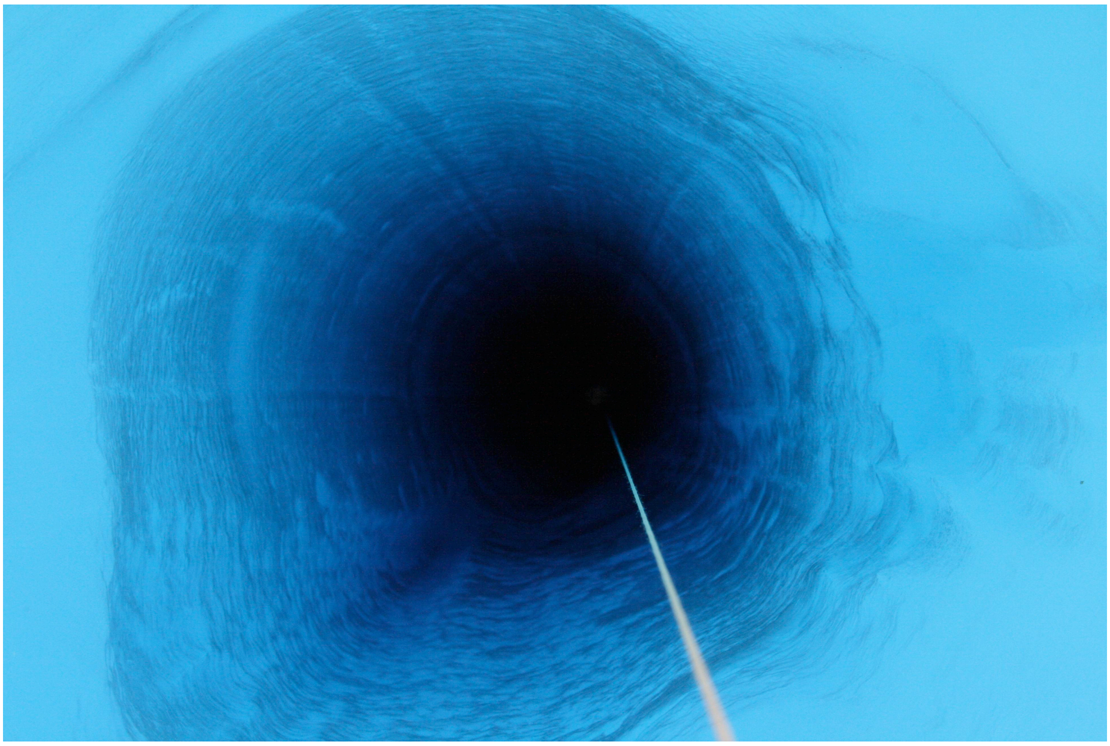
Field report

The installation and maintenance of wireless water pressure sensors and thermistors at Russell glacier, West-Greenland

21 June 2010 – 1 September 2011

Ice2sea work package WP2.2: basal lubrication by surface melt



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Cover image: view into hole 1 after installation of the wireless system

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List of acronyms

AWI	Alfred Wegener Institute, Bremerhaven, Germany
AWS	Automatic Weather Station
GPS	Global Positioning System
IGES	Institute of Geography and Earth Sciences, Aberystwyth University, UK
IMAU	Institute for Marine and Atmospheric Research (Utrecht University)
IPCC	Intergovernmental Panel on Climate Change
KISS	Kangerlussuaq International Science Support
NEEM	North Greenland Eemian Ice Drilling
SHR	location of the experiment experiment, part of the IMAU K-transect at the West-Greenland ice margin
Pt660	Ice Cap Point 660, terminus of the Volkswagen road at the edge of the Greenland ice sheet that starts in Kangerlussuaq

Map of Russell glacier, West-Greenland

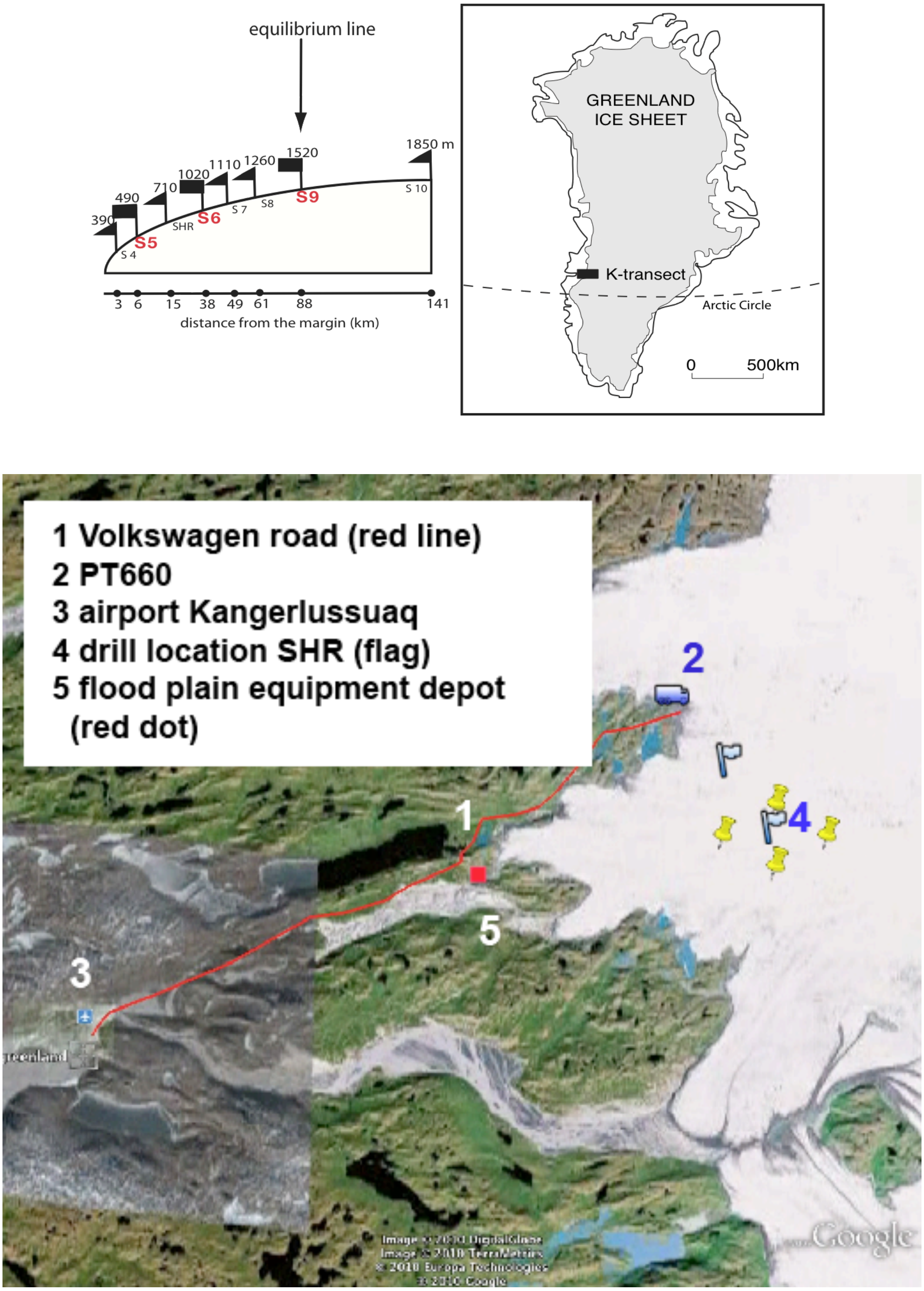

Figure 1. Overview of the fieldwork area in West-Greenland. (top panel) the IMAU K-transect and (lower panel) a Google Earth view of important locations during the fieldwork at and around Russell glacier, West-Greenland.

