DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2015/88

PROMICE 2014

Report for the 2014 operational phase of the Programme for Monitoring of the Greenland Ice Sheet

Signe B. Andersen, Andreas P. Ahlstrøm, Morten L. Andersen, Jason E. Box, Michele Citterio, Charalampos Charalampidis, William Colgan, Robert Fausto, Signe Hillerup Larsen, Horst Machguth, Dorte Petersen, Dirk van As, Martin Veicherts & Karen Edelvang

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF CLIMATE, ENERGY AND BUILDING

GEUS

DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2015/88

PROMICE 2014

Report for the 2014 operational phase of the Programme for Monitoring of the Greenland Ice Sheet

Signe B. Andersen, Andreas P. Ahlstrøm, Morten L. Andersen, Jason E. Box, Michele Citterio, Charalampos Charalampidis, William Colgan, Robert Fausto, Signe Hillerup Larsen, Horst Machguth, Dorte Petersen, Dirk van As, Martin Veicherts & Karen Edelvang

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF CLIMATE, ENERGY AND BUILDING

G E U S

Contents

Summary 4

Automatic weather stations 6

Ice velocity mapping 10

Calculation of ice discharge and total mass balance 14

Glacier Mapping 18

Observations of runoff from the Greenland ice sheet.. 22

Outlet glacier GPS trackers & Extreme Ice Survey time lapse photography 27

Collaboration with DMI models 32

Outreach 39

Related projects 41

WMO CryoNet.. 42

References 46

Appendix A

Appendix B -Promice publications

Appendix C –Minutes from PROMICE advisory group meeting

Appendix D –PROMICE Newsletters

Appendix E - ROSA paper

Summary

The Programme for monitoring of the Greenland Ice Sheet (PROMICE) is as an on-going effort to monitor changes in the mass budget of the Greenland Ice Sheet and is operated by the Geological Survey of Denmark and Greenland (GEUS) in collaboration with the National Space Institute (DTU Space) and the Greenland Survey (ASIAQ) started in 2007.

A central part of PROMICE is the network of presently 22 automatic weather stations (AWS) situated in the ablation zone of the Greenland ice sheet. In combination with air borne surveys of ice thickness and mapping of ice velocities estimates of the mass loss of the Greenland ice sheet can be made. Also mapping of individual glaciers and ice caps surrounding the ice sheet is done to assess the mass loss. The PROMICE data can be used directly as indicators of climate change - becoming more and more valuable as the monitoring period increases. Furthermore the programme contributes through observations to process-oriented studies to understand the mass loss as well as validation efforts to improve ice sheet models and future predictions.

PROMICE is committed to maintain an accessible, safe and thoroughly documented database for storing and disseminating the data free of charge to the climate research community.

This report updates on PROMICE activities for the year 2014. It is not intended to give a complete overview of the programme. More information about PROMICE may be found in the earlier PROMICE reports (Ahlstrøm et al., 2011, Andersen et al., 2013, Andersen et al., 2014).

The mass loss from the Greenland ice sheet has increased significantly since the beginning of this century. Even though 2014 has not been a record year, large melt rates were observed. In 2014 there was a weak tendency towards inflow of warmer air from the South along the West coast of Greenland (North Atlantic Oscillation in the negative phase). This lead to melting roughly around the 2008-2012 average and considerably higher than in 2013, yet lower than in the record melt years 2010 and 2012.

Some main achievements for 2014 are:

- Successful monitoring by 22 Greenland ice sheet automatic weather stations
- A new weather station was installed on the Kobbefjord glacier
- The first results of quantifying the dynamic mass loss from the entire Greenland ice sheet were published
- The first ice velocity maps of the entire ice sheet margin were made in collaboration with the ESA CCI Ice Sheets project
- Intensified collaboration with DMI on evaluating and improving ice sheet models using PROMICE observations
- The PROMICE historical mass balance data base was finalized and was made freely available for download on the PROMICE website (see Newsletter no. 7, Appendix D)
- The PROMICE aerophotogrammetric map of all Greenland peripheral glaciers and ice caps and were made freely available for download on the PROMICE website
- Ice thickness measurements from the PROMICE airborne survey data were made freely available for download on the PROMICE website

- PROMICE contributed to Polar Portal, a website where Danish research institutions display the results of their monitoring of the Greenland ice sheet and the sea ice in the Arctic to the general public (polarportal.org)
- PROMICE participated in the establishment of CryoNet, an upcoming standardized network of ground-based cryospheric monitoring sites initiated by the World Meteorological Organization
- The PROMICE team contributed to 13 externally reviewed ISI-tracked scientific journal publications in 2014

Automatic weather stations

The network

The PROMICE station network currently consists of automatic weather stations (AWS) transects in eight melt regions of the Greenland ice sheet (GrIS), adding up to 22 stations in total, of which 19 are on the ice sheet proper (Figure 1). In each region, one station is located in the lower ablation zone close to the margin, and one or two in the middle/upper ablation zone, to obtain elevation gradients in the measured variables. Exceptions are KAN_U and QAS_A, located in the lower part of the accumulation zone; MIT and NUK_K, positioned on independent glaciers; and KAN_B, located on tundra, one kilometre from the ice sheet. The AWS measure all important meteorological variables: air temperature (aspirated), pressure and humidity, wind speed, downward and upward solar (shortwave) and terrestrial (longwave) radiation. The AWS also record temperature profiles in the upper 10 m of ice, GPS-derived location and diagnostic parameters such as station tilt angles. A pressure transducer and two sonic rangers measure snow and surface height change due to ablation and accumulation. Most variables are measured every ten minutes, with all data stored locally awaiting collection during maintenance visits. Hourly averages of the most transient variables are transmitted via satellite between days 100 and 300 of each year, while a selection of the remaining variables is transmitted at six-hour intervals. Transmissions have a lower (daily) frequency in the winter period to save battery power and transmission costs. All data and metadata including sensor specifications are archived in the PROMICE database and made freely available for display and download at www.promice.dk.

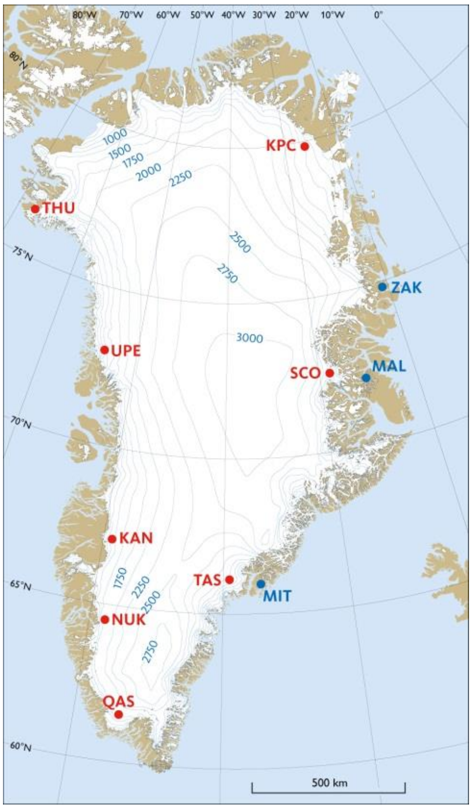


Figure 1. *Location and identification codes of PROMICE automatic weather stations. Dotted lines are elevation contours in m above sea level. Red dots represent PROMICE stations, blue dots other GEUS stations.*

Servicing the stations in the field

In 2014, we serviced PROMICE stations in seven regions, namely Scoresbysund (SCO), Tasiilaq (TAS), Qassimiut (QAS), Nuuk (NUK), Kangerlussuaq (KAN), Upernavik (UPE) and Thule (THU). Only the remote Kronprins Christian Land (KPC) site was not visited this year, but transmissions indicate that the stations operate normally.

In the visited regions, PROMICE activities and instrumentation are co-sponsored by other projects. PROMICE funding covers the maintenance of two AWSs per region (and none at KAN), but the programme receives data from three (QAS and NUK) or four (TAS and KAN) stations in some regions. Due to changes in co-funding projects, NUK_N was relocated to an independent glacier and renamed NUK_K, as collaboration with Asiaq further intensifies.

Three stations (TAS_A, QAS_U and KAN_U) are currently accompanied by snow pack analyzers (SPA) that can provide measurements of changes in the snow pack during melt in spring. In the QAS region, a conventional stake line was also serviced to supplement the QAS automated ablation measurement. In the SCO, QAS, NUK and UPE region we serviced GPSs and/or time-lapse cameras in addition.

Measurements

Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation at all AWSs on the ice sheet may be found in appendix A together with detailed statistics on net ablation and air temperature. We briefly describe the measurements below.

Figure 2 gives an overview of the ablation totals for all years. Annual ablation totals in the southern part of Greenland typically amount to 3-9 metres (at the lower TAS, QAS and NUK stations), while ablation totals at the more northerly SCO_L and UPE_L stations amount to 2-3 metres at low altitudes (< 500 m a.s.l.). The ablation totals from the upper stations (>500 m a.s.l.) amount typically to 0.0-3.0 metres and indicate that ablation is highly dependent on elevation, latitude and local climate. On average, 2014 yielded roughly the net ablation of the 2008-2012 average, and was typically exceeded only by 2010, 2012 and often 2011 ablation, which were years with large melting. Since the start of PROMICE, the AWS network recorded 106 annual ablation totals, a 98% success rate due to the combination of various measurement methods (pressure transducer, sonic ranger and stakes).

All PROMICE stations record a distinct annual cycle in air temperature. As is common in the Arctic climate, temporal variability is largest in winter due to a more vigorous atmospheric circulation. The amplitude in the annual air temperature cycle is largest for stations at high latitudes or high elevations since above-freezing temperatures and thus a melting ice surface capable of local thermo-regulation, are least frequent at these stations. The more northerly stations also show a larger annual temperature cycle due to the increasing contrast in the lengths of polar day and night with increasing latitude. The smallest amplitude in the annual temperature cycle is seen at QAS_L, the most southerly PROMICE site. The 2013/14 winter measurements show that temperatures in the north and east of Greenland were relatively high compared to other PROMICE years, and low in the south and west. In the 2014 summer the south was relatively warm, while the northwest was cold. July temperatures were mostly low, especially in east Greenland. The negative and positive temperature anomalies occurred at QAS_L in April (1.8 standard deviations below average) and at KPC_U in October (1.5 standard deviations above average). Overall, we have an 82% success rate in collecting monthly average temperatures, and this value is expected to increase when collecting data in the field in 2015.

The wind regimes over the ice sheet are distinctly different between regions. Winds are stronger at the higher-positioned AWSs. The highest monthly-mean wind speed values were recorded at KAN_M and KAN_U (1270 and 1840 m a.s.l.), and TAS_U and TAS_A (570 and 900 m a.s.l.). The strongest mean wind occurs in winter, causing a more pronounced yearly cycle. The exception to the rule is the THU region in northwest Greenland, which does not show a yearly wind speed cycle. These THU AWSs are positioned on a protruding lobe of the ice sheet that does not sufficiently function as a barrier for mesoscale-scale weather systems, resulting in strong winds year-round. Storms are fairly common in the TAS region, as measured by the AWSs. These storm events are known as Piteraqs and build up momentum due to the alignment of katabatic and large-scale synoptic scale weather forcing. These notorious storms have repeatedly caused severe damage to the town of Tasiilaq. The Piteraq on 27 April 2013 as measured at TAS_U was exceptionally strong in reference to the whole PROMICE period, with winds exceeding 42 m/s (150 km/h) at about 3 m above the surface. Further investigations of this phenomenon can be found in a 2014 paper by Van As et al. (Appendix 4).

An important instrument on the PROMICE AWS is the radiometer, measuring the up- and downward radiative fluxes, which govern the surface energy budget and thus melt of the ice sheet. Both the short- and longwave components show a large annual cycle, with distinct differences with latitude (see e.g. the length of the polar night from shortwave radiation). In regions with a more frequent cloud cover (e.g. TAS) the radiative fluxes show a larger interannual variability than in regions where clear skies prevail (e.g. KAN).

The surface albedo is generally high in the cold, snow-covered interior of the ice sheet (>0.75), and lower along the ice sheet margin where melting occurs in summer. In wintertime, the ice sheet is fully snow covered except where wind erosion dominates. Depending on the location of each AWS in the ablation area, snow melt starts in April or May as seen from air temperatures and decreasing albedo. Thereafter, albedo drops throughout the melt season until snowfall occurs in autumn, yielding a distinct annual cycle which is largest at the high-melt sites. Surface melt chiefly causes this annual darkening of the ice sheet surface as snow undergoes heat-driven metamorphosis, or completely melts to expose darker bare ice. The ice sheet surface may also darken as impurities collect on the ice surface or supraglacial meltwater-filled features become more abundant. We find that surface albedo on average drops below fresh snow values as monthly-mean temperatures exceed –2°C due to an increase in surface melt. Although absorbed solar radiation is the primary source of melt energy, the melt-albedo feed-back is initiated by the energy fluxes that respond to changes in temperature, such as down-ward longwave radiation and the turbulent heat fluxes. Since both atmospheric warming and ice sheet darkening increase surface melt intensity and melt area, the anticipated future warming will result in a self-reinforcing ice sheet mass loss contribution from the melt-albedo feedback. At the PROMICE sites, where ice surfaces after the winter snow cover has melted, the length of the bare ice season is most important for annual ablation as the interannual vari-ability in albedo minimum is small. Whereas during 2013 summer albedo was higher than in previous years, the 2014 values were lower than those of 2013, approaching the low values measured in the summers of 2010-2012.

The bottom right plots in the AWS data figures illustrate GPS-derived elevation. All stations display a lowering over the years which is mostly due to it moving downslope, with the flowing ice. These GPS show a remarkable amount of detail and information that is yet fairly unex-plored in PROMICE. The small but distinct annual cycles in elevation may suggest an intimate interplay between surface melt in summer and dynamic thickening in winter. Also, the lower-ing illustrate that once every few years the AWSs need to be relocated to their original position to safeguard that data series are from the same climate zone / elevation.

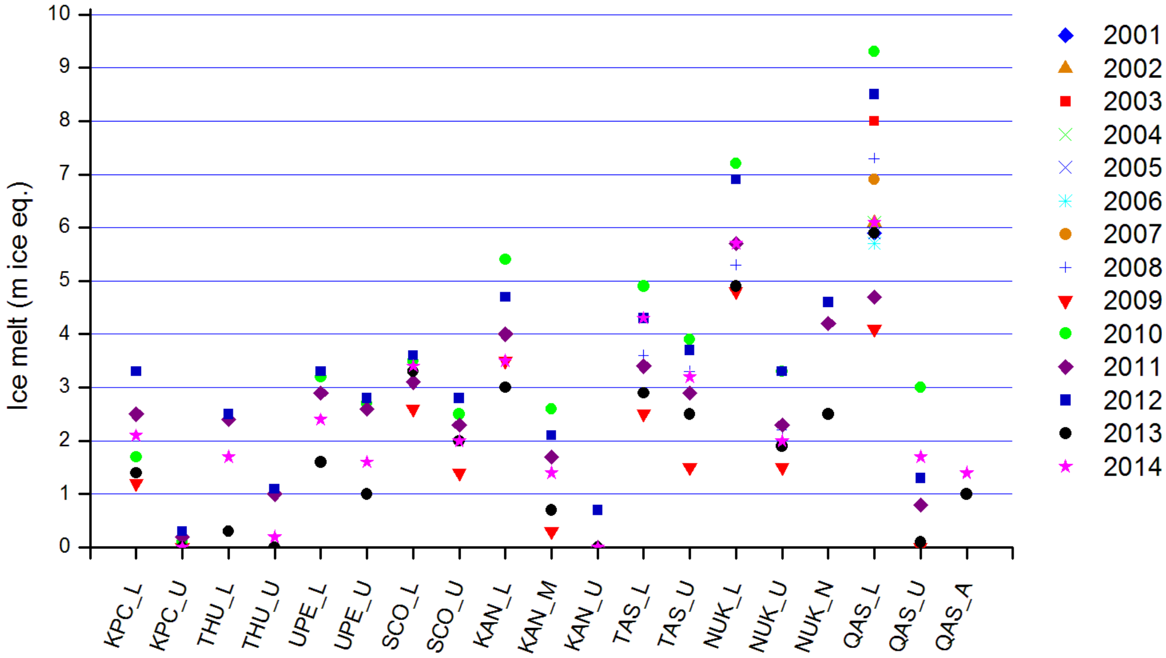


Figure 2. *Net annual ablation records for all PROMICE stations 2002-2014.*

Ice velocity mapping

At GEUS, surface velocities of the ice sheet margin has been derived for the winters 1995/96 and 2009/10 based on data from ERS-2 and ALOS/PALSAR synthetic aperture radar (SAR) satellite data, respectively. The resulting ice velocity maps may be seen in Figure 3. The velocity maps have been validated against ground-based GPS measurements with good agreement (Ahlstrøm et al. 2013, Andersen et al. 2015). The ice sheet surface velocities have been derived with SUSIE (Scripts and Utilities for SAR Ice-motion Estimation), a processing chain developed for GEUS by DTU Space, based on a commercial software package distributed by GAMMA Remote Sensing.

When comparing the velocity maps from 1995/96 and 2009/10 the overall picture is one of increasing ice velocities and retreat of the outlet glaciers in accordance with other studies (Joughin et al., 2010; Moon et al., 2014). However, the dynamics of the Greenland ice sheet are complex and slowdown is also observed in a smaller number of cases. In Figure 4, the velocity changes of Academy glacier and Hagen glacier NE Greenland between the winters 1995/996 and 2009/2010 can be seen, showing a speed up of Hagen Glacier and a slowdown of Academy Glacier.

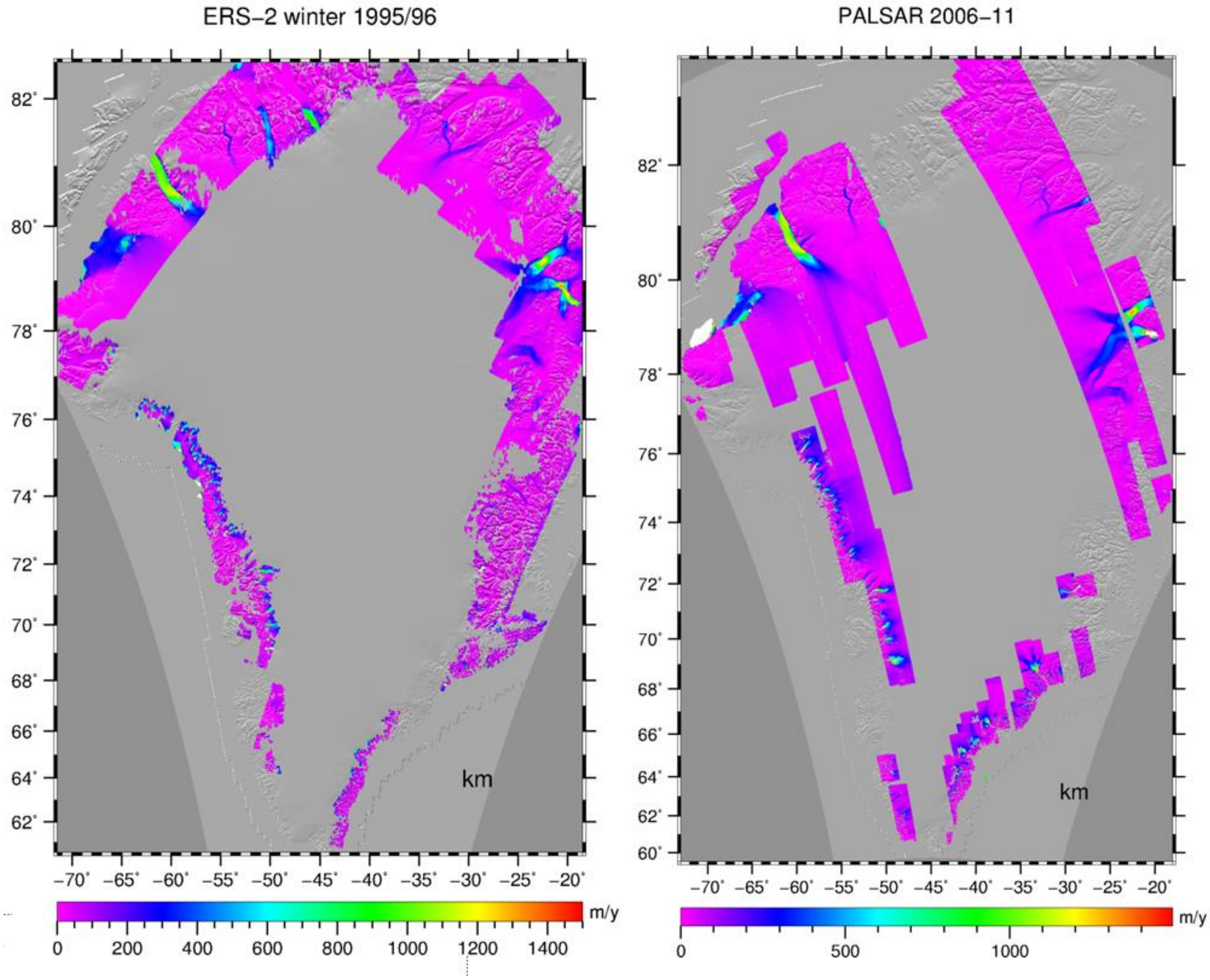


Figure 3: Ice velocities from ERS-2 satellite data (winter 1995/96) and from ALOS PALSAR satellite data (winter 2009/10).

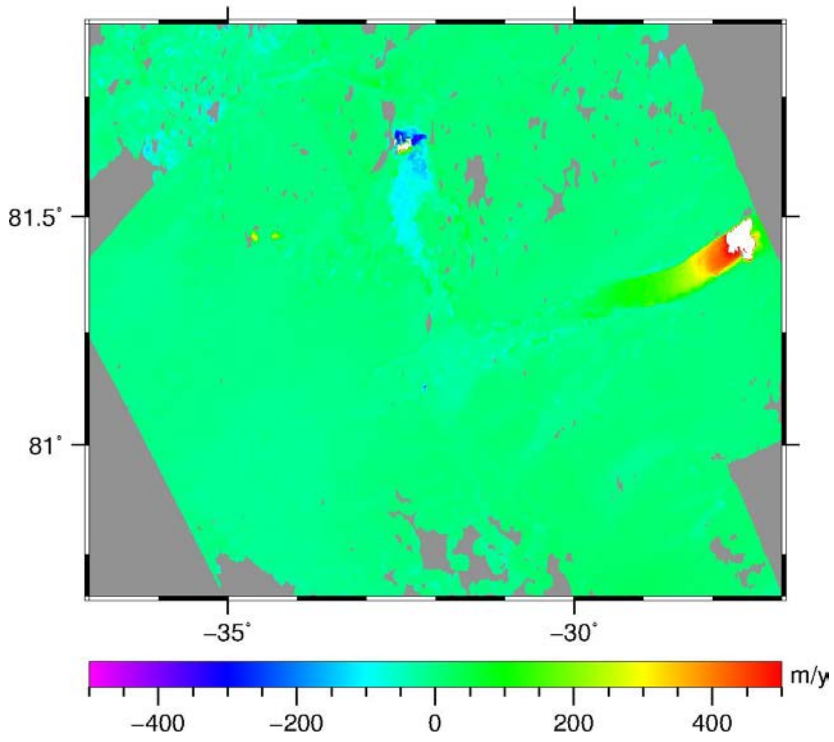


Figure 4: Ice velocity change of Academy and Hagen Glacier, NE Greenland, between the winters 1995/96 and 2009/10, derived from ERS-2 and ALOS PALSAR data.

The aim is to provide ice sheet velocities at regular intervals in order to assess the changes in ice flow dynamics and quantify the impact of the changes on the mass loss of the Greenland ice sheet. Combining the ice velocity maps with ice thickness observations across a flux perimeter around the ice sheet allows quantification of the dynamic mass loss from glacier discharge as described in the next chapter.

Producing velocity maps over a region as large as the Greenland Ice Sheet is a major undertaking, relying on the existence and availability of radar remote sensing data. A major obstacle in producing ice velocity maps within PROMICE has been the availability of suitable SAR satellite data. Until now, data has been scarce or only available at commercial rates not affordable to PROMICE. Even at research rates (production cost) it can be costly to acquire data to cover the vast area of the entire Greenland Ice sheet and this has not been possible within the budget. Presently GEUS is involved in the ESA Climate Change Initiative, Ice Sheets Project. This project is lead by DTU-Space and one of the two major products to be provided is ice velocity maps from ESA's SAR missions. The project benefits PROMICE significantly by providing access to SAR data. The data used for the ice velocity maps presented here come from the collaboration between PROMICE and the ESA_CCI Ice Sheets project. The ERS data was provided through the ESA_CCI while the PALSAR data was provided by PROMICE and the ALDEN project.

Recently the Sentinel 1a satellite has been launched by ESA and the first velocity maps derived from the acquired data look very promising. These data are free of charge and should provide data for velocity maps of the entire Greenland ice sheet twice a year in the near future.

The future existence of satellite radar data over Greenland is not a given fact. PROMICE team members actively engage in hearings on future satellite missions organized by the European Space Agency to stress the need for radar data over the Greenland Ice Sheet. Without this data, assessing changes in the ice sheet contribution to sea level change ends up relying on satellite missions aimed at altimetry and gravity measurement. These have proven useful in highlighting ice sheet volume and mass changes over very large areas, but crucially lack the explanatory power to drive the process-based studies needed to improve modelling capabilities.

Calculation of ice discharge and total mass balance

Using the PROMICE-collected airborne ice thickness observations from 2007 and 2011, we computed the ice discharge flux (F) through a cross-section of the ice sheet defined by the PROMICE flight path (Figure). Surface Mass Balance (SMB) data from the MAR regional climate model was used to calculate the solid ice discharge at the coast (D). With D and SMB known, the total mass balance (TMB) of the entire Greenland Ice sheet can be calculated using the simple equation TMB = SMB-D. The method is the so-called "input-output" method, since it quantifies how much net mass is added to the ice sheet from precipitation and melt (SMB) with how much is lost through iceberg calving (D). The PROMICE airborne laser and radar data is central in our implementation, since knowledge of the ice thickness at the flux gate is naturally required. An update of this work is planned when third airborne campaign is carried out in 2015 – resulting in a span of 8 years of data.

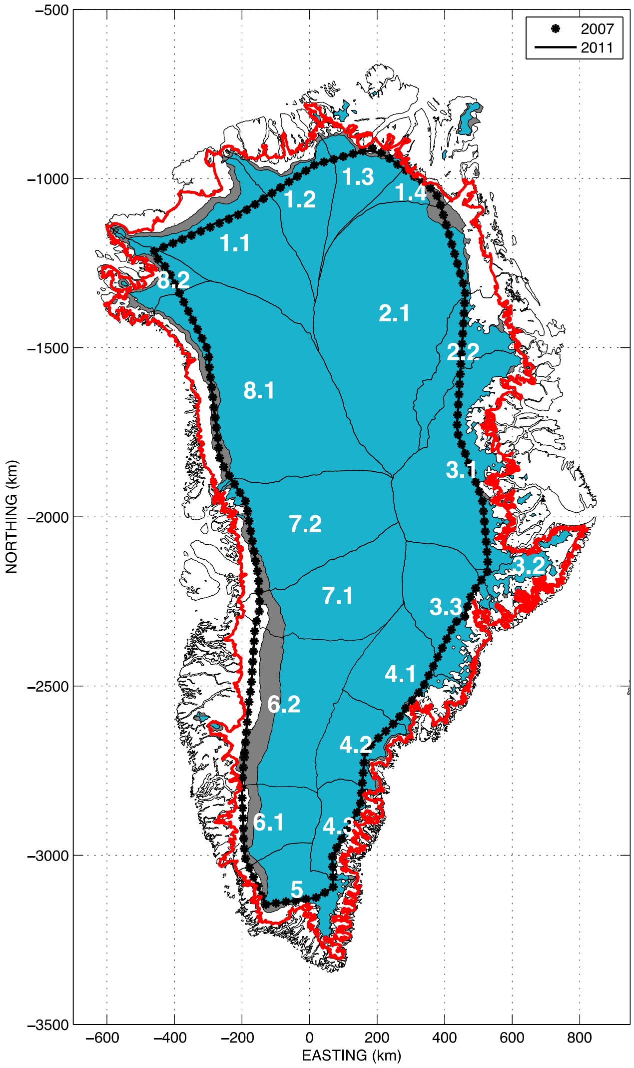


Figure 5: Flight path of the 2007 and 2011 PROMICE airborne surveys. The red line indicates the ice margin; the blue region indicates the 2007-2011 accumulation zone, and the grey region indicates area that has transformed from accumulation to ablation since the reference climatology period mean (1961-1990). White numbers indicate basin numbers.

The study was published in the international journal “Earth and Planetary Science Letters” (5-year impact factor 5.038) in January 2015. The study demonstrated the separation of the mass loss components (D and SMB) in 18 separate basins (Figure 6).

The total iceberg discharge is estimated to 515 ± 57 Gt/yr, and the total mass loss for the period 2007-2011 is 262 ± 21 Gt/yr. Both of these estimates fit well with other studies that employ the same and other methods (Figure7).

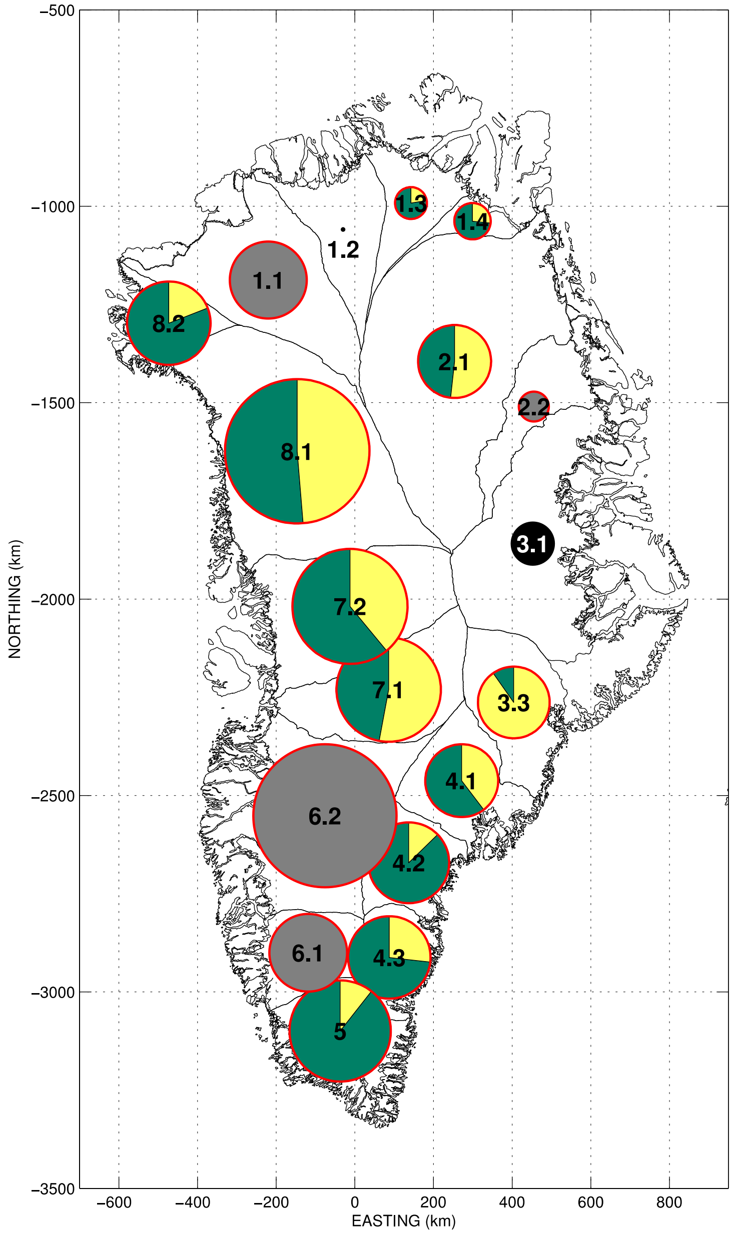


Figure 6: Partition of 2007-2011 mean mass loss into surface mass balance (dark green) and ice dynamics (yellow) components. Gray circles denote basins in which the partition of mass balance components is not possible. Circle size is proportional to total mass balance. Red perimeters indicate negative total mass balance. Black circles indicate mass balance of zero within uncertainty. Numbers indicate basin names.

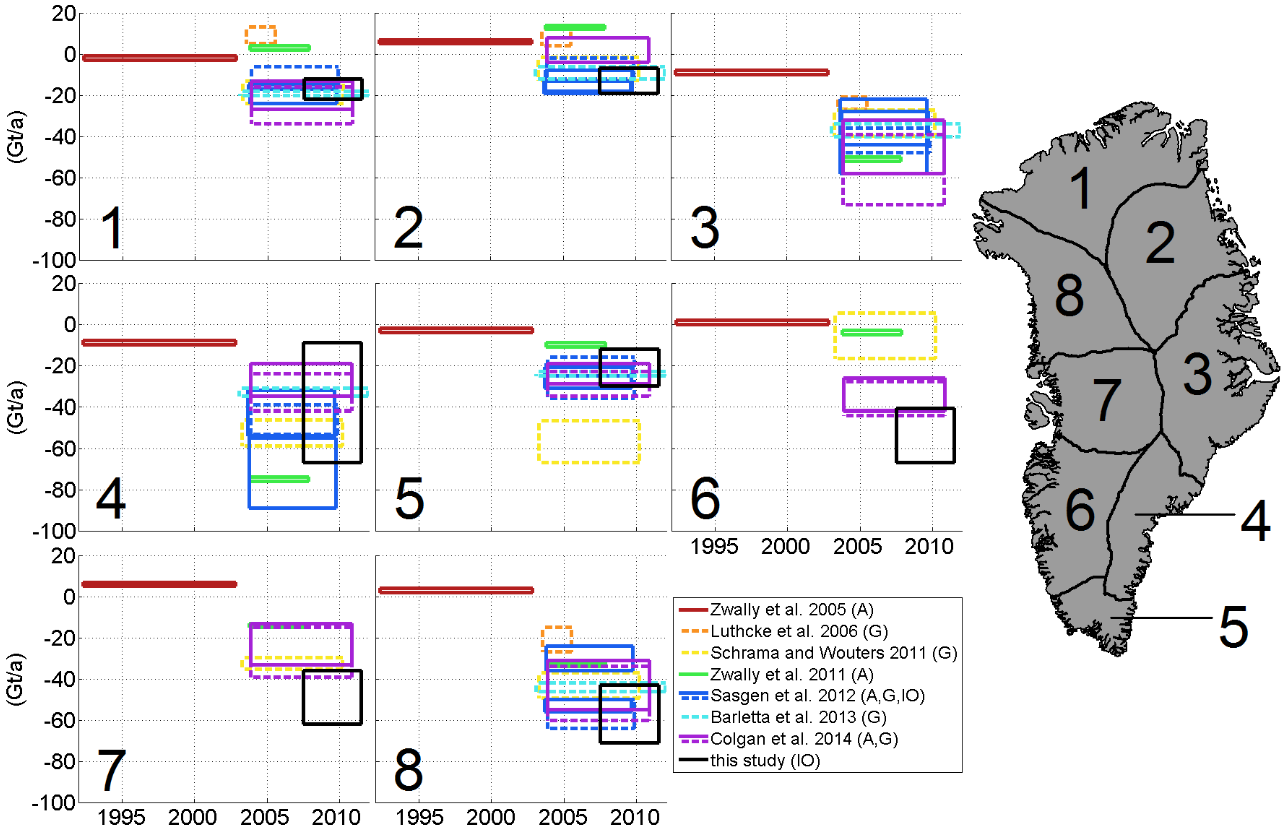


Figure 7: Mass balance estimates for Greenland's eight major drainage basins (inset) derived through altimetry (A), gravimetry (G) and input-output (IO) approaches (Zwally et al., 2005; Luthcke et al., 2006; Schrama and Wouters, 2011; Zwally et al., 2011; Sasgen et al., 2012; Barletta et al., 2013; Colgan et al., 2014). The horizontal extent of each box denotes observation period, while the vertical extent denotes reported uncertainty. Solid lines denote estimates for the ice sheet proper, while dashed lines denote estimates that include peripheral glaciers.

Glacier Mapping

Regional climate models as well as many other modelling and remote sensing applications require gridded inputs, and ice masks are widely used in these contexts. During 2014 several raster datasets were produced based on the glacier polygon masks described in Citterio & Ahlstrøm (2013). Simple vector to raster conversion tools are available in existing GIS software packages. However, most of these tools only produce classified output where each pixel is assigned a class code representing a surface cover type, e.g. 'ice', 'land', 'ocean' and so on. Binary masks ('ice', 'non-ice') would not satisfy the requirement of delivering ice cover grids providing the accurate area fraction covered by ice within each pixel, i.e. a rational number ranging between 0 and 1 representing no, partial and complete ice cover. This kind of raster is usually produced efficiently in one of two ways: by rasterizing the vector polygons into a binary mask at much higher resolution, summing the area of 'ice' sub-pixels and divide it by the area of the output pixel containing them, or by repeatedly sampling the vector polygons at random points within each output pixel and dividing the number of 'ice' by the number of 'non-ice' samples. No existing implementation of these methods was found which satisfies all requirements, particularly in the case of the ice mask grid requested by DMI for the 5 km high resolution HIRHAM runs (Fig. 8, also including Iceland and Arctic Canada), where the grid projection is specified by two arrays of cell center coordinates.

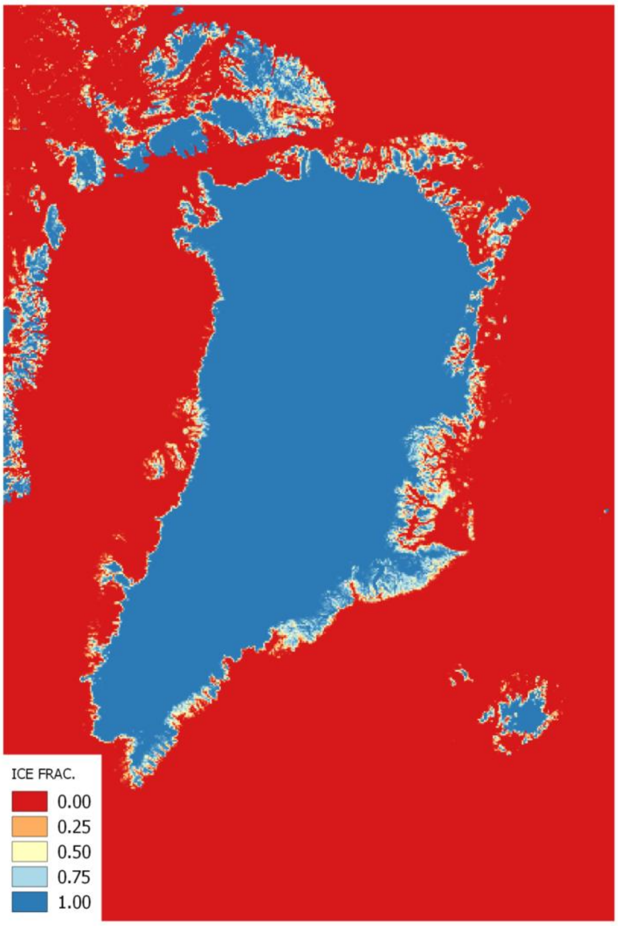


Fig. 8 – Ice mask provided to DMI for the 5 km high resolution HIRHAM runs, mapping all land ice masses in Greenland, Iceland and Arctic Canada.

The large size of Greenland also creates computer memory problems for many existing implementations. For these reasons, a new gridding program was developed to carry out the vector to raster conversion. The glacier polygons described in Citterio & Ahlstrøm (2013) and a vector representation of the desired output raster are intersected and the resulting fragments within each output grid cell are collected and their areas summed, optionally keeping track of the glacier connectivity class of the parent polygon (glacier, glacier in contact with the ice sheet, and ice sheet proper). The program can produce output grids in GeoTIFF and NetCDF formats on many different cartographic projections, correctly compensating for distortions introduced by non-area conserving projections through an internal intermediate representation of the vector polygons in the Lambert azimuthal equal area projection.

