, Svalbard*
	Nikolay Osokin	*Dynamics of snow cover characteristics exerting influence on stability of the permafrost on Svalbard*
	ZHOU Chunxia	*Monitoring Glacier Displacement in Western Svalbard Using Landsat 8 and Sentinel-1 Data*
	Li Zhongqin	*Long-term glacier mass-balance monitoring of Austre Lovénbreen glacier in Ny-Ålesund Svalbard*
	Rune Gundersen	*High temporal and spatial interferometric radar measurements of Kronebreen, Spitsbergen.*
	Alex Messerli	*Norwegian Copernicus Glacier Service: Glacier products for Svalbard using Sentinel-2*
16:45-17:15	**Posters**	
17:15-17:45	Hanne H. Christiansen	*SCC concluding presentation: Using Svalbard for educating the next generation of Arctic Scientists*
17:45-19:00	**Posters (continued)**	
19:00-21:00	**Liestøl Symposium dinner**	

Schedule (cont.)

Thursday, Nov. 9		
09:00-09:20	Jacek A. Jania	*On problems with mass balance studies of Svalbard tidewater glaciers*
09:20-09:40	Thorben Dunse	*Glacier-freshwater runoff: a possible driver of autumn phytoplankton blooms in seas around Svalbard*
09:40-10:00	Alistair Everett	*Seals like plumes*
10:00-10:30	**Coffee**	
10:30-10:50	Riko Noormets	*Geophysical seafloor mapping applications in the fjords and shelf of Svalbard*
10:50-11:10	Nina Kirchner	*Long Term Underwater Sensing (LoTUS) at calving fronts in western Spitsbergen*
11:10-11:30	Tom Rune Lauknes	*Terrestrial and airborne remote sensing of calving glaciers in Svalbard*
11:30-12:30	**Lunch**	
12:30-12:50	Alexander Minakov	*Late Cenozoic geodynamics in Svalbard: interplay of glaciation, seafloor spreading and mantle convection*
12:50-13:10	Torgeir Opeland Røthe	*Holocene glacier fluctuations reconstructed from lake sediment at Kløsa and Vårfluesjøen, Spitsbergen*
13:10-13:30	Elisabeth Isaksson	*Two decades of Svalbard ice core studies – progress and remaining challenges*
13:30-13:50	Per Holmlund	*New photogrammetric methods and the use of old photographs for quantitative analyses of glacier changes*
13:50-14:20	**Coffee**	
14:20-14:40	Sergey Marchenko	*Thermal conductivity and water content of firn at Lomonosovfonna derived from subsurface temperature measurements*
14:40-15:00	Veijo A. Pohjola	*The mass balance of Nordenskiöldbreen and Lomonosovfonna 2006-2017.*
15:00-15:20	C.H. Reijmer	*Climate and surface energy balance of Nordenskiöldbreen, Svalbard: 10 years of in situ observations*
15:20-15:40	Malgorzata Blaszczyk	*Fresh water input to the Hornsund Fiord (Southern Spitsbergen)*
15:40-16:00	Florian Tolle	*10 years of monitoring in the Austre Lovénbreen catchment: results, cooperations and perspectives*
16:00-16:20	Songtao Ai	*A radio wave velocity model contributing to precise ice volume estimation on Svalbard glaciers*
16:20-18:00	**Break**	
18:00-20:00	**Liestøl Symposium dinner**	

Budget

Rental of auditorium, lunches, coffee breaks, for 50 participants:	50,000
Two group dinners, for 50 participants:	50,000
Total:	100,000