1 Background and motivation

This field report describes fieldwork performed at the Russell glacier in West-Greenland at the ice sheet margin during the period 21th June to 16th July 2010 and presents preliminary data from the period 5th July 2010 to 1st September 2011. The partners participating in this project were the Institute for Marine and Atmospheric Research, Utrecht University (IMAU), Netherlands, the Alfred Wegener Institute (AWI), Germany and the Institute of Geography and Earth Sciences (IGES), Aberystwyth University, UK. The activities described took place in the framework of the ice2sea project in the context of sub-work package WP2.2 described below.

The ice2sea program aims at reducing the uncertainties in the contribution of continental ice in projections of future sea-level rise as addressed by the IPCC. Specifically the understanding of the key processes that govern the loss of continental ice must be improved. Sub-work package WP2.2 concentrates on the basal lubrication by surface melt. A pilot study on the Russell Glacier (West-Greenland) has revealed a strong coupling between surface meltwater production and ice velocity (Van de Wal et al., 2008). At present, however, a lack of information on subglacial water pressure hampers the data interpretation.

One of the specific tasks within WP2.2 was to study the relation between subglacial water pressure, glacier motion and surface melt. This report describes the experiment at Russell glacier close to Kangerlussuaq in West Greenland. Mass balance station SHR in the K-transect was chosen (Figure 1) as the drilling location. The K-transect was established in 1990 and currently constitutes eight locations with mass balance and GPS measurements and four locations with automatic weather stations (AWS); the latter have been operational since August 2003 at S5, S6 and S9 and since August 2010 at S10 (Van de Wal et al., 2005; Van den Broeke, 2009). Location SHR lies in the marginal ice zone and was chosen because the summer speed-up at this location is the largest along the K-transect (Van de Wal et al., 2008).

The AWI hot water drill was used to drill two holes at SHR to the bottom of the ice sheet, after which pressure and temperature sensors were installed inside to monitor subglacial water pressure and the vertical temperature profile. Simultaneously, the surface melt water production and GPS location at the ice surface were monitored.

2 Travel itinerary

During the months preceding the expedition, Wim Boot (equipment and electronics at IMAU) developed, prepared and tested all equipment while Paul Smeets (researcher) arranged the field work logistics, housing, ice camp facilities and field work permits. At the same time Frank Wilhelms and co-workers of the AWI performed a thorough revision of their hot water drill. All equipment was packed and shipped at the end of May 2010 and arrived at June 14th in Kangerlussuaq (Greenland). In Appendix A, a timetable lists field work related activities for the period May 2010 to September 2011 and in Figure 1 an overview of important fieldwork locations is given.

At June 9th an ice thickness radar survey was performed near SHR by Rickard Pettersson (Uppsala University, Sweden) and Sam Doyle (Aberystwith University, UK). At June 21th Wim Boot, Paul Smeets (IMAU) and Frank Wilhelms, Melanie Behrens, Martin Leonhardt, Gunther Lawer, Sebastian Göller and Kalle Jepsen (AWI) arrived in Kangerlussuaq and were housed at the KISS centre.

All equipment and supplies were collected from the Pilersuisoq ship transport storage in Kangerlussuaq and stored at the NEEM terrain. While the IMAU team was preparing and testing the subglacial measurement system, the AWI team was unpacking their containers, checking/testing their drill and preparing wooden basements for positioning of the drill and its six heaters at the ice. To reduce flight hours by helicopter we decided to transport all equipment over land from Kangerlussuaq to a position close to the front of Russell glacier. At June 24th and 25th all equipment including 30 drums filled with gasoline (10) and diesel (20), were transported along the Volkswagen road (no 1, Figure 1) to a location about 5 kms from the snout of Russell glacier using a 4-wheel drive truck with crane (no 5, Figure 1).

Upon arrival at Kangerlussuaq it appeared that the chartered helicopter transport, arranged beforehand, was grounded and waiting for repair due to damage from a recent incident on the ice. After 1.5 week of regular email and telephone contact between Alun Hubbard, Paul Smeets, a private helicopter charter company and the charter department of Air Greenland we succeeded to arrange a helicopter charter from Air Greenland for two days at July 1st and 2nd. Unfortunately, the weather conditions at the morning of July 1st were unfavorable with mist and low clouds along the transfer flight line from Nuuk to Kangerlussuaq so that the helicopter arrival was postponed until late afternoon. At 15h30 the helicopter arrived and, after having discussed the situation with the pilot, we decided to start early next morning, July 2nd.

Upon arrival at the flood plane on July 2nd our team was split up. One team remained at the flood plain (Melanie Behrens, Sebastian Göller, Kalle Jepsen, Wim Boot) to prepare sling loads for helicopter transport while the other team (Frank Wilhelms, Paul Smeets, Martin Leonhardt, Günther Lawer) was moved to the fieldwork location to handle arrival of the sling loads at the ice. First, survival gear was dropped in the field work area and then the ice team was taken on the ice to decide on a location to set-up the drill equipment and the camp site. From then on, a continuous flow of sling loads was flown to the drill site finishing the available helicopter fuel for that day around 17h00. The ice team started to set-up the field camp while the flood plain team went back to the KISS centre in Kangerlussuaq. At July 3rd the remaining equipment was flown onto the ice after having used about 20 sling loads in total. Both teams were joined at the ice and started to build the camp and hot water drill. At July 4th around 15h00 the AWI finished building their drill and started drilling. The IMAU installed the Automatic Weather Station and the winches and antennas for the subglacial measurement system whereafter they continued testing the wireless subglacial system. Drilling of the first hole was finished at July 6th 05h20 after about 50 hrs of continuous drilling. Bedrock was reached at about 600 m below the ice surface. After some preparations the IMAU started to lower the first wireless subglacial instruments in the hole at 08h00. The wireless probes were attached to a Kevlar rope and lowered into the hole using an electronically controlled winch. At 11h30 all subglacial probes were successfully installed in the hole and the reception of nearly all wireless probes was very good.

At July 5th Bas de Boer and Mirena Olaizola from the IMAU had arrived in Kangerlussuaq and at July 7th they were flown to the ice camp. At the same time the helicopter was used to move the drill winch to another location for drilling a second hole. At the end of July 7th the AWI started drilling the second hole and finished drilling on July 8th around 22h00 after which IMAU personnel successfully lowered their second set of subglacial instruments in the second hole. At July 9th we started to pack all equipment and helicopter transport was arranged for July 10th. After flying all day with sling loads to Pt660 all equipment and personnel was back on land around 17h00. The following three days were used to transport all equipment from Pt660 back to Kangerlussuaq using a 4-wheel drive truck and either stored in 2 containers or sent back to Germany and the Netherlands. At July 16th the experiment was finished and most people flew back home.