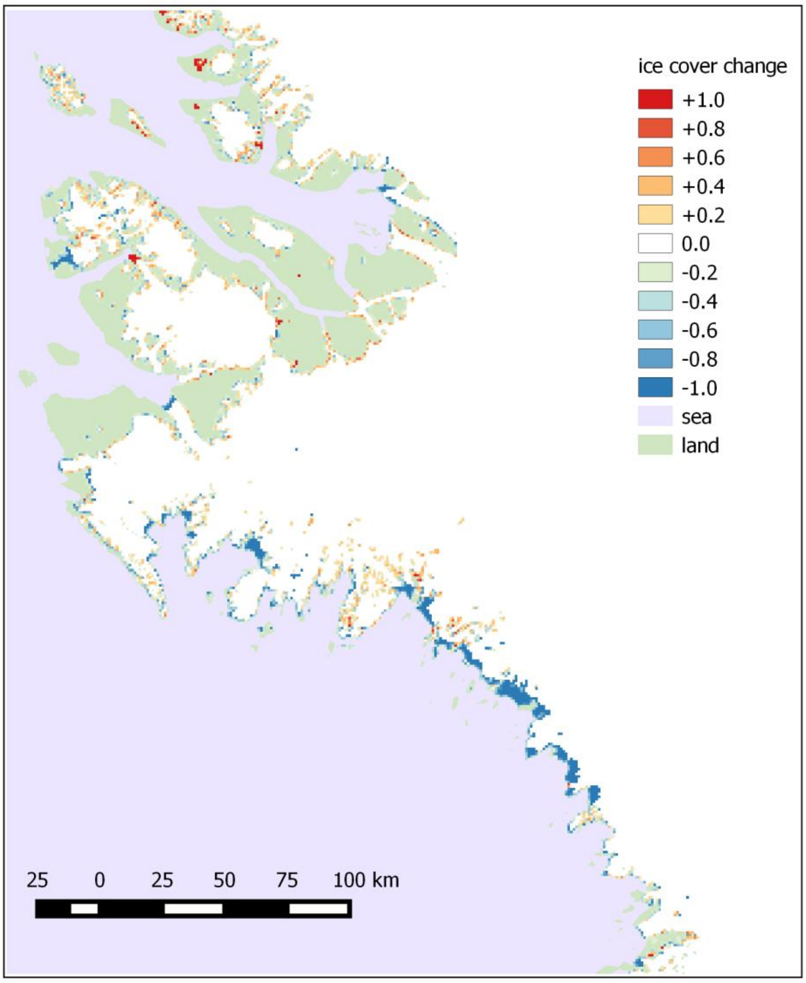


Fig. 9 – Ice cover change in NW Greenland from comparing the grid by Bamber et al. (2013) and the PROMICE grid produced from the vectors described in Citterio & Ahlstrøm (2013).

The algorithm has been optimized to lower memory usage in exchange for longer running time, and the implementation is written to execute in parallel on 8 processing cores to reclaim some speed. In this configuration, all Greenland can be gridded at a 1 x 1 km cell size in ca. 1.5 days on a recent desktop computer. Support is included to exactly match the extent and projection of an existing dataset, and to produce optional output grids of cell centers coordinates, true cell area, Tissot indicatrix, and grid cell indices. Figure 9 shows strong glacier retreat in Melville Bay quantified by comparing the ice cover from two independent datasets produced on the same grid as an application of the accurate vector to raster conversion and grid matching afforded by the new program.

Even in cases when both datasets being compared are available in vector form, gridding and subtracting the resulting rasters avoids the complexity of topological operations and reduces the errors introduced by small distortion and geolocation errors. The capability of accurately quantifying glacier margin changes from gridded datasets irrespective of their original projection and resolution is also a requirement for future PROMICE glacier mapping. During 2014 an algorithm was developed to automatically map glacier margins from Landsat imagery and, once available, from ESA Sentinel 2 imagery. The method is based on the availability of a vector glacier mask covering the region on interest at a different point in time, which is used as truth in training the algorithm to recognize the local spectral signatures of snow, clean ice, moderately dusty ice, water and land in the visible and near-infrared spectrum. To allow for margin fluctuations occurred since the date of the training glacier mask, no pixels very close to the margin are used for training. To deal with localized abrupt changes such as the appearance of a nunatak or the rapid advance of a surging glacier the impact of each 'ice' training pixel is weighted according to its similarity with the typical spectral signatures of ice and snow. This allows the algorithm to correctly map objects which did not exist in the training dataset when their spectral signature is not ambiguous. To prevent small local inaccuracies of the pre-existing map from propagating into the new product, the training and classification are done iteratively using only a relatively thin subsample of randomly selected pixels for each iteration. Currently, the major source of misclassification is the presence of water close or in contact to the terminus. Water and ice have the same spectral signatures at the wavelengths used in the current implementation, and absolute radiance is not used to avoid dealing with illumination differences. These limitations will be addressed in future work.

The final classification output is obtained by averaging all iterations, providing both a new ice cover grid and an associated confidence grid expressing how reliable the classification is at any location. The first results of this work, applying the algorithm only to individual Landsat scenes, were presented at the AGU conference (Citterio et al., 2014) where it was shown that the performance of the algorithm in terms of classification accuracy without any scene-specific tuning is comparable (Fig. 10) to existing maps produced with manual supervision and editing by a human operator, except for margins in contact with lakes and the sea. Future work will develop the software implementation to deal with multi-scene datasets with the ultimate aim of covering large regions or all Greenland in the coming years.

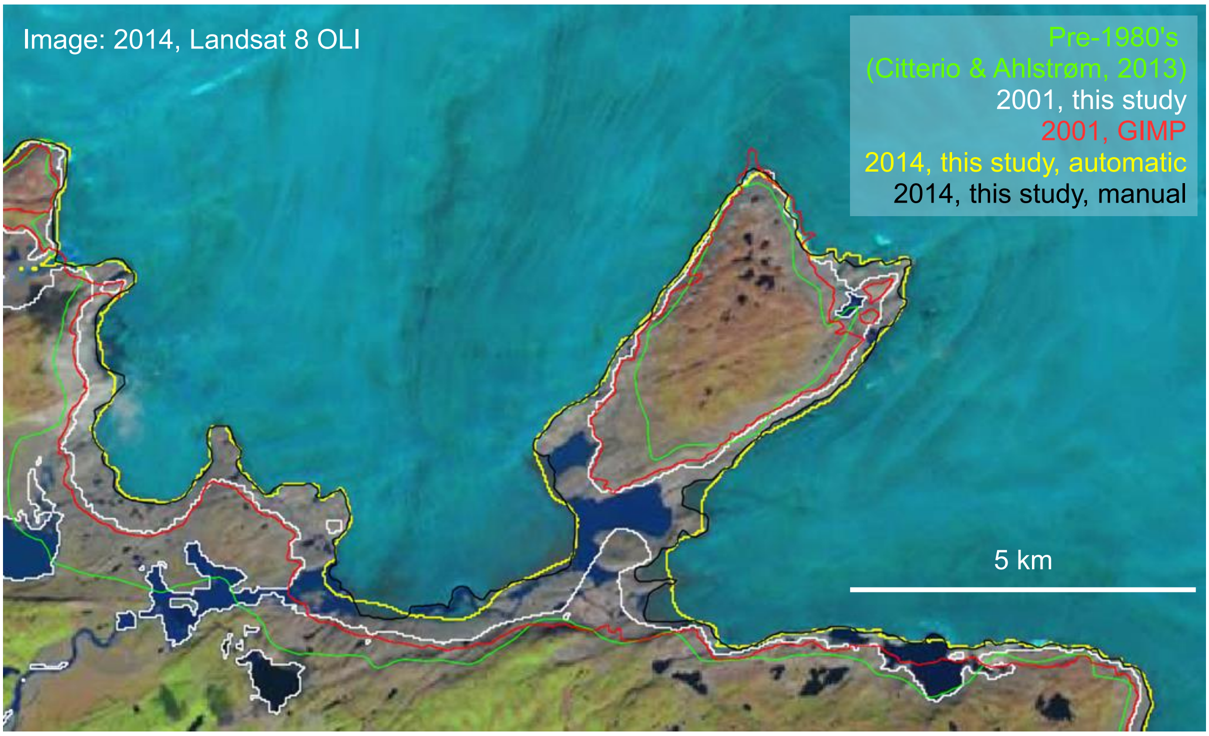


Fig. 10 – Example showing the performance of the new ice mapping algorithm (white and yellow lines for 2001 and 2014, respectively) over a sector of the ice sheet margin at the Qassimiut Lobe (Citterio et al., 2014). The manually digitized 2014 margin and a published dataset referred to year 2001 (Howat et al., 2014) are also provided for reference. Misclassification due to lakes adjacent to ice can be seen and will be addressed in the future.

Observations of runoff from the Greenland ice sheet

The best measure of runoff from the Greenland ice sheet is obtained by gauging hydrological catchments that include a part of the ice sheet margin. Such time series illustrate the observed runoff and provides a highly useful way to validate or calibrate regional climate models (RCM's), especially if the ice sheet part of the catchment is large (Van As et al., 2014; Langen et al., 2015). Difficulties include subtracting the non-ice sheet contribution to the discharge, correctly delineating the catchment on/within the ice sheet and dealing with peaks from glacial lake outburst floods or internal storage in the ice sheet. PROMICE has supported the post-processing of the discharge observations from Tasersiaq, whereas the monitoring program is run by Asiaq and financed by the Government of Greenland. Tasersiaq is one of the largest known hydrological catchment in Greenland in terms of outflow (see location in Figure 11). This time series of discharge is currently being prepared for scientific publication, implying that we cannot show the results yet as this precludes publication in most journals. What is presented in the following is thus the background information for the generation of the discharge time series, in order to provide an overview of the activity.

The time series of runoff from Lake Tasersiaq has been calculated from a measured time series of water level in the lake and the stage-discharge relation. The stage-discharge relation is based on a number of manual discharge measurements carried out at different water levels.

Position of hydrometric station

Continuous monitoring of lake Tasersiaq started in July 1975 with establishment of the hydrometric station 308, situated at N66˚18'04'', W51˚18'22'' approximately 3.7 km from the outlet of the lake. In august 1978 the measuring program was expanded to include a number of climate parameters and this station was named station 105_1. In 1994 the station was replaced, the number of measured climate parameters reduced and this new station was named station 105_2. During the extreme melt year of 2012 the water level in the lake was unusable high and station 105_2 was flooded. To reduce the risk of future flooding a station was established at higher ground further 9.5 kilometers upstream in 2013. At this new position the station was renamed to station 105_3.

The positions of measuring stations and years of operation are given in table1.

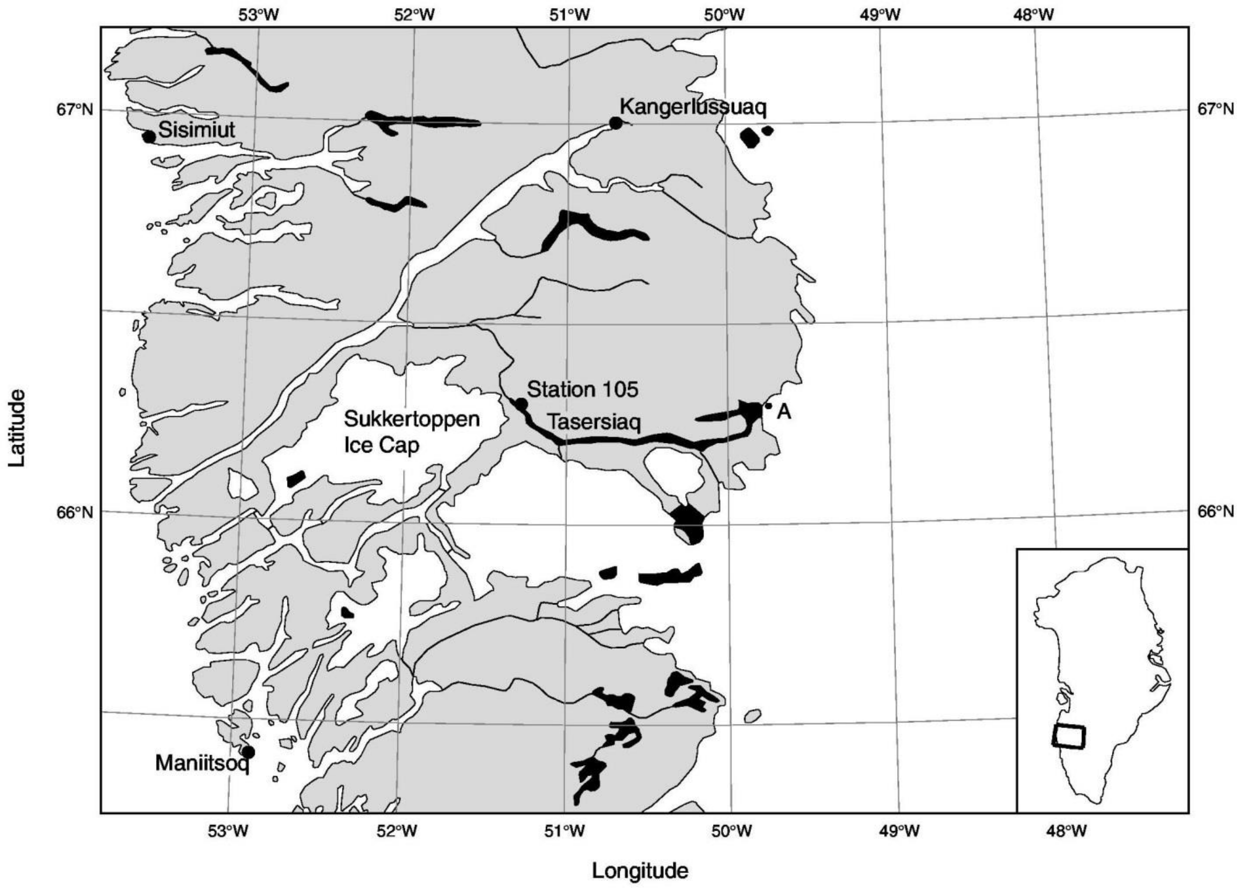


Figure 11. Position of station 105 at the outlet of Lake Tasersiaq. The "A" on the ice sheet margin marks the position of an automatic weather station operated 1999-2001 in the Imersuaq Project leading up to the PROMICE activities in this catchment.

Table 1. Position of measuring stations.

Station no.	Station name	Coordinate Longitude	Coordinate Latitude	Elevation m.a.s.l.	Set up Date	Shut down Date
308	Tasersiaq	W51˚18'22''	N66˚18'04''	Approx. 690	07. July 1975	31. Dec. 1980
105_1	Tasersiaq	W51˚18'07''	N66˚18'00''	Approx. 730	27. Aug. 1978	20. Aug. 1993
105_2	Tasersiaq	W51˚17'50''	N66˚17'51''	Approx. 690	10. Aug. 1994	28. July 2014
105_3	Tasersiaq	W51˚08'24''	N66˚14'22''	Approx. 700	13. July 2013	In operation

Measuring water level

The water level is measured by pressure transducers placed at the lake bottom. At station 308 a pressure point at the lake bottom was connected to a mercury column manometer on land. A float followed changes in the position of the mercury surface and the position of the float was registered at a paper chart. Daily values of water level were manually read from the chart and these readings have later been digitalized.

At all the other stations water level is measured by use of electronic pressure sensors. For the 105 stations instantaneous measurement of water level has been stored at the data logger every third hour all year round. During visits to the station leveling of the water surface relative to reference points on land has been carried out. Based on these measurements and concurrent measurements from the pressure transducers the position of each sensor has been calculated. Changes in sensor position between visits have been investigated and corrections for any sudden changes have been carried out as described in Asiaq's procedure for water level measurements. Based on the sensor position and the measured water pressure a time series of the position of the water surface has been calculated.

Stage-discharge relation

In order to establish a stage-discharge relation manual discharge measurements have been carried out near the outlet of the lake. All measurements are of the area-velocity type, where the velocity of the water has been measured at different depths in a number of verticals evenly distributed over a well-defined cross section in accordance with ISO748. The discharge is then calculated by integration of the velocities over the cross sectional area.

With 40 manual discharge measurements the stage-discharge relation for Tasersiaq is well supported within the span of water levels, where the manual discharge measurements have been carried out, Figure 12. However as a stage-discharge relation is an empirical relation extrapolation beyond this interval has a higher degree of uncertainty. In total just under 7% of the discharge from the full discharge time series is found by extrapolation of the Qh-relation beyond the maximum manually measured discharge. However these high discharges are not divided equally between years; in fact for half the years extrapolation is not needed at all.

Half the data points have discharge values found by extrapolation to values lower than the minimum manually measured discharge of 7 m^3/s. As the extrapolation to low values has a lower constrain of zero discharge, the absolute uncertainty on these values are limited. Further the periods with low discharge only contribute around 1% of the total discharge and is thus of limited importance for parameters relevant for evaluating ice sheet melting like e.g. the yearly discharge, the maximum discharge or the length of the season with high discharge.

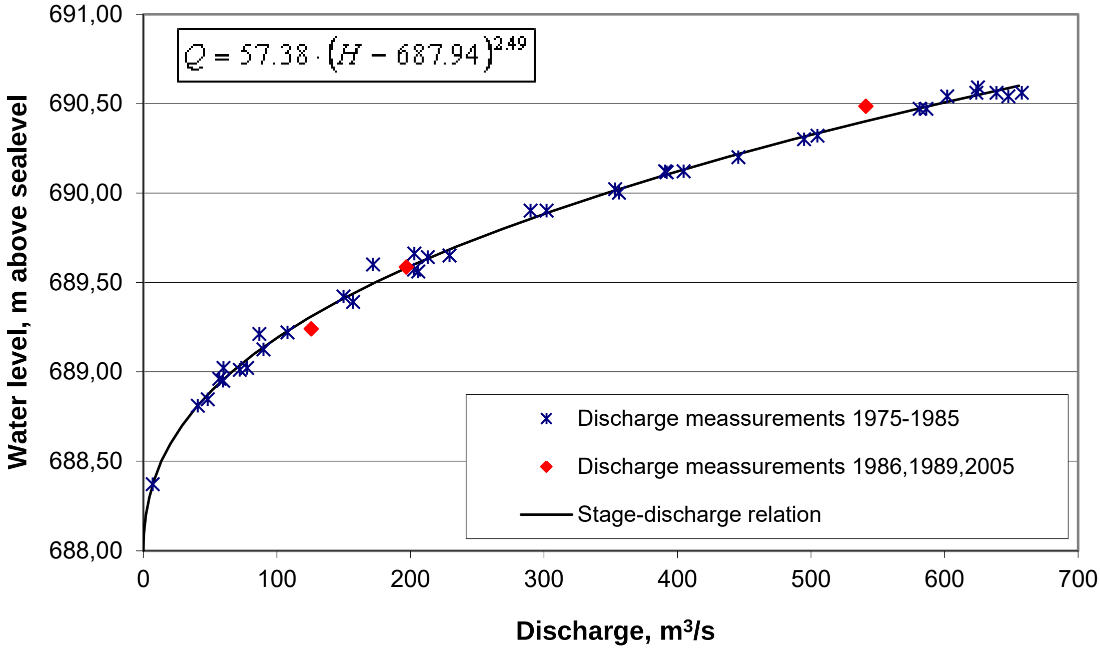


Figure 12. Stage-discharge relation for Tasersiaq.

Data coverage

The discharge time series for Tasersiaq, which covers 38.5 years, does have data gaps of varying length and character. Small gaps of typical one day exist in connection with some of the technical inspections where maintenance of the station has been carried out. Other small gaps are caused by periods with low battery voltage which ends when the solar panel recharges the batteries. Small gaps of up to seven days have been filled by linear interpolation.

Some larger gaps during winter periods exist, especially in the years 1975-1979. During these years the pressure sensor was placed at relatively low water level causing the sensor to be within the ice layer forming on the lake during winter. Thus no reliably data of the water pressure exist for the winter period in these years.

Due to the remote position of the measuring site and the high transportation cost – helicopter being the only practically means of transportation to the station - the station is normally only visited once a year. Some major data gaps (e.g. 1993-1994 and 2005-2006) therefore exist in connection with technical break down of the data logger or other essential parts of the station. An overview of the data coverage is given in Figure 13.

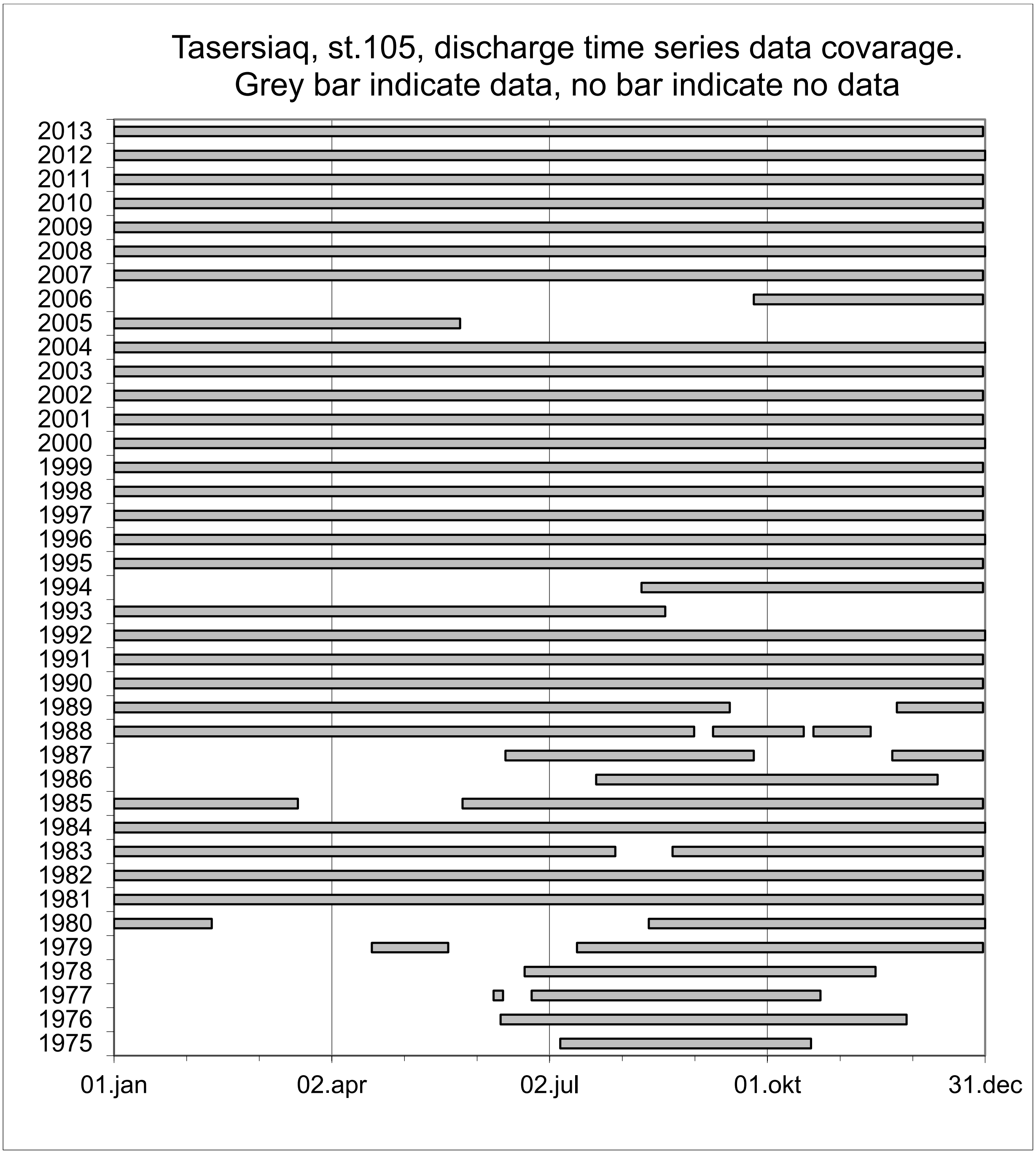


Figure 13. Tasersiaq discharge time series data coverage.

Outlet glacier GPS trackers & Extreme Ice Survey time lapse photography

The GPS trackers employed in PROMICE are situated on selected fast-flowing marine-terminating outlet glaciers from the Greenland ice sheet. They are designed and deployed to evaluate the accuracy of the velocity maps needed to calculate mass loss from discharge of ice into the ocean, as done in e.g. Andersen et al. (2015). The GPS tracker instruments and the data analysis methods were thoroughly discussed in earlier PROMICE reports (e.g. Ahlstrøm & Box, 2013) and thus only developments and activities in 2014 will be given here.

The developer of the GPS trackers utilized in PROMICE, Dr. Alberto Behar, tragically crashed in his plane January 2015 and was killed. This sad incident has caused a pause in the data collection from the GPS trackers in the first part of 2015 as various technical issues and transfer of transmission accounts was sorted out. Agreements on website maintenance of http://geus.motionterra.com and server hosting has been resolved and will be continued. The website provides a user-friendly way to access the near real-time GPS tracker information with an easy-to-use Google Earth interface. In this way, access to tracker data is immediately available online by simple download or browser viewing, including on-screen GPS track-plotting and the most recent data and tracker statistics displayed by mouse-click.

As of January 2015, PROMICE has 7 GPS trackers currently active and transmitting, while 1 GPS tracker has ceased transmitting, but may come back online. Active transmissions cover the following sites (see figure 14): Daugaard-Jensen Glacier (DJG), two Upernavik Glaciers (UPE), Kangiata Nunata Sermia (KNS), Akullersuup Sermia (AKS). Transmissions have not been resumed from a third Upernavik Glacier outlet, from Qajuutap Sermia (QAJ) and Helheim Glacier (HEL). Maintenance of HEL was terminated due to cost considerations.

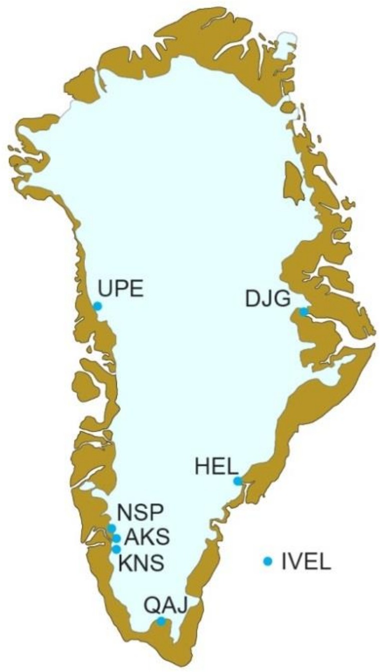


Figure 14. Map showing glaciers with GPS trackers funded directly by PROMICE/IVEL.

Figure 15. Maintenance of GPS tracker on Upernavik Isstrøm. To the lower right Dr. Andreas Ahlstrøm, to the left Dr. Alberto Behar.

The tracker data has played an important role in validating velocity fields produced in the major ESA Climate Change Initiative for Ice Sheets project along the same lines as a previous publication (Ahlstrøm et al., 2013).

Use of the GPS tracker data is also envisaged in the PhD project entitled 'Modelling the Upernavik Glacier Complex', funded internally by GEUS with additional support from University of Copenhagen. This project is focused on utilizing the GPS tracker data in conjunction to velocity fields derived from satellite data as forcing to the Ice Sheet System Model (ISSM) which is a higher-order ice-dynamics model developed at the Jet Propulsion Laboratory of the California Institute of Technology (http://issm.jpl.nasa.gov/). A first manuscript is submitted from this work, focussing on satellite velocity maps, but will move more towards methodological development to quantify seasonal variability in ice-dynamic mass loss which is the primary concern for PROMICE.

A second PhD project entitled 'Multi-millennial ice volume changes of the Greenland ice sheet' was initiated in late 2014 at GEUS. The ISSM will also be employed in this project, utilizing velocity maps which may be validated using the GPS trackers and the GPS instruments mounted on the PROMICE automatic weather stations.

An example of recent GPS data from Daugaard-Jensen Glacier (retrieved January 2015) is shown in Figure 16.

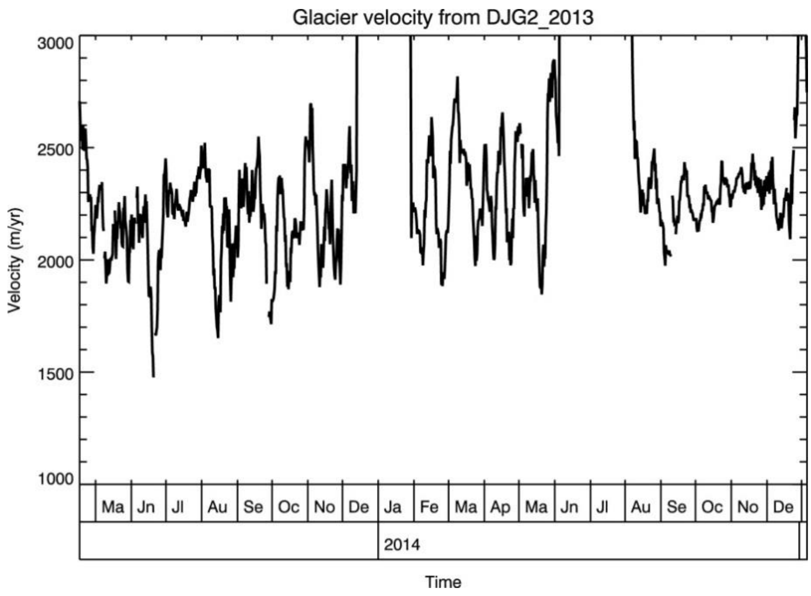


Figure 16. Sample velocity data derived from GPS tracker DJG2 on Daugaard-Jensen Glacier in East Greenland (see Fig. 14).

EIS time lapse cameras are currently in operation at Glacier 1 (the fastest) of the Upernavik Isstrøm, at Daugaard-Jensen Glacier, Kangiata Nunata Sermia. The EIS camera at Helheim has been discontinued to reduce field costs. The EIS cameras are producing high-resolution records of glacier movement that can be processed to yield velocity fields at very high temporal and spatial resolution.

Processing of these image archives to yield velocity fields have been commenced at GEUS by several students, utilizing the open source image processing software ImGRAFT (http://imgraft.glaciology.net/) developed at University of Copenhagen in the project SVALI (which GEUS is engaged in due to PROMICE) and described in Messerli and Grinsted (2015). The first results from this work was presented at the IASC Network for Arctic Glaciology Annual Workshop in Obergurgl, Austria, in 2015 (Christiansen et al., 2015).

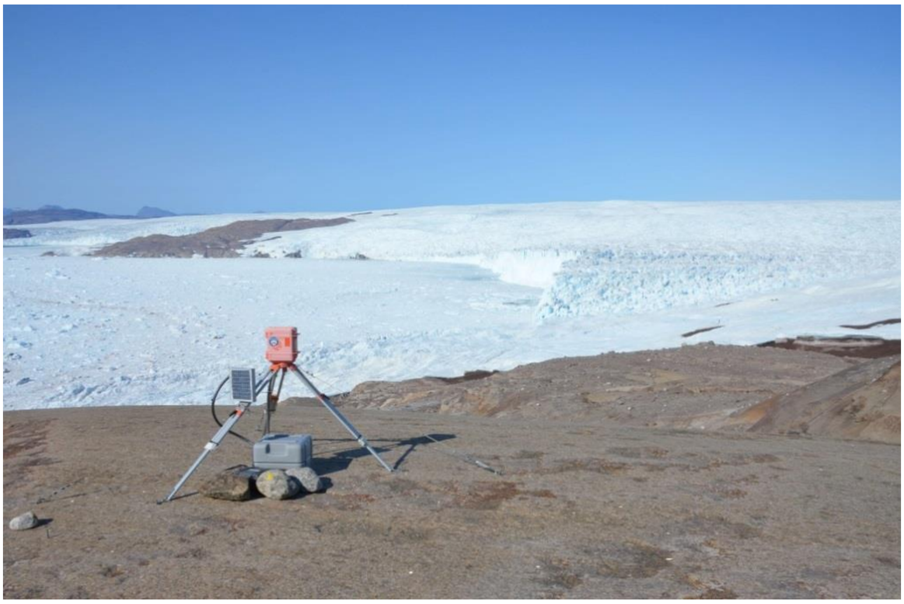


Figure 17. EIS camera and GPS tracker on rock overlooking Glacier 1 of the Upernavik Isstrøm.

Fig. 18 illustrates an emerging set of results engaging two students from Copenhagen University and one student from the Technical University of Denmark. Further on engagement, the Facebook group “Extreme Ice Survey - Team Copenhagen” (https://www.facebook.com/EISCph) currently has 129 members. A SVALI PhD student is using photos from the Upernavik glacier to constrain a model of ice flow.

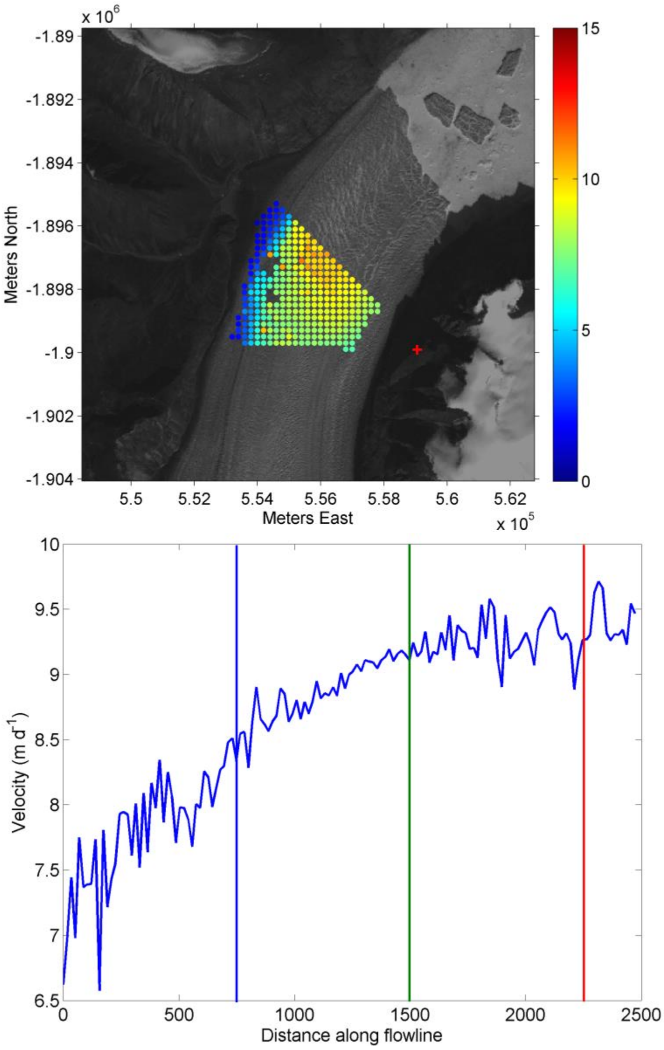


Fig. 18 (left) example of the spatial pattern of glacier velocity overlain on a satellite image and (right) velocity along the flow line at Daugaard Jensen glacier, indicating the grounding line at the position indicated by the vertical green line.

Apart from the velocity fields, the imagery also offers compelling outreach material as movies of ice-dynamic mass loss.

Collaboration with DMI models

A strong collaboration is running with DMI regional climate modelers Peter Langen and Ruth Mottram.

GEUS is collaborating with DMI on developing a coupling between observations and physical parameterizations based on observations with their regional climate model. Thus, through collaboration with DMI, PROMICE will contribute to the development of predictive models.

The PROMICE data provides possibilities for developing physical parameterizations that may be utilized in models. GEUS is engaged in establishing a new parameterization for the refreezing of meltwater in the snow on the ice sheet, a work using PROMICE observations and which is currently funded by FNU and SVALI. Refreezing of meltwater in the snow on the ice sheet is a process that is currently inadequately modelled and which will be a major factor in determining the future contribution to sea level rise from the Greenland ice sheet.

PROMICE data are also extremely valuable for validation purposes, and furthermore carries a strong potential for direct use in models to provide calibrated mass-balance products as both demonstrated in this chapter.

Regional climate model HIRHAM5

Recent collaboration with DMI has resulted in major advances of the HIRHAM5 Regional Climate Model (RCM) subsurface model that calculates daily surface mass balance (SMB). The advances were made to the subsurface model employed by Langen et al. (2015). The major advances are inclusion of densification processes and a MODIS derived albedo. The HIRHAM5 subsurface model now accounts for density varying processes that give a more physical representation of meltwater storage in the snow and firn and meltwater runoff. MODIS albedo with noise rejection after Box et al. (2012) was employed to give a more accurate surface energy balance (SEB) calculation. SEB determines melt intensity. As a consequence of the added densification processes, the representation of the mass and energy exchange through the subsurface layers had to be changed. The inclusions of these updates have also made the HIRHAM5 subsurface scheme more physical in how it handles the refreezing of liquid water and water flow through the subsurface. First, it updates the liquid water content of the surface snow layer by including all water contributions from at the surface. Then, it estimates the amount of energy available for liquid water freezing based on the temperature of each snow layer. If freezing occurs in a given layer, its liquid water content is decreased and its temperature is increased accordingly. The water flow through the snow layers is then simulated. The liquid water content of the snowpack is modeled as a series of reservoirs, one for each model layer. Water flow occurs when the liquid water content exceeds the maximum liquid water holding capacity (W_{liq} max in kg m^{-2}) set to 5%.

Validation

PROMICE mass loss measurements are being used successfully to evaluate the accuracy of mass loss output from RCMs.

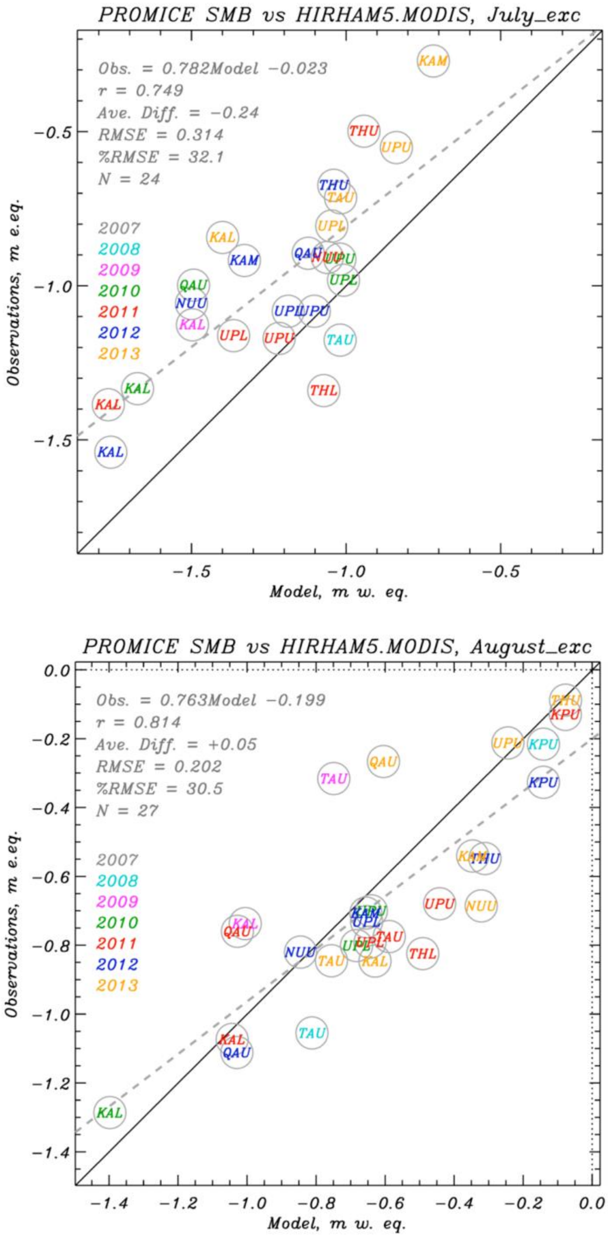


Fig. 19. Comparison of surface mass balance between PROMICE pressure transducer and HIRHAM calculations that employ MODIS albedo. The two months with greatest melt are shown. Each data point indicates the PROMICE station location and year.

Fig. 19 illustrates monthly PROMICE pressure transducer-derived surface ablation rate (Fausto et al., 2012) and monthly total SMB from HIRHAM5. HIRHAM5 does (as other models, van As et al., 2014) underestimate ablation rates , especially at the lower (_L) sites, where the albedo is overestimated by models not including background ice impurities. The RCMs cannot fully resolve where melt rates are highest.

Table 2 provides the first of its kind all-models vs all-observations, common data set, “apples-to-apples” surface mass balance assessment. Previously, the comparisons have been between models (Vernon et al., 2013). We’re changing the focus to the observations. The results indicate the MAR model has the highest overall skill while the DMI MODIS and 7.11 versions are the most skillful in two ways; 1) Inter-annually as measured by the correlation (R) for multiple years in a given month and 2) with the intercept at zero meaning HIRHAM5 is putting the equilibrium line (where accumulation and ablation balance) in the right place. The fact that HIRHAM5 has higher overall horizontal resolution (5.0 km) as compared to 20 km with MAR and 11 km with RACMO is part of the explanation. It’s very impressive MAR is performing best given that it simulates albedo while HIRHAM5 ingests an observed parameterization of the albedo.

