



## **MOSKUS EXPEDITION – The Stauning Alps**

April 17<sup>th</sup> – 22<sup>nd</sup> May 2018

*An expedition of dual purpose: to summit unclimbed mountains in the Staunings Alps, and to conduct scientific research on glaciers in the region. Unsupported and beset with frequent bad weather, this ambitious two-man effort presented an enormous physical challenge at times but, ultimately, proved to be an immensely rewarding High-Arctic adventure.*



# GRNLND 2018

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Team Moskus' Campsite, Gurreholm Dal – 7th May 2018

## INTRODUCTION:

This report serves as the official record for our expedition to Greenland in the spring of 2018. It will cover all aspects of the trip, from the inception of the idea right through to the journey home, detailing the planning, logistics, mountaineering and scientific work that were involved in the process. As such, this document will be a useful source of information for anyone who is travelling to eastern Greenland during the winter or springtime, especially if they intend to be based in and around the Scoresbysund fjord system.

### BACKGROUND:

This expedition was carried out by 'Team Moskus', which consisted of Matt Hay (27) and Leo Carew (27).

We met and became friends when we were nineteen years old, on a 9-week expedition to Svalbard, organised by the British Exploring Society (then BSES) in 2010. That trip was a formative experience for both of us, igniting an interest in and passion for all things Arctic that still burns strongly. Both of us have returned to the Arctic numerous times since our inaugural adventure, and our increased polar experience gave us the confidence to conceive of planning a self-led, unsupported expedition to the high latitudes. Leo, in particular, has spent significant time in the Arctic in the years since 2010. He qualified as an 'Arctic Nature Guide' from Svalbard's UNIS University in 2014 and worked as a guide for several expedition cruise companies touring Iceland, Greenland and Svalbard in subsequent summers.

In the autumn of 2017, we both realised that we would be able to take time off in 2018 and were keen to make the most of this opportunity by organising an expedition. Initially, we considered climbing Alaska's famous mountain *Denali*, but after much discussion decided that it was environmentally irresponsible to fly halfway around the world on such a self-centred mission.

Having established carbon emissions as a mutual concern, we consequently resolved to limit our flight time for any potential expedition to 4 hours or less (from the U.K.). We also determined to offset our expedition's transport-related emissions, ensuring that the endeavour was carbon-negative overall. Anything less than this seemed insane, given the speed at which the Arctic is warming due to anthropogenic climate change. Finally, we wished for our expedition to have either a scientific or cultural aim, so that we could contribute knowledge to a cause beyond our own self-development.

Given these criteria we expected that Greenland, with its relative proximity to the U.K., might be a sensible location for our expedition. When we then read Molly Thompson's expedition report, from her 2017 trip to the Stauning Alps, which called for future expeditions to continue a scientific project her team had initiated, we began to focus on that mountain range in greater detail. A spring expedition to the Staunings would provide us with the ice and snow we craved, as well as innumerable mountaineering possibilities. It is also only a three-hour flight from the U.K. (via Iceland) to the region's airport: Constable Point. Finally and crucially, by continuing the Thompson expedition's research we would be able to fulfil our own ambition of contributing to a valuable scientific project. Thus, we agreed to a spring expedition in Arctic Greenland, focussed in and around the Stauning Alps.

In honour of the plentiful Musk Ox in the region, and the country's Danish colonial heritage, we decided to call ourselves Team Moskus and that GRNLND2018 would be our expedition's name. All that was left was to determine our specific objectives and to start planning an Arctic adventure.

#### **ORIGINAL OBJECTIVES:**

Our expedition was planned to be an unsupported, five-week trip to Greenland with two distinct aims:

1. To summit at least two unclimbed peaks in the Stauning Alps mountain range
2. To conduct scientific research, including continuation of the work Thompson *et al.* started on the Roslin glacier, one of largest glaciers in the southern Stauning Alps.

#### **TEAM MEMBERS:**

##### **MATTHEW HAY – EXPEDITION LEADER**



A former weather forecaster who spent his career working for the Royal Air Force (RAF), Matt is no stranger to the Arctic. Having undertaken two expeditions with the British Exploring Society, to Svalbard and Finnmark respectively, Matt has spent many a night camped out on ice and snow. He is also an accomplished

backcountry skier, with experience gained in the Scotland, Iceland and Norway.

His passion for the Arctic is matched only by his love of the natural world and wildlife in particular; encounters with some of Greenland's megafauna during the expedition were an absolute highlight for him. A professional background in meteorology and climatology mean that he is also extremely interested in the Arctic from a scientific perspective too, as climatic changes are now altering the environments of the far north at an astonishing pace.