During the yearly maintenance visit of all stations along the K-transect at August 17th 2010 an IMAU team visited the drill site and collected all data from the subglacial system. At June 4th 2011 Sam Doyle (IGES) visited SHR and collected the second data set that indicated a good operation of the wireless system until April 2011. The system appeared to have stopped receiving data unexpectedly due to an empty battery pack. Guided by this information Wim Boot (IMAU), who had just returned to Kangerlussuaq from an experiment with the wireless system at the NEEM site, visited SHR at June 7th 2011 and installed a new battery pack. At September 1st, during the yearly maintenance visit of the K-transect, an IMAU team collected the latest data set from the wireless system, installed a new battery pack and a different surface antenna.

3 The fieldwork

3.1 Ice thickness radar survey

Before the drilling operation the ice thickness close to location SHR was surveyed by means of ice radar measurements performed at three locations on June 9th by Sam Doyle (IGES) and Rickard Pettersson (Uppsala University, Sweden). The results from all three locations consistently agreed on an ice thickness of about 565 m, ideal for the configuration of the AWI hot water drill that has a standard hose length of about 630 m.

3.2 Hot water drilling

The hot water drill that we used is owned by the AWI. Before the fieldwork the drill was fully checked and revised at the AWI in Bremerhaven, Germany. The hot water drill is originally designed to work on Antarctica to drill large diameter holes through shelf ice. As a result its size (surface area 6x4 m), weight (3 tons) and fuel consumption are quite large (Figure 2). Once in operation the drill needs continuous attention of at least 2

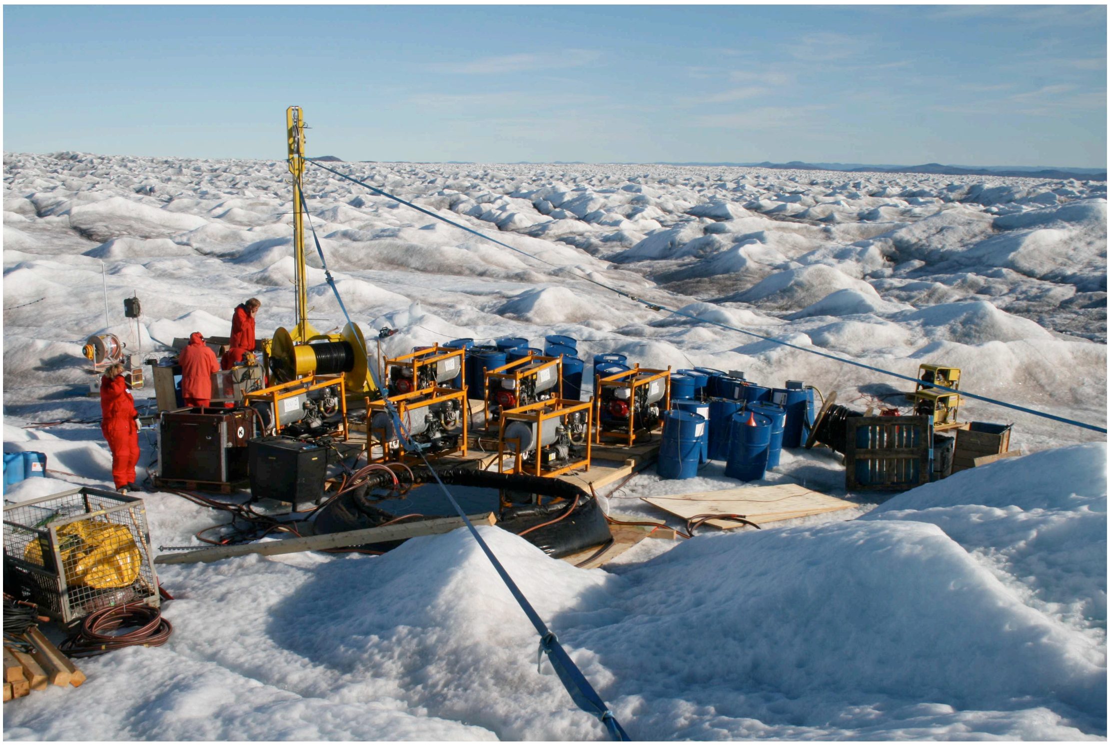

Figure 2. The hot water drill from the AWI in operation at the field site.

people and for one hole with a diameter of 40 cm about 5 drums of diesel and 2 drums of gasoline were used.

The drill (Figure 2) consists of 6 large heaters (the 6 yellow frames), a tall mast guiding the hose into the hole (large vertical yellow boom), a hose winch containing 630 m of special isolated drill hose (the yellow cylinder containing the black hose just below the guiding boom). While operated the drill needs a continuous supply of liquid water for which a large water bladder is used (in front of the drill, Figure 2). Water from a nearby melt stream was used to keep the bladder filled.

For drilling a hole initially a narrow pilot drill head is used, after which a so-called reamer head enlarges the diameter of the hole. The drill speed with the pilot drill head attached was 100 m per 5 h and with the reamer head the drill speed was doubled. To finish the first hole with a depth of about 600 m took 50 hours of continuous drilling. Since the diameter of the first hole appeared larger than necessary and refreezing was no problem the drilling speed for the second hole was doubled.

3.3 Geodetic GPS measurements

For precise monitoring of the ice surface velocities the team from Aberystwyth University (AU-IGES) has operated a permanent geodetic GPS network in the K-transect area since 2007, including site SHR. Close to the drill site and at 4 locations arranged in strain quadrant around the drill site AU-IGES installed 5 high precision geodetic GPS for year-round operation. The GPS instruments measure the horizontal and vertical surface displacement in time at 10 min intervals. The type of instrument used is Trimble R7 type GPS system with intelligent power regulation and powered by 80 W solar panels. The data from these ice based GPS instruments is corrected against 2 permanent GPS instruments called GNSS base-stations.

3.4 Subglacial measurements

The IMAU designed wireless subglacial probes must transmit through hundreds of m thick glacier ice, and were tested for the first time during this experiment. The probes of the subglacial measurement system are designed to withstand water pressures of up to 100 bar resembling the equivalent of over 1000 m of glacier ice. The probes are especially made thick walled plastic tubes with an external diameter of 50 mm. The left panel in Figure 3 shows the cross section of a probe with at its left end a pressure sensor inserted that is specified up to 100 Bar. To survive peaks in water pressure the upper design limit of the pressure sensors is 300 Bar while the accuracy is ± 0.1 m water level. The purple cylinder in the middle is a Lithium type battery that provides energy for at least 5 years. On the right (in green) is the circuit card containing the transmitter antenna and electronics.