Table 2. Comparison of surface mass balance between PROMICE ablation observations from pressure transducer and the result from the leading models. The most skill full model is highlighted green.

model	month	RMSD., m w e	RMSD %	model minus obs., m w e	R	slope, unitless	intercept, m w e	mean obs., m w e	N PROMICE AWS station years
updated Box (2013) reconstruction	JUN	0.30	50	0.03	0.692	0.665	-0.22	-0.60	20
	JUL	0.33	32	0.05	0.449	0.569	-0.48	-1.04	20
	AUG	0.27	37	0.21	0.810	0.918	-0.26	-0.73	20
	JJA	0.30	40	0.10	0.650	0.717	-0.32	-0.79	20
HIRHAM5 ver.2012	JUN	0.25	47	-0.01	0.764	0.838	-0.08	-0.53	29
	JUL	0.3	31	0.03	0.7	0.641	-0.36	-0.96	25
	AUG	0.3	47	0.19	0.717	0.781	-0.29	-0.64	28
	JJA	0.28	42	0.07	0.714	0.753	-0.24	-0.71	27
HIRHAM5 ver. MODIS albedo	JUN	0.29	55	-0.19	0.844	0.784	0.03	-0.53	29
	JUL	0.32	33	-0.23	0.781	0.958	0.18	-0.96	25
	AUG	0.19	29	0.06	0.855	0.821	-0.16	-0.64	28
	JJA	0.27	39	-0.12	0.827	0.854	0.02	-0.71	27
HIRHAM5 ver. 7.11	JUN	0.30	57	-0.19	0.838	0.761	0.02	-0.53	29
	JUL	0.33	34	-0.24	0.775	0.933	0.16	-0.96	25
	AUG	0.19	30	0.05	0.849	0.786	-0.18	-0.64	28
	JJA	0.27	40	-0.13	0.821	0.827	0.00	-0.71	27
MAR3.5	JUN	0.24	45	0.04	0.820	0.770	-0.15	-0.53	29
	JUL	0.28	30	-0.01	0.711	0.647	-0.33	-0.96	25
	AUG	0.22	34	0.11	0.820	0.854	-0.19	-0.64	28
	JJA	0.25	36	0.05	0.784	0.757	-0.22	-0.71	27
RACMO2	JUN	0.29	48	0.06	0.689	0.750	-0.19	-0.60	20
	JUL	0.30	28	0.01	0.535	0.750	-0.27	-1.04	20
	AUG	0.26	35	0.21	0.875	1.043	-0.19	-0.73	20
most skillful	JJA	0.28	37	0.09	0.700	0.848	-0.22	-0.79	20

Calibrated Surface Mass Balance Maps

Fusion of PROMICE climate station data with DMI regional climate modeling yields a "best-of-both-worlds" given the advantage of field data of absolute accuracy with the advantage of models providing complete coverage. The DMI regional climate model HIRHAM5 (Christensen et al., 2006; Langen et al., 2012) has a complimentary set of advantages/disadvantages, namely; complete spatial coverage but unknown accuracy. PROMICE monthly ablation rates and ice core-derived accumulation rates after Box et al. (2013) are compared with DMI HIRHAM5 output to calibrate and because this has not been done before, produce a first more 'absolutely accurate' surface mass balance (SMB) maps (Fig. 20). Despite the fact that the calibrated ablation rates are 17.3% smaller than pre-calibration, calibrated accumulation rate is also lower by 25.4%, producing an even more negative 2012 surface mass balance. Another first in this assessment is the first ever negative SMB for Greenland. By comparison, the uncalibrated 2013 SMB is 310 Gt while the calibrated 2013 SMB is 52% less, at 204 Gt.

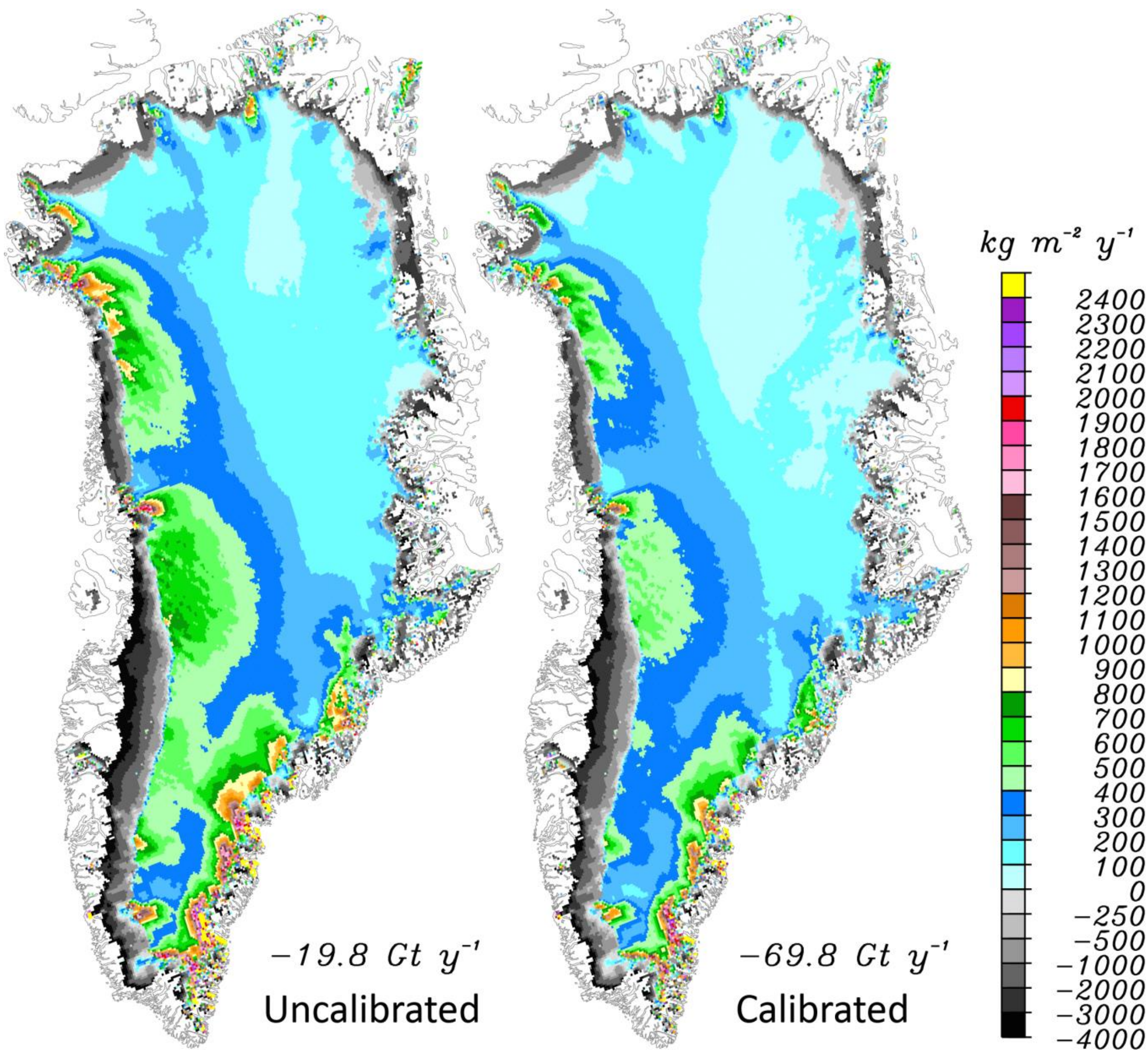


Fig. 20. Record melt year 2012 Greenland ice surface mass balance maps with and without PROMICE calibration. Note the total annual mass flux differs by more than 120 Gt., or ~30% of the total mass balance.

River Discharge from the most visible Greenland river

We're further evaluating HIRHAM5 output through comparison with field data from a site GEUS has just been very fortunate to inherit: the now 9 year continuous Watson river Kanger-lussuaq, West Greenland river discharge series from Prof. Bent Hasholt. Not only is Watson River the most visible Greenland river, it is also the best studied (e.g., Hasholt et al. 2013; Mik-kelsen et al. 2013; van As et al. 2012). The fact that the slope of the best fit is off the 1:1 line does not necessarily mean HIRHAM5 has an absolute bias. The bias could be from the also uncertain catchment basin delineation.

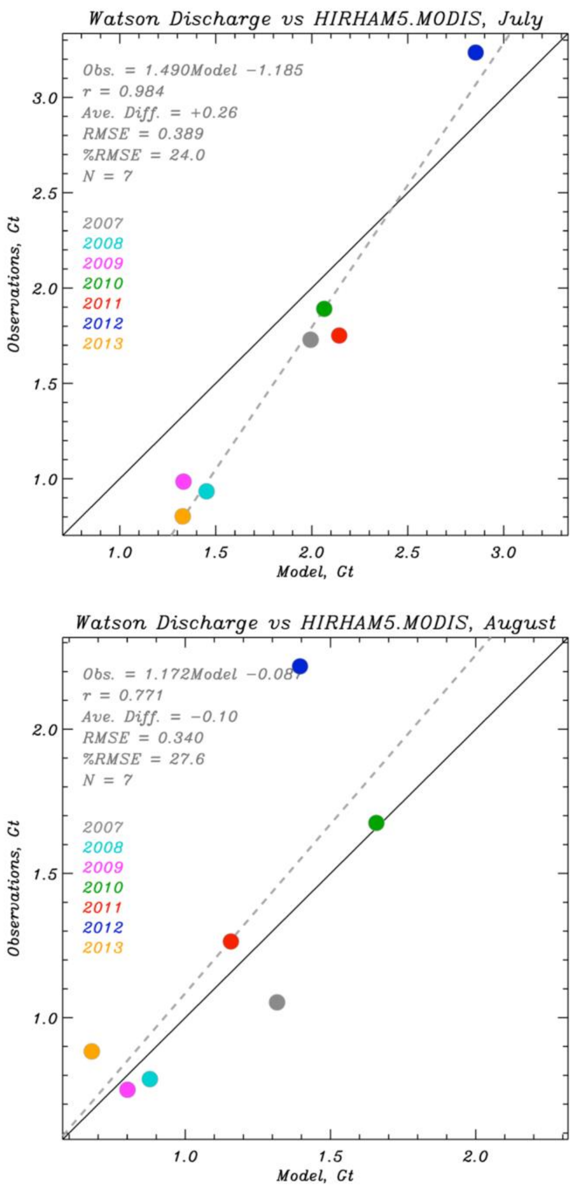


Fig. 21. Comparison of Watson river Kangerlussuaq, West Greenland discharge with HIRHAM calculations that employ MODIS albedo. The two months with greatest melt are shown. Each data point indicates the year.

Outreach

The PROMICE website (www.promice.org) provides information on the project as well as the possibility to browse and download data. It was recently updated to include download possibilities for three new products. These are: the PROMICE map of margins of all ice masses in Greenland (Citterio and Ahlstrøm, 2013), the ice thickness from the Airborne surveys carried out in August 2007 and 2011 and the PROMICE historical surface mass balance data from the ablation zone of the ice sheet and the local glaciers of Greenland. The data are available for everyone and at no charge by filling in a short form.

The AWS data is a vital ingredient for determining the surface melt on the Greenland ice sheet, and are crucial to many other surface mass balance studies that GEUS employees are involved in. But importantly, the data are becoming increasingly interesting to external users as well. As of April 2015, 132 different data users registered on the PROMICE website. Of these, 49 users are from the US, 40 are from EU, 17 users are from Denmark and four are from Greenland. As the data records grow in length and more people are aware of the PROMICE data products, the PROMICE website is visited more frequently and data downloads occur more often. The purpose of data download as stated by the users differs highly, ranging from scientific to educational and private. Below follows a few selected user-written purposes of download from 2014:

- Data analysis on microbial communities in snow from a 2014 expedition across the Greenland Ice cap
- The data will be used for comparison with Danish Meteorology Institute weather model forecasts
- I will use the temperature data to calculate surface runoff for Russell glacier
- Intercomparison between the regional climate MAR model and PROMICE
- Modeling of brightness temperatures using a radiative transfer model and in situ for comparison with L-band passive microwave satellite brightness temperatures (SMOS)
- Teaching 3rd year undergraduate students about data handling and mass and energy balance on ice sheets
- I am downloading this data in order to continue with a project to relocate the Raven training site on the Greenland Ice Sheet for the Air National Guard. The weather data will inform flying conditions to the new location that will be chosen for the runway

A number of products related to PROMICE are displayed on the Polar Portal a website where Danish research institutions display the results of their monitoring of the Greenland ice sheet and Arctic sea ice to the general public.

A new e-learning website isskolen for children aged 12 to 14, giving a basic introduction to ice and climate change was developed in all Nordic languages and English. Versions in Greenlandic, German and French will be implemented by June 2015. The webpage is published by the Nordic centre of excellence SVALI in collaboration with PROMICE and maintained at GEUS. www.isskolen.dk.

Two PROMICE newsletters were published in 2014: ‘Promice Airborne Snapshots of Ice Flow Volume and Iceberg Production in 2007 to 2011’ and ‘Data Rescue: Greenland Surface Mass Budget Database’ (Appendix D).

Related projects

PROMICE demonstrates the Danish responsibility to monitor the Greenland ice sheet. The PROMICE AWS network presently includes 22 stations on the ice sheet. Only 14 of these have been funded by PROMICE. The rest have been funded by the ongoing Greenland Analogue Project (GAP) and a number of previous projects including SEDIMICE, REFREEZE and Imglaco. In addition GEUS also maintains three stations on the A. P. Olsen ice cap in the GlacioBaisis project within the Greenland Ecosystem Monitoring framework.

In this way the monitoring effort is enhanced and PROMICE is provided with additional field instrumentation, logistics sharing and instrument knowhow, making it more cost effective. Also the field work of the smaller research projects benefit strongly from PROMICE and would in many cases not have been feasible without the PROMICE platform to build upon. A 2014 project which collaborated with PROMICE on field work was the EMERALD project funded by 'VILLUM FONDENs Young Investigator Programme' and focusing on exploring the Emerging Microbial Ecosystem of the Greenland Ice Sheet and its impact on the surface energy budget.

PROMICE team members were in 2014 involved in a number of national and international research projects including the European Space Agency (ESA) funded Climate Change Initiative Ice Sheets (CCI_Ice Sheets) and CryoClim and the Nordic Top Research Initiative Center of Excellence 'Stability and Variations of Arctic Land Ice' (SVALI), RETAIN funded by The Danish Council for Independent Research, the Geocenter project 'Multi-millennial ice volume changes of the Greenland ice sheet' and Dark Snow. All of these projects make use of PROMICE data and provides PROMICE with additional scientific insights and data.

Also three Ph.D. projects are currently performed at GEUS in connection with PROMICE. They are entitled respectively: 'Modelling the Upernavik Glacier Complex', 'Multi-millennial ice volume changes of the Greenland ice sheet' and 'Improving Greenland ice sheet surface mass budget models of the accumulation zone'.

Of high importance is the long term consistent knowledge and data which PROMICE can provide to the projects and which makes the PROMICE project team members attractive as project partners. E.g. Danish institutions have a strong involvement in the ESA CCI_Ice_sheets project and it is led by DTU Space. A large component of the project is concerned with ice velocity mapping. This is partly based on the ice velocity mapping knowhow maintained in Denmark due to the ice velocity mapping tools developed within PROMICE. Also data from PROMICE are valuable for validation of the satellite derived products in the ESA CCI_Ice_sheets project.

PROMICE team members have also engaged in applied glaciology by performing commercial evaluations of future hydropower potential in Greenland and AWS of the type developed within PROMICE have been sold for commercial and research purposes.

In this respect, PROMICE provides knowledge and data of use directly for society and also for international projects enhancing the possibility of Danish involvement. At the same time PROMICE serves as a way to utilize and sustain the scientific insights, instruments and data obtained in the related research projects. Adding value to PROMICE, the related research projects and the Danish realm.

WMO CryoNet

Work within the World Meteorological Organization (WMO) Global Cryosphere Watch (GCW) in 2014 has been aimed at refining the structure and design criteria of CryoNet, the upcoming standardized network of ground-based cryospheric monitoring sites, at selecting an initial list of CryoNet sites, and at starting the review of existing standards and best practices.

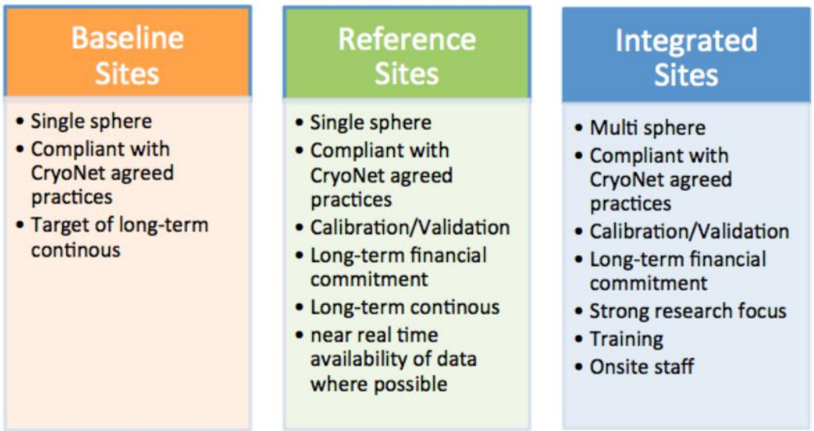


Fig. 4 – Design of the WMO GCW CryoNet network, composed of Baseline, Reference and Integrated Sites. The major requirements for joining CryoNet are listed.

PROMICE contributes to this ongoing organization effort through a member in the GCW Steering Group and in the CryoNet Team (Dr. Michele Citterio). Fig. 4 shows the current design of CryoNet, whose building blocks are called Stations and Sites. The preliminary selection of initial contributing sites (Tab. 1) is being further developed through an online questionnaire and database of site characteristics, which are publicly accessible at www.globalcryospherewatch.org. Currently, the two largest in situ monitoring programs in Greenland are PROMICE and Zackenberg ZERO. The aim is to complete all documents required for the next WMO Congress in May 2015, when the resolution establishing GCW as a core WMO activity will be put to vote.

ID	**Station**	Elevation (m)	Country	Region	Type
1	Sodankylä	180	Finland	Europe	Integrated
2	Zackenberg	0-1500	Greenland/Denmark	Europe	Integrated
3	Sonnblick	3105	Austria	Europe	Integrated
4	Weissfluhjoch/Davos	2540	Switzerland	Europe	Integrated
5	SIGMA-A	1490	Greenland/Denmark	Europe	Baseline
6	PROMICE (20+ stations across Greenland)	270-1850	Greenland/Denmark	Europe	Baseline
7	Eureka	610	Canada	North America	Reference
8	Barrow	11	USA	North America	Reference
9	Tiksi	n/a	Russian Federation	Asia	Integrated
10	Cape Baranova	30	Russian Federation	Asia	Baseline
11	Tianshan	2130	China	Asia	Integrated
12	Mt. Everest	5210	China	Asia	Baseline
13	Yakutsk	220	Russian Federation	Asia	Integrated
14	Dome C	3222	n/a	Antarctica	Reference

Table 1 – Table of initial CryoNet sites

References

Ahlstrøm, A.P., D. van As, M. Citterio, S.B. Andersen, F.M. Nick, P. Gravesen, K. Edelvang, R.S. Fausto, M.L. Andersen, S.S. Kristensen, E.L. Christensen, J.P.M. Boncori, J. Dall, R. Forsberg, L. Stenseng, S. Hanson and D. Petersen. 2011. PROMICE 2007-2010. Final report for the establishment phase of the Programme for Monitoring of the Greenland Ice Sheet. Danmarks og Grønlands Geologiske Undersøgelser, Rapport 2011/118, 178 pp.

Ahlstrøm, A.P. & J.E. Box (2013): 'Monitoring the outlet glaciers of the Greenland Ice Sheet' *in*: Andersen, S.B. et al. (2013): 'PROMICE 2011-2012 Final report for the 2011-2012 operational phase of the Programme for Monitoring of the Greenland Ice Sheet', Geological Survey of Denmark and Greenland Report 2013/54, 82 pp.

Ahlstrøm A.P., S.B. Andersen, M.L. Andersen, H. Machguth, F.M. Nick, I. Joughin, C.H. Reijmer, R.S.W. Van de Wal, J.P. Merryman Boncori, J.E. Box, M. Citterio, D. Van As, R.S. Fausto, A. Hubbard (2013): 'Seasonal velocities of eight major marine-terminating outlet glaciers of the Greenland ice sheet from continuous in situ GPS instruments', Earth Syst. Sci. Data, 5, 277-287, doi:10.5194/essd-5-277-2013.

Andersen, M.L., L. Stenseng, H. Skourup, W. Colgan, S.A. Khan, S.S. Kristensen, S.B. Andersen, J.E. Box, A.P. Ahlstrøm, X. Fettweis, R. Forsberg (2015): 'Basin-scale partitioning of Greenland ice sheet mass balance components (2007-2011)', Earth and Planetary Science Letters, 409, 89–95.

Andersen, S.B., Ahlstrøm, A.P., Andersen, M.L., Box, J.E., Citterio, M., Fausto, R., Machguth, H., van As, D., Edelvang, K., Forsberg, R., Skourup, H., Sørensen, L.S., Kristensen, S.S., Dall, J., Boncori, J.P.M. & Petersen, D. 2013: PROMICE 2011-12. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2013/54, 82 pp.

Andersen, S.B., Ahlstrøm, A.P., Andersen, M.L., Box, J.E., Citterio, M., Colgan, W.T., Fausto, R., van As,D., Forsberg, R., Skourup, H., Sørensen, L.S., Kristensen, S.S., Dall, J., Kusk, A. & Petersen, D. 2014: PROMICE 2013. Report from the 2013 operational phase of the Programme for Monitoring of the Greenland Ice Sheet. Danmarks og Grønlands Geologiske Undersøgelse Rapport. 2014/57. GEUS, 72 pp.

Bamber, J. L., J. A. Griggs, R. T. W. L. Hurkmans, J. A. Dowdeswell, S. P. Gogineni, I. Howat, J. Mouginot, et al. "A New Bed Elevation Dataset for Greenland." The Cryosphere 7, no. 2 (March 22, 2013): 499–510. doi:10.5194/tc-7-499-2013.

Box, J. E., X. Fettweis, J.C. Stroeve, M. Tedesco, D.K. Hall, and K. Steffen. 2012. Greenland ice sheet albedo feedback: thermodynamics and atmospheric drivers, The Cryosphere, 6, 821-839. doi:10.5194/tc-6-821-2012

Box, J. E. 2013. Greenland ice sheet mass balance reconstruction. Part II: Surface mass balance (1840-2010), J. Climate,Vol. 26, No. 18. 6974-6989. doi:10.1175/JCLI-D-12-00518.1

Christiansen, P.S., J.E. Box, A. Ahlstrøm, A. Messerli, A. Grinsted (2015): 'Using time lapse photogrammetry to examine spatial temporal variations in Greenland outlet glacier dynamics', IASC Workshop on the dynamics and mass budget of Arctic Glaciers 23-25 March 2015, Obergurgl, Austria, p.12.

Christensen, O. B., M. Drews, J. H. Christensen, K. Dethloff, K. Ketelsen, I. Hebestadt, and A. Rinke, 2006: The HIRHAM Regional Climate Model. Version 5. Danish Meteorological Institute Technical Report, No. 06-17 (available at dmi.dk).

Citterio M., R.S. Fausto, A. Ahlstrøm & S.B. Andersen (2014) - A novel multispectral glacier mapping method and its performance in Greenland. AGU Fall Meeting 2014, San Francisco, USA, 15-19 December 2014, C42A-05. (oral presentation)

Citterio, M., and A. P. Ahlstrøm. 'Brief Communication "The Aerophotogrammetric Map of Greenland Ice Masses".' The Cryosphere 7, no. 2 (11 March 2013): 445–49. doi:10.5194/tc-7-445-2013.

Colgan, W., Abdalati, W., Citterio, M., Csatho, B., Fettweis, X., Luthcke, S., Moholdt, G., , Stober, M., 2014. Hybrid inventory, gravimetry and altimetry (HIGA) mass balance product for Greenland and the Canadian Arctic. The Cryosphere Discussions 8, 537–580.

Fausto RS, Van As D, Ahlstrøm AP and Citterio M (2012) Assessing the accuracy of Greenland ice sheet surface ablation measurements by pressure transducer. J. Glac., 58 (212), 1144-1150 (doi: 10.3189/2012JoG12J075)

Hasholt, B., A. B. Mikkelsen, M. H. Nielsen and M. A. D. Larsen (2013), Observations of Runoff and Sediment and Dissolved Loads from the Greenland Ice Sheet at Kangerlussuaq, West Greenland, 2007 to 2010, Zeitschrift fur Geomorphologie 57 (Suppl. 2), 3-27, doi: 10.1127/0372-8854/2012/00121

Howat, I. M., A. Negrete, and B. E. Smith. 'The Greenland Ice Mapping Project (GIMP) Land Classification and Surface Elevation Data Sets'. The Cryosphere 8, no. 4 (2014): 1509–18.

Joughin, I., Smith, B. E., Howat, I. M., Scambos, T., and Moon, T. (2010).Greenland flowvariability fromice-sheet-wide velocitymapping. Journal of Glaciology, 56(197):415–430.

Langen, P.L., R.H. Mottram, J.H. Christensen, F. Boberg, C.B. Rodehacke, M. Stendel, D. van As, A.P. Ahlstrøm, J. Mortensen, S. Rysgaard, D. Petersen, K.H. Svendsen, G. Aðalgeirsdóttir and J. Cappelen (2015) 'Quantifying energy and mass fluxes controlling Godthåbsfjord freshwater input in a 5 km simulation (1991-2012)', Journal of Climate, doi: http://dx.doi.org/10.1175/JCLI-D-14-00271.1.

Langen, P.L., R. H. Mottram, J. H. Christensen, F. Boberg, C. B. Rodehacke, M. Stendel, D. van As, A. P. Ahlstrøm, J. Mortensen, S. Rysgaard, D. Petersen, K. H. Svendsen, G. Aðalgeirsdóttir, J. Cappelen, 2015. Quantifying energy and mass fluxes controlling Godthåbsfjord freshwater input in a 5 km simulation (1991-2012). Journal of Climate, doi: 10.1175/JCLI-D-14-00271.1

Luthcke, S. B., Zwally, H. J., Abdalati, W., Rowlands, D. D., Ray, R. D., Nerem, R. S., Lemoine, F. G., McCarthy, J. J., Chinn, D. S. (2006). Recent Greenland ice mass loss by drainage system from satellite gravity observations. Science 314 (5803), 1286–1289.

Messerli, A. and A. Grinsted (2015): 'Image georectification and feature tracking toolbox: ImGRAFT', Geosci. Instrum. Method. Data Syst., 4, 23–34, www.geosci-instrum-method-data-syst.net/4/23/2015/doi:10.5194/gi-4-23-2015.

Mikkelsen, A. B., B. Hasholt, N. T. Knudsen and M. H. Nielsen (2013), Jökulhlaups and sediment transport in Watson River, Kangerlussuaq, West Greenland, Hydrology Research, 44(1), 58-67, doi:10.2166/nh.2012.165. In Edition.

Moon, T., I. Joughin, B. Smith, M. R. van den Broeke, W. J. van de Berg, B. Noel, and M. Usher (2014), Distinct patterns of seasonal Greenland glacier velocity, Geophysical Research Letters, 41 (20) 7209–7216

Rignot, E. and Kanagaratnam, P. (2006). Changes in the velocity structure of the Greenland ice sheet. Science, 311(5763):986–990.

Sasgen, I., van den Broeke, M., Bamber, J. L., Rignot, E., Sorensen, L. S., Wouters, B., Martinec, Z., Velicogna, I., Simonsen, S. B., 2012. Timing and origin of recent regional ice-mass loss in Greenland. Earth and Planetary Science Letters 333, 293–303.

Schrama, E. J. O., Wouters, B., FEB 12 2011. Revisiting Greenland ice sheet mass loss observed by GRACE. Journal of Geophysical Research - Solid Earth 116.

Van As D., M.L. Andersen, D. Petersen, X. Fettweis, J.H. van Angelen, J.T.M. Lenaerts, M.R. van den Broeke, J.M. Lea, C.E. Bøggild, A.P. Ahlstrøm and K. Steffen (2014) 'Increasing meltwater discharge from the Nuuk region of the Greenland ice sheet and implications for mass balance (1960-2012)', J. Glac., 60 (220), 314-322,doi: 10.3189/2014JoG13J065.

Van As D, Hubbard AL, Hasholt B, Mikkelsen AB, Van den Broeke MR and Fausto RS (2012) Large surface meltwater discharge from the Kangerlussuaq sector of the Greenland ice sheet during the record-warm year 2010 explained by detailed energy budget observations. Cryosph., 6, 199-209 (doi: 10.5194/tc-6-199-2012)

Van As D, Fausto RS, Steffen K and PROMICE project team (2014) Katabatic winds and piteraq storms: observations from the Greenland ice sheet. Geol. Surv. Denmark Greenland Bull., 31, 83-86

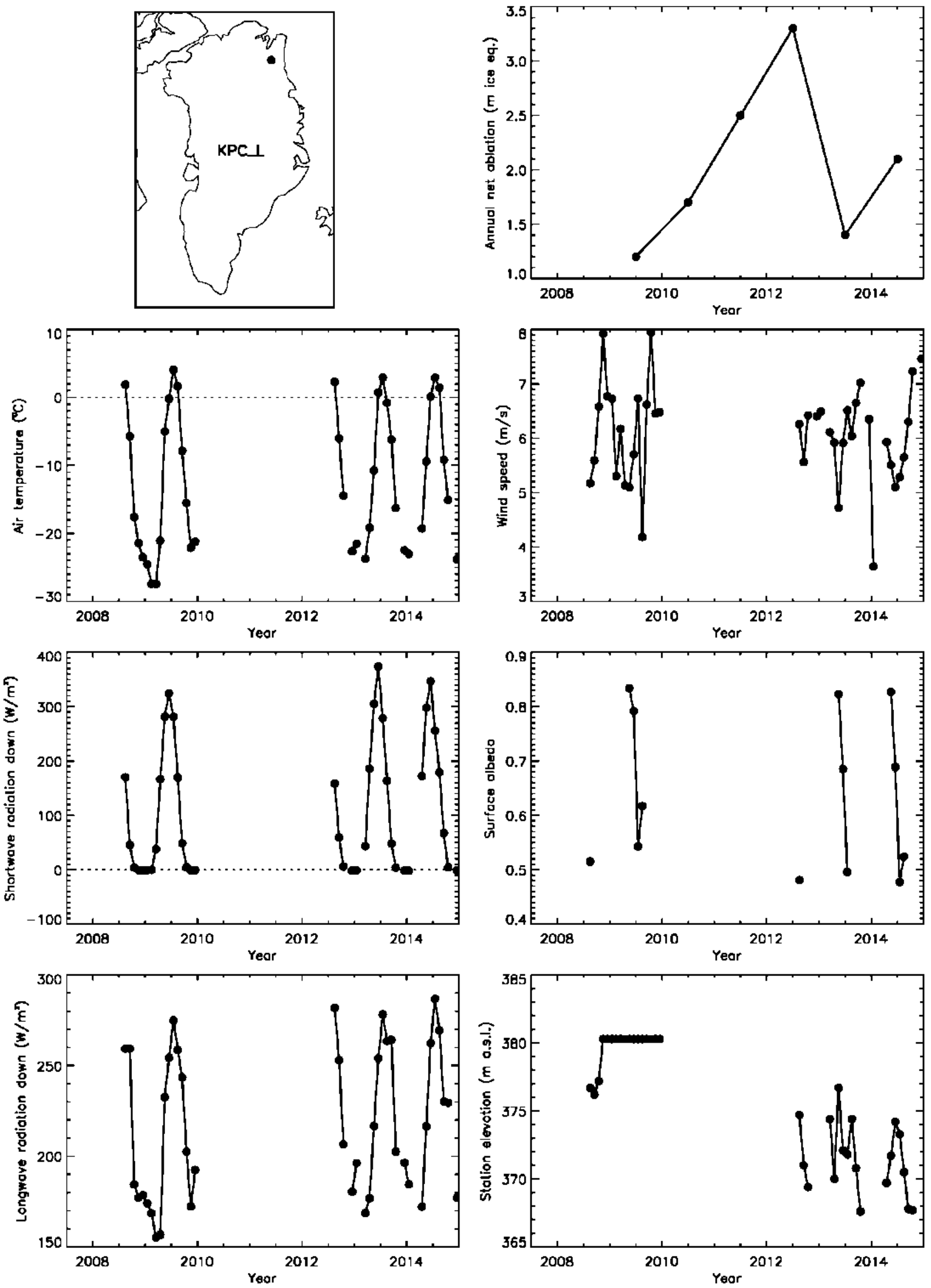
Vernon, C.L., J.L. Bamber, J.E. Box, M.R. van den Broeke, X. Fettweis, E. Hanna, and P. Huybrechts. 2013. Surface mass balance model intercomparison for the Greenland ice sheet, The Cryosphere, 7, 599-614. doi:10.5194/tc-7-599-2013

WMO GCW (2014) - Final Report of the CryoNet Team Meeting, First Session. Reykjavik, Iceland, 20-22 January 2014. Report 4/2014, 28 p.

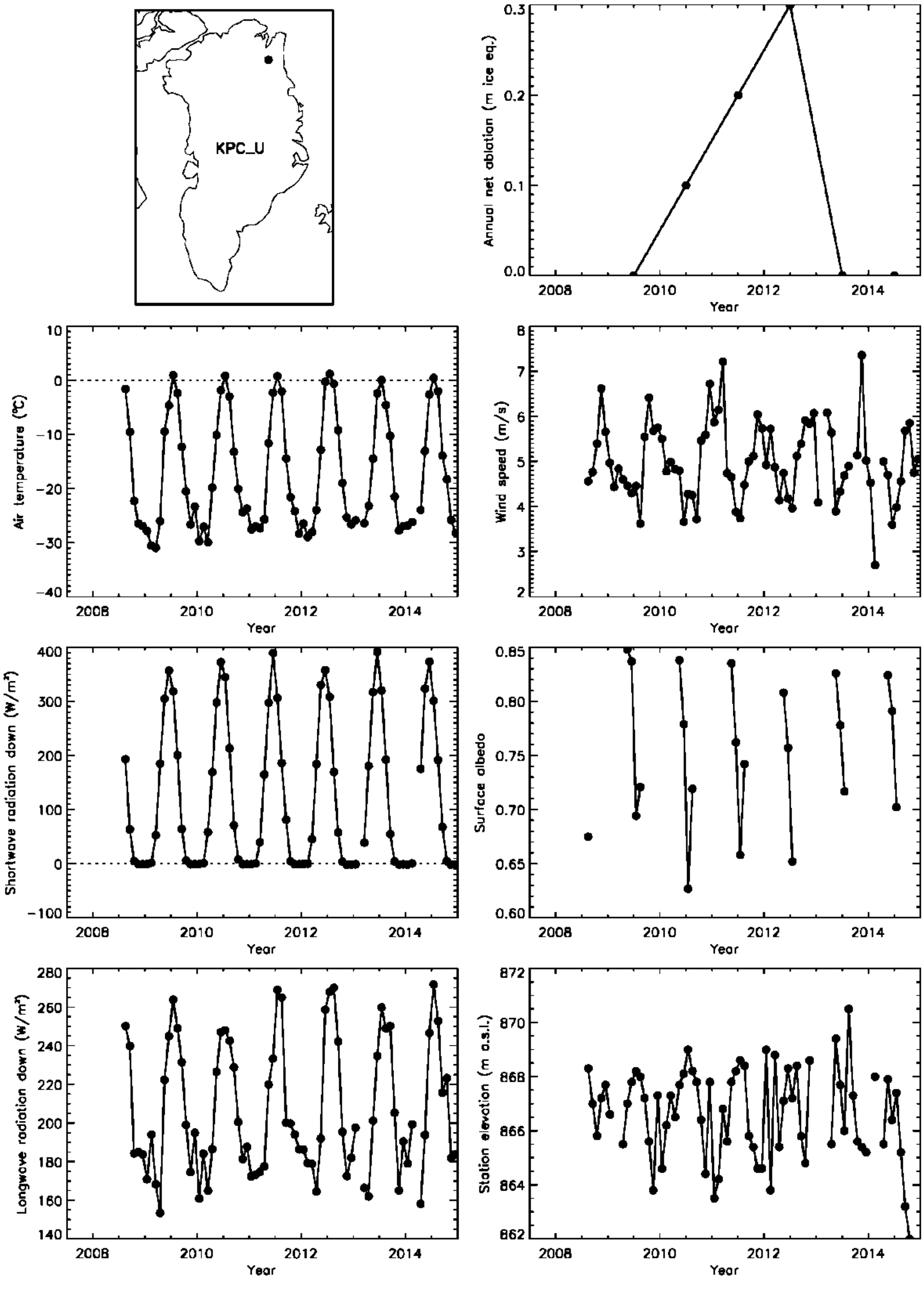
Zwally, H. J., Giovinetto, M. B., Li, J., Cornejo, H. G., Beckley, M. A., Brenner, A. C., Saba, J. L., Yi, D., 2005. Mass changes of the Greenland and Antarctic ice sheets and shelves and contributions to sea-level rise: 1992-2002. Journal of Glaciology 51 (175), 509–527.

Zwally, H. J., Li, J., Brenner, A. C., Beckley, M., Cornejo, H. G., Dimarzio, J., Giovinetto, M. B., Neumann, T. A., Robbins, J., Saba, J. L., Yi, D., Wang, W., 2011. Greenland ice sheet mass balance: distribution of increased mass loss with climate warming; 2003-07 versus 1992-2002. Journal of Glaciology 57 (201), 88–102.

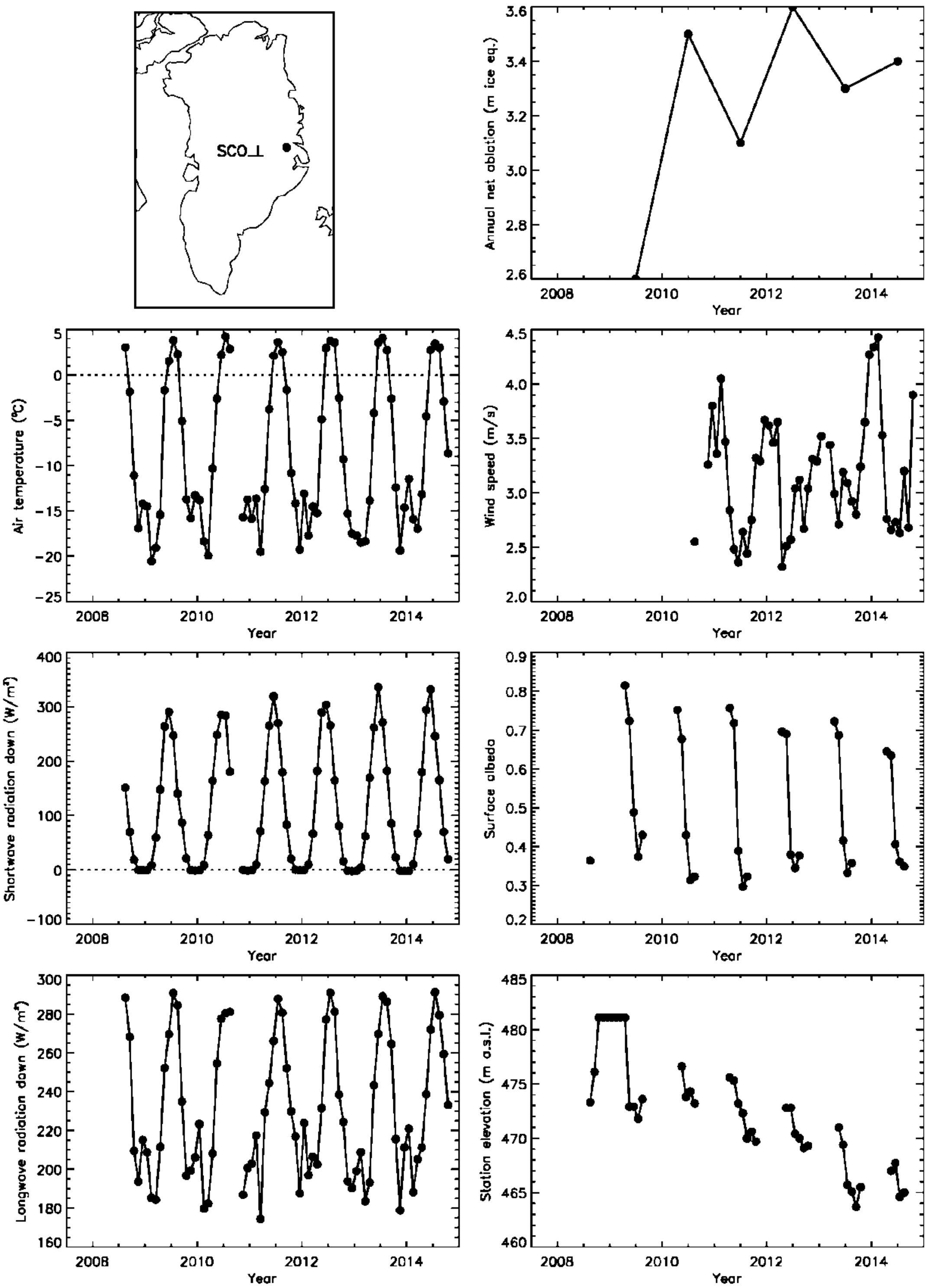
Appendix A



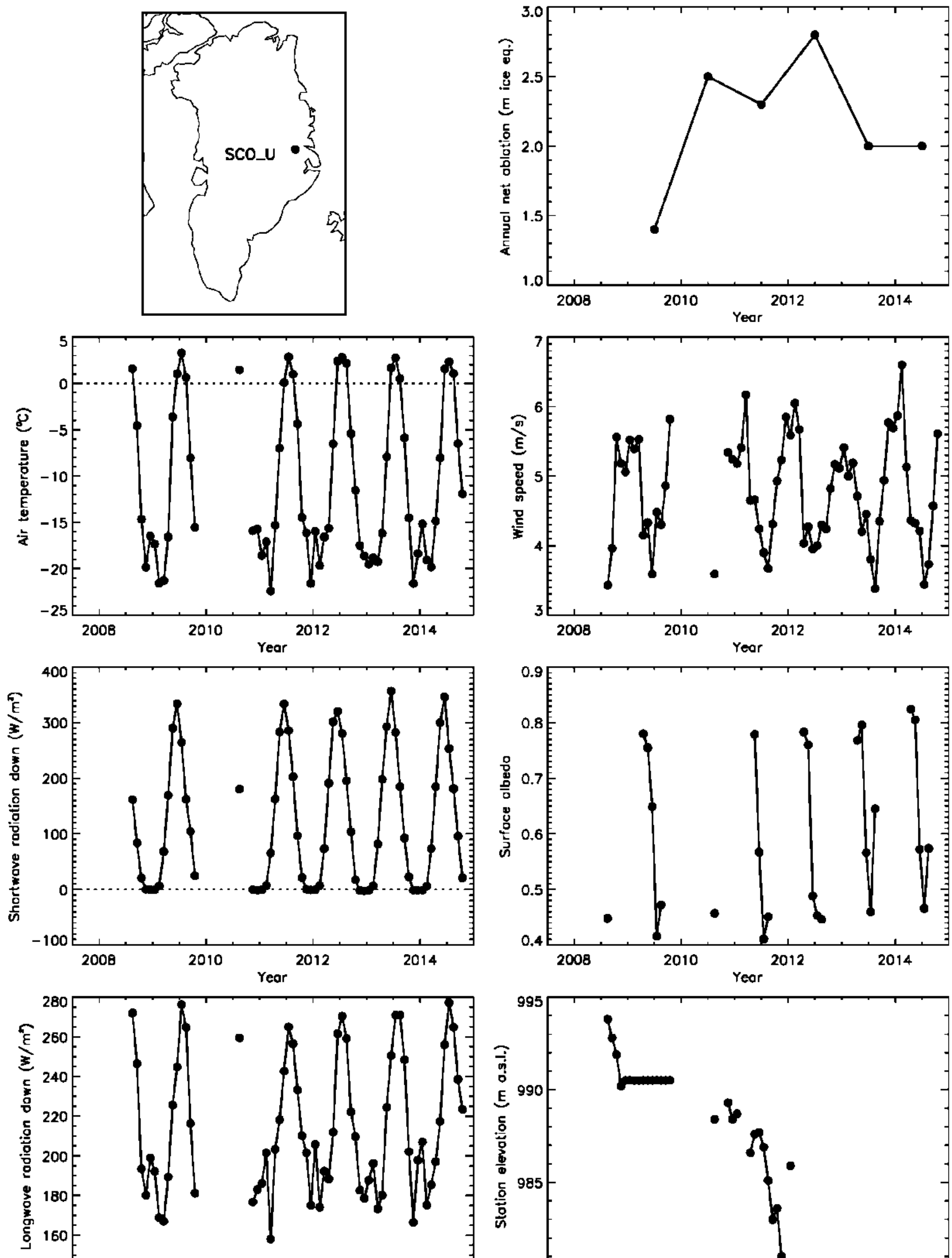
Figur A 1 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for KPC_L AWS on the ice sheet.