Registered participants

Name	**Country**	**Institution**
Adam Nawrot	Poland	Institute of Geophysics, Polish Academy of Sciences
Aga Nowak	Norway	Western Norway University of Applied Science
Alexander Minakov	Norway	UiO, CEED
Alexandra Messerli	Norway	Norwegian Polar Institute
Alistair Everett	Norway	Norwegian Polar Institute
Andreas Köhler	Norway	University of Oslo
Andrey Fedorov	Russia	Russian Academy of Sciences
Andy Hodson	UK	UNIS
Ann Christin Auestad	Norway	The University Centre in Svalbard (UNIS)
Anna Nikulina	Russia	Arctic and Antarctic Research Institute
Anna Maria Trofaier	Norway	SIOS
Anshuman Bhardwaj	Sweden	Luleå University of Technology
Bartłomiej Luks	Poland	Institute of Geophysics Polish Academy of Sciences
Bas Altena	Norway	University of Oslo
Camille Crapart	Norway	Institut Français
Carleen Reijmer	Netherlands	Utrecht University
Christopher Nuth	Norway	University of Oslo, Department of Geosciences

Chunxia Zhou	China	Wuhan University
Dagrun Vikhamar-Schuler	Norway	MET-Norway
Dorota Czopek	Poland	AGH University of Science and Technology
Elisabeth Isaksson	Norway	Norwegian Polar Institute
Ellen Karin Mæhlum	Norway	
Erik Schytt Holmlund	Sweden	Stockholm University, Department of Physical Geography
Florian Tolle	France	Laboratoire Théma Université de Franche-Comté
Gleb Tarasov	Russia	Arctic and Antarctic Research Institute
Gwenaelle Hamon	Norway	Climate and Cryosphere (CliC) Project
Halfdan P. Kierulf	Norway	Norwegian Mapping Authority, Geodetic Institute
Ilaria Baneschi	Italy	CNR-IGG
Jacek A. Jania	Poland	University of Silesia
Jack Kohler	Norway	Norwegian Polar Institute
Jan Rasmus Sulebak	Norway	Research Council Norway
Jon Ove Hagen	Norway	University of Oslo
Julian Podgórski	Poland	Institute of Geophysics, Polish Academy of Sciences
Kjetil Schanke Aas	Norway	University of Oslo
Kristian Breili	Norway	Norwegian Mapping Authority, Geodetic Institute
Lawrence Hislop	Norway	Climate and Cryosphere (CliC) Project
Lefauconnier Bernard	France	Norskpolarinstitutt-retired
Li Zhongqin	China	Wuhan University
Liss Marie Andreassen	Norway	NVE
Liudmila Konoreva	Russia	The Polar-Alpine Botanical Garden and Institution
Makan Konte	France	ISIM BUSINESS SCHOOL
Małgorzata Błaszczyk	Poland	University of Silesia
Marco Brönner	Norway	NGU
Margrete Keyser	Norway	Svalbard Science Forum
Marie-Andrée Dumais	Norway	NGU / NTNU
Marta Majerska	Poland	Nicolaus Copernicus University
Nick Cox	UK	British Antarctic Survey
Nikolay Osokin	Russia	Institute of Geography RAS
Nina Kirchner	Sweden	Stockholm University
Olav Orheim	Norway	
Olga Sidorova	Russia	Arctic and Antarctic Research Institute
Per Holmlund	Sweden	Stockholm University, Department of Physical Geography
Pierre-Marie Lefeuvre	Norway	UiO, Department of Geosciences
Piotr Glowacki	Poland	Institute of Geophysics, Polish Academy of Sciences
Richard Morris	Norway	Norwegian Polar Institute
Riko Noormets	Norway	UNIS

Rune Gundersen	Norway	Ispas
Rune Storvold	Norway	Norut
Sergey Marchenko	Sweden	Uppsala University
Songtao Ai	China	Wuhan University
Thomas Vikhamar Schuler	Norway	University of Oslo, Department of Geosciences
Thorben Dunse	Norway	UiO, Department of Geosciences
Tom Rune Lauknes	Norway	Norut
Torgeir Opeland Røthe	Norway	Bjerknes Centre for Climate Research
Veijo Pohjola	Sweden	Uppsala university
Ward van Pelt	Sweden	Uppsala University, Department of Earth Sciences
Maria Pogozheva	Russia	Federal State Institution Zubov State Oceanographic Institute
Feiteng Wang	China	Chinese Academy of Sciences

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