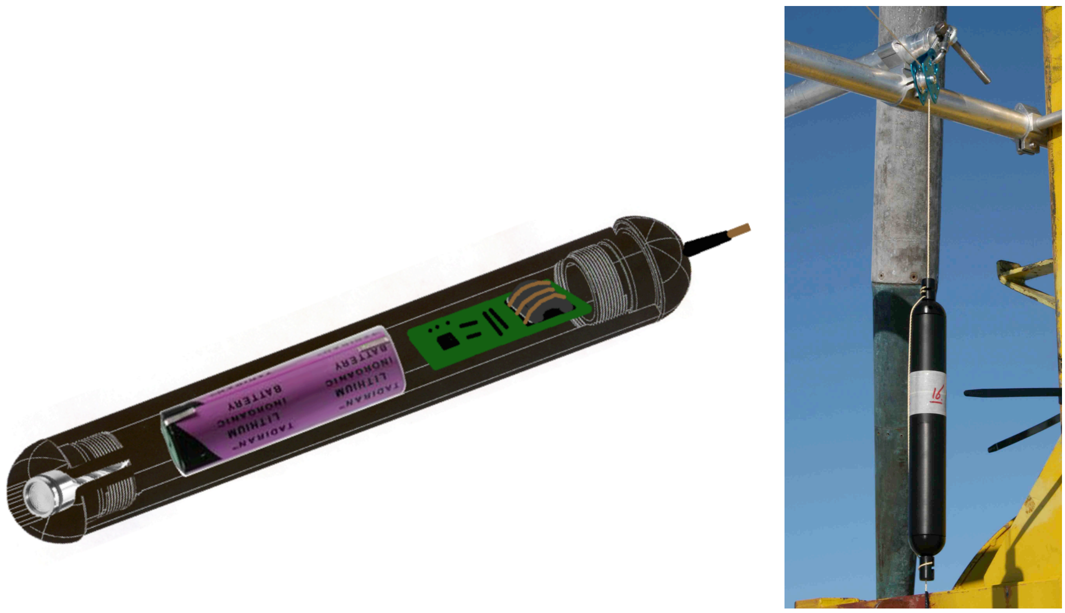

Figure 3. Left, an inside view of the probes used in the wireless subglacial measurement system. Right, probe number 16 attached to its Kevlar rope, ready to be lowered in hole 1. In the background the reamer drill head is visible.

The right panel in Figure 3 shows a probe attached to the Kevlar rope just before lowering into hole 1. On the ice surface two antennas and a receiver/datalogger monitor the signals from the wireless probes. The antennas each consist of two wires forming a cross with dimensions of about 4 m and both crosses have a different orientation relative to each other to accommodate the reception of the polarized signal from the probes. Every two hours all probes (27) send data several times at short time intervals to make sure that the receiver securely collects data from all probes. A more comprehensive description of the system and a presentation of the first results is given in a paper that was submitted recently by Smeets et al. (2011).

AWI personnel drilled two holes of which the first one contains a wireless system with a pressure probe situated 0.5 m above the bottom of the hole, while a temperature profile consisting of 23 probes was installed at a distance of 1.5, 5.5, 10.5, 15.5 m and continuing at intervals of 25 m from the bottom to a distance of 551.5 m from the bottom and 58.5 m from the ice surface. In addition, a tilt probe was attached at 24 m from the bottom. Inside the second hole we installed one wired pressure/temperature probe and one wireless pressure sensor. The wired system is connected to the surface via an ordinary serial/power cable and is used as a backup and check of the wireless system.

3.5 Automatic weather station and IMAU GPS

The Automatic Weather Station (AWS) that was installed at the drill site is standard IMAU design that is currently used at glaciers and ice caps worldwide. Currently four AWS are operational at the K-transect (Figure 1) since August 2003 at S5, S6 and S9 and since August 2010 at S10 (Van de Wal et al., 2005; Van den Broeke, 2009).

The mast construction of the AWS is adapted to the summer melt conditions on most glaciers and ice caps. It is not rigidly fixed to the surface but consists of a central pole and four legs that spread out from the centre making a small angle with the surface (Figure 4). Once placed, the legs descend about 0.5 m into the ice through melting, and are then firmly fixed. In the course of the melt season, the masts maintain their upright position within a few degrees and the measurement height remains almost constant.

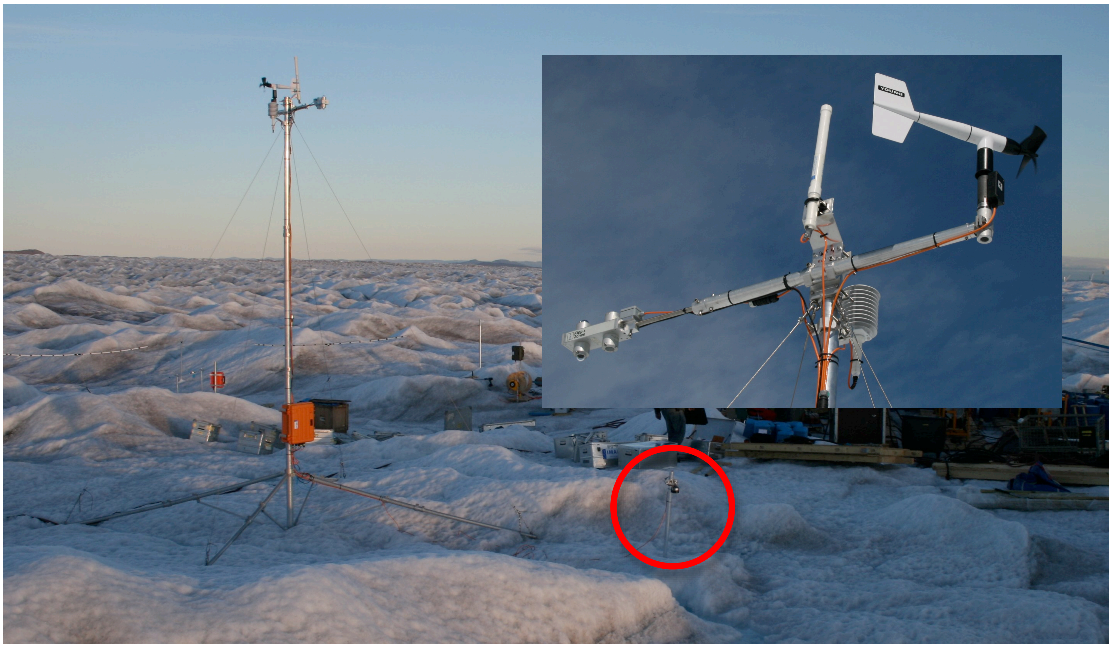

Figure 4. AWS at the drill site and a detailed view on the upper boom holding the sensors. The red circle indicates the sonic height ranger.

At the AWS, wind speed, wind direction, temperature and relative humidity measurements are performed at about 4 m height. The combined temperature/humidity sensor is housed in non-ventilated radiation shields. A net radiometer also mounted at 4 m measures all four radiation components separately together with the radiometer body temperature. In Figure 4 the top right panel shows a detail of the upper boom with the radiation, temperature/humidity and propeller-vane sensor together with the satellite antenna. Also installed close to the AWS at a mass balance stake is a single frequency GPS system (Den Ouden et al., 2010). Surface height measurements are performed with a sonic height ranger on a separate pole located close to the AWS (red circle in Figure 4). A Campbell CR10X datalogger, sampling every 30 seconds, stored 30-min averages. Energy is provided by a battery pack located in a separate box.

4 Preliminary results

First the data from the subglacial wireless system is presented whereafter, in a separate paragraph, these results are shortly discussed in relation to the simultaneously measured AWS and GPS data.

4.1 Subglacial pressure

The operation of the subglacial system was successful and an almost continuous dataset from July 6th, 2010 to September 1st, 2011 was retrieved so far. In Figure 5 the first subglacial pressure data collected 42 days (August 16th, 2010) after the start of the experiment are presented to illustrate how well the results from the wireless and wired probes compare each other.