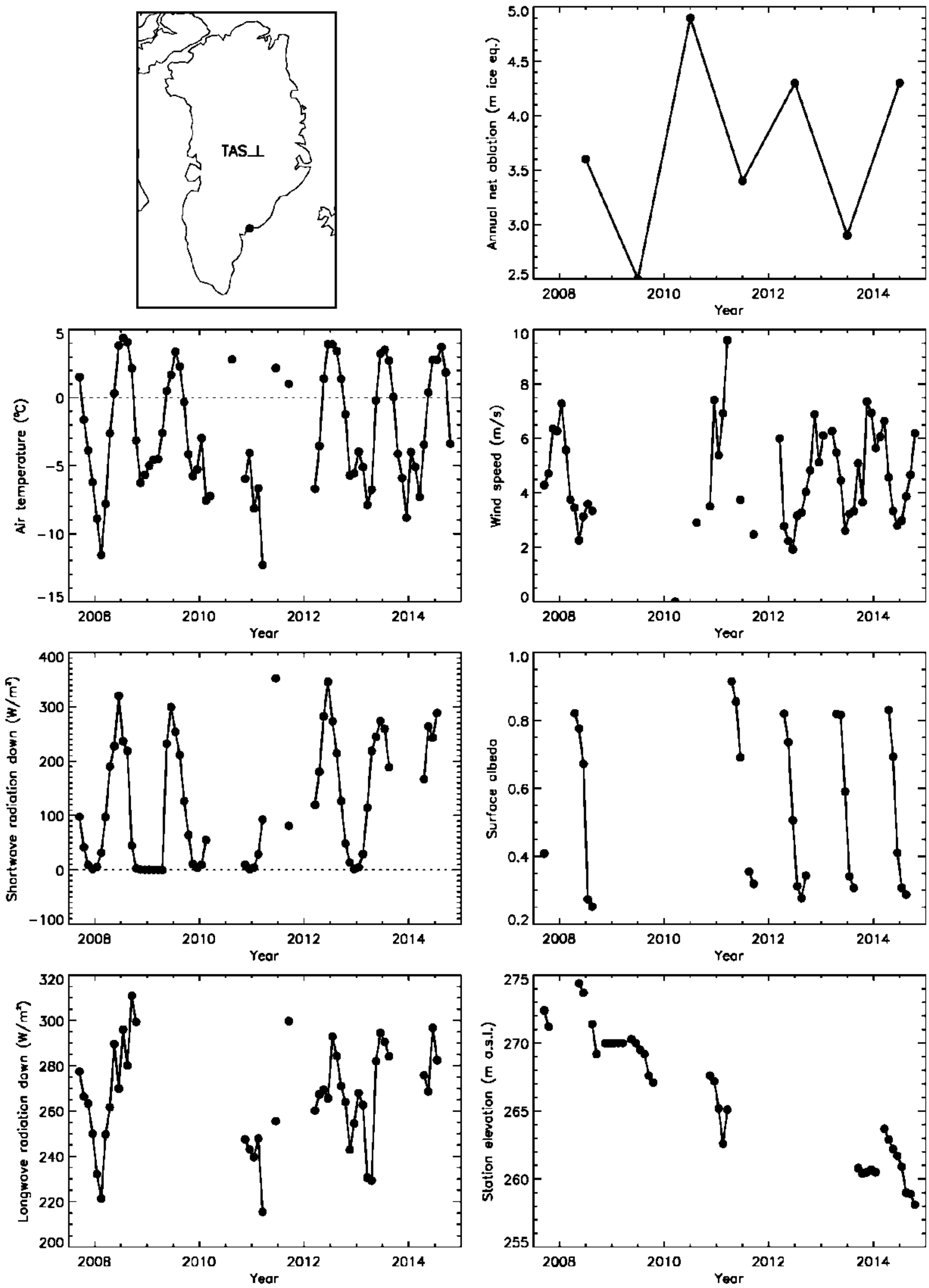
Figur A 2 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for KPC_U AWS on the ice sheet.



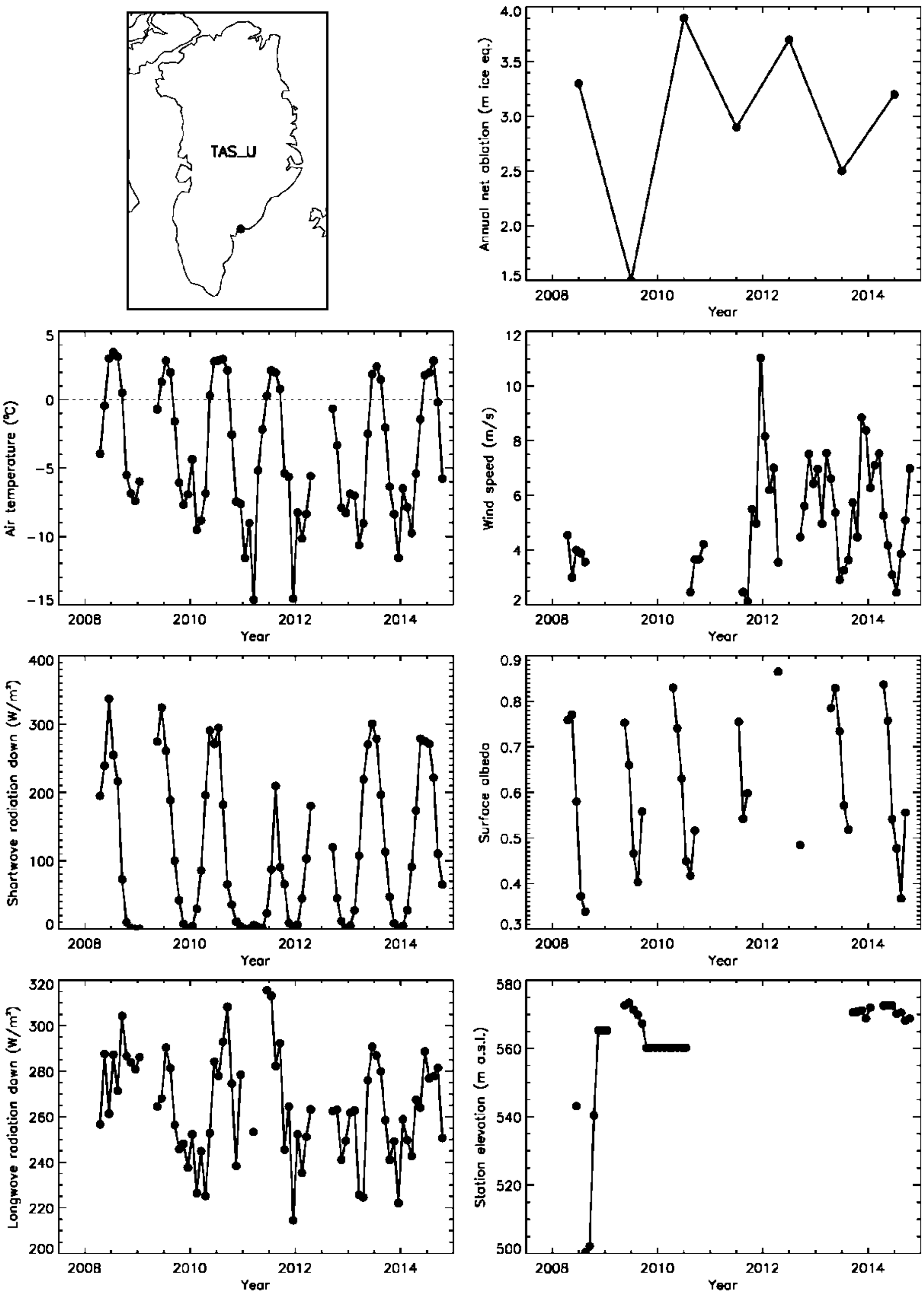
Figur A 3 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for SCO_L AWS on the ice sheet.



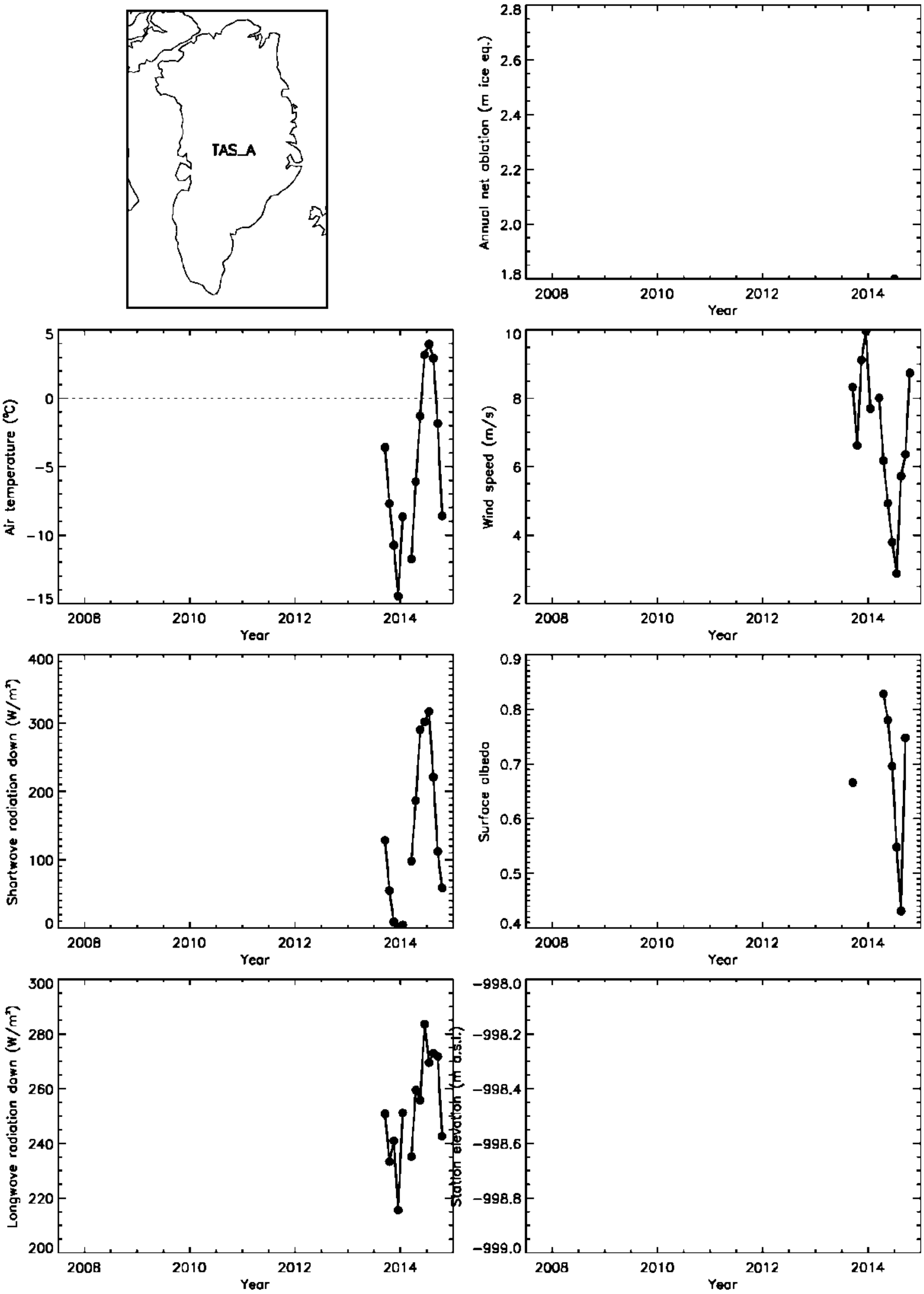
Figur A 4 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for SCO_U AWS on the ice sheet.



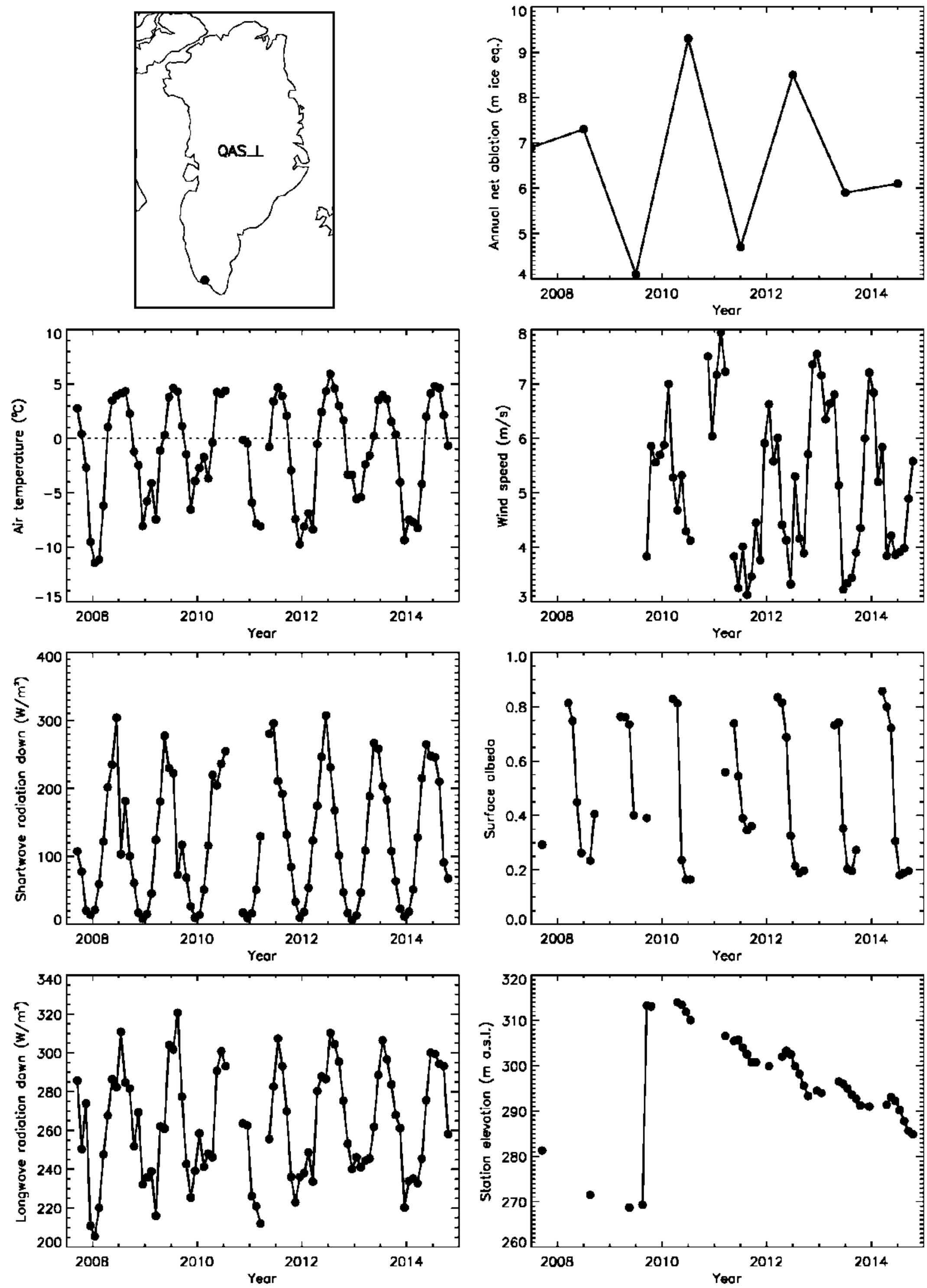
Figur A 5 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for TAS_L AWS on the ice sheet.



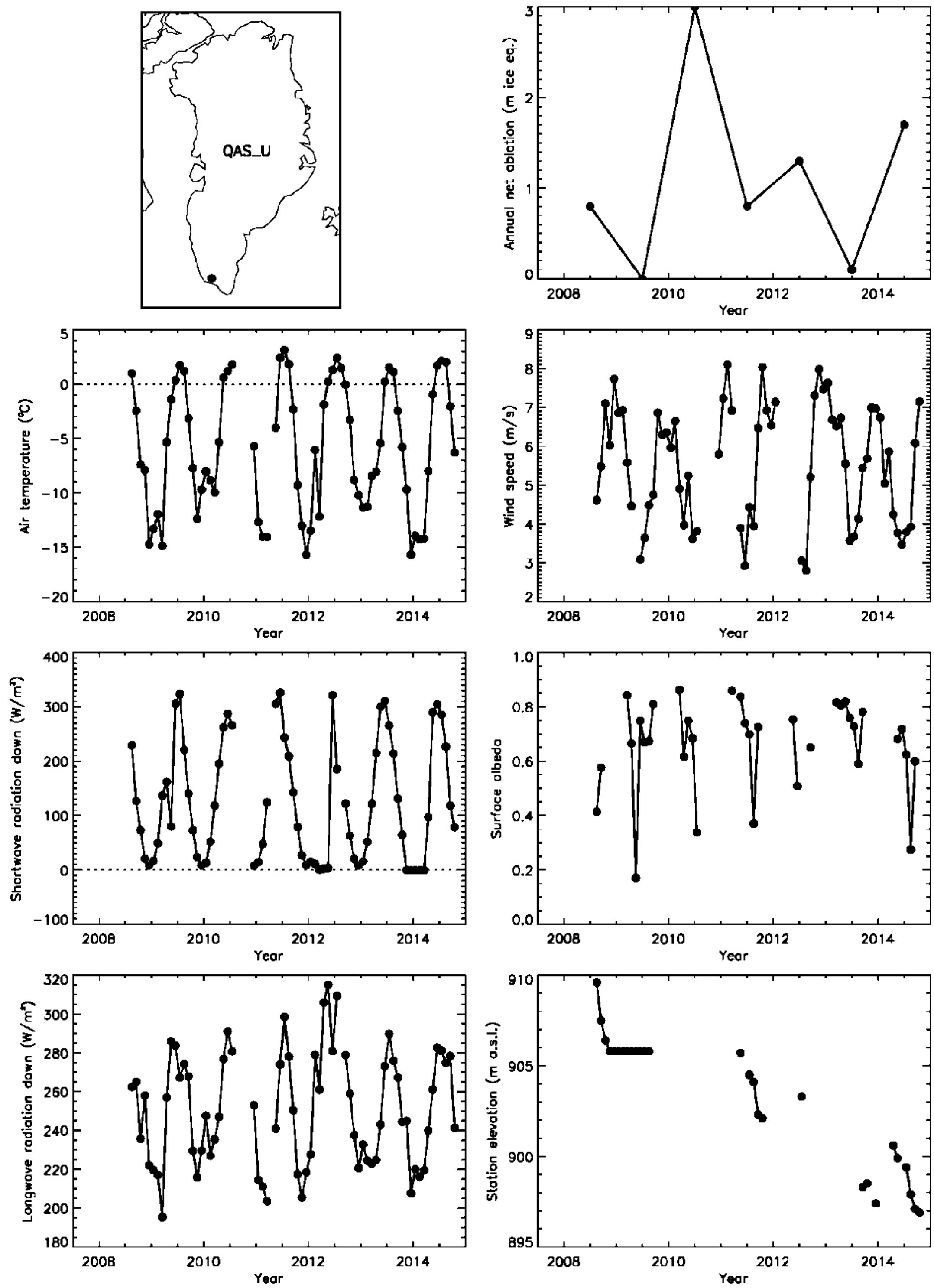
Figur A 6 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for TAS_U AWS on the ice sheet.



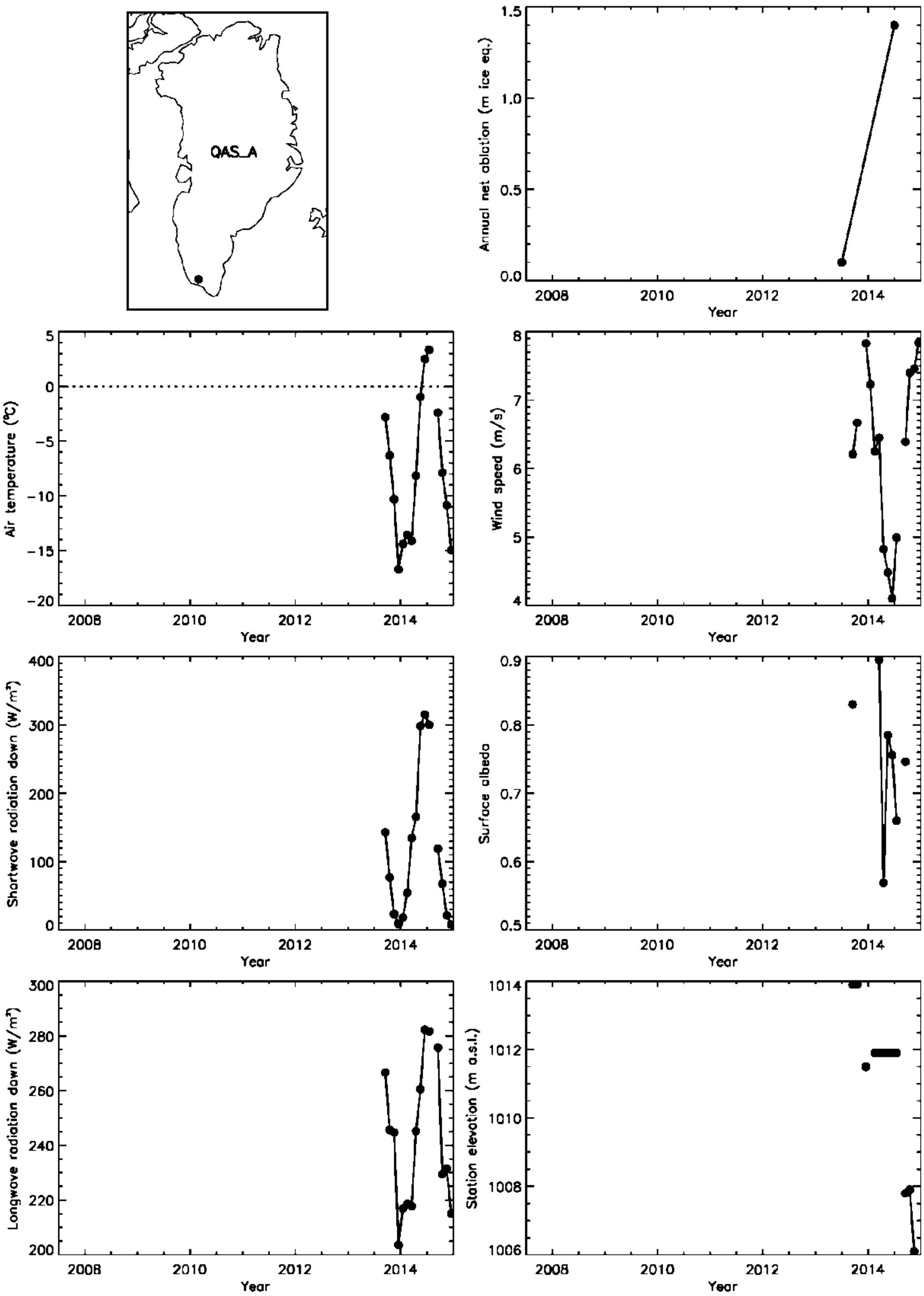
Figur A 7 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for TAS_A AWS on the ice sheet.



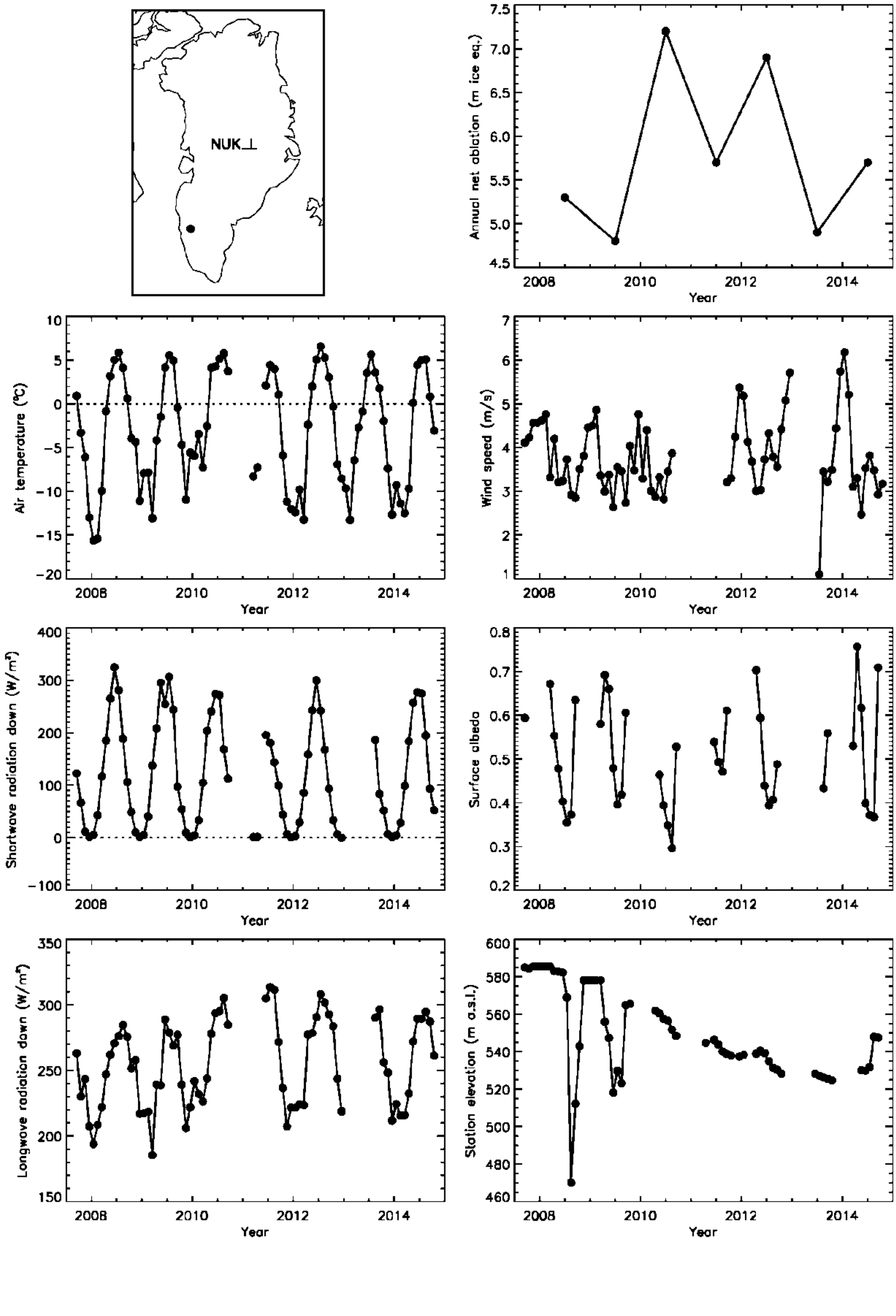
Figur A 8 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for QAS_L AWS on the ice sheet.



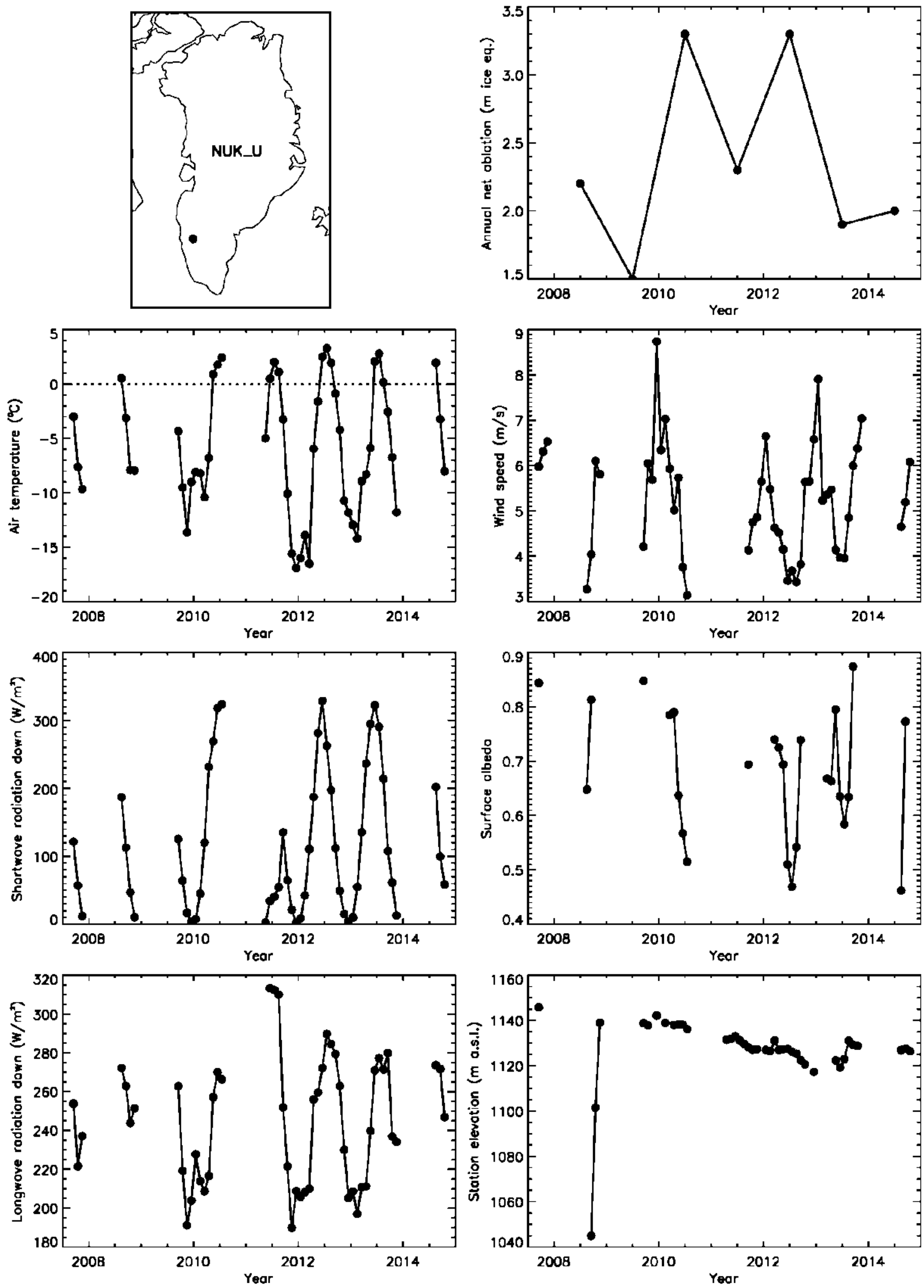
Figur A 9 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for QAS_U AWS on the ice sheet.



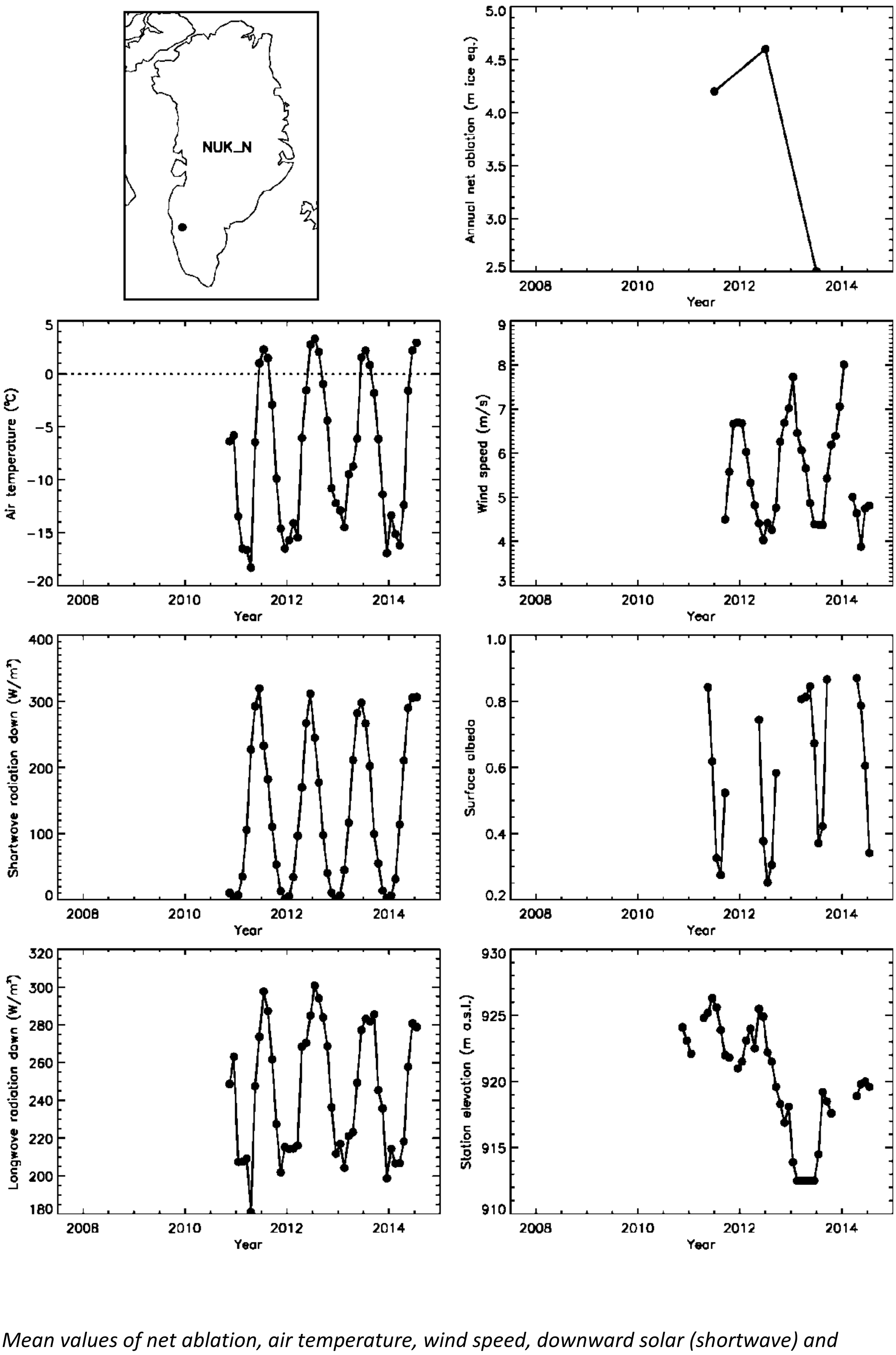
Figur A 10 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for QAS_A AWS on the ice sheet.



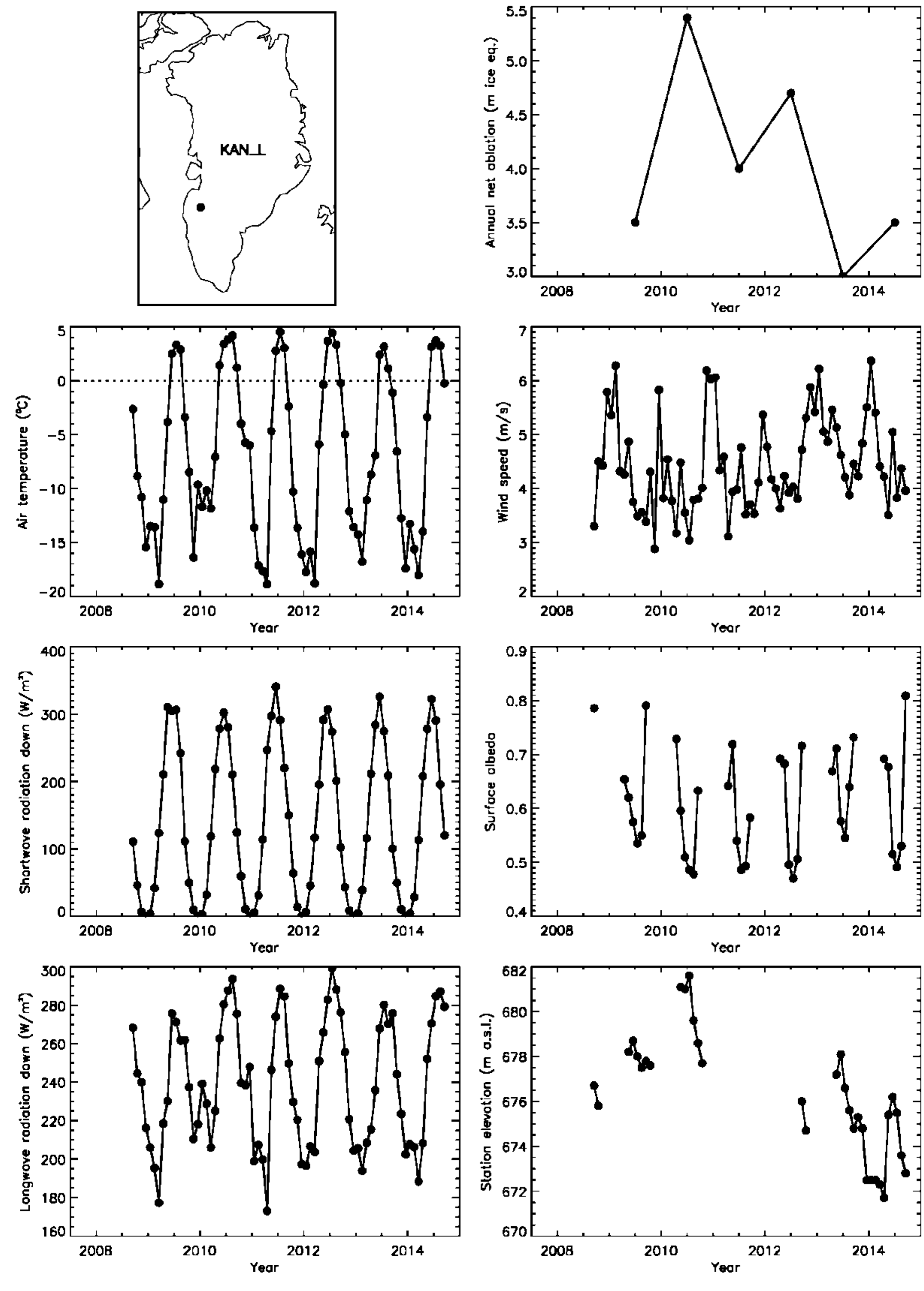
Figur A 11 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for NUK_L AWS on the ice sheet.