### **LEO CAREW – MOUNTAIN LEADER, EXPEDITION MEDIC**



Despite his youth, Leo is already something of a polar veteran, having spent 18 months living in a tent in Svalbard while undertaking training as an Arctic Guide with Tromsø University. In addition to this, he is an experienced mountaineer, with Mont Blanc and two >6,000m Himalayan peaks under his belt, in addition to extensive experience in Scotland and Norway. Currently, Leo is training to become an Army Doctor at Bart's and the London. His

medical expertise was an invaluable asset during our expedition, though fortunately, only required once or twice. In his spare time he has also written and published '*The Wolf*', the first in a trilogy of historical fiction novels that draw upon the anthropological knowledge Leo gained from his undergraduate degree.

### **ANNA WEGUELIN – U.K. LIAISON**



An essential part of the expedition team, Anna was Team Moskus' U.K. liaison, receiving near daily satellite phone calls from Greenland and relaying weather information in return. Anna then passed on expedition news to friends, family and also to Rachel Dobbs, who was in charge of the GRNLND2018 social media feeds while Matt and Leo were in the field.

No stranger to mountains or the cold, Anna has

experience ski mountaineering in the Scottish Highlands. Her preferences, however, are for balmy climes than were on offer in Greenland and so she kindly agreed to support the expedition effort from afar. Team Moskus are hugely grateful to both Anna and Rachel for all their help.

**ACKNOWLEDGEMENTS:**

No expedition to the Arctic happens without a great deal of planning and support. We were overwhelmed by the advice and encouragement we received when putting this trip together. In particular, we are hugely indebted to several institutions and societies who gave us financial assistance when we applied for grants and funding.

We would like to take this opportunity to thank:



**Scottish  
Arctic Club**



The Scottish Mountaineering Trust

In addition, we were fortunate to secure sponsorship from some excellent businesses, many of them local to Matthew in rural Perthshire. They were:



Our original sponsor, Extreme Adventure Food provided Team Moskus with more than 200,000 kcal of purpose-built expedition rations at a substantial and much-needed discount. These included dehydrated main meals, flapjacks and an electrolyte drink which together formed the backbone of our supplies. Widely recognised as a leader in the field, their contribution was invaluable in keeping weight and costs low, whilst ensuring we had high-quality nutrition.



Our diet in the Arctic could well be described as 'Oat Cuisine'. We consumed enormous quantities of this cereal, with porridge for breakfast and oatcakes snacked on throughout the day. Aberfeldy Oatmeal sponsored us with porridge oats for the entire expedition as well as healthy supply of their delicious oatcakes.



The undisputed king of oat-based snack foods, Nairn's endorsement of our expedition was great news for our dietary





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variety. They supplied us with ten different flavours of oatcakes, as well as other biscuits and snack products. We can confirm that their 'AstroBites' are out of this world, and are hugely grateful to them for making our consumption of oats anything but monotonous.



Discovered by Team Moskus in a London coffee shop, Jimini's are a French company committed to lowering the environmental footprint of the protein we eat. All of their products are derived from insects and we were delighted to secure their endorsement for our expedition. They supplied us with a great variety of protein bars made from cricket flour. These proved an excellent supplement to our diet, being tasty, lightweight and high in protein, which helped our recovery after long days of pulking or mountaineering.



Craigdon Mountain Sports have a collection of Outdoor Stores in Scotland, with one branch based in Perth. The shop owner, Karla Schnell, along with her team were extremely generous to Team Moskus, bestowing a hefty discount on expedition equipment bought in Craigdon as well as lending us climbing gear. Craigdon also saved the day when one of Matt's skis was written off in Iceland, mere days before the expedition's departure to Greenland. They managed to secure a replacement and ship it to Leo before he left the U.K. A kind ski shop in Reykjavík then swapped the bindings over at no cost.



Another Perthshire business, Glen Lyon coffee roasters' enthusiasm for our adventure was wonderful. They supplied us not only with a variety of their different coffee beans, but also with a 'backcountry brew kit'. This allowed us to hand grind beans in Greenland and enjoy fresh filter coffee in our tent or when we stopped for lunch. It is hard to overstate how much we came to value this daily luxury. Not only was the coffee warm and caffeinated, it was also delicious; full of delicate, subtle tastes that were otherwise lacking in our expedition rations.