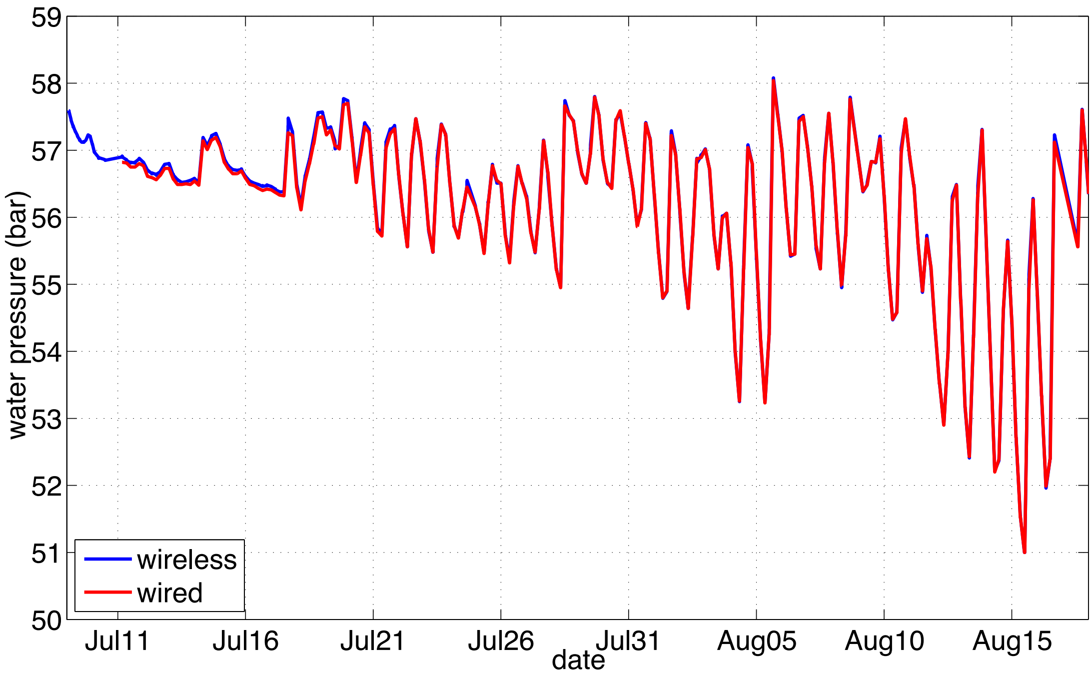

Figure 5. Subglacial pressure from the wireless (blue) and wired (red) pressure sensors located in hole 1 and 2, respectively during the period July 6th to August 18th, 2010.

For a proper comparison, we only selected data that were simultaneously measured by both probes within a time window of 30 min. Hole 2 contained the wired sensor that was approximately 22 m deeper than hole 1 and to correct for this we offset the wireless pressure data by +2.2 bar. The absence of data gaps demonstrates that the wireless system is well capable of transmitting data continuously through 600 m thick ice. The average difference and standard deviation between both timeseries is only 0.02 and 0.04 bar, respectively. These small random differences are explained by the subglacial pressure variations within the 30 min time window.

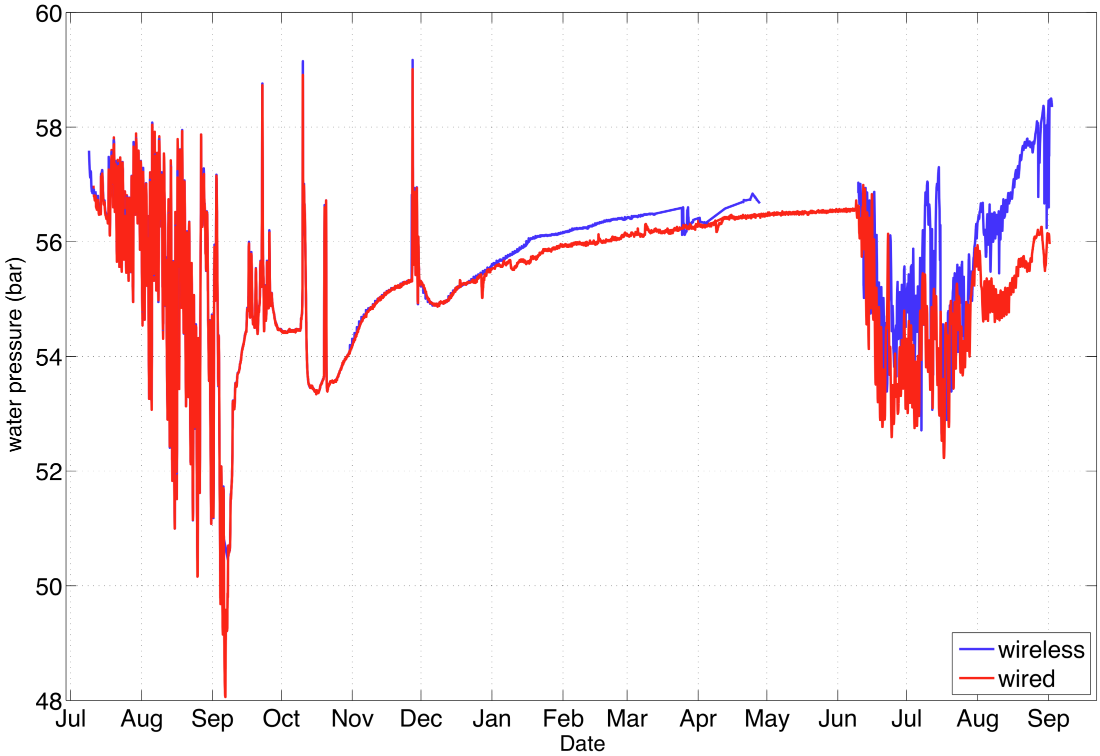

Figure 6. Subglacial pressure data from the wireless (blue) and wired (red) pressure sensors located in hole 1 and 2, respectively for the period July 2010 to September 2011.

Figure 6 shows the complete timeseries of subglacial pressure measurements for wired and wireless data available to date covering the period from 6 July 6th, 2010 to September 1st, 2011. The lack of wireless data during May resulted from an empty battery pack of the logger/receiver system at the ice surface. After replacement at June 7th, 2011 all wireless probes were received again. These data illustrate the flawless operation of the wireless system for a period of 420 days. Currently the wireless system is still operational and the probes are expected to send data for at least another 4 years. It is important to note that the temperature profile data (discussed hereafter) indicate that to date the pressure probes have never been frozen in, hence, these observations relate to water pressure.

During both periods with continuous high summer melt (~July to Sept, 2010 and June to Spet, 2011) subglacial pressure always shows a clear daily cycle as was already illustrated in Figure 5. In between these periods with intense melt two features can be distinct. The gradual increase in pressure throughout winter and the immediate response of pressure to isolated melt events at the beginning of winter in 2010 (Sept to Dec 2010). The gradual increase indicates that the melt water that is present within the glacier ice throughout the year slowly accumulates because of a partial close off of the hydraulic system during winter, thereby increasing the water level and pressure in the lower part of the catchment. The immediate response of pressure to melt events illustrates the very quick response of the hydraulic system to sudden changes in the available amount of surface melt water. Remarkable is the slowly increasing pressure difference after Dec 2010 for which we currently do not have an explanation.