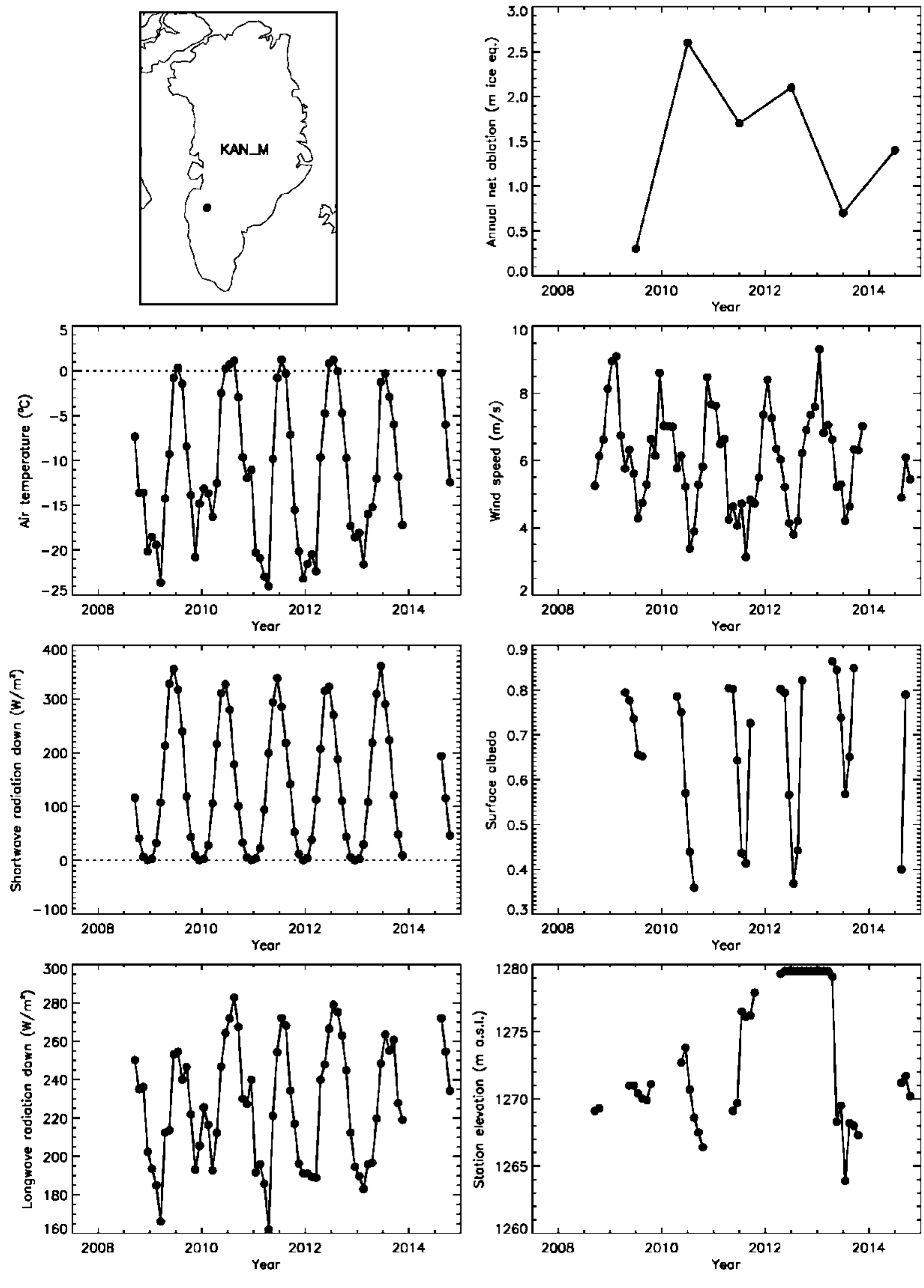
Figur A 13 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for NUK_U AWS on the ice sheet.



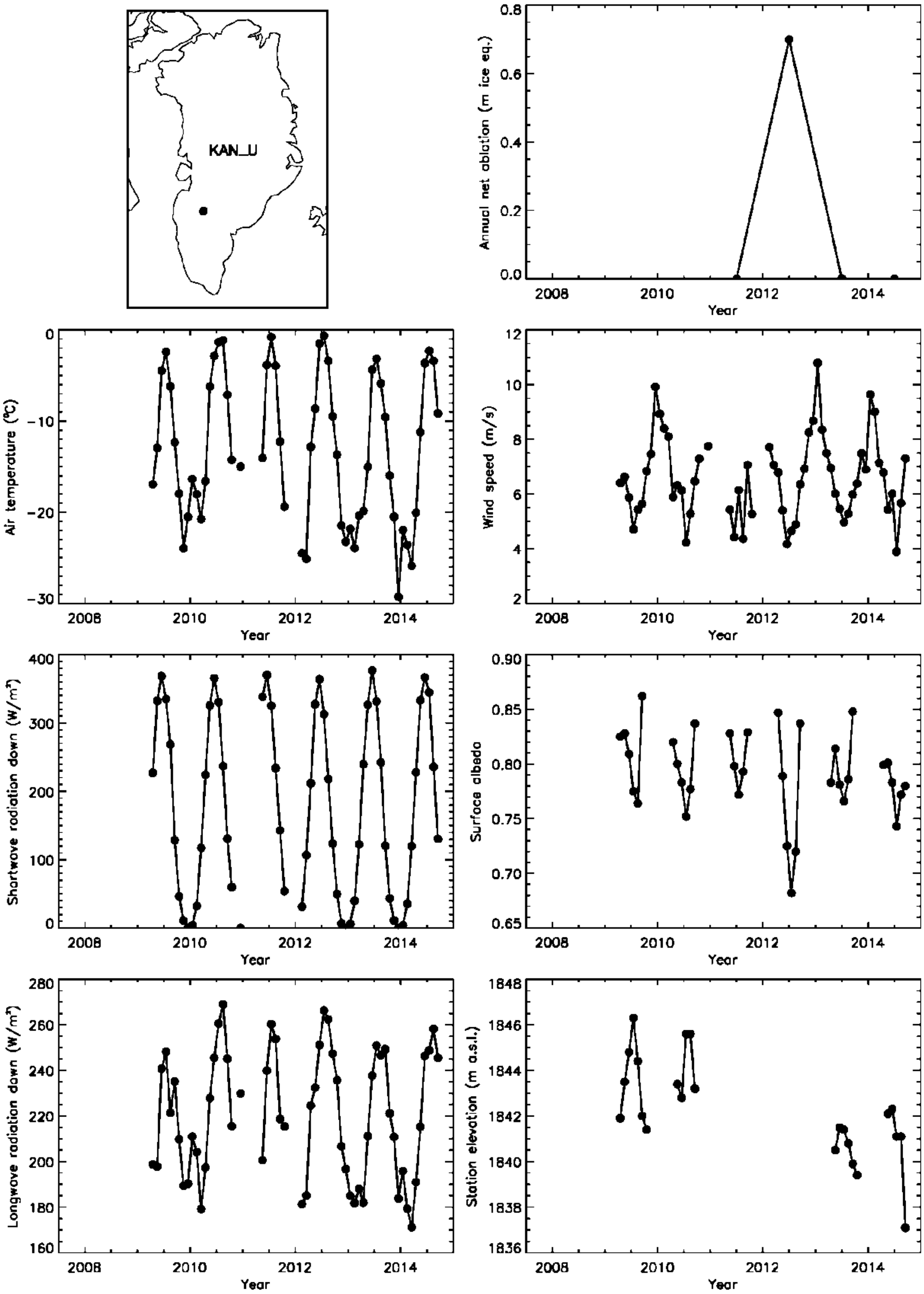
Figur A 13 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for NUK_N AWS on the ice sheet.



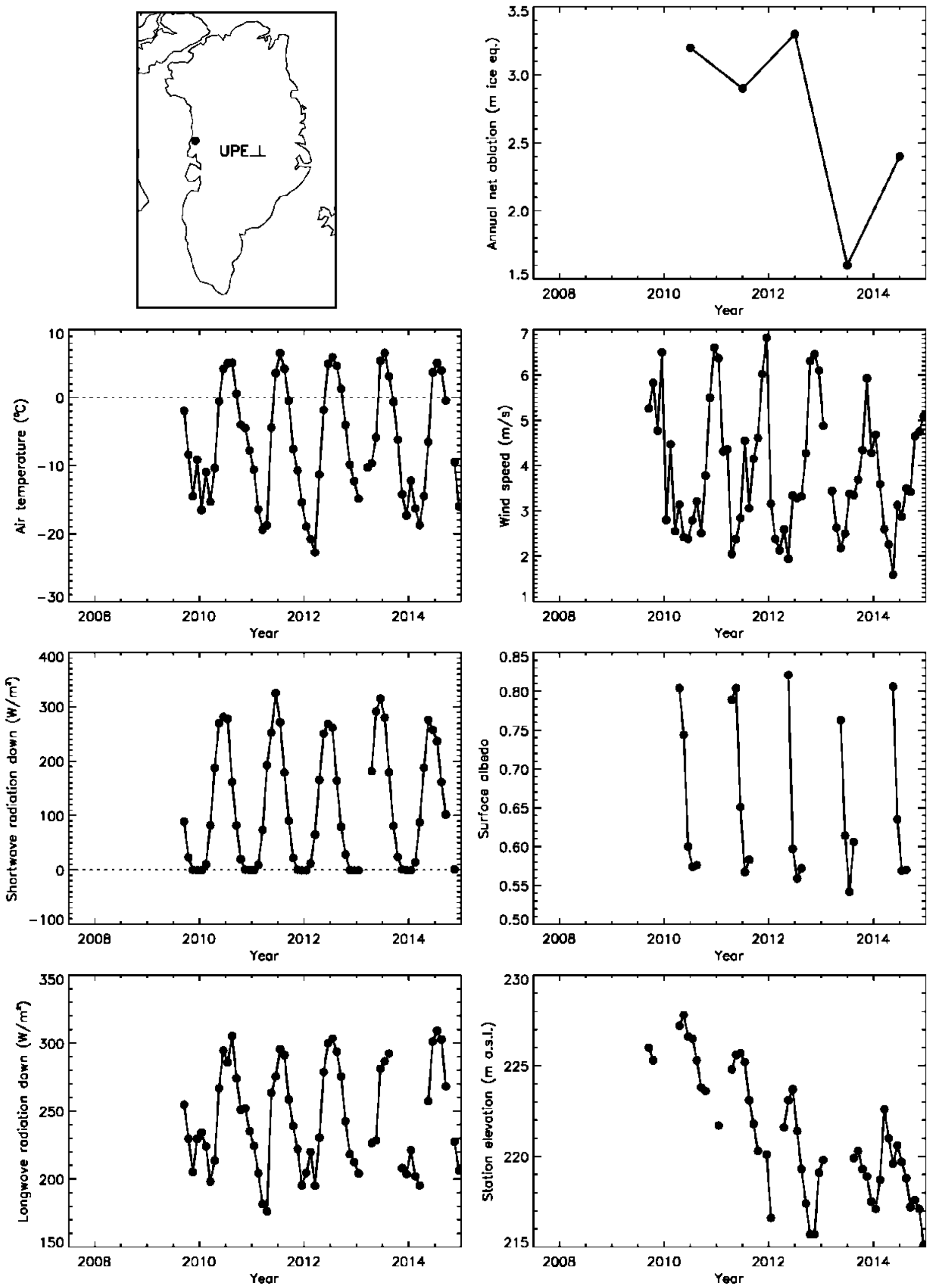
Figur A 14 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for KAN_L AWS on the ice sheet.



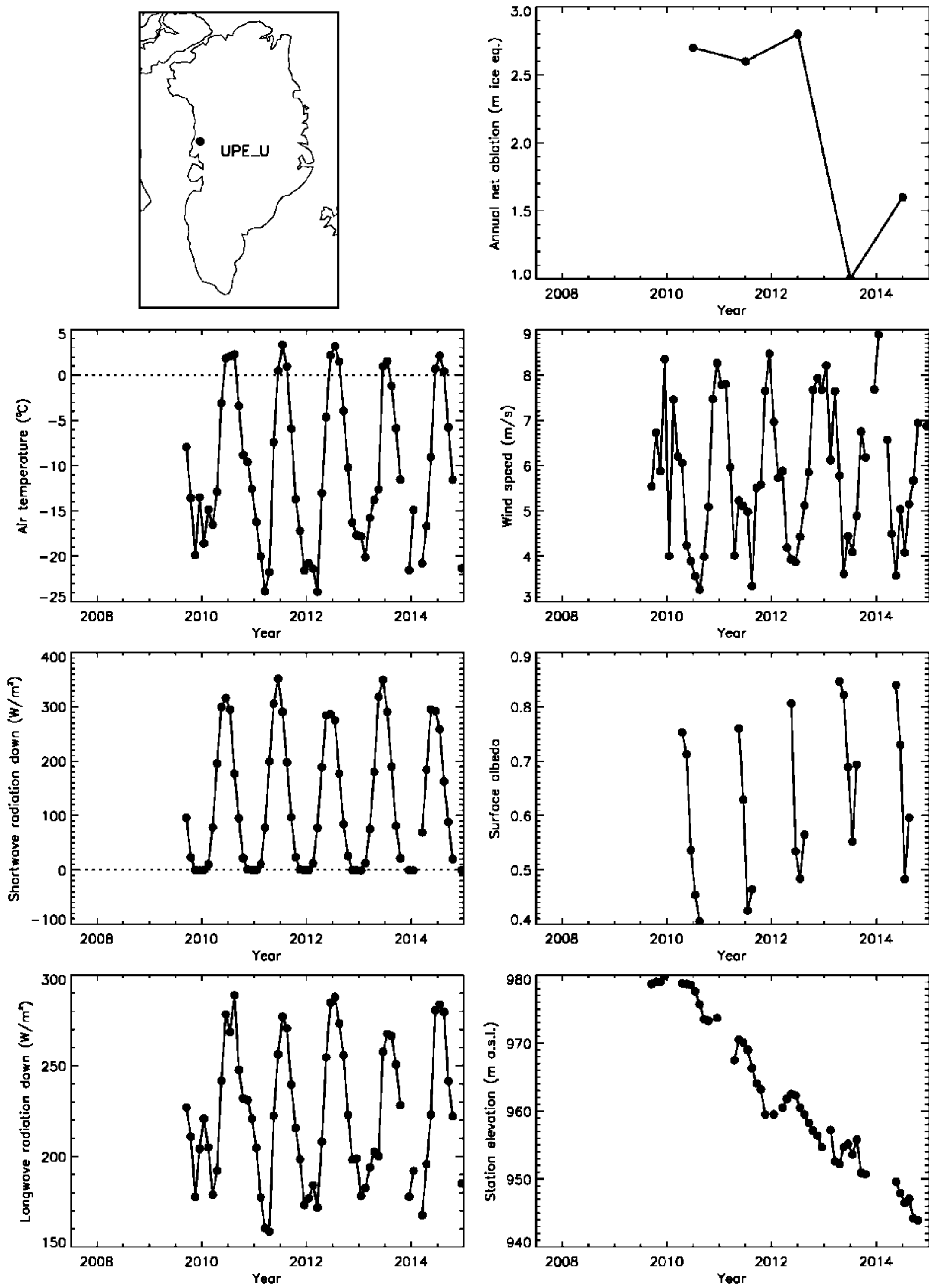
Figur A 15 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for KAN_M AWS on the ice sheet.



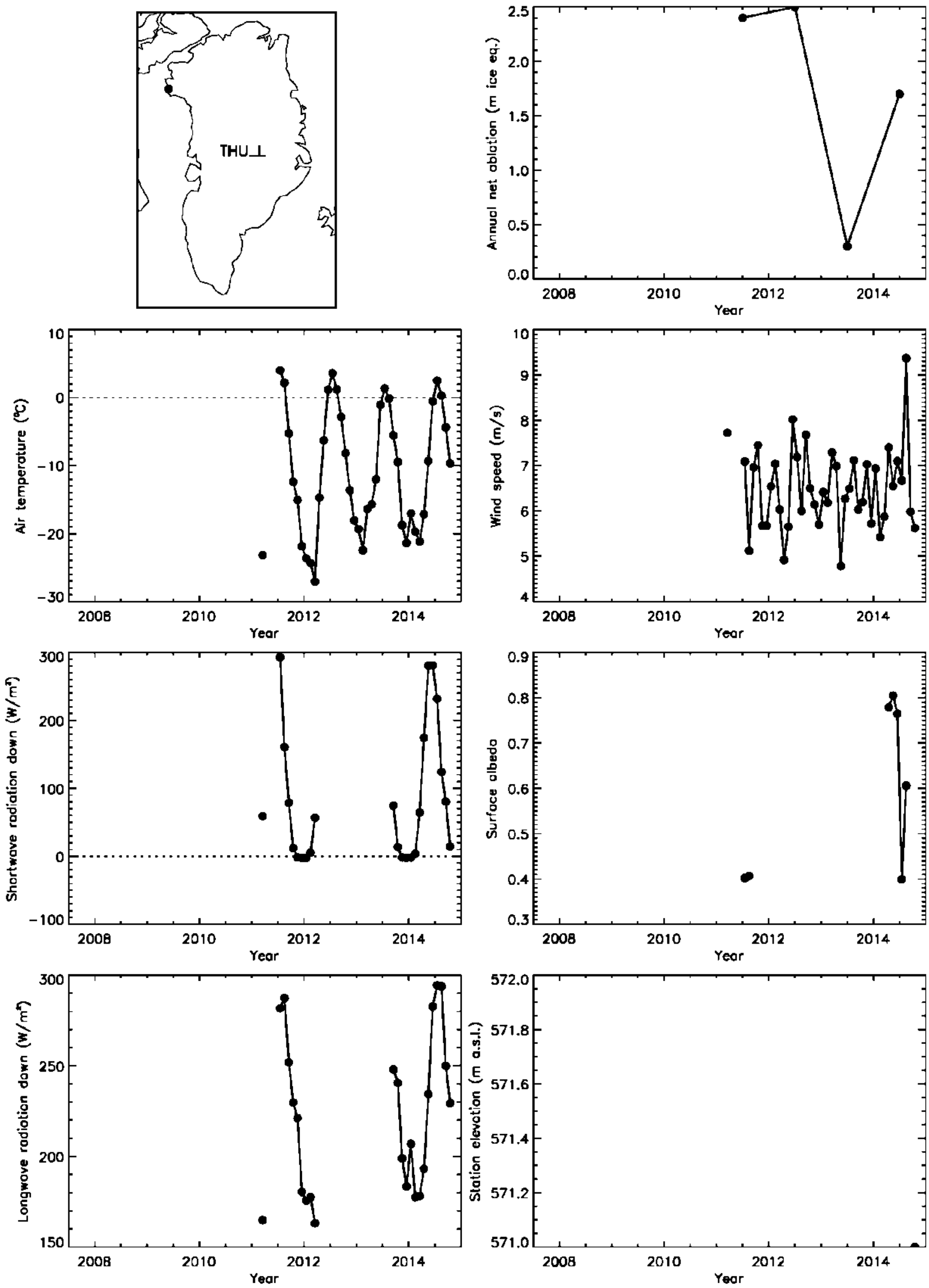
Figur A 16 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for KAN_U AWS on the ice sheet.



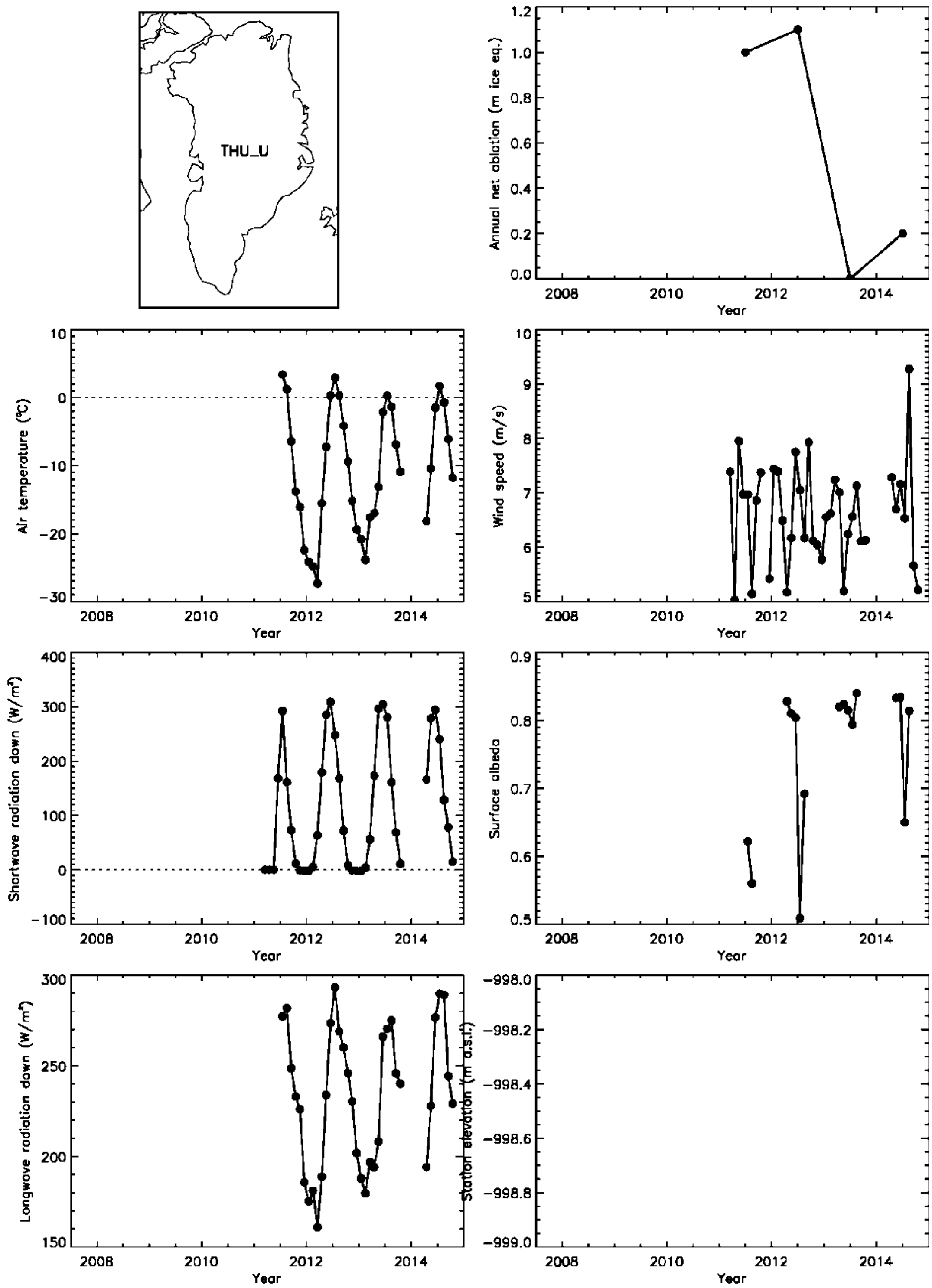
Figur A 17 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for UPE_L AWS on the ice sheet.



Figur A 18 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for UPE_U AWS on the ice sheet.



Figur A 19 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for THU_L AWS on the ice sheet.



Figur A 40 Mean values of net ablation, air temperature, wind speed, downward solar (shortwave) and terrestrial (longwave) radiation, surface albedo and surface elevation for THU_U AWS on the ice sheet.

Appendix B – Science from the PROMICE team

This appendix details the scientific results produced by PROMICE team members with relation to their activities in PROMICE. This means that commercial activities apart from that dealing with the climate change-hydropower relationship have not been listed. The appendix is divided in three, showing 73 peer-reviewed scientific publications, 131 scientific conference contributions and 21 reports. Publications marked with * have been cited in the 2014 IPCC AR5 report.

Peer reviewed scientific publications

2014

1. Andersen, ML. Stenseng, H. Skourup, W. Colgan, S. Khan, S. Kristensen, S. Andersen, J. Box, A. Ahlstrøm, X, Fettweis and R. Forsberg. 2015. Basin-scale partitioning of Greenland ice sheet mass balance components (2007–2011). Earth and Planetary Science Letters. 409: 89-95. doi:10.1016/j.epsl.2014.10.015
2. Andersen ML, Andersen SB, Stenseng L, Skourup H, Colgan W, Kristensen SS, Merryman Boncori JP, Ahlstrøm AP, Fettweis X, Forsberg R, Citterio M, Box JE, Van As D and Fausto RS (2014) Mass loss from an ice-sheet drainage basin in West Greenland. Geol. Surv. Denmark Greenland Bull., 31, 87-90

3. Andersen ML, Stenseng L, Skourup H, Colgan W, Khan SA, Kristensen SS, Andersen SB, Box JE, Ahlstrøm AP, Fettweis X and Forsberg R (2014) Basin-scale partitioning of Greenland ice sheet mass balance components (2007–2011). Earth Planetary Sci. Lett., 409, 89-95 (doi:10.1016/j.epsl.2014.10.015)

4. Colgan W, Box JE, Fausto RS, Van As D, Barletta VR and Forsberg R (2014) Surface albedo as a proxy for the mass balance of Greenland's terrestrial ice. Geol. Surv. Denmark Greenland Bull., 31, 91-94

5. Davis, J.L.,J. De Juan Verger, M.Nettles, P.Elo´Segui, M.L.Andersen, 2014, Evidence for non-tidal diurnal velocity variations of Helheim Glacier, East Greenland, Journal of Glaciology, Vol. 60, No. 224, 2014 doi: 10.3189/2014JoG13J230

6. Doyle SH, Hubbard A, Fitzpatrick AAW, Van As D, Mikkelsen AB, Pettersson R and Hubbard B (2014) Persistent flow acceleration within the interior of the Greenland Ice Sheet. Geophys. Res. Let., 41 (3), 899-905 (doi:10.1002/2013GL058933)

7. Fitzpatrick AAW, Hubbard AL, Box JE, Quincey DJ, van As D, Mikkelsen APB, Doyle SH, Dow CF, Hasholt B and Jones GA (2014) A decade (2002–2012) of supraglacial lake volume estimates across Russell Glacier, West Greenland. Cryosph., 8, 107-121 (doi: 10.5194/tc-8-107-2014)

8. Lea JM, Mair DWF, Nick FM, Rea BR, Van As D, Morlighem M, Nienow PW and Weidick A (2014) Fluctuations of a Greenlandic tidewater glacier driven by changes in atmospheric forcing: observations and modelling of Kangiata Nunaata Sermia, 1859–present. Cryosph., 8, 2031-2045

(doi:10.5194/tc-8-2031-2014)

9. Lea JM, Mair DWF, Nick FM, Rea BR, Weidick A, Kjær KH, Morlighem M, Van As D and Schofield JE (2014) Terminus-driven retreat of a major southwest Greenland tidewater glacier during the early 19th century: insights from glacier reconstructions and numerical modelling. J. Glac., 60 (220), 333-344 (doi:10.3189/2014JoG13J163)
10. Mernild SH, Malmros JK, Yde JC, Wilson R, Knudsen NT, Hanna E, Fausto RS and Van As D (2014) Albedo decline on Greenland’s Mittivakkat Gletscher in a warming climate. Int. J. Climatol. (doi:10.1002/joc.4128)
11. Tedesco, M., J E. Box, J. Cappelen, X. Fettweis, T.S. Jensen, T. Mote, A.K. Rennermalm, L.C. Smith, R.S.W. van de Wal, and J. Wahr, 2014, Greenland Ice Sheet, [in "State of the Climate in 2013"]. Bull. Amer. Meteor. Soc., 95 (7), S5-S49.
12. Van As D, Andersen ML, Petersen D, Fettweis X, Van Angelen JH, Lenaerts JTM, Van den Broeke MR, Lea JM, Bøggild CE, Ahlstrøm AP and Steffen K (2014) Increasing meltwater discharge from the Nuuk region of the Greenland ice sheet and implications for mass balance (1960-2012). J. Glac., 60 (220), 314-322 (doi: 10.3189/2014JoG13J065)
13. Van As D, Fausto RS, Steffen K and PROMICE project team (2014) Katabatic winds and piteraq storms: observations from the Greenland ice sheet. Geol. Surv. Denmark Greenland Bull., 31, 83-86

2013

1. Ahlstrøm A.P., S.B. Andersen, M.L. Andersen, H. Machguth, F.M. Nick, I. Joughin, C.H. Reijmer, R.S.W. Van de Wal, J.P. Merryman Boncori, J.E. Box, M. Citterio, D. Van As, R.S. Fausto, A. Hubbard (2013): ‘Seasonal velocities of eight major marine-terminating outlet glaciers of the Greenland ice sheet from continuous in situ GPS instruments’, Earth Syst. Sci. Data, 5, 277-287, doi:10.5194/essd-5-277-2013.
2. *Bolch, T., L.S. Sørensen, N. Mölg, H. Machguth and F. Paul. 2013. Changes of Greenland’s local glaciers and ice caps observed from ICEsat. Geophysical Research Letters, 40(5) 875-881; doi:10.1002/grl.50270
3. *Citterio, M. & Ahlstrøm, A.P. 2013: Brief communication "The aerophotogrammetric map of Greenland ice masses". The Cryosphere 7, 445-449.
4. Colgan, W., Abdalati, W., Citterio, N., Csatho, B. Fettweis, X., Luthcke, S., Moholdt, G. & Stober, M. 2013: Hybrid inventory, gravimetry and altimetry (HIGA) mass balance product for Greenland and the Canadian Arctic. The Cryosphere Discussions 8, 537-580.
5. Colgan, W., Luthcke S., Abdalati, W. & Citterio, M. 2013: Constraining GRACE-derived cryosphere-attributed signal to ireegularly shaped ice-covered areas. The Cryosphere 7, 1901-1914.
6. Fausto, R.S., Colgan, W. & Langen, P.L. 2013: Real-Time Changes in Arctic Ice Presented in Online Portal. EOS transactions American Geophysical Union 94(44), 397-398.

7. Fitzpatrick A.A.W., Hubbard, A., Joughin, I., Quincey, D.J., Van As, D., Mikkelsen, A.P.B., Doyle, S.H., Hasholt, B., Jones, G.A 2013: Ice flow dynamics and surface meltwater flux at a land-terminating sector of the Greenland Ice Sheet. Journal of Glaciology 59(216), 687-696.
8. *Machguth, H., P. Rastner, T. Bolch, N. Mölg and L.S. Sørensen. 2013. Future sea level rise contribution of Greenland's glaciers and ice caps. Environmental Research Letters, 8 025005 doi:10.1088/1748-9326/8/2/025005
9. Mernild, S.H. , Knudsen, N.T., Yde, J.C., Hoffman, M.J., Limpscomb, W.H., Hanna, E., Malmros, J.K. & Fausto, R.S. 2013: Thinning and slowdown from Greenland¿s Mittivakkat Gletscher. Journal of glaciology 59(216), 11.
10. *Nick, F.M., Vieli, A., Andersen, M.L., Payne, T. Edwards, T., Joughin, I., Pattyn, F. & van der Wal, R.S.W. 2013: Contributions from the Greenland marine outlet glaciers to global sea level rise as climate continues to warm. Nature 497,235–238,doi:10.1038/nature12068
11. Rennermalm, A.K., Smith, L.C., Chu, V.W., Box, J.E., Forster, R.R., Van den Broeke, M.R., Van As, D. & Moustafa, S.E. 2013: Evidence of meltwater retention within the Greenland ice sheet. The Cryosphere 7, 1433-1445.
12. Simonsen, S. B; Stenseng, L; Adalgeirsdottir, G.; Fausto, R. S.; Hvidberg, C. S.; Lucas-Picher, P Assessing a multilayered dynamic firn-compaction model for Greenland with ASIRAS radar measurements. Journal of Glaciology, Vol. 59, No. 215, 2013, p. 545-558.
13. Van As, D., Fausto, R.S., Colgan, W.T., Box. J.E., Ahlstrøm, A.P., Andersen, S.B., Andersen, M.L., Charalampidis, C., Citterio, M., Edelvang, K., Jensen, T.S., Larsen, S.H., Machguth, H., Nielsen, S., Veicherts, M. & Weidick, A. 2013: Darkening of the Greenland ice sheet due to the melt-albedo feedback observed at PROMICE weather stations. In: Bennike, O., Garde, A.A, & Watt, W.S.(eds): Review of Survey Activities 2012. Geological Survey of Denmark and Greenland Bulletin 28, 69-72.

2012

1. *Andresen CS, Straneo F, Ribergaard MH, Bjørk AA, Andersen TJ, Kuijpers A, Nørgaard-Pedersen N, Kjær KH, Schjøth F, Weckström K and Ahlstrøm AP (2012) Rapid response of Helheim Glacier in Greenland to climate variability over the past century. Nature Geosc., 5, 37-41 (doi: 10.1038/ngeo1349)
2. Banwell AF, Arnold N, Willis I, Tedesco M and Ahlstrøm A (2012) Modelling supraglacial water routing and lake filling on the Greenland Ice Sheet. J. Geophys. Res., 117, F0401 (doi: 10.1029/2012JF002393)
3. Banwell AF, Willis I, Arnold N, Messerli A, Rye C and Ahlstrøm A (2012) Calibration and validation of a high resolution surface mass balance model for Paakitsoq, west Greenland. J. Glac., 58 (212), 1047-1062 (doi: 10.3189/2012JoG12J034)
4. Fausto , R.S., S.H. Mernild, B. Hasholt, A.P. Ahlstrøm and N.T. Knudsen. 2012. Modeling suspended sediment concentration and transport for Mittivakkat Glacier, Southeast Greenland. Arctic, Antarctic and Alpine Research Vol. 44., No. 3, 306-318.
5. Fausto, R.S., D. Van As, A.P. Ahlstrøm, S.B. Andersen, M.L. Andersen, M. Citterio, K. Edelvang, et al. 2012. Ablation Observations for 2008–2011 from the Programme for Monitoring of the Greenland Ice Sheet (PROMICE). Geological Survey of Denmark and Greenland Bulletin 26, 73–76.
6. Fausto RS, Van As D, Ahlstrøm AP and Citterio M (2012) Assessing the accuracy of Greenland ice sheet surface ablation measurements by pressure transducer. J. Glac., 58 (212), 1144-1150 (doi: 10.3189/2012JoG12J075)

7. Fausto R.S., D. van As and the PROMICE team. 2012. Ablation observations for 2008–2011 from the Programme for Monitoring of the Greenland Ice Sheet (PROMICE). Geol. Surv. Denmark Greenland Bull., 26, 73-76.
8. Jiskoot, H., D. Juhlin, H. St Pierre, and M. Citterio. 2012. Tidewater Glacier Fluctuations in Central East Greenland Coastal and Fjord Regions (1980s–2005). Annals of Glaciology 53, no. 60, 35–44.
9. *Kargel, J.S., A.P. Ahlstrøm, R.B. Alley, J.L. Bamber, T.J. Benham, J.E. Box, C. Chen, M. Citterio, et al. 2012. Brief Communication: Greenland's Shrinking Ice Cover: 'Fast Times' but Not That Fast. The Cryosphere 6, no. 3, 533–537.
10. *Leclercq, P.W., A. Weidick, F. Paul, T. Bolch, M. Citterio, and J. Oerlemans.(2012) Brief Communication: Historical Glacier Length Changes in West Greenland. The Cryosphere Discussions 6, no. 4, 3491–3501.
11. Mernild, S.H., N.T. Knudsen, J.C. Yde, M.J. Hoffman, W.H. Limpscomb, E. Hanna, R.S. Fausto and J.K. Malmros. 2012. Retreat, thinning, and slowdown from Greenland's Mittivakkat Gletscher. The Cryosphere Discuss., 6, 2005-2036.
12. Mikkelsen et al. In preparation. Meltwater runoff and ice sheet velocity response during the new record melt year 2012 in southwest Greenland.
13. Nick, F.M., A. Luckman, A. Vieli, C.J. van der Veen, D. van As, R.S.W. van de Wal, F. Pattyn, A.L. Hubbard and D. Floricioiu. 2012. The response of Petermann Glacier, Greenland, to large calving events, and its future stability in the context of atmospheric and oceanic warming. Journal of Glaciology 58 (208), 229-239.
14. Nick F. M., A. Vieli, M. L. Andersen, T. Payne, T. Edwards, I. Joughin, , F. Pattyn, and R.S.W. van der Wal. Under revision, 2012. Contributions from the Greenland marine outlet glaciers to global sea level rise as climate continues to warm. Nature 497, 235-238 (doi. 10.1038/nature12068).
15. *Rastner, P., T. Bolch, N. Mölg, H. Machguth and F. Paul. 2012. The first complete glacier inventory for entire Greenland. The Cryosphere., 6, 1483-1495 (doi: 10.5194/tc-6-1483-2012)
16. Simonsen, S.B., L. Stenseng, G. Adalgeirsdottir, R.S. Fausto and C.S. Hvidberg. Submitted, 2012. Assessing a multi-layered dynamic firn compaction model for Greenland with ASIRAS radar measurements. Journal of Glaciology.
17. van As, D., A.L. Hubbard, B. Hasholt, A.B. Mikkelsen, M.R. van den Broeke and R.S. Fausto. 2012. Large surface meltwater discharge from the Kangerlussuaq sector of the Greenland ice sheet during the record-warm year 2010 explained by detailed energy budget observations. Cryosphere 6, 199-209.
18. Weidick, A., O. Bennike, M. Citterio and N. Nørgaard-Pedersen. 2012. Neoglacial and historical changes in southern West Greenland, with special emphasis on the area around Kangersuneq fjord. Geological Survey of Denmark and Greenland Bulletin 27, 68 pp.

2011

1. Andersen, M.L., M. Nettles, T.B. Larsen, P. Elosegui, G.S. Hamilton and L.A. Stearns. 2011. Quantitative estimates of velocity sensitivity to surface melt variations at a large Greenland outlet glacier. Journal of Glaciology 57 (204), 609-620.
2. Box , J.E., A. Ahlstrøm, J. Cappelen, X. Fettweis, D. Decker, T. Mote, D. van As, R.S.W. van de Wal, B. Vinther and J. Wahr. 2011. Greenland [in "State of the Climate in 2010"]. Bull. Amer. Meteor. Soc. 92 (6), S161-171.
3. Brown, K.J., H. Seppä, G. Schoups, R.S. Fausto, P. Rasmussen and H.J.B Birks. 2011. A spatio-temporal reconstruction of Holocene temperature change in southern Scandinavia. The Holocene, DOI: 10.1177/0959683611414926.
4. Fausto, R.S., A.P. Ahlstrøm, D. van As and K. Steffen. 2011. Present-day temperature standard deviation parameterization for Greenland. J. Glaciol. 57 (206), 1181-1183.

5. van As, D.. 2011. Warming, glacier melt and surface energy budget from weather station observations in the Melville Bay region of northwest Greenland. Journal of Glaciology 57 (202), 208-220.
6. Van As, D., R.S. Fausto, A.P. Ahlstrøm, S.B. Andersen, M.L. Andersen, M. Citterio, K. Edelvang, et al. 2011. Programme for Monitoring of the Greenland Ice Sheet (PROMICE): First Temperature and Ablation Record. Geological Survey of Denmark and Greenland Bulletin 23, 73–76.
7. Van As, D., R.S. Fausto, A.P. Ahlstrøm, S.B. Andersen, M.L. Andersen, M. Citterio, K. Edelvang, P. Gravesen, H. Machguth, F.M. Nick, S. Nielsen and A. Weidick. 2011. Temperature and ablation records from the Programme for Monitoring of the Greenland Ice Sheet (PROMICE). Geological Survey of Denmark and Greenland Bulletin 23, 73-76.
8. van As, D., R.S. Fausto and the PROMICE team. 2011. Programme for Monitoring of the Greenland Ice Sheet (PROMICE): first temperature and ablation records. Geol. Surv. Denmark Greenland Bull. 23, 73-76.
9. Weidick A. & Citterio M. 2011. The ice-dammed lake Isvand, West Greenland, has lost its water. Journal of Glaciology 57(201), 186-188.

2010

1. Andersen, M.L., T.B. Larsen, M. Nettles, P. Elosegui, D. van As, G.S. Hamilton, L.A. Stearns, J.L. Davis, A.P. Ahlstrøm, J. de Juan, G. Ekström, L. Stenseng, S.A. Khan, R. Forsberg and D. Dahl-Jensen. 2010. Spatial and temporal melt variability at Helheim Glacier East Greenland, and its effect on ice dynamics. Journal of Geophysical Research 115, 18 pp. doi:10.1029/2010JF001760.
2. de Juan, J., P. Elosegui, M. Nettles, T.B. Larsen, J.L. Davis, G.S. Hamilton, L.A. Stearns, M.L. Andersen, G. Ekström, A.P. Ahlstrøm, L. Stenseng, S.A. Khan and R. Forsberg. 2010. Sudden increase in tidal response linked to calving and acceleration at a large Greenland outlet glacier. Geophysical Research Letters 37 (12501), 5 pp., doi:10.1029/2010GL043289.
3. Mernild, S.H., I.M. Howat, Y. Ahn, G.E. Liston, K. Steffen, B.H. Jakobsen, B. Hasholt, B. Fog, and D. van As. 2010. Freshwater flux to Sermilik Fjord, SE Greenland. Cryosphere 4, 453-465.
4. *Nick, F.M., C.J. van der Veen, A. Vieli, and D.I. Benn. 2010. A physically based calving model applied to marine outlet glaciers and implications for the glacier dynamics. Journal of Glaciology 56 (199), 781-794.
5. van As, D. 2010. Changes in temperature and glacier melt from weather station observations in the Melville Bay region of North-West Greenland. J. Glaciol. 57 (202), 208-220.

2009

1. Citterio M., R.H. Mottram, S.H. Larsen and A.P. Ahlstrøm. 2009. Glaciological investigations at the Malmbjerg mining prospect, central East Greenland. Geological Survey of Denmark and Greenland Bulletin 17, 73-76.
2. Citterio, M., F. Paul, A.P. Ahlstrøm, H.F. Jepsen and A. Weidick. 2009. Remote sensing of glacier change in West Greenland: accounting for the occurence of surge-type glaciers. Annals of Glaciology 50(53), 70-80.
3. Dawes, P.R. and D. van As. 2009. An advancing glacier in a recessive ice regime: Berlingske Bræ, North-West Greenland. In: Bennike, O., Garde, A.A. & Watt, W.S. (eds): Review of Survey activities 2009. Geological Survey of Denmark and Greenland Bulletin 20, 79-82.