4.2 Subglacial temperature profile

From all wireless temperature sensors the same time series as for pressure were retrieved. During the first visit to the drilling location, 42 days after the start of the experiment, visual inspection of the holes showed that they were still filled with water. In September 2011 most sensors were frozen in as can be seen in Figure 7 showing the average temperature profiles at July 19th and August 18th, 2010 and August 31st, 2011 as a function of depth below water level. For reference the theoretical reduction of the melt temperature with pressure for air free and air saturated water is plotted (solid and dashed line, respectively). Note that soluble impurities in the water can alter these curves substantially (i.e., they further lower the melting point, Paterson, 1994). In general, the measurements follow the theoretical curves at the beginning of the experiment (July 6th, 2010), although some scatter is present. The small deviations from the theoretical curves can be partly explained by measurement uncertainty of the thermistors used (their accuracy is about ± 0.1 ºC). Furthermore, when probes are in contact with the nearby ice wall (the hole will have some degree of inclination) the temperature will become lower then the melting point.

As time progresses a clear temperature profile develops with a well defined minimum around 150 m below water level (i.e., around 200 m below the ice surface) and a gradual increase below. Smeets et al. (2011) showed that the temperature sensors clearly sense the pressure induced changes of the melt temperature during the melt season in 2010. Ones frozen in these temperature variations disappear as is evident from the data of the melt season 2011 (not shown). However, the lowest 7 temperature sensors (red circle in Figure 7) clearly showed small temperature variations during the melt season of 2011 indicating that these probes are still submerged in water. We can also conclude from this that the pressure probe, being the lowest in the profile, has not yet been frozen in.

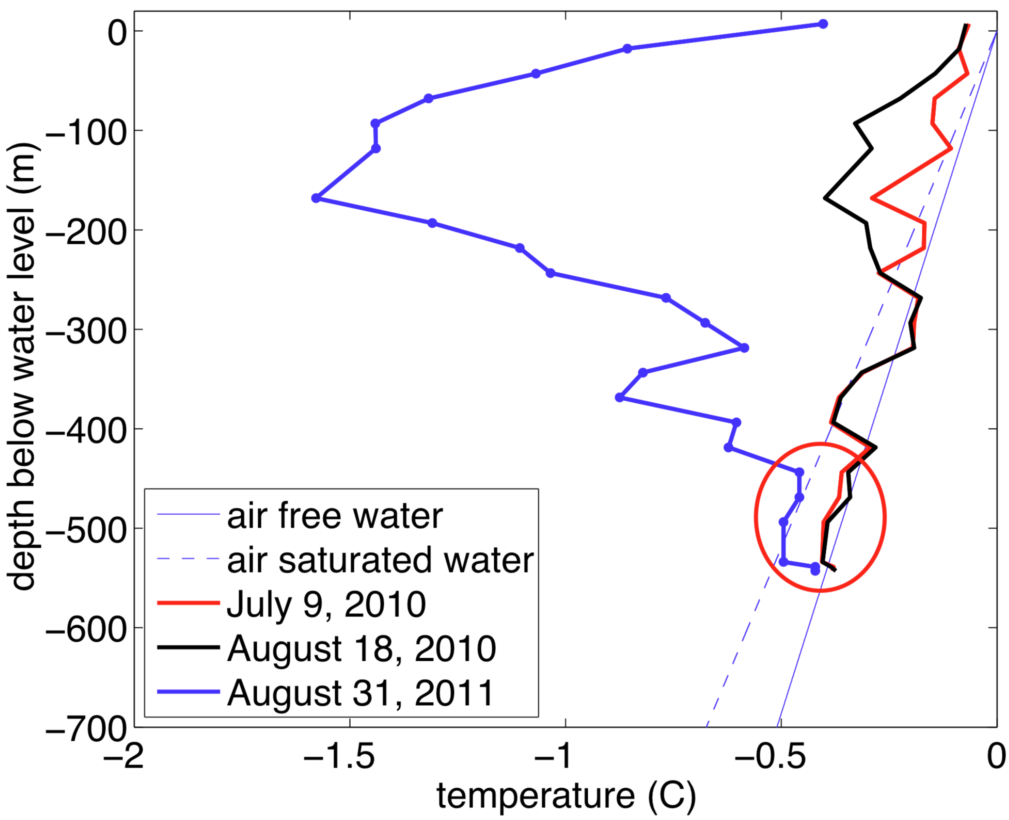

Figure 7. Average temperature profiles in hole 1 at July 9th (red) and August 18th (black) in 2010 and August 31st (blue) in 2011 as a function of depth below the water level, together with the theoretical curves for the melting point of air free and air saturated water (blue solid and dashed lines, respectively). The red circle indicates the lowest 7 temperature sensors and the pressure sensor.

4.3 Subglacial pressure versus surface melt and ice velocity

As mentioned before, the daily variation of subglacial pressure at small timescales is expected to relate in a systematic way to the amount of surface melt water and the ice surface velocity. Figure 8 shows the daily averaged variation of all three parameters as a function of hour of the day. The available melt energy and surface velocity were calculated from data of the IMAU AWS at SHR and the geodetic GPS system from IHE closest to SHR, respectively. The averages are calculated from the period July 18th to 31st (see also Figure 9), since longer timeseries from the geodetic GPS systems are not yet available.

The daily maximum in surface melt is observed around 14h00 local time (WGST), while the maxima in subglacial pressure and velocity lag about 3 hours. This result agrees with our idea that the summer speed up of glacier ice at the Greenland ice margin is driven by the melt water induced increase of subglacial pressure. The delay time between the maxima in surface melt water production and subglacial pressure probably relates to the efficiency of the hydraulic system and the size of the melt water catchment area upstream of location SHR. Note that there is also a 4 to 5 hour delay in the morning between the initial increase of melt and pressure that probably relates to the filling of empty pockets of glacier ice after which the subglacial water level can rise. While subglacial pressure has a very regular daily cycle, velocity drops to its background wintertime value during the night and early morning. Melt water induced speed up apparently occurs above a certain subglacial pressure threshold.

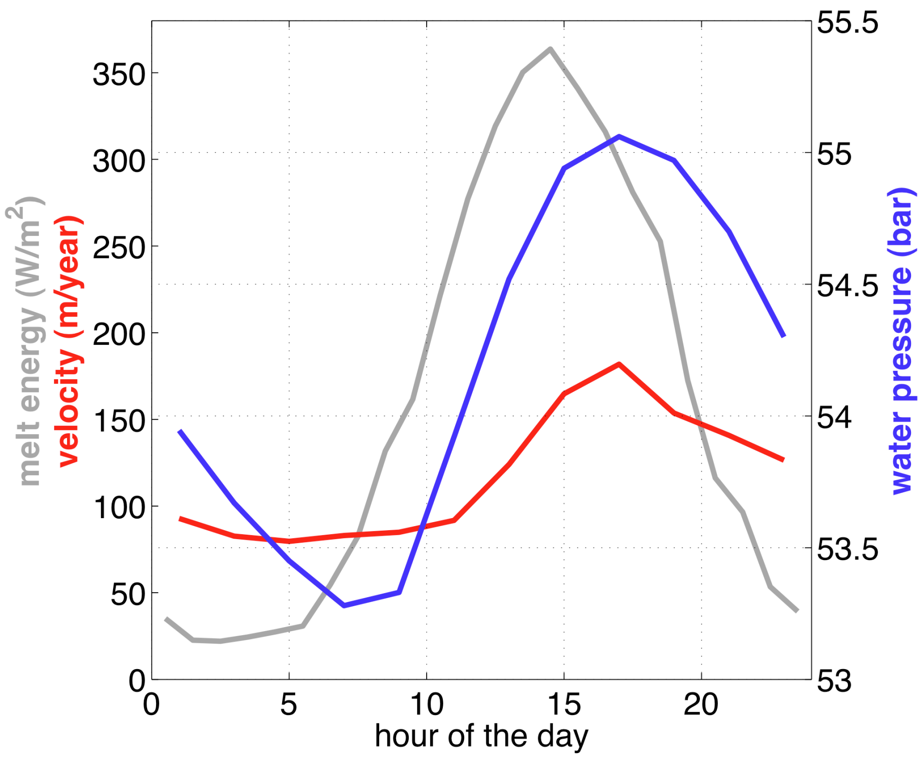

Figure 8. Averaged diurnal variation of available surface melt energy (grey), surface velocity (red) and subglacial water pressure (blue) as a function of hour of the day (WGST).

The latter is nicely illustrated by plotting the full timeseries of subglacial pressure and ice velocity used for Figure 8 (Figure 9). A continuous diurnal cycle in subglacial pressure is present but this is not always the case for velocity. During a period of 3 days around 26th July the subglacial water pressure is apparently below the threshold value for speed-up.

Figure 10 shows the complete timeseries of subglacial water pressure and surface velocity as observed with the IMAU GPS system. The latter is much less accurate than a geodetic system (Den Ouden et al., 2010) and its time resolution is limited by a 7 day running.

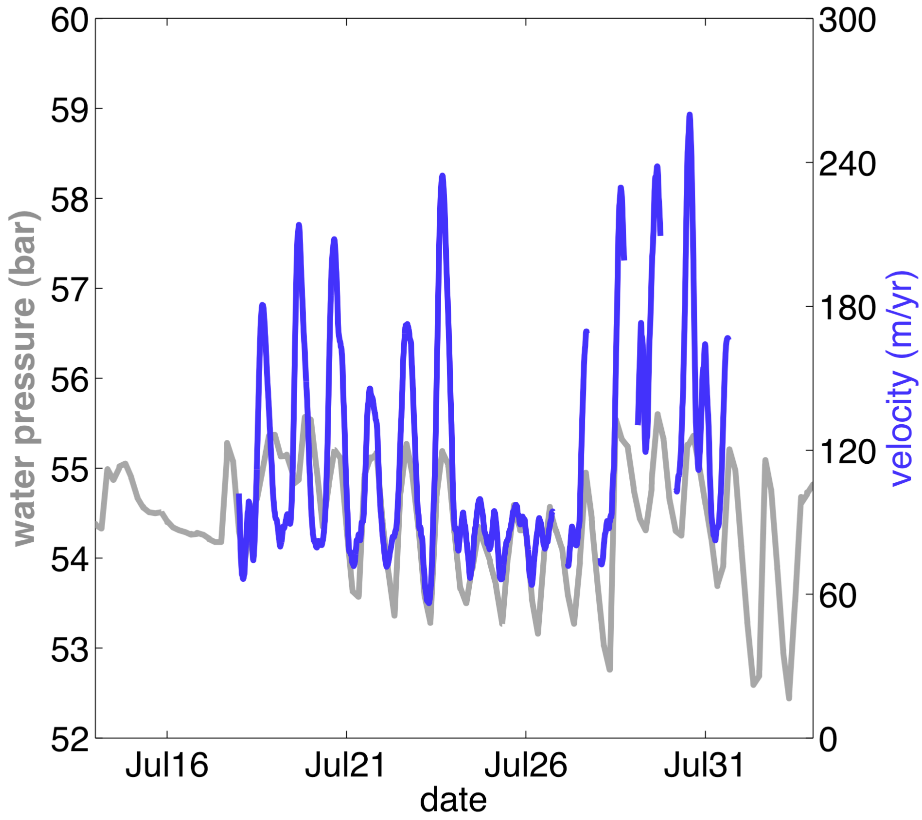

Figure 9. Subglacial water pressure and surface velocity from a geodetic GPS system near SHR for a period in July 2010.

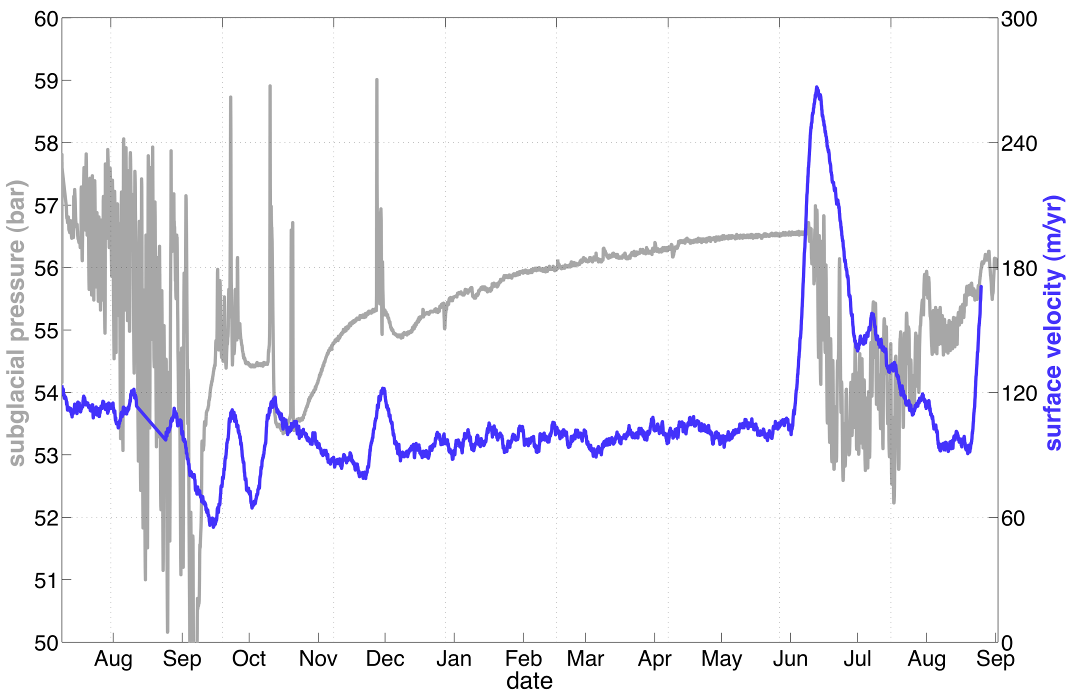

Figure 10. Subglacial water pressure and surface velocity (IMAU GPS system) for the period July 2010 to September 2011.

At timescales of a week the relation between pressure and ice velocity is as straightforward as for daily variations. For example, during 2010 velocity clearly follows the trends in pressure variations. The very low pressure in September 2010 results in a substantial slowing down well below its background speed. The melt events that occur thereafter at the beginning of winter immediately induce a speed up.

At the scale of seasonal variations, however, the interpretation is not straightforward at all. The variations of pressure throughout the melt season in 2010 and 2011 differ considerably and even seem reversed. As argued by Van de Wal et al. (2008) it can be speculated that the efficiency of the hydraulic system throughout a melt season depends on the way it was sculptured the year before. However, a full explanation of these differences requires further research that is beyond the scope of this report.

5 Outlook

The subglacial and AWS data set are almost continuous to date. The data from the geodetic GPS and the seismic experiment performed at SHR are currently being processed. After completion of this the interpretation and publication of the complete timeseries will be started.