4. Fausto, R.S., A.P. Ahlstrøm, D. van As, C.E. Bøggild and S.J. Johnsen. 2009. A new present-day temperature paramerization for Greenland. Journal of Glaciology 55(189), 95-105.
5. Fausto, R.S., A.P. Ahlstrøm, D. van As, S.J. Johnsen, P.L. Langen and K. Steffen. 2009. Improving surface boundary conditions with focus on coupling snow densification and meltwater retention in large-scale ice-sheet models of Greenland. Journal of Glaciology 55(193), 869-878.
6. Mottram, R., C. Nielsen, A.P. Ahlstrøm, N. Reeh, S.S. Kristensen, E.L. Christensen, R. Forsberg, and L. Stenseng. 2009. A new regional high-resolution map of basal and surface topography for the Greenland ice sheet margin at Paakitsoq, West Greenland. Annals of Glaciology 50 (51), 105-111.
7. *Nick, F.M., A. Vieli, I.M. Howat, and I. Joughin. 2009. Large-scale changes in Greenland outlet glacier dynamics triggered at the terminus. Nature Geoscience 2, 110-114.
8. van As, D., C.E. Bøggild, S. Nielsen, A.P. Ahlstrøm, R.S. Fausto, S. Podlech, M.L. Andersen. 2009. Climatology and ablation at the South Greenland ice sheet margin from automatic weather station observations. Cryosphere Disc. 3 (1), 117-158.

2008

1. Ahlstrøm, A.P. and the PROMICE project team 2008. A new programme for monitoring the mass loss of the Greenland ice sheet. In: Bennike, O. & Higgins, A.K.(eds): Review of Survey activities 2007. Geological Survey of Denmark and Greenland Bulletin 15, 61-64.
2. Ahlstrøm A.P., P. Gravesen, S.B. Andersen, D. van As, M. Citterio, R.S. Fausto, S. Nielsen, H.F. Jepsen, S.S. Kristensen, E.L. Christensen, L. Stenseng, R. Forsberg, S. Hanson, D. Petersen and the PROMICE Project Team. 2008. A new programme for monitoring the mass loss of the Greenland ice sheet. Geological Survey of Denmark and Greenland Bull. 15, 61-65.
3. Nettles, M., T.B. Larsen, P. Elosegui, G.S. Hamilton, L.A. Stearns, A.P. Ahlstrøm, J.L. Davis, M.L. Andersen, J. de Juan, S.A. Khan, L. Stenseng, G. Ekström and R. Forsberg. 2008. Step-wise changes in glacier flow speed coincide with calving and glacial earthquakes at Helheim Glacier, Greenland. Geophysical Research Letters 35, L24503, 5 pp. doi:10.1029/2008GL036127.
4. Smelror, M., A. Ahlstrøm, L. Ekelund, J.M. Hansen, K. Nenonen and A.K. Mortensen. 2008. The Nordic geological surveys: Geology for society in practice. Episodes 31(1), 193-200.

2007

1. Ahlstrøm, A.P., C.E. Bøggild, O.B. Olesen, D. Petersen and J.J. Mohr. 2007. Mass balance of the Amitsulôq ice cap. Glacier Mass Balance Changes and Meltwater Discharge. IAHS Red Books 318, 107-115 International Association of Hydrological Sciences. IAHS Press.
2. Fausto, R.S., C. Mayer and A.P. Ahlstrøm. 2007. Satellite derived surface type and melt area of the Greenland ice sheet using MODIS data from 2000 to 2005. Annals of Glaciology 46, 35-42.
3. Weidick, A. & O. Bennike. 2007. Quaternary glaciation history and glaciology of Jakobshavn Isbræ and the Disko Bugt region, West Greenland: a review. Geological Survey of Denmark and Greenland Bulletin 14, 78 pp.

Scientific presentations & abstracts at conferences

2014

1. Ahlstrøm, A.P., Andersen, S.B., van As, D., Citterio, M., Fausto, R.S., Andersen, M.L., Colgan, W.T., Box, J.E., Veicherts, M., Forsberg, R., Skourup, H., Barletta, V. & Petersen, D. 2014: Observational data from the Programme for Monitoring of the Greenland Ice Sheet (PROMICE). PARCA 2014. 28 January, 2014. Maryland, U.S.A.. NASA.
2. Ahlstrøm, A.P., Hillerup Larsen, S. & Andersen, S.B. 2014: Hvordan kommunisere forskning og hvordan kommunisere klimaendringer?. journalister, kommunikationsspecialister og andre interesserede. , Oslo, Norge.
3. Ahlstrøm, A.P. & Larsen, S.H. 2014: Communicating Climate Research. Nordic Branch Meeting of the International Glaciological Society. 30 October- 1 November, 2014. Vík, Iceland. International Glaciological Society. NIGS2014 Abstracts.
4. Ahlstrøm, A.P. 2014: How to spread the word to the general public on the impact of climate change. Top-level Research Initiative Flagship Conference. 18-19 November, 2014. Stockholm, Sweden. Norden Top-level Research Initiative..
5. Andersen, S.B., Ahlstrøm, A.P., Andersen, M.L., Box, J.E., Citterio, M., Colgan, W.T., Fausto, R., van As,D., Forsberg, R., Skourup, H., Sørensen, L.S., Kristensen, S.S., Dall, J., Kusk, A. & Petersen, D. 2014: Programme for Monitoring of the Greenland Ice Sheet. AGU Fall Meeting 2014. 14-19 December, 2014. San Fransisco, California, U.S.A.. American Geophysical Union. Eos trans., 1.
6. Andersen, S.B., Ahlstrøm, A.P., Andersen, M.L., Box, J.E., Citterio, M., Colgan, W.T., Fausto, R., van As,D., Forsberg, R., Skourup, H., Sørensen, L.S., Kristensen, S.S., Dall, J., Kusk, A. & Petersen, D. 2014: Program for monitoring of the Greenland Ice Sheet. International Glaciological Society Nordic Branch Meeting. 29-31 October, 2014. Viik, Iceland. International Glaciological Society.
7. Andersen, S.B. 2014: PROMICE in-situ data for validation, ESA CCI Ice Sheets. ESA CCI progress meeting. 10-11 June, 2014. Lyngby, Denmark. ESA.
8. Andersen, M. L. Tine B. Larsen, Gordon S. Hamilton, Meredith Nettles, Automatic detection of iceberg calving events using seismic observations, AGU Fall meeting 2014.
9. Box, J., Greenland ice sheet reflectivity, Dansk Meteorologisk Institut, 29 Jan, 2014
10. Charalampidis C., Changing Surface-Atmosphere Energy Exchange and Refreezing Capacity of the Lower Accumulation Area, West Greenland (Abstract #C43A-0375), AGU Fall Meeting, San Francisco, USA, 15-19 December, 2014.
11. Box, J., Greenland Dark Snow, NPI, Tromsø, 10 March, 2014
12. Box, J., R. Mottram, P.L. Langen, F. Boberg, and The Promice Team, Ranking spatially and temporally variable Greenland ice surface melt factors, EGU, Vienna, 2 May, 2014
13. Box, J., R. Mottram, P.L. Langen, M. Stibal, D. van As, R.S. Fausto, and S. L'Hermitte, Albedo feedbacks on the Greenland Ice Sheet and Arctic glaciers, International Arctic Science Committee (IASC) Albedo feedbacks on the Greenland Ice Sheet and Arctic glaciers, Bristol. UK, 21 September, 2014
14. Box, J., Darkening Greenland ice: integrating a spectrum of climate change processes, LGGE, Grenoble, 14 January, 2015
15. Charalampidis C., Changing surface-atmosphere energy exchange and refreezing capacity of the lower accumulation area, west Greenland, invited talk at Zentralanstalt für Meteorologie und Geodynamik (ZAMG), Vienna, Austria, 22 January 2015.

16. Charalampidis C., Changing Surface-Atmosphere Energy Exchange and Refreezing Capacity of the Lower Accumulation Area, West Greenland (Abstract # #G43B-0978), AGU Fall Meeting, San Francisco, USA, 15-19 December, 2014.
17. Charalampidis C., Surface-atmosphere energy exchange at the lower accumulation area of the Greenland ice sheet, Nordic branch IGS meeting, Iceland, 1 November 2014.
18. Charalampidis C., Surface-atmosphere energy exchange at the lower accumulation area of the Greenland ice sheet, SVALI annual meeting, Iceland, 29 October 2014.
19. Charalampidis C., Surface-atmosphere energy exchange at the lower accumulation area of the Greenland ice sheet, SVALI workshop on melt water retention of glaciers, ARTEK, DTU, 15 October 2014.
20. Colgan W. et al., In-situ Greenland ice sheet measurements for satellite data product development ESA/ESTEC Workshop on Novel Mission Concepts for Snow and Cryosphere Research, 16- 17 September, 2014

2013

1. Ahlstrøm, A.P., Forsberg, R., Skourup, H., Sørensen, L.S., Citterio, M., Kjær, K.H., Bjørk, A.A., Khan, S. A. & Andersen, S.B. 2013: Three decades of elevation change on the Geikie Plateau ice cap, East Greenland. AGU Fall Meeting 2013. 9-13 December, 2013. San Francisco, California, U.S.A.. American Geophysical Union. Eos Trans. AGU, Fall Meet. Suppl., Abstracts, 1 p.
2. Ahlstrøm, A.P., Spada, G. & Grinsted, A. 2013: Ice2sea - Preliminary results for sea level rise in Denmark by 2100 [Briefing af Departementet (KEBMIN) - I samarbejde med koordinator David Vaughan, NERC-BAS, UK]. 19/02-2013.
3. Andersen, S.B. 2013: Ice_Sheets_CCI: Essential Climate Variables for the Greenland Ice Sheet. ESA LIving planet symposium 2013. 9-13 September, 2013. Edinburgh, United Kingdom. European Space Agency., 1 p.
4. Boncori, J.M., Andersen; M.L., Kamstra, M., Dall, J., Kusk, A., Andersen, S.B., Bechor, N., Bignami, C., Gourmelen, N., Joughin, I., Jung, H., Luckman, A., Bevan, S., Mouginot, J., Neelmejer, J., Scharrer; K., Scheuchl, B. & Strozzi, T. 2013: Results of the Ice Velocity Round Robin Algorithm Intercomparison Within the Esa Ice_Sheets_CCI Project. ESA Living planet symposium 2013. 9-13 September, 2013. Edinburgh, United Kingdom. European Space Agency. Proceedings, 1 p.
5. Colgan,W., W. Abdalati, J. Box, B. Csatho, R. Fausto, X. Fettweis, S. Luthcke, T. Scambos, D. van As, J. Wahr, H. Zwally. 2013. Millennial scale ice dynamics and the spatial partition of Greenland mass change. American Geophysical Union Fall Meeting. San Francisco, USA.
6. Colgan, W., H. Rajaram and X. Fettweis. 2013. Projecting West Greenland's future tidewater glacier discharge with Monte Carlo. European Geophysical Union General Assembly. Vienna, Austria.
7. Fausto,Robert; Ahlstrøm,Andreas; Andersen,Signe; Andersen,Morten; Citterio,Michele; Colgan,William; van As,Dirk The importance of accumulation in Greenland ice sheet mass loss in record-setting melt years. EGU General Assembly 2013, 7-12 April, 2013 in Vienna, Austria, id. EGU2013-9373
8. Levinsen, J.F., Forsberg, R., Meister, R., Hogg, A., Shepherd, A., Khvorostovsky, K., Dall, J., Kusk; A., Nagler, T., Scharrer, K., Andersen, S.B. & Andersen, M.L. 2013: ESA Ice Sheets CCI: Overview and surface elevation change results for the Greenland Ice Sheet. AGU Fall Meeting

2013. 9-13 December, 2013. San Francisco, California, U.S.A.. American Geophysical Union. Eos Trans. AGU, Fall Meet. Suppl., Abstracts, 1p.

9. Van As, D., Andersen, M.L., Petersen, D., Fettweis, X., Van Angelen, J.H., Lenaerts, J.T.M., Van den Broeke, M.R., Lea, J., Steffen, K., Bayou, N., Bøggild, C.E. & Ahlstrøm, A.P. 2013: Increasing meltwater discharge from the Nuuk (SW) region of the Greenland ice sheet and implications for glacier mass balance (1989-2012). CLIVAR. Boston, USA
10. Van As, D., Andersen, M.L., Petersen, D., Fettweis, X., Van Angelen, J.H., Lenaerts, J.T.M., Van den Broeke, M.R., Lea, J., Steffen, K., Bayou, N., Bøggild, C.E. & Ahlstrøm, A.P. 2013: Increasing meltwater discharge from the Greenland ice sheet into Nuuk Fjord and implications for glacier mass balance (1989-2012). IASC. Obergurgl, Austria...
11. Van As, D., Box, J.E., Fausto, R.S., Petersen, D., Citterio, M., Ahlstrøm, A.P., Andersen, S.B. & Steffen, K. 2013: Greenland ice sheet melt area, volume, and runoff from satellite and in situ observations. AGU. San Francisco, USA..

2012

1. Ahlstrøm, A.P. and J.O. Hagen. 2012. Glaciers and ice caps in the Arctic - a significant contribution to sea level rise. AMAP Climate Expert Group Workshop, Victoria, British Colombia, Canada, Arctic Monitoring and Assessment Programme.
2. Andersen, S.B. 2012. Monitoring of the Greenland icesheet from space within PROMICE. G-NET workshop, DTU-Space, May 8, 2012.
3. Andersen, S.B., D. van As, A.P. Ahlstrøm, J.P. Merryman Boncori, M. Citterio, R. Forsberg, S.S. Kristensen, J. Dall, L. Stenseng, D. Petersen, E.L. Christensen, R.S. Fausto. 2012. Programme for Monitoring of the Greenland Ice Sheet. CRES summer school, University of Copenhagen, May 21-25, 2012.
4. Citterio, M. and A.P. Ahlstrom. Accepted. A high detail benchmark dataset of mid-1980’s ice margin positions for all Greenland ice masses. AGU Fall Meeting Abstracts, December 3, 2012.
5. Citterio Michele and Andreas P Ahlstrøm - A high detail benchmark dataset of mid-1980’s ice margin positions for all Greenland ice masses. AGU Fall Meeting 2012 3-7 December 2012, San Francisco, CA.
6. Larsen, S.H., M. Citterio, R.M. Hock and A.P. Ahlstrom. Accepted. Mass and surface energy balance of A.P. Olsen ice cap, NE Greenland, from observations and modeling (1995-2011). AGU Fall Meeting Abstracts, December 3, 2012.
7. Leclercq, P. W., A. Weidick, F. Paul, T. Bolch, M. Citterio, and J. Oerlemans. 2012. Historical Glacier Length Fluctuations in West Greenland. 14:5301, http://adsabs.harvard.edu/abs/2012EGUGA.14.5301L.
8. Machguth, H. 2012. A straightforward method for the automated calculation of glacier flow lines (Poster). 10th Swiss Geoscience Meeting.
9. Machguth, H., P. Rastner, T. Bolch, N. Mölg and L. Sørensen. 2012. Future sea level rise contribution from Greenland's local glaciers and ice caps; the impact of predicted high Arctic precipitation changes (Talk). 10th Swiss Geoscience Meeting.
10. Machguth, H., P. Rastner, T. Bolch, N. Mölg and L. Sørensen. 2012. Future sea level rise contribution from Greenland's local glaciers and ice caps; the impact of predicted high Arctic precipitation changes (abstract submitted). Nordic Branch Meeting of the International Glaciological Society, Stockholm.

11. Machguth, H., P. Rastner, F. Paul and T. Bolch. 2012. Sea level rise contribution of local glaciers and ice caps on Greenland, a detailed modelling approach (Talk). 3rd ice2sea open forum, Amsterdam.
12. Rastner, P., F. Paul, T. Bolch, R. Le Bris, N. Mölg and H. Machguth. 2012. The first glacier inventory for entire Greenland (Poster). European Geoscience Union General Assembly, Vienna.
13. Rastner, P., F. Paul, T. Bolch, R. Le Bris, N. Mölg and H. Machguth. 2012. The first complete glacier inventory for entire Greenland (Poster). 16th Alpine Glaciology Meeting, Zurich.

2011

1. Ahlstrom, A. P., M. L. Andersen, S. B. Andersen, J. M. Boncori, M. Citterio, J. Dall, R. S. Fausto, et al. 2011. Programme for Monitoring of the Greenland Ice Sheet (PROMICE). AGU Fall Meeting Abstracts 13 (December 1, 2011): 0725.
2. Andersen, M.L., T.B. Larsen and M. Nettles. 2011. Detection and spectral characterization of calving related seismic signals, Helheim Glacier, South East Greenland (Oral presentation). EGU spring meeting.
3. Andersen, S.B. 2011. Glaciological activities in Greenland 2011 and 2012. Meeting in the Danish network for the Greenland ice sheet, November 24, 2011.
4. Andersen, S.B., A.P. Ahlstrøm, J.M. Boncori and J. Dall. 2011. Programme for monitoring of The Greenland Ice Sheet -Ice surface velocities. American Geophysical Union, Fall Meeting 2011, abstract #C11D-0699.
5. Citterio M. 2011. Internals and performance of the GEUS automatic weather stations. Abstracts of the IASC Workshop on the use of automated measuring systems on glaciers, 23-26 March, Pontresina, Switzerland, 22-26.
6. Fausto, R.S. 2011. Automated ablation measurements using a pressure transducer. Rondo convention centre, Pontresina, Schweiz. IMAU.
7. Fausto, R.S., A.P. Ahlstrøm and D. van As. 2011. Using improved boundary conditions for mass balance modelling in large-scale ice sheet models of Greenland. EGU General Assembly 2011, Vienna, Austria, European Geosciences Union. Geophysical Research Abstracts 13, 1 p.
8. Jiskoot H., H. St. Pierre, D. Juhlin and M. Citterio. 2011. Coastal and fjord terminating tidewater glacier dynamics in central East Greenland. IGS 2011 International Symposium on Interactions of Ice Sheets and Glaciers with the Ocean, 5-10 June, La Jolla, CA, USA.
9. Machguth, H., F. Paul, P. Rastner, T. Bolch and A. Ahlstrøm. 2011. Future Evolution of Greenlandic Glaciers and Ice Caps under a Warming Climate; a Pilot Study for the Stauning Alper, East Greenland (Poster). Arctic Monitoring and Assessment Program (AMAP) Conference, Copenhagen.
10. Onac P.B., J.G. Wynn and M. Citterio. 2011. Ikaite in the Scărișoara Ice Cave (Romania): origin and significance. EGU 2011General Assembly, 3-8 April 2011, Vienna, Austria.
11. Rastner,P., T. Bolch, H. Machguth, S. Kass and F. Paul. 2011. The upcoming glacier inventory for Greenland (Poster). 15th Alpine Glaciology Meeting, Munich.
12. Rastner, P., T. Bolch, H. Machguth and F. Paul. 2011. The first complete glacier inventory for Eastern Greenland (Poster). AGU American Geophysical Union, San Francisco, USA.

2010

1. Ahlstrøm, A.P. 2010. Ice2sea WP3 Report (Presentation before the Steering Committee). 27 October, 2010.
2. Ahlstrøm, A.P. 2010. WP3 Foundation and Validation Data. Ice2sea First Open Forum, 16-18 March, 2010 Krakow, Poland. FP7 EU-project Ice2sea.
3. Ahlstrøm, A.P., S.B. Andersen, D. van As, M. Citterio, R. Fausto, R. Forsberg, S.S. Kristensen, L. Stenseng, J. Dall, J.P. Merryman Boncori, E.L. Christensen, D. Petersen and S. Hanson. 2010. Programme for Monitoring of the Greenland Ice Sheet - Recent Developments. IASC Network for Arctic Glaciology Annual Workshop. 8-10 March, 2010. Obergurgl, Austria. Innsbruck University & GEUS.
4. Ahlstrøm, A.P., D. van As, S.B. Andersen, J.M. Boncori, M. Citterio, R. Forsberg, S.S. Kristensen, J. Dall, L. Stenseng, D. Petersen, E.L. Christensen, R.S. Fausto and S. Hanson. 2010. Programme for Monitoring of the Greenland Ice Sheet. International Glaciological Society Nordic Branch Meeting 2010. 28-30 October, 2010. Copenhagen. Geological Survey of Denmark and Greenland (GEUS). S.B. Andersen (ed.): Nordic Glaciology. Abstract from Glaciological Society Nordic Branch Meeting, 28-30 October 2010. Danmark og Grønlands Geologiske Undersøgelse Rapport 2010/94.
5. Ahlstrøm, A.P., D. van As, J.P. Merryman, M. Citterio, R. Forsberg, S.S. Kristensen, S.B. Andersen, J. Dall, L. Stenseng, D. Petersen, E.L. Christensen and R.S. Fausto. 2010. PROMICE - Monitoring the mass loss of the Greenland Ice Sheet. IASC Network on Arctic Glaciology, Workshop and GLACIODYN meeting. 16-19 februar, 2009. Kananaskis, Canada. IASC Network on Arctic Glaciology. In: Ahlstrøm, A.P. & Sharp, M. (eds): The Dynamics and Mass Budget of Arctic Glaciers. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2010/127, 16-18.
6. Ahlstrøm, A.P. and A. Vieli. 2009. Inspiration & Insight – a tribute to Niels Reeh. AGU Fall Meeting 2009. 14-18 December, 2009. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 90(52), Fall Meet. Suppl., Abstracts, C34A-01.
7. Andersen, M.L., M. Nettles, T.B. Larsen, P. Elosegui, G.S. Hamilton, L.A. Stearns, D. van As, J. de Juan and J. L. Davis. 2010. Quantifying the influence of melt on velocity variations at a large Greenland outlet glacier (Poster presentation). AGU fall meeting.
8. Andersen, S.B., D. van As, M. Citterio, R. Fausto, J.P. Merryman, J. Dall, S.S. Kristensen, R. Forsberg, E.L. Christensen and D. Petersen. 2010. Programme for Monitoring of the Greenland Ice Sheet. Helheim Workshop. 25-26 March, 2010. Copenhagen. Geocenter Danmark / Geologisk Museum. Abstract volume, 20 only.
9. Andresen, C.S., T.J. Andersen, A. Kuijpers, G. Massé, K. Weckstrøm, A.P. Ahlstrøm, N. Nørgaard-Pedersen, A. Bjørk and K.H. Kjær. 2010. Reconstruction of the latest 100 years of iceberg calving from Helheim Glacier, Southeast Greenland, on basis of marine sediment cores from Sermilik Fjord. AGU Fall Meeting 2010. 13-17 December, 2010. San Francisco, California, U.S.A. American Geophysical Union. [Abstracts - Available on the internet], 1 p.
10. Boncori, J.P.M., J. Dall, A.P. Ahlstrøm and S.B. Andersen. 2010. Validation and operational measurements with SUSIE - A SAR ice motion processing chain developed within PROMICE. Living Planet Symposium. 28 June, 2010. Bergen, Norway. ESA. Proceedings, 5 only.
11. Citterio M. and A. Ahlstrøm. 2010. The GlacioBasis glacier monitoring programme at A.P. Olsen Ice Cap (Zackenberg, NE Greenland). IGS Nordic Branch Meeting, 28-30 October 2010, Copenhagen, Denmark.

12. Jiskoot H., H. St. Pierre, D. Juhlin, M. Citterio. 2010. Tidewater Margin Dynamics in Central East Greenland Over two Decades. Eos Trans AGU, Fall Meet. 2010, Suppl, Abstract C23C-0633.
13. Johannesson, T. and 16 co-authors. 2010. The Impact of Climate Change on Glaciers and Glacial Runoff in the Nordic Countries (Talk). Conference on Future Climate and Renewable Energy: Impacts, Risks and Adaptation, Oslo, Norway.
14. Machguth, H. 2010. Future Scenarios of Surface Mass Balance of the Greenland Ice Sheet in the Paakitsoq Area, Illulisat, West Greenland (Talk). Nordic Branch Meeting of the International Glaciological Society, Copenhagen:
15. Machguth, H. and A. Ahlstrøm.2010. Surface Mass Balance of the Greenland Ice Sheet in the Paakitsoq Area, Illulisat, West Greenland - Scenarios and Related Uncertainties (Talk). Conference on Future Climate and Renewable Energy: Impacts, Risks and Adaptation, Oslo, Norway.

2009

1. Ahlstrøm, A.P. 2009. Danish Glaciology in Greenland. PARCA Meeting. 30 September - 1 October, 2009. Seattle, U.S.A. National Aeronautics and Space Administration (NASA).
2. Ahlstrøm, A.P., R.H. Mottram, C. Nielsen, N. Reeh, S.B. Andersen, S.S. Kristensen, E.L. Christensen, L. Stenseng, R. Forsberg and M. Stendel. 2009. Estimating the future ice sheet hydropower potential in Pakitsoq, Ilulissat, West Greenland. Climate and Energy Systems Workshop. 11-12 May, 2009. Copenhagen. DONG Energy. Abstract volume, 1 p.
3. Ahlstrøm A.P., D. van As, M. Citterio, R. Forsberg, S.S. Kristensen, S.B. Andersen, J. Dall, L. Stenseng, D. Petersen., E.L. Christensen and R.S. Fausto. 2009. PROMICE - Monitoring the mass loss of the Greenland Ice Sheet (oral contribution). Nuuk Climate Days 2009 - Changes of the Greenland Cryosphere Workshop & The Arctic Freshwater Budget International Symposium, Nuuk, Greenland, 25 - 27 August 2009.
4. Ahlstrøm, A.P., D. van As, M. Citterio, P. Gravesen, R. Forsberg, E.L. Christensen, S.S. Kristensen, D. Petersen, S.B. Andersen, L. Stenseng, R.S. Fausto and S. Hanson. 2009. Monitoring the mass loss of the Greenland ice sheet. Climate Change: Global Risks, Challenges & Decisions. 10-12 March, 2009. Copenhagen. University of Copenhagen & International Alliance of Research Universities (IARU). IOP Conference Series: Earth and Environmental Science 6, 012003.
5. Ahlstrøm, A.P., D. van As, J.P. Merryman Boncori, M. Citterio, R. Forsberg, S.S. Kristensen, S.B. Andersen, J. Dall, L. Stenseng, D. Petersen, E.L. Christensen, R.S. Fausto and S. Hanson. 2009. Monitoring the Mass Loss of the Greenland Ice Sheet. Changes of the Greenland Cryosphere. 25-27 August, 2009. Nuuk, Greenland. National Space Institute, DTU. Abstract volume, 1 p.
6. Andersen, M.L., M. Nettles, T.B. Larsen, P. Elosegui, G.S. Hamilton, L.A .Stearns, D. van As, J. de Juan and J.L. Davis. 2009. Surface Melt and its Effect on Helheim Glacier Dynamics (Poster presentation). AGU fall meeting.
7. Andersen, M.L., M. Nettles, T.B. Larsen, P. Elosegui, G.S. Hamilton, L.A. Stearns, D. van As, J. de Juan, J.L. Davis. 2009. Surface Melt and its Effect on Helheim Glacier Dynamics. Eos Trans. AGU, 90(52), Fall Meet. Suppl., Abstract C21D-0465

8. Andersen, S.B., A. Ahlstrøm, D. van As, M. Citterio, S. Nielsen and C.T. Thomsen. 2009. The new 'Programme for Monitoring of the Greenland Ice Sheet' data base. AGU Fall Meeting 2009. 14-18 December, 2009. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 90(52), Fall Meet. Suppl., Abstracts, C31A-0433.
9. Citterio M., L.H. Kaufmann, C. Sigsgaard, M.P. Tamsdorf and A. Ahlstrøm. 2009. The November 2008 glacial lake outburst flood from A.P. Olsen Cap (Zackenberg River catchment, North East Greenland) (poster). International Workshop on Glacier Hazards, Permafrost Hazards and GLOFs in Mountain Areas: Processes, Assessment, Prevention, Mitigation. 10 – 13 November 2009, Vienna.
10. Citterio, M., R. Mottram and A. Ahlstrom. 2009. Preliminary assessment of the surge potential of Arcturus Glacier at the Malmbjerg mining prospect (Stauning Alps, central East Greenland) (poster). International Workshop on Glacier Hazards, Permafrost Hazards and GLOFs in Mountain Areas: Processes, Assessment, Prevention, Mitigation. 10 – 13 November 2009, Vienna.
11. de Juan, J., P. Elosegui, N. Nettles, J.L. Davis, T. Larsen, A. Ahlstrøm, M.L. Andersen, G. Ekstrom, R. Forsberg, G.S. Hamilton, S.A. Khan, K.M. Schild, L.A. Stearns and L. Stenseng. 2009. Ocean tides modulation of flow at Helheim Glacier, East Greenland, observed using GPS. AGU Fall Meeting 2009. 14-18 December, 2009. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 90(52), Fall Meet. Suppl., Abstracts, C11A-01.
12. Merryman Boncori, J.P., J. Dall, A.P. Ahlstrøm and S.B. Andersen. 2009. A SAR Ice-Motion Processing Chain in Support of PROMICE (Programme for Monitoring of the Greenland Ice-Sheet). 6th International Workshop on Advances in the Science and Application of SAR Interferometry - Fringe 2009 Workshop. 30 November - 4 December, 2009. Frascati, Italy. European Space Agency. ESA Special Publication SP-677, 1 p.
13. Mottram R.H., M. Citterio, and A.P. Ahlstrøm. 2009. Applied glaciology and mineral resource exploitation in the Arctic: the Malmbjerg case study in East Greenland (oral contribution). Procs. of the 2009 EGU General Assembly, Vienna, Austria, 19 - 24 April 2009.
14. Nettles, M., P. Elosegui, T. Larsen, J.L. Davis, G.S. Hamilton, L.A. Stearns, M.L. Andersen, J. de Juan, E. Malikowski, I. Gonzalez, N. Okal, B. Johns, G. Ekstrom, A. Ahlstrøm, L. Stenseng, S.A. Khan, K.M. Schild, R. Forsberg and S.A. Veitch. 2009. Geodetic observations of short-time-scale changes in glacier flow at Helheim and Kangerdlugssuaq Glaciers, East Greenland. AGU Fall Meeting 2009. 14-18 December, 2009. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 90(52), Fall Meet. Suppl., Abstracts, C11A-02.
15. Paul F., M. Citterio, A. Ahlstrom, H.F. Jepsen and A. Weidick. 2009. A new inventory of local glaciers for a part of West Greenland: Methods, challenges and changes (oral contribution). Procs. of the 2009 EGU General Assembly, Vienna, Austria, 19 - 24 April 2009.
16. Petach, T.A., J.L. Davis, M. Nettles, P. Elosegui, J. de Juan, G.S. Hamilton, T. Larsen, A.P. Ahlstrøm, M.L. Andersen, G. Ekstrom, R. Forsberg, S.A. Khan, K.M. Schild, L.A. Stearns and L. Stenseng. 2009. A Kinematic Model of the Surface Velocity of Helheim Glacier, Greenland. AGU Fall Meeting 2009. 14-18 December, 2009. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 90(52), Fall Meet. Suppl., Abstracts, C23B-0501.

2008

1. Ahlstrøm, A.P., R.H. Mottram, C. Nielsen, N. Reeh, S.B. Andersen, S.S. Kristensen, E.L. Christensen, L. Stenseng and R. Forsberg. 2008. Estimating the future ice sheet hydropower potential in Paakitsoq, Ilulissat, West Greenland. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C23A-0588 only.
2. Ahlstrøm, A.P., D. van As, M. Citterio, S.B. Andersen, R.S. Fausto, M.L. Andersen, R. Forsberg, L. Stenseng, E.L. Christensen, S.S. Kristensen and S. Hanson. 2008. A new programme for monitoring the mass loss of the Greenland ice sheet. IASC-WAG Meeting. 28 January - 1 February, 2008. IASC Working group on Arctic Glaciology, Obergurgl, Austria. Abstract volume, 1 p.
3. Ahlstrøm A.P., D. van As, M. Citterio, S.B. Andersen, R.S. Fausto, M.L. Andersen, R. Forsberg, L. Stenseng, E.L. Christensen, S.S. Kristensen and S. Hanson. 2008. A new programme for monitoring the mass loss of the Greenland ice sheet. Workshop on the dynamics and mass budget of Arctic glaciers / GLACIODYN (IPY) meeting, 7-10 March 2008, Obergurgl, Austria
4. M.L. Andersen, T.B. Larsen, P. Elósegui, D. Dahl-Jensen and A.P. Ahlstrøm. 2008. Analysis of a regional seismic signal from a glacial earthquake at the Helheim glacier, Southeast Greenland(Poster presentation). EGU spring meeting.
5. Andersen, M.L., T.B. Larsen, M. Nettles, P. Elósegui, D. Dahl-Jensen, and A.P. Ahlstrøm. 2008. Analysis of a regional seismic signal from a glacial earthquake at the Helheim glacier, Southeast Greenland. Geophysical Research Abstracts, Vol. 10, EGU2008-A-06521, SRef-ID: 1607-7962/gra/EGU2008-A-06521. EGU General Assembly 2008.
6. Andersen, M.L., T.B. Larsen, M. Nettles, P. Elósegui, A.P. Ahlstrøm, L.A. Stearns, G. Hamilton, J.L. Davis, J. de Juan, G. Ekström, R. Forsberg, S. A. Khan, L. Stenseng and K. Schild. 2008. Surface Energy Balance Model of the Helheim Glacier, Southeast Greenland(Oral presentation). AGU fall meeting.
7. Andersen, M.L., T. B. Larsen, M. Nettles, P. Elosegui, A. P. Ahlstrom, L. A. Stearns, G. S. Hamilton, K. Schild, J. L. Davis, J. de Juan, G. Ekstrom, R. Forsberg, S. A. Khan, and L. Stenseng. 2008. Surface energy balance model of the Helheim Glacier, southeast Greenland. Eos Trans. AGU, 89, Abstract C42A-05.
8. Andersen, M.L., T.B. Larsen, M. Nettles, P. Elosegui, A.P. Ahlstrøm, L.A. Stearns, G.S. Hamilton, K. Schild, J.L. Davis, J. de Juan, G. Ekström, R. Forsberg, S.A. Khan and L. Stenseng. 2008. Surface Energy Balance Model of Helheim Glacier, Southeast Greenland. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C42A-05 only.
9. Andersen, M.L., T.B. Larsen, M. Nettles, P. Elósegui, D. Dahl-Jensen and A. Ahlstrøm. 2008. Analysis of a regional seismic signal from a glacial earthquake at the Helheim glacier, Southeast Greenland. EGU General Assembly 2008. 13-18 April, 2008. Vienna, Austria. European Geosciences Union. Geophysical Research Abstracts 10 [Available on CD-Rom only], 1 p.
10. Bøggild, C.E., S. Rysgaard, J. Mortensen, R. Kallenborn, M. Truffer, R. Forsberg, A.P. Ahlstrøm and D. Petersen. 2008. Linking Ice Sheet Freshwater Discharge and Marine production in Greenland via Fiord Circulation. 'FreshLink', an Interdisciplinary Project Involving Researchers from Multiple Countries. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C51B-07.

11. Citterio, M. 2008. Meteorologia glaciale in Groenlandia: dalla ricerca sul cambiamento climatico alle applicazioni nei settori idroelettrico e minerario. Milano, Italy. Universita di Milano and Comitato Glaciologico Italiano, 19. June, 2008.
12. Citterio M., A.P. Ahlstrom, R.S. Fausto, C. Sigsgaard and M. Tamstorf. 2008. The GlacioBasis monitoring programme at Zackenberg research station (NE Greenland): First achievements and long term plans. Procs. 33rd IGC, Oslo, 6 – 14th August 2008.
13. Citterio, M., F. Paul, A.P. Ahlstrøm, H.F. Jepsen and A. Weidick. 2008. Remote sensing of glacier change on Disko Island, Nuussuaq Peninsula and Svartenhuk Halvø (West Greenland) since the Little Ice Age. 33rd International Geological Congress 2008. 6-14 August, 2008. Oslo, Norway. International Geological Congress Committee (IGCC). Abstract volume (CD-Rom only), 1 p.
14. Davis, J.L., P. Elosegui, J. de Juan, M. Nettles, A.P. Ahlstrøm, M.L. Andersen, G. Ekström, R. Forsberg, G. Hamilton, A. Khan, T. Larsen, L. Stearns and L. Stenseng. 2008. Determining the Timing of Helheim Glacial Earthquakes from Glacier-Based GPS Time Series. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, G53C-03 only.
15. de Juan, J., P. Elosegui, M. Nettles, T.B. Larsen, J.L. Davis, A.P. Ahlstrøm, M.L. Andersen, G. Ekström, R. Forsberg, G.S. Hamilton, S.A. Khan, K.M. Schild, L.A. Stearns and L. Stenseng. 2008. Sub-daily glacier flow variations at Helheim Glacier, East Greenland, using GPS. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C31C-0518, 1 p.
16. Elosegui, P., M. Nettles, J.L. Davis, G.S. Hamilton, T.B. Larsen, I. Gonzalez, E. Malikowski, L.A. Stearns, J. de Juan, E.M. Hill, A.P. Ahlstrøm, M.L. Andersen, G. Ekström, R. Forsberg, S.A. Khan, L. Stenseng, K.M. Schild, M. Okal and B. Johns. 2008. Determining glacier flow with novel polar GPS systems. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, G13B-0657, 1 p.
17. Fausto, R.S., A.P. Ahlstrøm and S.J. Johnsen. 2008. Coupling snow densification and melt-water retention in a large-scale ice sheet model. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C31B-0488.
18. Hamilton, G.S., S.A. Khan, K.M. Schild, L.A. Stearns, M. Nettles, A.P. Ahlstrøm, M.L. Andersen, J.L. Davis, G. Ekström, P. Elosegui, R. Forsberg, J. de Juan, T.B. Larsen and L. Stenseng. 2008. Iceberg Calving and flow dynamics at Helheim Glacier, East Greenland, from time-lapse photography. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C13A-0565, 1 p.
19. Larsen, T.B., M.L. Andersen, M. Nettles, P. Elósegui, A.P. Ahlstrøm, J.L. Davis, J. de Juan, G. Ekström, R. Forsberg, G.A. Hamilton, S.A. Khan, L.A. Stearns and L. Stenseng. 2008. Glacial earthquakes in Greenland. EGU General Assembly 2008. 13-18 April, 2008. Vienna, Austria. European Geosciences Union. Geophysical Research Abstracts 10 [Available on CD-Rom only], 1 p.
20. Larsen, T.B., M. Nettles, P. Elosegui, M.L. Andersen, A.P. Ahlstrøm, J.L. Davis, J. de Juan, G. Ekström, R. Forsberg, G.S. Hamilton, S.A. Khan, L.A. Stearns, L. Stensen. 2008. East Greenland Glacier Dynamics: An Interdisciplinary study of Helheim Glacier. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C41A-0479, 1 p.

21. Larsen, T.B., M. Nettles, P. Elosegui, M.L. Andersen, A.P. Ahlstrøm, J.L. Davis, J. de Juan, G. Ekström, R. Forsberg, G.S. Hamilton, S.A. Khan, L.A. Stearns, and L. Stenseng. 2008. East Greenland Glacier Dynamics: An Interdisciplinary Study of Helheim Glacier. Eos Trans. AGU, 89, Abstract C41A-0479.
22. Long, S.M., I. Willis, N. Arnold and A.P. Ahlstrøm. 2008. Subglacial Meltwater Drainage at Paakitsoq, West Greenland: Insights From a Distributed, Physically Based Numerical Model. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C42A-03.
23. Nettles, M., T.B. Larsen, P. Elósegui, A.P. Ahlstrøm, J.L. Davis, J. de Juan, G. Ekström, R. Forsberg, G.S. Hamilton, S.A. Khan, M.L. Andersen, L.A. Stearns and L. Stenseng. 2008. Short-time-scale variations in flow speed observed at Helheim Glacier, East Greenland. EGU General Assembly 2008. 13-18 April, 2008. Vienna, Austria. European Geosciences Union. Geophysical Research Abstracts 10 [Available on CD-Rom only], 1 p.
24. Nettles, M., T.B. Larsen, P. Elosegui, G.S. Hamilton, L.A. Stearns, A.P. Ahlstrøm, J.L. Davis, M.L. Andersen, J. de Juan, S.A. Khan, L. Stenseng, G. Ekström, R. Forsberg and K.M. Schild. 2008. Glacier acceleration, glacial earthquakes, and ice loss at Helheim Glacier, Greenland. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, G23A-02 only.
25. Nick, F.M., C.J. van der Veen, A. Vieli and D. Benn. 2008. A calving law for ice sheet models; Investigating the role of surface melt on dynamics of Greenland outlet glaciers. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C31C-0513.
26. Paul, F., M. Citterio, A.P. Ahlstrøm, H.F. Jepsen and A. Weidick. 2008. A new inventory of local glaciers and ice caps for part of West Greenland: methods, challenges and change assessment. International Workshop on World Glacier Inventory. 20-21 September, 2008. Lanzhou, China. International Glaciological Society. Abstract volume, 1 p.
27. van As, D. and A.P. Ahlstrøm. 2008. Mass-balance measurements from a network of automatic weather stations in the ablation zone of the Greenland Ice Sheet. AGU Fall Meeting 2008. 15-19 December, 2008. San Francisco, U.S.A. American Geophysical Union. Eos Trans. AGU, 89(53), Fall Meet. Suppl. Abstracts, C31B-0494.