At present the wireless subglacial measurements are still operational while a nearby weather station and geodetic GPS system continue to operate as well and it is hoped for that the current timeseries can be further extended. It is foreseen that the wireless probes send data for at least another 4 years and during this period (or even longer) the IMAU will maintain their datalogger/receiver system at the ice surface during their annual visit of the K-transect.

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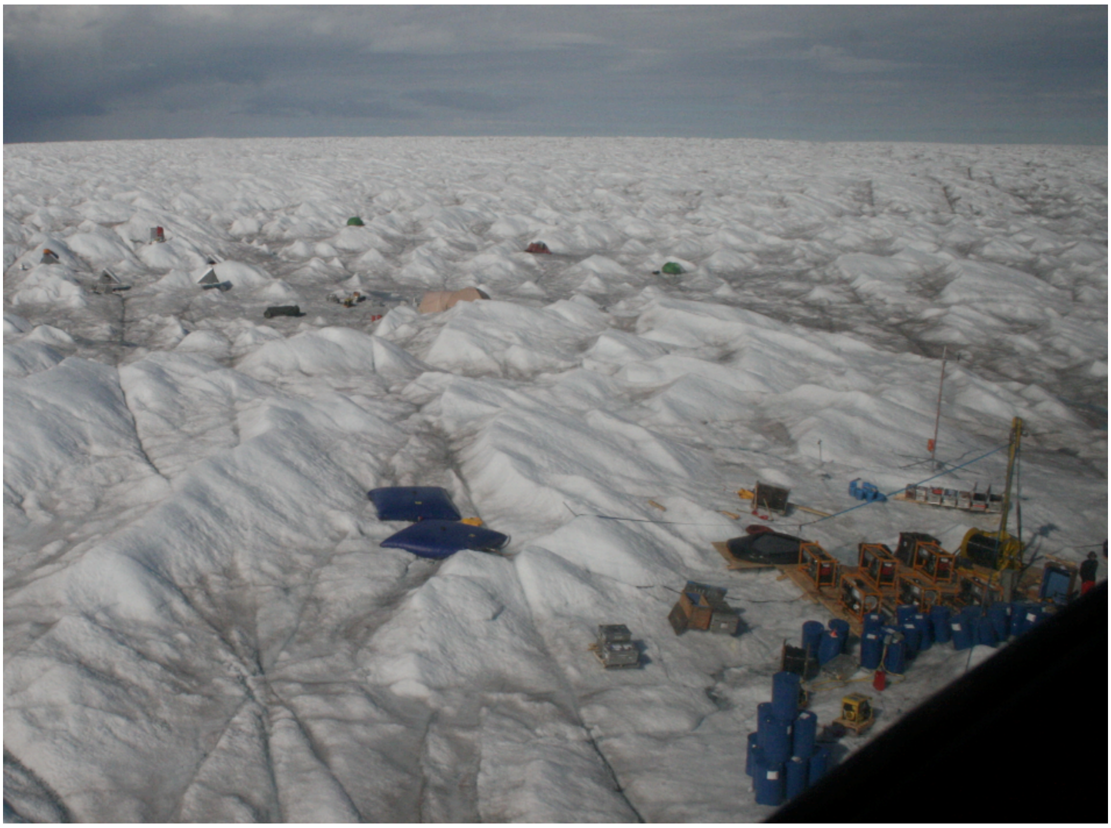

Figure 11. Aerial overview of the field camp at SHR in July 2010 on Russell glacier. In the lower right corner the AWI ice drill surrounded by oil drums and 2 large blue water bladders. In the top left corner the scattered tents of the camp.

Appendix A Timetable

The following timetable lists activities during the fieldwork period June 9th to July 16th, 2010 and includes all visits at the fieldwork site after the experiment until September 1st, 2011. Locations are indicated in Figure 1.

June 9th	*radar survey near SHR by Rickard Pettersson (Uppsala University, Sweden) and Sam Doyle (Aberystwith University, UK)*
June 21th	*arrival at Kangerlussuaq of Wim Boot and Paul Smeets (IMAU) and Frank Wilhelms, Melanie Behrens, Martin Leonhardt, Gunther Lawer, Sebastian Göller and Kalle Jepsen (AWI)*
June 22nd	*moving and preparing all equipment, try arranging helicopter charter*
June 23rd	*moving and preparing all equipment, try arranging helicopter charter*
June 24th	*moving and preparing all equipment, try arranging helicopter charter, 30 fuel drums arranged and filled, start truck transport of equipment to ice edge*
June 25th	*truck transport to ice edge*
June 26th	*try arranging helicopter charter*
June 27th	*try arranging helicopter charter*
June 28th	*try arranging helicopter charter*
June 29th	*try arranging helicopter charter*
June 30th	*helicopter charter arranged from Air Greenland, flight planned 1 and 2 July,*
July 1st	*waiting for helicopter, transfer from Nuuk is delayed due to low clouds on the way, helicopter arrival at 15h30.*
July 2nd	*start of transport of equipment from flood plain on to the ice, 4 people start-up the camp at the ice*
July 3rd	*finish transport of all equipment on to the ice, all team members camp at the ice now, finish building camp. start building hot water drill*
July 4th	*installation of AWS and preparations/testing for subglacial measurement system by the IMAU. AWI finishes building and testing the drill, start to drill first hole*
July 5th	*AWI is drilling continuously using 3 teams, IMAU is preparing testing subglacial measurement system*
July 6th	*first hole finished at 05h00, reaching bed at 610 m below ice surface, IMAU installs the wireless subglacial measurement system, AWI prepares for second hole*
July 7th	*Bas de Boer and Mirena Olaizola arrive, the helicopter is used to move the drill winch to other position for drilling the second hole, AWI starts to drill the second hole*
July 8th	*AWI finishes second hole at 22h00, IMAU installs second wireless system together with a wired back-up system*
July 9th	*AWI tests drill, Frank Wilhelms and Paul Smeets fly back and forth to Kangerlussuaq, arrival of Elisabeth Helmke in Kangerlussuaq and at ice*
July 10th	*packing of all equipment (drill, camp, AWS, subglacial system)*
July 11th	*transport of all equipment to Pt 660 and personnel to Kangerlussuaq*
July 12th	*transport of equipment from Pt 660 to Kangerlussuaq*
July 13th	*transport of equipment from Pt 660 to Kangerlussuaq*
July 14th	*transport of equipment from Pt 660 to Kangerlussuaq, packing equipment in container or prepare to send to Europe*
July 15th	*transport of equipment from Pt 660 to Kangerlussuaq finished, packing equipment in container or prepare to send to Europe finished*
July 16th	*Experiment at the drill site finished*
July 25th	*seismic measurements carried out close to drill site by a team from IGES*
August 17th	*a team from the IMAU visits the drill site during their yearly maintenance visit of the K-transect stations and collects all data from the subglacial measurement system and installs a new battery pack for the*

	logger/receiver system
June 4th 2011	*PhD student Sam Doyle (IGES) visits SHR to collect data*
June 7th 2011	*technician Wim Boot (IMAU) visits the drill site to change the battery pack of the subglacial logger system and restart the wireless system*
Sept 1st 2011	*a team from the IMAU visits the drill site during the yearly maintenance visit of the K-transect stations; they collect all data from the subglacial measurement system, change the battery pack and install a different receiver antenna at the ice surface*