2007

1. Ahlstrøm, A.P. 2007. Monitoring of the Greenland Ice Sheet (Talk). AMAP Coordination Group Meeting, 2 February, 2007.
2. Ahlstrøm, A.P. 2007. PROMICE - A new monitoring programme for the Greenland Ice Sheet. Nordic Branch Meeting of the International Glaciological Society 2007. 25 October, 2007. Uppsala, Sweden. Uppsala University.
3. Ahlstrøm, A.P. 2007. PROMICE - a new monitoring programme for the Greenland Ice Sheet. GLIMS Workshop. 6 July, 2007. Perugia, Italy. Global Land Ice Monitoring from Space.
4. Ahlstrøm, A.P. 2007. PROMICE - a new programme for monitoring of the Greenland ice sheet. Zackenberg Basic Strategy Workshop. 28 March, 2007. Roskilde. Dansk Polarcenter.
5. Ahlstrøm, A.P. 2007. Results from the AMAP Expert Group on Climate, UV and Ozone [Talk: AMAP Coordination Group Meeting]. 2 February, 2007.

6. Ahlstrøm, A.P., F. Paul, H. Jepsen, M. Citterio, A.M. Solgaard and S.B. Andersen. 2007. Glacier retreat on Disko Island, West Greenland. IUGG 2007 Perugia, XXIV IUGG General Assembly. 2-13 July, 2007. Perugia, Italy. International Union of Geodesy and Geophysics, 1 p.
7. Ahlstrøm A.P., D. van As, M. Citterio, S.B. Andersen, R.S. Fausto, M.L. Andersen, R. Forsberg, L. Stenseng, E.L. Christensen and S.S. Kristensen. 2007. A new Programme for Monitoring the Mass Loss of the Greenland Ice Sheet (Poster presentation). Procs. AGU 2007 Fall Meeting, San Francisco, USA.
8. Ahlstrøm, A.P., D. van As, M. Citterio, S.B. Andersen, R.S. Fausto, M.L. Andersen, R. Forsberg, L. Stenseng, E.L. Christensen, S.S. Kristensen and S. Hanson. 2007. A new Programme for Monitoring the Mass Loss of the Greenland Ice Sheet. AGU Fall Meeting 2007. 10-14 December, 2007. San Francisco, U.S.A., American Geophysical Union. Eos Trans. AGU, 88(52), Fall Meet. Suppl., Abstract, C11A-0083.
9. Davis, J. L., P. Elosegui, G. Hamilton, L. Stearns, M. Langer, M. Nettles, and T.B. Larsen. 2007. Mechanisms for Tidally Induced Glacier Deformation and Flow Variations, East Greenland. Eos Trans. AGU, 88(52), Abstract G33B-1234.
10. Elosegui, P., J.L. Davis, M. Nettles, T.B. Larsen, A.P. Ahlstrøm, J. de Juan, G. Ekström, R. Forsberg, G. Hamilton, S.A. Khan, M. Andersen, L. Stearns and L. Stenseng. 2007. Geodetic Measurements and Analysis of Glacier Kinematics in East Greenland. AGU Fall Meeting 2007. 10-14 December, 2007. San Francisco, U.S.A., American Geophysical Union. Eos Trans. AGU, 88(52), Fall Meet. Suppl. Abstracts, G33C-02.
11. Fausto, R.F., A.P. Ahlstrøm, C.E. Bøggild and S.J. Johnsen. 2007. New present day temperature parameterization and degree day model for Greenland. AGU Fall Meeting 2007. 10-14 December, 2007. San Francisco, U.S.A., American Geophysical Union. Eos Trans. AGU, 88(52), Fall Meet. Suppl. Abstracts, C51A-0103.
12. Larsen, T.B., M.L. Andersen, M. Nettles, P. Elosegui, A.P. Ahlstrøm, J.L. Davis, D. de Juan, G. Ekström, R. Forsberg, G.S. Hamilton, S.A. Khan, L.A. Stearns and L. Stenseng. 2007. Regional rumble: a seismological study of glacial earthquakes in Greenland. AGU Fall Meeting 2007. 10-14 December, 2007. San Francisco, U.S.A., American Geophysical Union. Eos Trans. AGU, 88(52), Fall Meet. Suppl. Abstracts, G23A-02, 1 p.
13. Larsen, T.B., T.M. Jørgensen, M. Nettles, A.P. Ahlstrøm, J. Krüger, W. Hanka and G. Ekström 2007. Regional rumble: glacial eaerthquakes in Greenland. EGU General Assembly 2007. 16-20 April, 2007. Vienna, Austria. European Geosciences Union. Geophysical Research Abstracts 9 [Available on CD-Rom only], 1 p.
14. Nettles, M., T.B. Larsen, P. Elósegui, A.P. Ahlstrøm, J.L. Davis, J. de Juan, G. Ekström, R. Forsberg, G.S. Hamilton, S.A. Khan, M.L. Andersen, L. Stearns and L. Stenseng. 2007. Short-time-scale variations in flow speed and behavior, Helheim Glacier, East Greenland. AGU Fall Meeting 2007. 10-14 December, 2007. San Francisco, U.S.A., American Geophysical Union. Eos Trans. AGU, 88(52), Fall Meet. Suppl. Abstracts, C13A-08.
15. van As, D. and A.P. Ahlstrøm. 2007. A Long-Term Network of Automatic Weather and Ice Monitoring Stations in the Ablation Zone of the Greenland Ice Sheet. AGU Fall Meeting 2007. 10-14 December, 2007. San Francisco, U.S.A., American Geophysical Union. Eos Trans. AGU, 88(52), Fall Meet. Suppl. Abstracts, C11A-0084.

Reports

2014

1. Andersen, S.B., Ahlstrøm, A.P., Andersen, M.L., Box, J.E., Citterio, M., Colgan, W.T., Fausto, R., van As,D., Forsberg, R., Skourup, H., Sørensen, L.S., Kristensen, S.S., Dall, J., Kusk, A. & Petersen, D. 2014: PROMICE 2013. Report from the 2013 operational phase of the Programme for Monitoring of the Greenland Ice Sheet. Danmarks og Grønlands Geologiske Undersøgelse Rapport. 2014/57. GEUS, 72 pp.
2. Smidt-Jensen, T. 2014, Area changes of Greenland marine terminating glaciers, Master Thesis KU
3. Antoft, J. A. 2014, Studying surface melt area on the Greenland ice sheet, 2001-2014, Master Thesis IGN

2013

1. Ahlstrøm, A.P., Sharp, M. 2013: The Dynamics and Mass Budget of Arctic Glaciers. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2013/14, 72 pp.
2. Ahlstrøm, A.P., Tijm-Reijmer, C. & Sharp, M. 2013: The Dynamics and Mass Budget of Arctic Glaciers. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2013/3, 83 pp.
3. Andersen, S.B., Ahlstrøm, A.P., Andersen, M.L., Box, J.E., Citterio, M., Fausto, R., Machguth, H., van As, D., Edelvang, K., Forsberg, R., Skourup, H., Sørensen, L.S., Kristensen, S.S., Dall, J., Boncori, J.P.M. & Petersen, D. 2013: PROMICE 2011-12. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2013/54, 82 pp.
4. Larsen, S. H., 2013, Surface mass and energy balance at A.P. Olsen Ice Cap (NE Greenland), Master Thesis.

2012

1. Andersen S.B. L.M. Andreassen, M. Citterio, R. Forsberg, J.O. Hagen, T. Heid, S.M. Hvidegaard, P. Jansson, T. Johanneson, J. Kohler, H. Machgut, L.S. Sørensen. 2012. Interrim report on current changes of land ice in the Arctic/N-Atlantic region –Report from the Nordic centre of excellence SVALI, October 2012
2. Citterio M., and A.P. Ahlstrøm. 2012. Evaluation of the future hydropower potential, Qasigiannguit area, West Greenand. Technical report
3. Jóhannesson, T., G. Adalgeirsdottir, A. Ahlstrøm, L.M. Andreassen, S. Beldring, H. Björnsson, P. Crochet, B. Einarsson, H. Elvehøy, S. Gudmundsson, R. Hock, H. Machguth, K. Melvold, F. Pálsson, V. Radic, O. Sigurdsson and T. Thorsteinsson. 2012. Hydropower, snow and ice. T. Thorsteinsson and H. Björnsson (eds). Climate Change and Energy Systems - Impacts, Risks and Adaptation in the Nordic and Baltic countries. Copenhagen, Nordic Council of Ministers, 223 pp.

2011

1. Ahlstrøm, A.P., D. van As, M. Citterio, S.B. Andersen, F.M. Nick, P. Gravesen, K. Edelvang, R.S. Fausto, M.L. Andersen, S.S. Kristensen, E.L. Christensen, J.P.M. Boncori, J. Dall, R.

Forsberg, L. Stenseng, S. Hanson and D. Petersen. 2011. PROMICE 2007-2010. Final report for the establishment phase of the Programme for Monitoring of the Greenland Ice Sheet. Danmarks og Grønlands Geologiske Undersøgelser, Rapport 2011/118, 178 pp.

2. Citterio, M., R.S. Fausto and H. Machguth. 2011. Glaciological hydropower feasibility in the Qasigiannguit area, West Greenland: Technical report. Geological survey of Denmark and Greenland, Ministry of Energy and Climate, Copenhagen, Denmark.

2010

1. Ahlstrøm, A.P. 2010. Previous glaciological activities relating to hydropower in Johan Dahl Land, South Greenland. Glaciological investigation. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2010/97, 56 pp.
2. Ahlstrøm, A.P. and M. Sharp (eds). 2010. The Dynamics and Mass Budget of Arctic Glaciers. Extended abstracts Workshop and Glaciodyn meeting, 16-19 Feb 2009, Kananaskis (Canada) IASC Network on Arctic Glaciology. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2010/127, 73 pp.
3. Andersen, S.B. (ed.) 2010. Nordic Glaciology. Abstract from Glaciological Society Nordic Branch Meeting, 28-30 October 2010. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2010/94, 81 pp.
4. Citterio M. and A.P. Ahlstrøm. 2010. GlacioBasis 2008-2009: status report for the glaciological monitoring programme at A.P. Olsen ice cap (Zackenberg, NE Greenland). GEUS technical report, 102 p.
5. Machguth, H., and A.P. Ahlstrøm. 2010. Ice Sheet Surface Mass Balance at Paakitsôq, West Greenland, derived from future scenario regional climate model data. Technical report, Geological survey of Denmark and Greenland, Ministry of Energy and Climate, Copenhagen, Denmark.

2009

6. Ahlstrøm, A.P., D. van As, M. Citterio, S.B. Andersen, F.M. Nick, P. Gravesen, K. Edelvang, R.S. Fausto, S.S. Kristensen, E.L. Christensen, J.P. Merryman Boncori, J. Dall, R. Forsberg, L. Stenseng, S. Hanson and D. Petersen. 2009. PROMICE 2007 - 2008. Status Report for the first two years of the Programme for Monitoring of the Greenland Ice Sheet. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2009/77, 74 pp.
7. Citterio M. and A.P. Ahlstrøm. 2009. Types of ice from the Greenland ice sheet of relevance to the production of bottled water: Technical report. GEUS technical report, 24 pp.
8. Citterio M., R.H. Mottram and A.P. Ahlstrøm. 2009. Glaciological investigations at Malmbjerg, Stauning Alper, East Greenland: Technical report 2008. GEUS technical report, 104 pp. (confidential).
9. Fausto, R.S. 2009. Improving surface boundary conditions for large-scale ice sheet models of Greenland. Ph.D. Thesis
10. Mottram, R., S. Hanson, S.S. Kristensen, A.P. Ahlstrøm, S.M. Hvidegaard, H. Skourup, L.S. Sørensen, J.E. Nielsen and L. Stenseng 2009. Ice sheet surface and basal topography from

radar and lidar, West Greenland. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2009/24, 25 pp.

2008

1. Ahlstrøm, A.P., R. Mottram, C. Nielsen, N. Reeh and S.B. Andersen. 2008. Evaluation of the future hydropower potential at Paakitsoq, Ilulissat, West Greenland. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2008/31, 16 pp.
2. Ahlstrøm, A.P., R. Mottram, C. Nielsen, N. Reeh and S.B. Andersen. 2008. Evaluation of the future hydropower potential at Paakitsoq, Ilulissat, West Greenland. Technical Report. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2008/37, 50 pp.
3. Citterio M. and R.H. Mottram. 2008. Glaciological investigations at Malmbjerg, Stauning Alper, East Greenland: Field report and results of GPR surveys. GEUS technical report, 50 pp.
4. Mottram R.H and M. Citterio. 2008. Predicted evolution of waste rock deposits on Arcturus Glacier, Stauning Alper, East Greenland: summary report. GEUS technical report, 20 pp.

2007

1. Ahlstrøm, A.P. 2007. Previous glaciological activities related to hydropower at Paakitsoq, Ilulissat, West Greenland. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2007/25, 42 pp.
2. Bergström, S., T. Jóhanneson, G. Adalgeirsdóttir, A. Ahlstrøm, L.M. Andreassan, J. Andréasson, S. Beldring, H. Björnsson, B. Carlsson, P. Crochet, M. de Woul, B. Einarsson, H. Elvehøy, G.E. Flowers, P.L. Graham, G.O. Gröndal, S. Gudmundsson, S. Hellström, R. Hock, P. Holmlund, J.F. Jónsdóttir, F. Pálsson, V. Radic, N. Reeh, L.A. Roald and S. Rogozova. 2007. Impacts of climate change on river runoff, glaciers and hydropower in the Nordic area. Joint final report from the CE Hydrological Models and Snow and Ice Groups, CE-6. Hydrological Service - National Energy Authority, Reykjavík, Iceland, 40 pp.

PROMICE in the public arena

The list below features a list of individual non-scientific public appearances by PROMICE team members in the public arena. The entries describe widely different efforts, ranging from extensive popular papers to brief interviews on the phone, from appearing in BBC World News HARDtalk program to an interview by 7th grade pupils for their school assignment. The list specifically excludes presentations at scientific conferences and scientific publications which are listed elsewhere. The list is intended to document and testify the gravity of the outreach effort in PROMICE.

2014

1. Ahlstrøm, A.P., Andersen, S.B., Van As, D., Citterio, M., Fausto, R.S., Andersen, M.L.& Box, J.E. 2014: PROMICE - monitering af indlandsisen [Foredrag for Minister Rasmus Helveg-Petersen (DK) og Minister Kim Kliesen (GRL), m.fl.]. 20/08-2014, Indlandsisen, nær Qassimiut, Sydgrønland. KEBMIN.
2. Ahlstrøm, A.P. (Interview-person) 2014: DR Nyhederne 18:30. DR1. Ørskov, O. (Journalist).
3. Ahlstrøm, A.P., Andersen, S.B., Andersen, M.L., Citterio, M., Van As, D., Fausto, R.S., Box, J.E., Veicherts, M., Edelvang, K., Forsberg, R. & Petersen, D. 2014: PROMICE - Monitoring of the Greenland Ice Sheet [Presentation for the UNFCCC Expert Review Panel]. 19 March, 2014.
4. Ahlstrøm, A.P. & Larsen, S.H. 2014: Is og klima. 12/06-2014, GEUS. Krebs Skole.
5. Andersen M. L. & Andersen S. B., 2014, Promice Airborne Snapshots of Ice Flow Volume and Iceberg Production in 2007 to 2011. In: PROMICE nyhedsbrev 6. Copenhagen. GEUS, 2 p.
6. Andersen, S. B., 2014. Grønlands indlandsis –hvordan har den det, Munkegaardsskolen, September 2014
7. Box, J., Effects of Ice Sheet Melting, IPCC media forum, Copenhagen, 31 October, 2014
8. Box, J., Changing equilibrium line altitude of the Greenland ice sheet, Norwegian glacier museum 25 year jubilee, Oslo, 21 January, 2015
9. Colgan, W and Machguth H., 2014, Data Rescue: Greenland Sur face Mass Budget Database. In: PROMICE nyhedsbrev 7. Copenhagen. GEUS, 2 p.

2013

1. Ahlstrøm, A.P. & Citterio, M. 2013: Retreating Ice [Website-formidling via PROMICE.org].
2. Ahlstrøm, A.P. 2013: Havspejlet i år 2100 og PROMICE. 21/02-2013, NBI, KU. Frederiksværk Gymnasium.
3. Andersen, S.B. 2013: Warm summer influences measuring data from satellite the winter after. In: PROMICE nyhedsbrev 4. Copenhagen. GEUS, 2 p.
4. Andersen, S.B. 2013: Ice melt closer to normal. In: PROMICE nyhedsbrev 5. Copenhagen. GEUS, 2 p.
5. Box, J.E. (Interview-person) 2013: The Big Picture - Green Report. RT.com [Russian TV]. Hartmann, T. (Journalist). 25/09-2013.
6. Colgan, W.,(Interview-person) 24 Feb 2014. M. Owens (Journalist). Liquid Water Inside Greenland's Ice Sheet: Implications of the Firn Aquifer. Fairfax Climate Watch. (web - 1500 words)

7. Colgan, W.,(Interview-person). 13 Aug 2013. C. Marshall (Journalist) One Greenland melt dynamic may not be as bad as feared. ClimateWire. (web - 800 words)
8. Colgan, W.,(Interview-person) 18 Jul 2013. S. Ogburn (Journalist) Scientists see runoff accelerating the surprising melt in Greenland's interior ice. ScienceWire. (web - 900 words)
9. Colgan, W., (Interview-person) 16 Jul 2013. K. Human (Journalist) Like butter: Study explains surprising acceleration of Greenland's inland ice. NASA. (web - 100 words)
10. Citterio, M. 2013: På sporet af den tabte is. In: PROMICE newsletter 2. København, 2.
11. Fausto, R. S. (Interview person) 2013: Extreems in climate [Hong Kong TV]. August 2013.

2012

1. Ahlstrøm, A.P. 2012: Programmet til overvågning af Indlandsisens massetab. 25 Januar, 2012. København. Selskabet for Arktisk Forskning og Teknologi.
2. Ahlstrøm, A.P. 2012: Overvågningen af indlandsisen. 19 Marts, 2012. GEUS. Baltic Sea Project (UNESCO).
3. Andersen, S.B. 2012: Afbræk af Petermann. Grønlands Radioavis,KNR 17 juli.
4. Andersen, S.B. 2012: Spændende, bekymrende og overraskende. Grønlands Radioavis, KNR 25. juli.
5. Andersen, S.B. 2012: Forsker om chockbilleder fra Grønland: Ingen grund til bekymring 26 juli – Endnu, BT 26 juli 2012.
6. Andersen, S.B. 2012: Ingen grund til panik over varm indlands is. Videnskab.dk 30. juli 2012.
7. Fausto, R.S. 2012: Radio24syv. http://arkiv.radio24syv.dk/video/6997330/3-planet-fra-solen-uge-36-2012
8. Citterio, M. 2012: DR1 TV Avisen: video interview on the July event of surface melt conditions covering most of the Greenland ice sheet
9. Citterio, M. 2012: July 21, 2012 - På sporet af den tabte is. PROMICE newsletter no. 2
10. Citterio, M. 2012: June 6-7, 2012 - Joined experts discussion during the workshop on the future glacier monitoring network of Chilean glaciers and presented "Red glacio-meteorólogica en Groenlandia: The PROMICE Network of Weather Stations in Greenland"
11. Citterio, M. 2012: Lecture on 'Remote sensing of Glaciers of ice and rocks on Disko Island', Dept. of Geography and Geology, University of Copenhagen.
12. Van As, D 2012: Interviewed on climate tipping points by documentary makers for The Weather Channel and many more channels. Potentially 200 million viewers.
13. Van As, D 2012: Interviewed on Greenland climate research by VPRO Dutch television.
14. Van As, D: 2012: Interviewed about the high melt and destroyed bridge in Kangerlussuaq, Sermitsiaq.

2011

1. Ahlstrøm, A.P. (Interview-person) 2011: Danske forskere sikrer bedre klimamodeller. 27 Juni, 2011. Søgaard, J. (Journalist) DR P1 [Radioprogrammet Klima og Miljø].
2. Ahlstrøm, A.P. (Interview-person) 2011: Indlandsisen skrumper med rekordfart. 8 April, 2011. Foghsgaard, L. (Journalist) Weekendavisen - Sektionen Ideer, 4-5.
3. Ahlstrøm, A.P. (Interview-person) 2011: Indlandsisen skrumper med rekordfart. 8 April, 2011. Ritzaus Bureau.
4. Ahlstrøm, A.P. (Interview-person) 2011: Deadline 22:30 Indlandsisen skrumper med rekordfart. 9 April, 2011. Martin Breum (Journalist) Danmarks Radio DR2, 5:40 minutter.

5. Ahlstrøm, A.P. (Interview-person) 2011: Indlandsisen skrumper med rekordfart. 9 April, 2011. Ritzau.
6. Andersen, S.B. 2011: Vokser isen på Antarktis? Ingeniøren, 8 oktober, 2011. Ingeniøren, Spørg Scientariet.
7. Andersen, S.B., 2011: Afbræk af Pine Island Glacier, Antarktis. DR-radioavisen, 4. November.
8. Edelvang, K., A.P. Ahlstrøm og S.B. Andersen. 2011: Indlandsisen smelter og så stiger havet. Kronik i Ingeniøren, 04. november 2011
9. Fausto, R.S. 2011: Ismålinger skal forbedre klimaberegninger. Videnskab.dk

2010

1. Ahlstrøm, A.P. 2010: PROMICE - Freezing the retreat of ice. International Innovation Magazine. Research Media. International Innovation Magazine - Featured Project, 90-92.
2. Ahlstrøm, A. P. 2010: Climate Change Effects - the Danish Monitoring Programme for the Greenland Ice Sheet [Foredrag for UN-FCCC delegation - review af Danmarks 5. indberetning]. 23. juni, 2010. Copenhagen. Energistyrelsen.
3. Ahlstrøm, A.P. 2010: PROMICE - Status for overvågningen af Grønlands indlandsis [Foredrag for ansatte på Geocenter Danmark]. 10. maj, 2010. København. GEUS.
4. Ahlstrøm, A.P. 2010: Overvågning af Indlandsisen i praksis [Demonstration for Klima og Energiminister Lykke Friis, Departementschef Thomas Egebo, DMU Direktør Henrik Sandbech, Rektor ved Aarhus Universitet Lauritz B. Holm-Nielsen, m.fl., 17. august, 2010].
5. Ahlstrøm, A.P. 2010: PROMICE - Overvågningsprogrammet for Grønlands Indlandsis. 07 december, 2010. København. GEUS.
6. Ahlstrøm, A.P. (Interview-person) 2010: Gigantisk isflage er brækket løs i Grønland. 11. august, 2010. Hvilsom, F. (Journalist) Politikens netavis.
7. Ahlstrøm, A.P. (Interview-person) 2010: Kæmpe isbjerg knækker af Petermann Gletsjeren. 7. august, 2010. Kaldan, J. (Journalist) DR Radioavisen 12-nyhederne.
8. Ahlstrøm, A.P. (Interview-person) 2010: Hvorfor bliver sne tungere i tøvejr? Vestergård, G.L. (Journalist) Videnskab.dk.
9. Ahlstrøm, A.P., S.B. Andersen, D. van As, M. Citterio and R.S. Fausto. 2010: PROMICE - Klima og Energiministeriets overvågningsprogram for indlandsisen [Foredrag for Klima og Energiminister Lykke Friis, Departementschef Thomas Egebo, DMU Direktør Henrik Sandbech, Rektor ved Aarhus Universitet Lauritz B. Holm-Nielsen, m.fl., 18. august, 2010].
10. Ahlstrøm, A.P., C.S. Andresen, N.N. Pedersen, M. Citterio, S.B. Andersen, D. van as and R.S. Fausto. 2010: GEUS Glaciological Activities in Greenland 2010 and 2011 [Seminar om Indlandsisen for forskere i Københavnsområdet med interesse for Indlandsisen]. 25 november, 2010. DMI.
11. Siewertsen, B., L.T. Pedersen, G. Adalgeirsdottir, K.K. Andersen and A.P. Ahlstrøm. 2010: Orientering om knækket istunge fra Petermann gletsjeren i Nordvestgrønland- RØD. 13/08-2010. Cover - til Klima og Energiminister Lykke Friis.

2009

1. Ahlstrøm, A.P. 2009: Grønlands Indlandsis og klimaet - hvad sker der? Geoviden - Geologi og Geografi 2009 (3), Geocenter Danmark., 8-15.

2. Ahlstrøm, A.P. 2009: Vandkraft i Grønland. Geoviden - Geologi og Geografi 2009 (3), Geocenter Danmark., 16-17.
3. Ahlstrøm, A.P. 2009: Verdensarv - Ilulissat [Undervisningsmateriale til Gymnasierne fra Danmarks Radio - dr.dk/gymnasium].
4. Andersen, S.B. 2009: Hvordan kommer temperaturstigningerne til at påvirke Grønland? In: Ingeniøren, 7. maj, 2009. Ingeniøren, Spørg Scientariet.
5. Ahlstrøm, A.P. 2009: Ice ages and the Greenland Ice Sheet [DIS undervisning af amerikanske college-studerende]. 15 Sep., 2009.
6. Ahlstrøm, A.P. 2009: Klimaprojekt for 7. klasse [Omkring klimaforandringer og indlandsisen. Interview af Line og Signe fra 7.kl., Marbækskolen, Skibby]. 7. dec., 2009
7. Ahlstrøm, A.P. 2009: The Greenland Ice Sheet and Jakobshavn Isbræ in a global warming perspective [Pressebriefing]. 3 July, 2009. Udsendt af Klima og Energiministeriet.
8. Ahlstrøm, A.P. (Interview-person) 2009: Meet the Danes [Optræder som fotostat og med filmklip]. COP15. 7-18 December, 2009. Copenhagen, Denmark. Udenrigsministeriet.
9. Ahlstrøm, A.P. (Interview-person) 2009: Greelands Ice Sheet Melting Faster Than Ever. 13-NOV-09. Seidler, C. (Journalist) Spiegel Online International.
10. Ahlstrøm, A.P. (Interview-person) 2009: Greenland's glaciers under threat from climate change. Allagui, S. (Journalist), AFP.
11. Ahlstrøm, A.P. (Interview-person) 2009: Grönlands Eisschild ist ein erwachender Riese. Seidler, C. (Journalist), Spiegel Online Wissenschaft [http://www.spiegel.de/wissenschaft/natur/0,1518,634515,00.html].
12. Ahlstrøm, A.P. (Interview-person) 2009: Grönlands Eisschild schmilzt so schnell wie nie. 13 Nov. 2009. Seidler, C. (Journalist) Spiegel Online Wissenschaft.
13. Ahlstrøm, A.P. (Interview-person) 2009: Grønlandsk klimasucces for Hedegaard - Klimaministre skal lære af gletsjer. Springborg, S.(Journalist), Berlingske - Web-TV.
14. Ahlstrøm, A.P. (Interview-person) 2009: HARDtalk on the road. Sackur, S. (Journalist), BBC World News – HARDtalk.
15. Ahlstrøm, A.P. (Interview-person) 2009: The Greenland Ice Sheet Is an Awakening Giant. Seidler, C. (Journalist), Spiegel Online International [http://www.spiegel.de/international/world/0,1518,634629,00.html].
16. Ahlstrøm, A.P. (Interview-person) 2009: Verdensarv - Gletsjeren 1. Munk, A. (Journalist), DR AKtualitet Web. [http://www.dr.dk/Undervisning/verdensarv/dk_verdensarv/20090827163444.htm?play=%2FForms%2FPublished%2FPlaylistGen.aspx%3Fqid%3D1120057].
17. Ahlstrøm, A.P. (Interview-person) 2009: Verdensarv - Is fortæller om fortiden! Munk, A. (Journalist), DR Aktualitet Web [http://www.dr.dk/Undervisning/verdensarv/dk_verdensarv/20090827163444.htm?play=%2FForms%2FPublished%2FPlaylistGen.aspx%3Fqid%3D1120056].
18. Ahlstrøm, A.P. (Interview-person) 2009: Verdensarv - 12 km is!. Munk, A. (Journalist), DR Aktualitet Web [http://www.dr.dk/Undervisning/verdensarv/dk_verdensarv/20090827163444.htm?play=%2FForms%2FPublished%2FPlaylistGen.aspx%3Fqid%3D1120057].
19. Ahlstrøm, A.P. (Interview-person) 2009: Vores land i forandring. Nyborg, K. (Journalist), KNR.
20. Andersen, S.B. (Interview-person) 2009: Ugens Spørgsmål: Hvorfor stiger verdenshavene? (5) 30. jan., 2009. Ingeniøren, 2.

2008

1. Ahlstrøm, A.P. 2008: A new programme for monitoring the Greenland Ice Sheet [Gæstelærerforedrag i kursus for amerikanske studerende]. University of Washington.
2. Ahlstrøm, A.P. 2008: Den levende indlandsis [Webpræsentation P1 Natursyn. Tilrettelægger: Line Friis Møller].
3. Ahlstrøm, A.P. (Interview-person) 2008: Den levende indlandsis. Møller, L.F. (Journalist) DR-P1 Natursyn.
4. Ahlstrøm, A.P. (Interview-person) 2008: Grønland smelter - en grøn ø i fremtiden. Lykke, K. (Journalist) Kanal København.
5. Ahlstrøm, A.P. (Interview-person) 2008: Verdt å vite spesial Grønlandsisen litt for lang. Tarjem, G. (Journalist) NRK (Radioprogram), 31. december, 2008.
6. Andersen, S.B. 2008: Hvorfor er gletschere blå? Ingeniøren, "Spørg Scientariatet", 2. februar, 2008.
7. Andersen, S.B. 2008: Hvorfor stiger verdenshavene, når isen smelter? Ingeniøren, "Spørg scientariet" - webside, 4. december, 2008.
8. Andersen, S.B. 2008: Var den lille istid global? Ingeniøren, "Spørg Scientariet", 13. juni 2008 nr. 24.

2007

1. Ahlstrøm, A.P. 2007: Indlandsisen - en forhistorisk kæmpe på rystende ben. 5. oktober, 2007. Krebs Skole, København.
2. Ahlstrøm, A.P. 2007: Indlandsisen - en forhistorisk kæmpe på rystende ben. 21 marts, 2007. Taarbæk Skole. Taarbæk Kulturforening.
3. Ahlstrøm, A.P. 2007: Indlandsisen - en forhistorisk kæmpe på rystende ben. 10. oktober, 2007. Frederikssund. AOF Frederikssund.
4. Ahlstrøm, A.P. 2007: Indlandsisen - en forhistorisk kæmpe på rystende ben. 2. november, 2007. København. Institut for Geografi og Geologi, Københavns Universitet.
5. Ahlstrøm, A.P. (Interview-person) 2007: Interview 27. april, 2007. Madsen, K. (Journalist) DR P1 Miljømagasinet.
6. Ahlstrøm, A.P. (Interview-person) 2007: Det underlige vejr. 20 marts, 2007. Borenhoff, P. (Journalist) Det Grønne Område, Forsiden, 2. sektion.
7. Ahlstrøm, A.P. (Interview-person) 2007: Glacier retreat in Greenland - new islands appear. Latham, H. (Journalist) BBC World Service Newshour.
8. Ahlstrøm, A.P. (Interview-person) 2007: Globale klimaforandringer og Indlandsisen [Filmet interview - Skoleprojekt]. 14 marts, 2007.
9. Ahlstrøm, A.P. (Interview-person) 2007: Grønland smelter - Danmark drukner. 17 april, 2007. Rasmussen, R. (Journalist) DR1 TV-Avisen.
10. Ahlstrøm, A.P. (Interview-person) 2007: Grønlands klimabombe under lup. 11 marts, 2007. Andersen, P. (Journalist) Berlingske Tidende, Magasin s. 22.
11. Ahlstrøm, A.P. (Interview-person) 2007: Havene stiger hurtigere end tidligere antaget. 17 april, 2007. Johansen, L. & Eggen, A. (Journalister) DR2 Deadline.
12. Ahlstrøm, A.P. (Interview-person) 2007: Indlandsisens bidrag til det globale havniveau [Telefoninterview - Skoleprojekt]. 14 marts, 2007.

13. Ahlstrøm, A.P. (Interview-person) 2007: Interview om Jakobshavn Gletscher og PROMICE overvågningen af indlandsisen. 26. juni, 2007. TV2 News.
14. Ahlstrøm, A.P. (Interview-person) 2007: Isbjergfabrikken går amok. 3. februar, 2007. Pedersen, M. (Journalist) Ekstrabladet.
15. Ahlstrøm, A.P. (Interview-person) 2007: Løft til Polarforskningen. 18. januar, 2007. Høxbroe, A. (Journalist) DR Radioavisen.
16. Ahlstrøm, A.P. (Interview-person) 2007: Ny ø i Østgrønland. Strøm, J. (Journalist) KNR Grønlands Radio.
17. Ahlstrøm, A.P. (Interview-person) 2007: Polarforskning. 18. januar, 2007. Bo, A. (Journalist) TV2 Nyhederne.
18. Ahlstrøm, A.P.(Interview-person) 2007: Gennembrud af isdæmmet sø ved Søndre Strømfjord. 6 september, 2007. Rosing, K. (Journalist) DR Radioavisen.
19. Ahlstrøm, A.P., T.B. Larsen and S.A. Khan (Interview-personer) 2007: Viden Om - Klimaets Kanariefugl [Deltager i programmet]. Marker, A. & Bendtsen, J. (Journalister) DR2 Viden Om.
20. Ahlstrøm, A.P., S.B. Andersen, S. Nielsen, M. Citterio and R. Mottram. 2007: Overvågning af indlandsisen på Grønland. Kulturnatten 2007. 12. oktober, 2007. Geologisk Museum. Kulturnatten 2007 / Geocenteret.
21. Ahlstrøm, A.P., R. Forsberg and P. Gravesen. 2007: PROMICE - et overvågningsprogram for Grønlands indlandsis [Orienteringsmøde/workshop]. 26. februar, 2007.
22. Ahlstrøm, A.P. and T.B. Larsen (Interview-person) 2007: Spurtende gletschere kan udløse jordskælv. Willumsen, G. (Journalist) MiljøDanmark 1/2007, 34-37.
23. Ahlstrøm, A.P. and T.B. Larsen (Interview-personer) 2007: Natursyn - Indlandsis på skrump. 24 februar, 2007. Olesen, J. (Journalist) Danmarks Radio P1.
24. Ahlstrøm, A.P. and J.C. Yde (Interview-personer) 2007: Indlandsisen forsvinder. 6 marts, 2007. Steen, M. (Journalist) MetroXpress, 30-31.
25. Ahlstrøm, A.P., R. Forsberg and P. Gravesen (Interview-personer) 2007: Usikker på isen. 2 marts, 2007. Vestergaard, F. (Journalist) Weekendavisen, s. 6.
26. Thomsen, H.H., A. Ahlstrøm, T. Larsen and O. Bennike. 2007: Is i opbrud [Oplevelsesarrangement under Kulturnat København]. 12. oktober 2007. Geologisk Museum, København.

Appendix C –Minutes from PROMICE advisory group meeting

May 09-2014, 10-12.

Present: Dorthe Petersen (ASIAQ), René Forsberg (DTU), Christine Schøtt Hvidberg (KU), Peter Lang Langen (DMI), Ruth Mottram (DMI), Jason Eric Box (GEUS), Signe Bech Andersen (GEUS), Michele Citterio (GEUS), Andreas Peter Ahlstrøm (GEUS), Dirk van As (GEUS)

Apologies from: Karen Edelvang (GEUS), Aslak Grinsted (KU), Dorthe Dahl-Jensen (KU), Søren Rysgaard (GNRI), Peter Schmidt Mikkelsen (GNRI), Louise Sandberg Sørensen (DTU)

Agenda:

1. PROMICE Status
2. 5 min presentation from members
3. Discussion of PROMICE
4. Discussion of collaborative activities

Meeting minutes:

10:10-10:15 SIBA: Welcome
10:15 SIBA: PROMICE status
PROMICE goal: assess the mass loss using the budget method

- Presentation of DVA's observationally based melt product
- Dynamic mass loss estimated using DTU flights, velocity maps from Ian Joughin (NASA MEASURES progam) and RCM SMB from Xavier Fettweis using MAR
- GPS-tracking of outlet glaciers (RF comment: these are really important for many researchers, maybe develop airdrop versions)
- Mapping of local glaciers presented, plan to have updated area-change assessment. The ice mask produced is being utilized by the research community
- Related current projects listed (GlacioBasis, GAP, ESA_CCI, CryoClim, SVALI, IceLid, Refreeze) (RM comment: HARMONIE developers at DMI are very interested in observations to validate model results)
- Status 2013-2014 presented (long list on powerpoint)

Advisory Group contributions:

CSH (KU): First time at this meeting for me and my thoughts may seem somewhat preliminary. PROMICE is good because it provides in situ data, important for validation of RCM output and remote sensing. Even if satellite data has revolutionized our field, we still require in situ validation. From IPCC AR5 report we see that even in chapters on observations, climate model output is presented – so we really need real observations and observationally-based products. I read your recent PROMICE report and looked at the recent addition of a surface temperature map based on observations which is an important addition.

Likewise the observationally based albedo-product is very important. Personally, I would like to see PROMICE expand into the interior parts of the Greenland Ice Sheet with more AWS. An AWS at EastGRIP by 2015 would be a good point of collaboration between PROMICE and KU/CIC. We will have a single season at Renland icecap. I looked at the airborne survey, using the results as a flux gate requires good knowledge of what goes on beyond the flux gate towards the actual margin. The satellite-based velocity product is also very nice and extremely useful for glaciological applications. For example, CIC would like to examine the flux variations in the interior of the NE Greenland ice sheet – a big question is how dynamic changes will propagate inland. Looking at longitudinal strain-rates causing changes inland is important and made possible by these airborne measurements. Maybe do two flight lines in parallel and/or drainage basins. Time lapse cameras provide interesting new information on calving dynamics. (JEB comment: we should try to get funding for the time lapse cameras, as the initial funding has expired). Time-lapse images give a whole new type of information.

PLL (DMI): My experience with PROMICE – we've used data for model evaluation of HIRHAM5, e.g. over the Nuuk area (shows figures on powerpoint). Seeing how the model performs is important and is really valuable as you can see where the model needs to be changed as the answer is available at the AWS sites. DVA has been very quick and responsive and has provided exactly what was needed in terms of data formats. Data would be even easier to use if it was "cleaned" and made even more useful for modellers who are not always in a position to check the more "raw" data that may have issues with sensors and other things. Would be good to provide a standard "clean" product (JEB comment: we discussed this, and I did this for GC-Net by setting a quality flag so the user can decide what data to use, e.g. a flag would tell where the air temperature would be influenced by solar heating, etc.: we could develop a quality flag for PROMICE data as well). Better have PROMICE experts do the cleaning than users.
PolarPortal: experience from the PolarPortal work has been positive, but I have been unsure what part of the GEUS-stuff has been of PROMICE origin – that should be made more clear on the portal so that PROMICE gets advertised better. I would like to see that the PROMICE AWS-data would be more visible on the PolarPortal site. To somehow make the AWS data more available on the PolarPortal to get the information out to the public even more. AWS data is so much more concrete than model output and much easier for the layman to understand and relate to – we should develop some way of making it more visible – ideas have already been put forward and we should work on this (SIBA, DVA, JEB, MCIT comment: we must take care that the AWS time coverage is very short, so we need to make clear how these data relates to longer time series, so that users are not mislead by recent variability). (CSH: is there a check on the users of PolarPortal: answer JEB: yes we have information gathered by Google Analytics, but detailed analysis of this has not been done yet – but we may also actively define who our audience by shaping the content). (CSH: you could copy the way the passive microwave melt-product has become visible in the public, JEB: we are working on defining expected news that we can push).

RM (DMI): I want to repeat that the products I receive from DVA has been extremely useful and easy to use. I have not downloaded from the website though. I have been tweeting about PROMICE output. Maybe you should push using social media more, although organizations are not always supportive of this. You could use your beautiful pictures to push info. The new icemask product is very useful for the community. The PROMICE AWS data could of course be good to have inside the ECMWF system, but is also really good to have *outside* as it is then extremely useful for validation. From outside it seems that the Copenhagen-people are seen as a common “unit” – seen as a “supergroup” in a sense – and we are not seen as scientists from different institutions, we should use this and promote each other’s results and products (JEB: how do we do better collaborate/work together). RM: the modellers meeting Tuesday morning at NBI is a useful place/time to meet regularly on a semi-weekly basis. (JEB: how do we better unify CPH glaciology?)

RF (DTU): We have success in supporting each other in larger proposals and project applications to have broad CPH participation. (showing ESA_CII as a case of collaboration – ESA CCI products could just as well be marketed as National Danish products, not just ESA products). In CPH we have a lot of strong sides that we can and do combine. The new icemask is very important for the science community – it is important to have the final product out and available to everyone. It is important to carry out the airborne data collection even if the US teams do a lot of flying too. It might be useful to think in the GNET and how to collaborate from the PROMICE side. About PROMICE: what is the authorative body addressing mass change of the Greenland Ice Sheet? This should be PROMICE, thinking in the Greenland Government as well as ASIAQ. AWS are a very important asset for PROMICE. In DK we have a complete portfolio of methods with partner collaboration (DMI, DTU, GEUS, KU/NBI,…). Coordinate/use ESA ice_sheets and NASA IceBridge data. Use PROMICE to keep national know-how “sharp” (e.g. flights, UAVs, in-situ work). The UAV’s should be looked into as a possible platform for doing science. Integration with models is essential and the recent work on PolarPortal is extremely timely strengthening the GEUS-DMI collaboration. (DVA: how can we best make data useful, CSH: make it immediately useful to modellers)

CSH: we have recently started an effort to collect high-elev shallow cores to assess last 20 years of accumulation; collaboration on EastGRIP would be useful with a AWS.
SIBA: to RF: how do you propose we can provide an authorative number together? RF: with support from Morten Skovgaard Olsen you might have strong position…CSH: Maybe with the SWIPA report? SIBA: it is an international thing..RF: the IMBIE process was very useful and decided from the top (Tom Wagner and Mark Doherty) and PROMICE could collect results and provide a best estimate along those lines? DVA: let us have a 5-page combined report annually showing the results…RF: here the PolarPortal is a good platform…SIBA: polarportal is a good starting-point, part of the PROMICE reporting to the ministry could be such a short strong summary. JEB: thinks we should do a National Danish type of “Arctic Report Card” because we have all the competences here – we don’t need external input, it could be externally reviewed and then become citable which is essential, must be ISI-tracked. The GEUS bulletin is btw ISI-tracked. SIBA: thinks this is a good idea that we should push. JEB: I should make space for this work.
RF: How does the Greenland-side look at this (to DOP).

DOP (ASIAQ): We have improved a lot on the collaboration over the years, the workshop type of collaboration is very useful (research visit to GEUS). Coordination of activities is important, especially when it comes to field instrumentation and sites. Q for DVA: how do you plan to test you product? DVA answer: we need discharge data for that. Discussion of results are very important, especially so you know about and understand the data you work with (e.g. the discharge). It is important that you state detailed information about the data you give out, as the users often take data as absolute truth. Even if it is very time consuming, data must be thoroughly checked. More collaboration with ASIAQ is possible on the technical side of the AWS and the station visits, using the knowledge at ASIAQ to improve PROMICE AWS operation. (SIBA comment: good that a PROMICE-type AWS is being deployed at Kobbefjord now, to easier share knowledge). (RF: we have a similar thing between DTU and ASIAQ on permanent GPS-stations in towns). Maybe ASIAQ could visit e.g. the NUK site (DVA comment: we would always need 1 person from GEUS to stay on top of things, this year an ASIAQ person is coming along).

Programme for Monitoring of the Greenland Ice Sheet

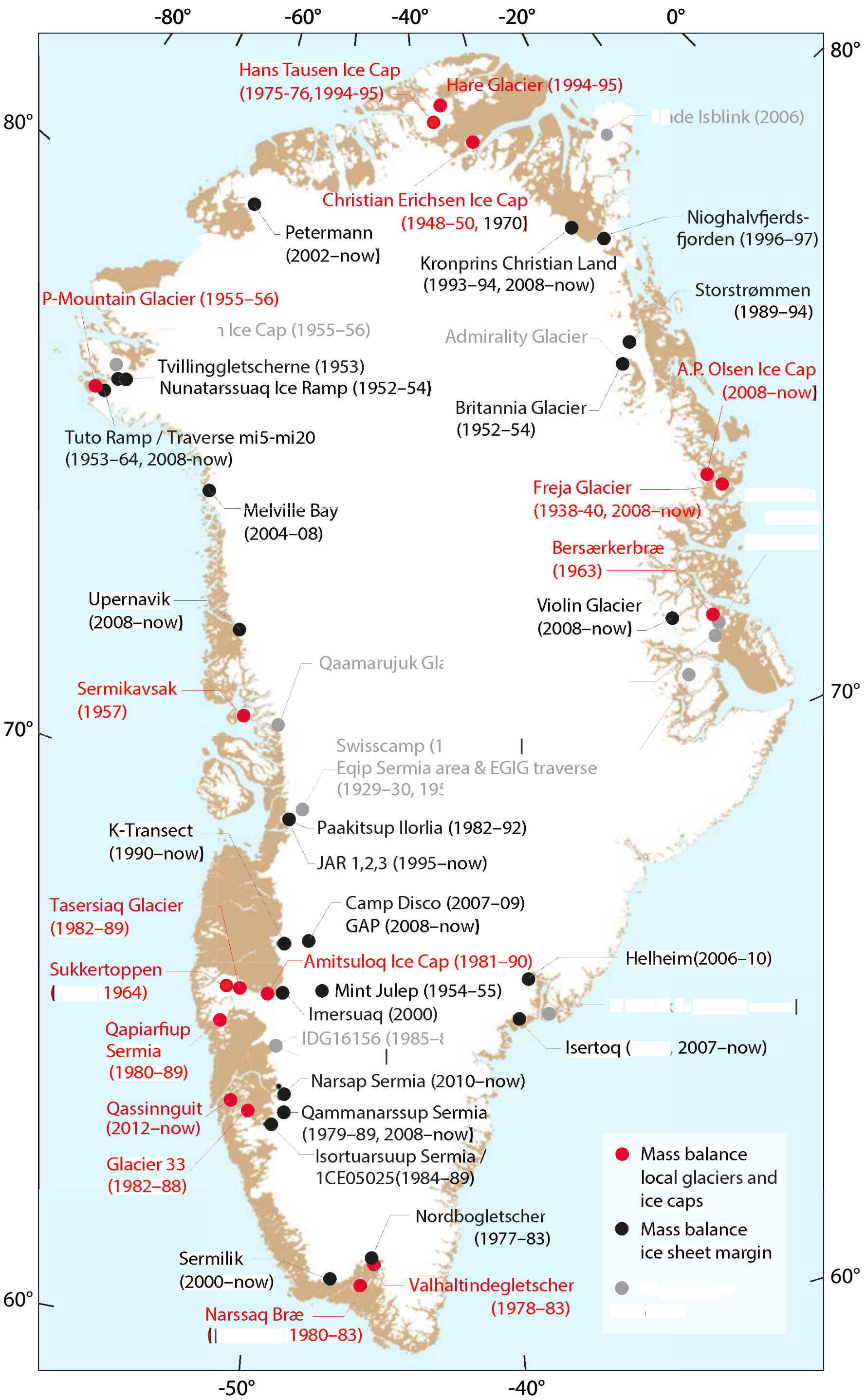
No 7 • 2014

Data Rescue: Greenland Surface Mass Budget Database

Extensive work rescuing old surface mass budget data is nearing completion and resulting in a new unique database with measurements from the Greenland ice sheet and peripheral glaciers

Surface mass budget, the net gain or loss of ice at a location, is an important indicator of ice sheet health. Two thirds of the Greenland ice sheet's current mass loss stems from its surface mass budget with iceberg production accounting for the remaining mass loss. The focus of PROMICE is maintaining a network of automated climate stations in the ice sheet melt area to observe surface mass budget. This network of climate stations is now observing surface mass budgets in eight regions of the ice sheet. The systematic collection of such observations is vital for the calibration and evaluation of regional climate models that simulate surface mass budget, and its change through time, across all of Greenland.

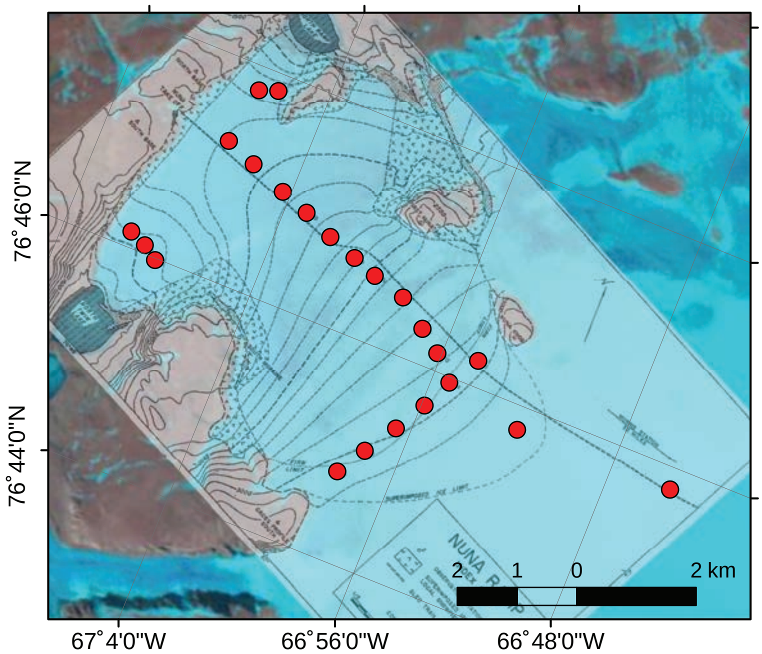
The most comprehensive surface mass budget model inter-comparison to date revealed a dramatic asymmetry in the calibration and evaluation data available in the ice sheet accumulation and melt areas[1]. Ice cores provide continuous surface mass budget records, over 3000 observation years across 100 sites were available in the accumulation area. By contrast, due to the necessity of repeated visits to measure annual melt, only 100 measurements from one single site were available in the melt area. Naturally, far more observations have been collected in the melt area throughout the history of Greenland glaciology research. A secondary focus of PROMICE has therefore been assembling historical surface mass budget observations



Map of the location and temporal description of the Greenland melt area and local glacier surface mass budget observations contained in the database.

K. Rodahl and H. Ahlmann measuring surface mass budget stakes on Freja Glacier during a 1939 Swedish expedition [2].

Example of geo-referencing a published map, from Nunatarssuaq in Northwest Greenland [3]*, to obtain stake coordinates.*



from the ice sheet melt area and surrounding local glaciers into a systematic database.

With valuable surface mass budget observations fragmented across studies, most of which are pre-digital or unpublished, or both, these historical data were effectively inaccessible to the global research community. Over the past five years, PROMICE has been digitizing field reports, reconstructing geographic site coordinates, and assessing data quality levels to assemble a database. Institutional knowledge, in the form of long-time GEUS glaciologists Anker Weidick and Henrik Højmark Thomsen, was crucial for knowing "where" and "when" to look for observations, and "how" to interpret and assemble various pieces of information. In collaboration with many partners, both within Denmark and internationally, the PROMICE team is excited to see this data rescue project nearing completion. The database and source documents are the subject of an upcoming scientific publication, and will become openly accessible via the PROMICE website in 2015.

With more than 2400 observations across 36 sites, the new database represents an order-of-magnitude improvement in the melt area and local glacier surface mass budget observations available to the global research community. The earliest surface mass budget observations date to a 1938 expedition to Freja Glacier, Northeast Greenland. Approximately 50 % of the observations have not been published before. Only 13 % of the data already existed in tabulated form, including coordinates. Approximately 60 % of the observations originate from GEUS field expeditions (previously by the Greenland Geological Survey, GGU). As data from several expeditions and campaigns have not yet been located, a possibility still exists to further enlarge the number of available observations. Overall, however, this very comprehensive database addresses a pressing community need for data assimilation and provides a powerful tool for understanding the response in Greenland glacier and ice sheet melt to climate over the past century.

[1] Vernon et al. 2013. Surface mass budget model intercomparison for the Greenland ice sheet. *The Cryosphere. 7: 599-614.*

[2] Ahlmann et al. 1942. Studies in North-East Greenland 1939-1940, Part III-IV. *Geografiska Annaler. 24: 1-50.*

[3] Nobles. 1960. Glaciological Investigations, Nunatarssuaq Ice Ramp, Northwestern Greenland. *Cold Regions Engineering and Research Laboratory. Technical Report 66.*

LINKS

http://www.promice.dk
http://nsidc.org/greenland-today/

PROMICE

PROMICE is financed by the Ministry of Climate, Energy and Building through the climate support programme DANCEA (Danish Cooperation for Environment in the Arctic), which is managed by the Danish Energy Agency.

- The purpose of PROMICE is to monitor the mass loss of the Greenland ice sheet, both the melting on the surface and the volume of icebergs discharged into the sea
- PROMICE is headed in Denmark by GEUS in cooperation with DTU Space and Asiaq in Greenland. Furthermore the programme collaborates with the Danish Meteorological Institute and foreign universities and authorities.
- Read more about PROMICE on promice.org, where you can find photos and videos, get direct access to measuring data from the ice sheet and the PROMICE outreach material. On the website you can also subscribe to our newsletter.
- Information can also be found on porlarportal.org a new website where Danish research institutions display the results of their monitoring of the Greenland ice sheet and the sea ice in the Arctic.

Authors
William Colgan, post doc, GEUS, Horst Machguth, post doc, DTU, Andreas P. Ahlstrøm, researcher, GEUS

Editor
Signe B. Andersen, Senior researcher, GEUS

Layout
Henrik Klinge Pedersen, GEUS.

Geological Survey of Denmark and Greenland
Øster voldgade 10
DK-1350 Copenhagen K
Denmark

Technical University of Denmark
Anker Engelunds Vej 1, 101A
DK-2800 Kgs. Lyngby
Denmark

Asiaq
Qatserisut 8, P.O. Box 1003
3900 Nuuk
Greenland

Ministry of Climate, Energy and Building
Stormgade 10–12
DK-1470 Copenhagen K
Denmark

Danish Energy Agency
Amaliegade 44
DK-1256 Copenhagen K
Denmark

Programme for Monitoring of the Greenland Ice Sheet

No 6 • 2014

PROMICE AIRBORNE SNAPSHOTS OF ICE FLOW VOLUME AND ICEBERG PRODUCTION IN 2007 TO 2011

By using airborne ice thickness measurements, the volume of ice flowing to the ocean is calculated.

In the PROMICE project two airborne surveys of the Greenland ice sheet's thickness were carried out, one in 2007 and one in 2011. The surveys followed a route tracing the perimeter of the ice sheet (Figure 1). In addition to advanced GPS equipment for high-precision position observations, the aircraft carried a radar for measuring the bed of the ice sheet and a laser for measuring the surface elevation. Together these two measurements provide ice thickness along the flight path. A single flight campaign takes approximately 10 days using the Dash-6 Twin Otter aircraft (Figure 2).

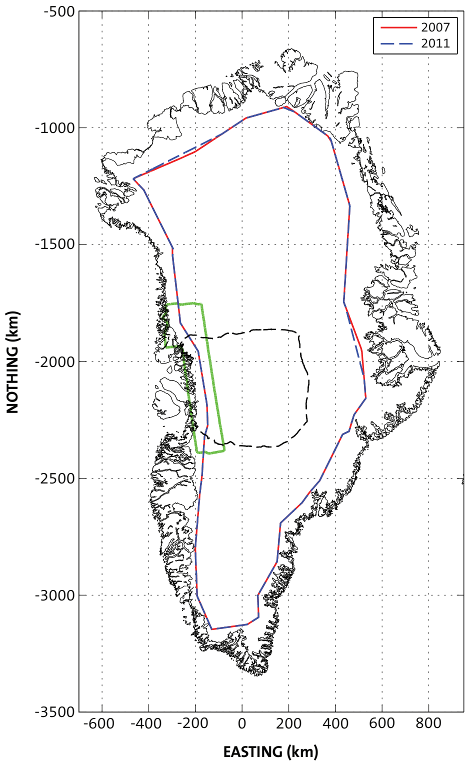


Figure 1. Location of the 2007 and 2011 flight lines. The green line indicates the area where the ice flow speed can be calculated from satellite images. The black dashed line shows the basin where we have calculated the dynamic mass loss.

Figure 2. Twin Otter plane from Air Greenland used for the data collection campaigns in 2007 and 2011. Photo: Lars Stenseng, DTU Space.

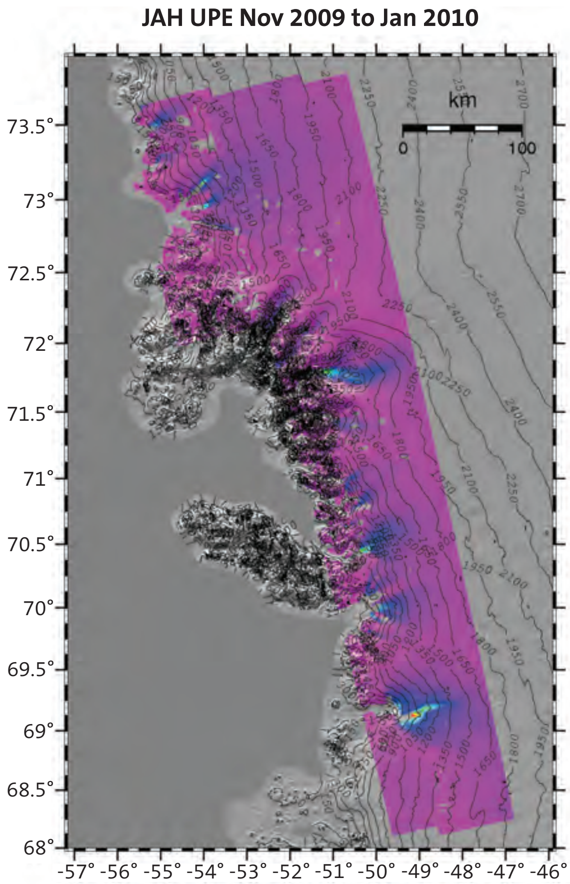
Using ice flow speed data from satellite measurements, thickness data allow us to calculate the amount of ice that flows out from the interior of the ice sheet. On its way to the coast some of the ice melts at the surface and runs off as melt water. What is left becomes icebergs that calve into the ocean from the large outlet glaciers, like Jakobshavn Isbræ on the west coast; the so-called *dynamic* mass loss. Flow speed is calculated from satellite images taken 46 days apart (Figure 3). By identifying the same features in the two images it is possible to calculate how fast, and in which direction the ice is flowing. The amount of ice that is melted at the surface can be estimated from ground data and computer models simulating the climate over longer periods. The difference between these two numbers is then the ice mass that leaves the ice sheet as icebergs.

When working with the mass balance of the Inland ice, it is typically divided into a number of independent basins. In a paper published in Geological Survey of Denmark and Greenland Bulletin later this year, we use this method to compute the volume of ice flowing out of the basin that is home to Jakobshavn Isbræ – the largest glacier in Greenland. The average ice mass flowing out from this catchment in 2007 and 2011 was approximately 70 Gigatonnes[1] per year, equivalent with nearly 10 tons per person on Earth, per year! Not all ice that flows into the ocean contributes to seal level rise, though. Just like some ice is melting along the margin of the ice sheet, some ice is also added by precipitation in the interior, thereby removing water from the oceans. Therefore, when discussing sea level rise, one must consider the total mass budget, where only the net deficit contributes to increasing sea levels.

How the dynamic mass loss is coupled to climate change is not well understood. Therefore it is valuable to investigate further.

Data from the airborne surveys are available by contacting info@promice.dk

[1] 1 Gigatonne = 1,000,000,000 tonnes, or one billion tonnes.



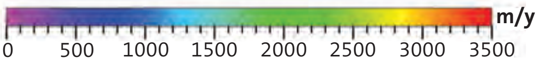


Figure 3. Ice flow speed and direction calculated from satellite images.

LINKS

http://www.promice.dk
http://nsidc.org/greenland-today/

PROMICE

PROMICE is financed by the Ministry of Climate, Energy and Building through the climate support programme DANCEA (Danish Cooperation for Environment in the Arctic), which is managed by the Danish Energy Agency.

- The purpose of PROMICE is to monitor the mass loss of the Greenland ice sheet, both the melting on the surface and the volume of icebergs discharged into the sea
- PROMICE is headed in Denmark by GEUS in cooperation with DTU Space and Asiaq in Greenland. Furthermore the programme collaborates with the Danish Meteorological Institute and foreign universities and authorities.
- Read more about PROMICE on promice.org, where you can find photos and videos, get direct access to measuring data from the ice sheet and the PROMICE outreach material. On the website you can also subscribe to our newsletter.
- Information can also be found on porlarportal.org a new website where Danish research institutions display the results of their monitoring of the Greenland ice sheet and the sea ice in the Arctic.

Authors
Morten Langer Andersen, forsker, GEUS.
Signe Bech Andersen, seniorforsker, GEUS.

Editor
Signe Bech Andersen, senior researcher, GEUS.

Layout
Annabeth Andersen, GEUS.

Geological Survey of Denmark and Greenland
Øster voldgade 10
DK-1350 Copenhagen K
Denmark

Technical University of Denmark
Anker Engelunds Vej 1, 101A
DK-2800 Kgs. Lyngby
Denmark

Asiaq
Qatserisut 8, P.O. Box 1003
3900 Nuuk
Greenland

Ministry of Climate, Energy and Building
Stormgade 10–12
DK-1470 Copenhagen K
Denmark

Danish Energy Agency
Amaliegade 44
DK-1256 Copenhagen K
Denmark

Katabatic winds and piteraq storms: observations from the Greenland ice sheet

Dirk van As, Robert S. Fausto, Konrad Steffen and the PROMICE project team*

In 2007 the Programme for Monitoring the Greenland Ice Sheet (PROMICE) was initiated to observe and gain insight into the mass budget of Greenland ice masses. By means of *in situ* observations and remote sensing, PROMICE assesses how much mass is gained as snow accumulation on the surface versus how much is lost by iceberg calving and surface ablation (Ahlstrøm *et al.* 2008). A key element of PROMICE is a network of automatic weather stations (AWSs) designed to quantify components of the surface mass balance, including the energy exchanges contributing to surface ablation (Van As *et al.* 2013).

The use of these AWS observations is not limited to studies of ice-sheet mass balance. PROMICE contributes to CryoNet (www.globalcryospherewatch.org/cryonet), the core network of surface measurement sites of the World Meteorological Organization (WMO) Global Cryosphere Watch. By real-time delivery through WMO, PROMICE observations contribute to improve both operational forecasting and climate analysis in the data-sparse Arctic. The Greenlandic population, highly dependent on accurate forecasting of weather conditions, benefits directly from these real-time observations. For instance, extreme surface wind speeds are a high-risk element in Greenland. The third-highest wind speed observed at the surface of the Earth (93 m/s or 333 km/h), was recorded in a 8–9 March 1972 storm at Thule in North-West Greenland (Stansfield 1972).

In this paper, we discuss the extent to which the Greenland ice sheet generates its own near-surface wind field. We use PROMICE data to gain insight into the interaction between air temperature, radiation and gravity-driven katabatic winds. We focus on a particularly powerful spring storm in 2013 that contributed to a fatality on an ice-sheet ski traverse attempt (Linden 2013).

Weather stations on the Greenland ice sheet

The original PROMICE network consisted of fourteen AWSs in seven ablation regions of the Greenland ice sheet, with each region monitored by a lower (L) and an upper (U) elevation station (Fig. 1; Ahlstrøm *et al.* 2008). PROMICE has collaborated logistically and financially with other projects in the regions of the TAS, QAS, NUK and KAN stations, leading to the installation of eight additional AWSs. The PROMICE

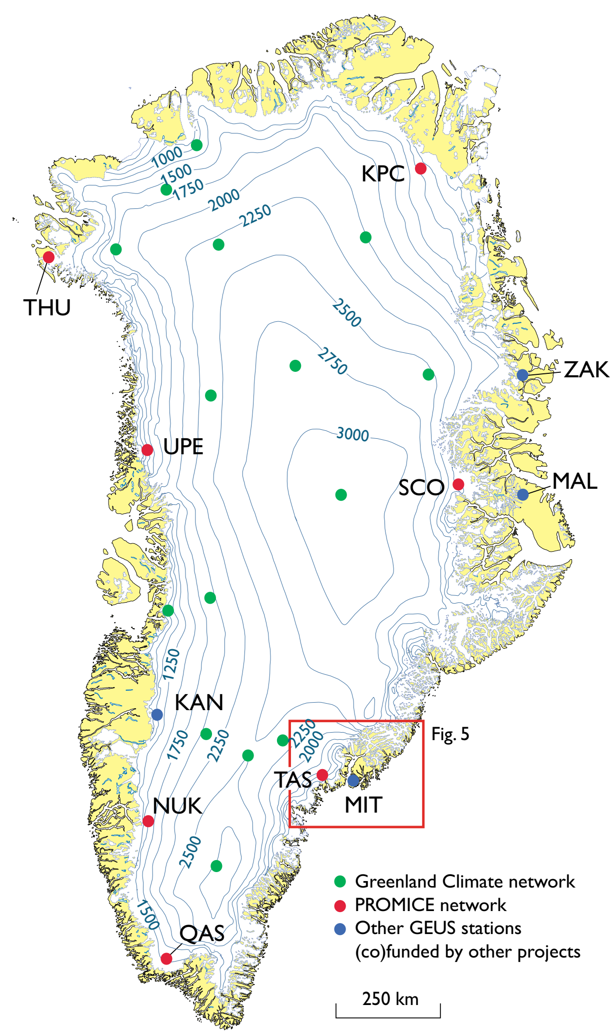


Fig 1. Map of Greenland showing the locations of automatic weather stations on the ice sheet and on local ice caps.

* Andreas P. Ahlstrøm, Signe B. Andersen, Morten L. Andersen, Jason E. Box, Charalampos Charalampidis, Michele Citterio, William T. Colgan, Karen Edelvang, Signe H. Larsen, Søren Nielsen, Martin Veicherts and Anker Weidick

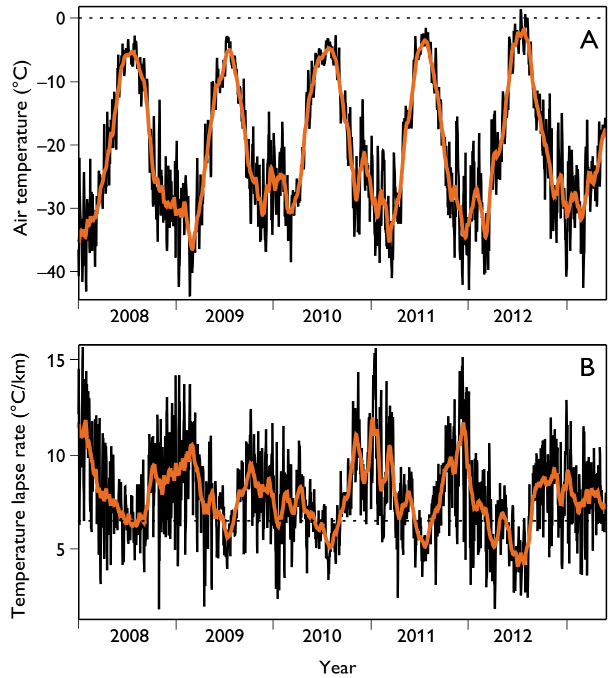


Fig. 2. **A**: Daily average (black) and 31-day average (red) air temperature over the Greenland ice sheet as determined from interpolated weather station observations from the GC-Net and PROMICE network. **B**: Same, but vertical near-surface temperature lapse rates. The dashed line shows a lapse rate of 6.5°C/km above which air masses are increasingly unstable.

AWS sites have been selected to complement the Greenland Climate Network (GC-Net), which chiefly monitors the ice-sheet accumulation area (Steffen *et al.* 1996).

Continuous PROMICE AWS observations include: air temperature (*c.* 2.7 m above surface), barometric pressure, air humidity, wind speed and direction (*c.* 3.1 m above surface) as well as down- and upward solar (shortwave) and terrestrial (longwave) radiation. The AWSs also record temperature profiles in the upper 10 m of the ice, GPS-derived location and diagnostic parameters such as station tilt angles. A pressure transducer and two sonic rangers measure snow and ice-surface height change associated with ablation and accumulation (Fausto *et al.* 2012). All data and metadata including sensor specifications are available at *www.promice.org*.

Here, we use averaged values of air temperature, wind speed and direction, and radiation components. Single wind measurements have an uncertainty of 0.3 m/s and 3° (Van As 2011) and are not adjusted for shifts in tilt, rotation or measurement height as this does not impact the outcome of this study. We also combine GC-Net and PROMICE temperature data to give the most complete observed meteorological depiction of the Greenland ice sheet currently possible. We calculated the daily average near-surface air temperature across the ice sheet between 2008 and 2013 by means of inverse-distance interpolation between as many as 32 AWSs that operated on a given day. We also determined the daily average vertical near-surface air-temperature lapse rate by means of a linear least-squares fit to all available data.

Atmospheric temperature and stability

The average near-surface air temperature over the Greenland ice sheet has a distinct annual cycle with minimum (winter) values between −20°C and −40°C (Fig. 2A). During the relatively short summer, temperatures are often around −5°C and are less variable due to (1) reduced cyclonic activity and (2) surface melting over large parts of the ice sheet. The latter is a moderating factor because near-surface temperatures are limited to near freezing. Since 2008, ice-sheet average air temperatures above 0°C have only been recorded on five days (11–13 and 28–29 July 2012) during which surface melting occurred over nearly the entire ice sheet (e.g. Nghiem *et al.* 2012).

The average near-surface air-temperature lapse rate over the ice sheet exhibits a reversed cyclicity as compared to air temperature with winter values often exceeding a 10°C decrease per vertical kilometre (Fig. 2B). Assuming a textbook value of a 6.5°C/km free-atmospheric lapse rate to be representative

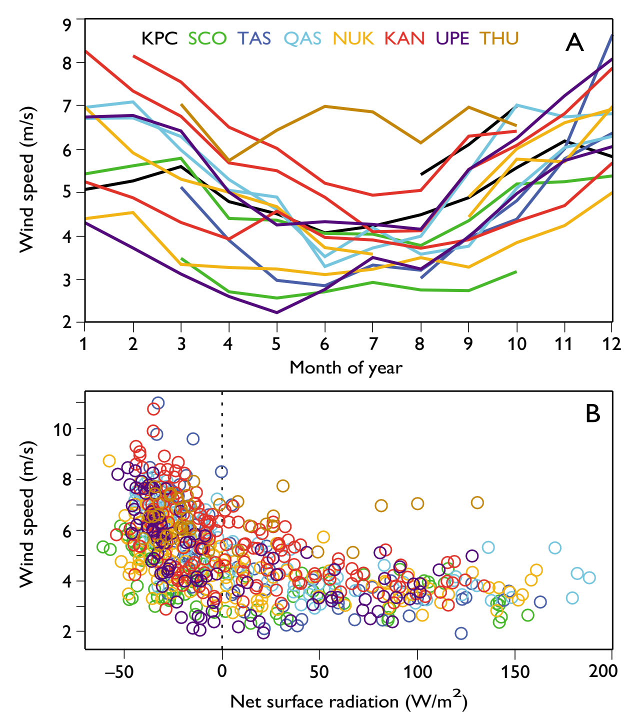


Fig. 3. **A**: The average annual cycle in wind speed at the PROMICE sites. Lines are drawn for each weather station, but only if three years of good data are available. **B**: The monthly average wind speed versus the net (shortwave + longwave) radiation budget. For locations of the stations see Fig. 1.

of the threshold between stable and unstable conditions over Greenland, this suggests that the near-surface atmosphere is commonly less buoyant (denser) at higher elevations than air at lower elevations. In a free atmosphere such a density difference over a few vertical kilometres would trigger an immediate adjustment through convection. Over the large horizontal scale of the Greenland ice sheet, the actual density gradients are roughly two orders of magnitude smaller, which adds insignificantly to the force balance. Figure 2B illustrates that during winter, the high elevation interior of the ice sheet cools more than lower elevation regions near the margin. As a result, the shallow (*c.* 100 m thick) stable atmospheric boundary layer that blankets the ice sheet attains an even larger temperature deficit compared to the free atmosphere at high elevation in winter. The larger this temperature deficit relative to the free atmosphere, the larger the density difference relative to the free atmosphere, and thus the larger the gravitational acceleration of the shallow boundary layer. This katabatic force increases linearly with increasing surface slope.

Katabatic winds

Winds over the Greenland ice sheet are strongest in winter (e.g. Steffen & Box 2001), as observed at every PROMICE AWS (Fig. 3A). While part of this increase is due to lower wintertime pressure and more frequent passage of cyclonic systems, the primary cause of stronger winter winds is surface radiative cooling. This well-known forcing mechanism of katabatic wind is apparent from stronger winds at more negative surface net radiation (Fig. 3B) and the strong correlation between the directions in slope and wind (see below). A negative radiation budget is common during winter due to little or no solar radiation at high latitudes when the upward emission of long-wave terrestrial radiation exceeds downward atmospheric radiation at the surface.

The wind regimes over the ice sheet do differ between regions. Winds are stronger at the higher-elevation AWSs due to the larger radiative cooling of the surface (provided a surface slope is present). The highest monthly-mean wind speed values in Fig. 3B were recorded at KAN_M and KAN_U (1270 and 1840 m a.s.l., red), and TAS_U and TAS_A (570 and 900 m a.s.l., blue).

Piteraq storms

The wind regimes at KAN and TAS are shown in a case study of the 2012/2013 winter (Fig. 4). Figure 4A illustrates that low-wind winter conditions are rare at KAN_U, PROMICE station at highest elevation. Figure 4B shows the dominant katabatic nature of winter winds. Nearly all measurements from KAN_U show the wind to blow from upslope direction (*c.* 90°, east), albeit deflected to the right (*c.* 135°, south-east) by the Coriolis effect due to the Earth's rotation. Typically, wind speeds at TAS_U are lower (but still non-zero) due to the weaker radiative cooling at lower elevation. Katabatic forcing also dominates here, given the persistent non-zero winds originating from the upslope direction of *c.* 0° (north) and more westerly directions due to Coriolis forcing. The major difference between the two data series in Fig. 4 is the frequency of strong wind events exceeding *c.* 20 m/s, which are more common in the TAS region. In the strongest storms, the wind direction pivots towards the regional free-atmospheric flow (Fig. 4B).

These storms are known in Greenland as piteraqs, and build up momentum due to the alignment of katabatic and large-scale (geostrophic) forcing (Oltmanns *et al.* 2014). These notorious storms have repeatedly caused severe damage to the towns such as Tasiilaq. The piteraq on 27 April 2013 (Fig. 4A), which jeopardised a sport expedition on the ice sheet (Linden 2013), was exceptionally strong at TAS_U in the context of the 2008 to 2013 PROMICE observational period, with 10-minute average wind speeds exceeding 42 m/s (150 km/h). During this event, four persons (C. Charalampidis, W.T. Colgan, H. Machguth and D. van As)

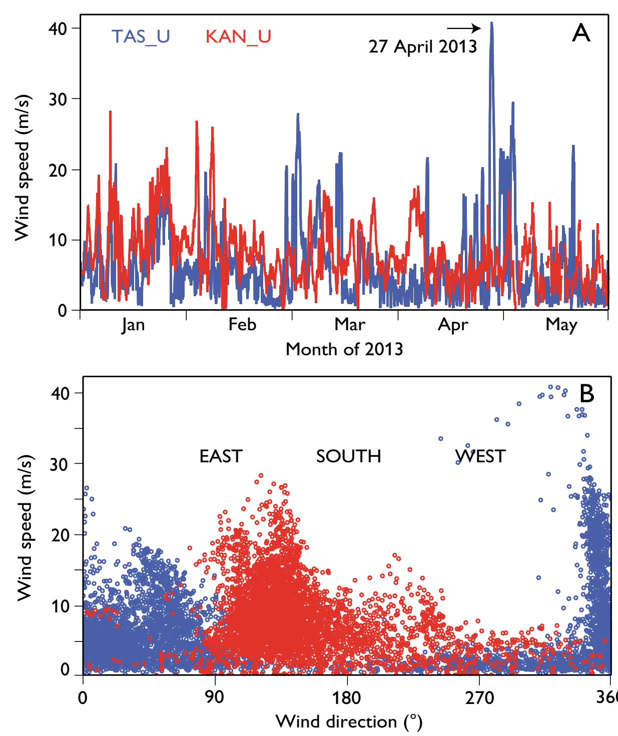


Fig. 4. **A**: Hourly average wind speed at TAS_U and KAN_U weather stations. The piteraq on 27 April 2013 is clearly visible in the TAS_U observations. **B**: Same, but wind speed plotted versus wind direction for the period from October 2012 to May 2013.

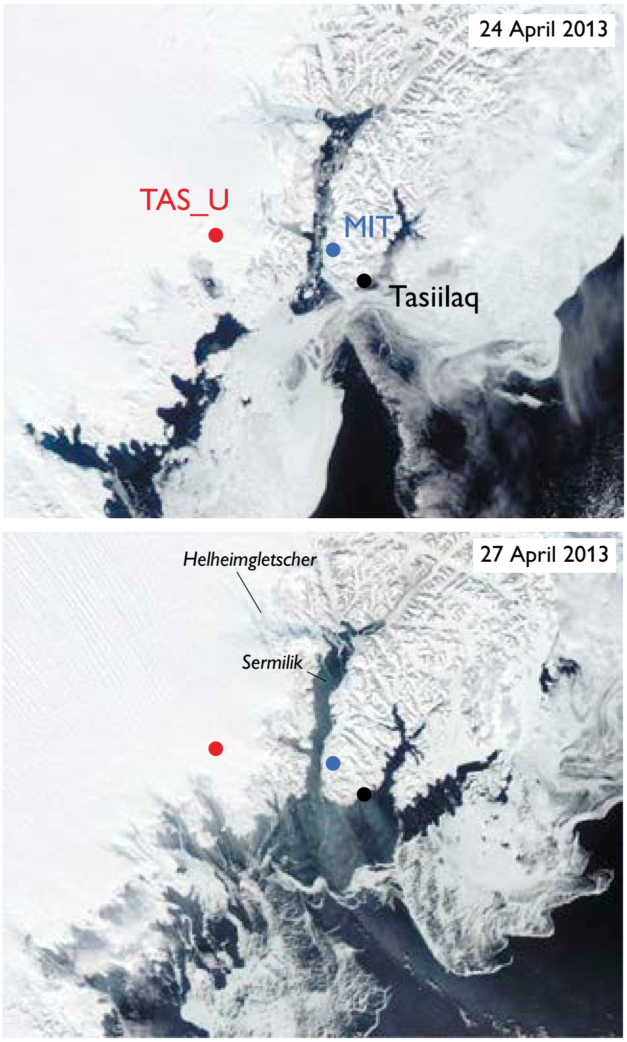


Fig. 5. MODIS satellite images of the Tasiilaq region of South-East Greenland on 24 and 27 April 2013, before and during a strong piteraq event. For location, see Fig. 1.

from the Geological Survey of Denmark and Greenland were in the field at KAN_U, and although they experienced wind speeds approximately one third of those at TAS_U (*c.* 300 km to the east) the white-out and heavy snowdrift yielded conditions too dangerous for them to leave shelter.

Satellite images from the 2013 piteraq event show that a large region was affected (Fig. 5). The striping on the ice sheet in the top left corner of the lower image shows the wind direction with snow transported toward and past the ice sheet margin. Large areas of sea and fjord ice disintegrated, and the 5–13 km wide Sermilik fjord, into which Helheimgletscher calves, was cleared of ice.

Clearly, katabatic winds and especially the piteraqs, have a large impact on the ice sheet and its immediate surroundings. Given increasing commercial activity around the periphery of the Greenland ice sheet, there is a growing impetus for understanding these winds and their response to climate change. Regional atmospheric model projections until the year 2100 suggests that while climate change will likely result in weaker winds in Greenland's flat interior, stronger winds may occur in steeper regions around the ice sheet periphery (Gorter *et al.* 2013).

Acknowledgements

PROMICE is funded by the Danish Ministry of Climate, Energy and Building and is operated by the Geological Survey of Denmark and Greenland. Several weather stations are (co)funded by the Greenland Analogue Project, the REFREEZE project and the Greenland Climate Research Centre.

References

Ahlstrøm, A.P. & the PROMICE project team 2008: A new programme for monitoring the mass loss of the Greenland ice sheet. Geological Survey of Denmark and Greenland Bulletin **15**, 61–64.

Fausto, R.S., Van As, D., Ahlstrøm, A.P. & Citterio, M. 2012: Assessing the accuracy of Greenland ice sheet surface ablation measurements by pressure transducer. Journal of Glaciology **58**(212), 1144–1150.

Gorter, W., van Angelen, J.H., Lenaerts, J.T.M. & van den Broeke, M.R. 2013: Present and future near-surface wind climate of Greenland from high resolution regional climate modelling. Climate Dynamics **42**, 1595–1611.

Linden, M. 2013: Greenland death: how 100 mph ice storms can blow in without warning. The Independent, 1 May 2013. London, UK.

Nghiem, S.V., Hall, D.K., Mote, T.L., Tedesco, M., Albert, M.R., Keegan, K., Shuman, C.A., DiGirolamo, N.E. & Neuman, G. 2012: The extreme melt across the Greenland ice sheet in 2012. Geophysical Research Letters **39**, L20502.

Oltmanns, M., Straneo, F., Moore, G.W.K. & Mernild, S.H. 2014: Strong downslope wind events in Ammassalik, Southeast Greenland. Journal of Climate **27**, 977–993.

Stansfield, J. 1972: The severe Arctic storm of 8–9 March 1972 at Thule Air Force Base, Greenland. Weatherwise **25**, 228–233.

Steffen, K. & Box, J.E. 2001: Surface climatology of the Greenland Ice Sheet: Greenland climate network 1995–1999. Journal of Geophysical Research: Atmospheres **106**(D24), 33951–33964.

Steffen, K., Box, J.E. & Abdalati, W. 1996: Greenland climate network: GC-Net. In: Colbeck, S.C. (ed.): Glaciers, ice sheets and volcanoes: a tribute to Mark F. Meier. CRREL special Report **96-27**, 98–103.

Van As, D. 2011: Warming, glacier melt and surface energy budget from weather station observations in the Melville Bay region of northwest Greenland. Journal of Glaciology **57**(202), 208–220.

Van As, D., Fausto, R.S., Colgan, W.T., Box, J.E. & PROMICE project team 2013: Darkening of the Greenland ice sheet due to the melt-albedo feedback observed at PROMICE weather stations. Geological Survey of Denmark and Greenland Bulletin **28**, 69–72.

Authors' addresses

D.v.A. and others, except K.S., *Geological Survey of Denmark and Greenland, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark.* E-mail: *dva@geus.dk*

K.S., *Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Zürcherstrasse 111, CH-8903 Birmensdorf, Switzerland.*