## PLANNING AND LOGISTICS:

### EXPEDITION LOCATION: The Stauning Alps

The Stauning Alps are located on the eastern coast of Greenland at a latitude of around 71° north. The region is bounded by Scoresbysund fjord to the south and Kong Oscar Fjord to the north. The area is characterised by a mixture of rocky and glaciated summits emerging from the valley glaciers and ice fields that cover the area. These glacier systems are independent of the main Greenland Ice Sheet (GIS) and consist of a complex system of valley glaciers with some small ice fields in the upper reaches of the range. The peaks in the Stauning Alps are generally between 1000 and 2500 metres, with the highest summits found in the central areas of the range. Peaks towards the outside of the region rise from a little above sea level, while those in the central parts of the range can be accessed from glaciers and cols at elevations of 1000 – 1500 metres. The region is bounded to the east by *Schuchert Dal*, a wide and relatively flat glacial valley, which provides access to eastern summits within the range.



The area is very remote, with the closest permanent settlement (Ittoqqoormiit – population 450) being nearly 200km to the southeast.

Access to the region is either from Constable Point airport, close to Ittoqqoormiit village, or via an airstrip at an old mining settlement at Mestersvig to the north.

The remaining part of any journey to the Stauning Alps must then be made by snow mobile over one to two days or, as in our case,



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### **TIMINGS:**

Having decided on the Stauning Alps for our location, we then established a timeframe for our expedition. Both members of Team Moskus wanted to spend over a month in the wilderness and, given our twin ambitions of science and mountaineering, agreed that 5 weeks was the minimum amount of time we should afford to the expedition.

Due to Leo's professional commitments we were unable to fly to Greenland until the 17<sup>th</sup> April. A five-week expedition then took us to the 22<sup>nd</sup> May – right at the end of the usual expeditioning season for this part of Greenland. As it happened, our trip coincided with a cool and exceptionally snowy spring meaning that we were not ever limited by a lack of snow or sea ice. The 2018 season could have extended well into June, though good conditions can never normally be guaranteed so late in the year.

### **LOGISTICS:**

Molly Thompson's expedition in 2017 had employed the services of the logistics company *Tangent Expeditions Ltd.*, a small outfit owned and operated by Paul Walker. Paul and his team are based at Constable Point airport and are one of two logistics providers in the region. The other being *Nanu Travel*, who are based in the village of Ittoqqortoormiit itself.

Given the success of the Thompson expedition we decided to contract *Tangent* as our consultants and logistics providers, to help us with permitting, firearms, transport and to give us advice on the geography of the region. In general we were pleased with the service that they provided; the team were very friendly and accommodating. We had one or two

problems with some of the advice they gave us for mountaineering in the region – more on this later – but otherwise they formed a stable backbone for both our expedition planning and execution.

*Tangent* determined a lot of our expedition's constraints. We were unable to secure enough funding to pay for snowmobile travel to and from the Stauning Alps, and were keen to incorporate a manhauling element to the expedition. Thus, we travelled most of the way there under our own steam, pulking for 9 days across a region known as Jameson Land. *Tangent* also concluded their winter operations in the final third of May, which meant that our expedition had to finish on the 22<sup>nd</sup> May. We were their final clients for the 2018 season.

### **MAPS:**

Mapping of the Stauning Alps is fairly poor, with the main source of information being the Geological Survey of Denmark (GEUS). Their website (<https://data.geus.dk/geusmap>) is an excellent resource for visualising the region. However, it does not serve as a detailed map for activities such as mountaineering. On the summits of some peaks, our view (i.e. reality) differed substantially from that outlined on the GEUS maps. As well as this, the latter's poor resolution (i.e. 100 metre contour lines) means that fairly large features, as well as the profile of mountainous terrain, are often invisible on the map itself.

To the map's credit, however, it has been updated to include information from an extensive survey by Anthony K. Higgins called '*Exploration history and place names of northern East Greenland*'. This document is a fantastic resource, a meticulous compilation of what has been climbed, named and visited within a large region of eastern Greenland. From this alone we were able to ascertain a lot of the mountaineering history of the Stauning Alps, seeing which mountains had been climbed, and by whom. Unfortunately, the survey only includes information from before 2008. This meant that for the most recent decade we had to research elsewhere to discover what remained unclimbed.

We also benefitted hugely from Molly Thompson's expedition. They had secured sponsorship from *SatMap Systems Ltd.*, a Global Positioning Systems company, who helped them to create higher-resolution maps from satellite imagery. These maps were purposed to include slope angles and landscape features, such as rivers and meltwater channels, which are only visible in the summer months. As a result, the Thompson expedition was able to create visualisations of avalanche risk, heavily crevassed terrain and subnivean geographical features, like streams. They lent laminated versions of these maps to Team Moskus for the duration of our expedition.

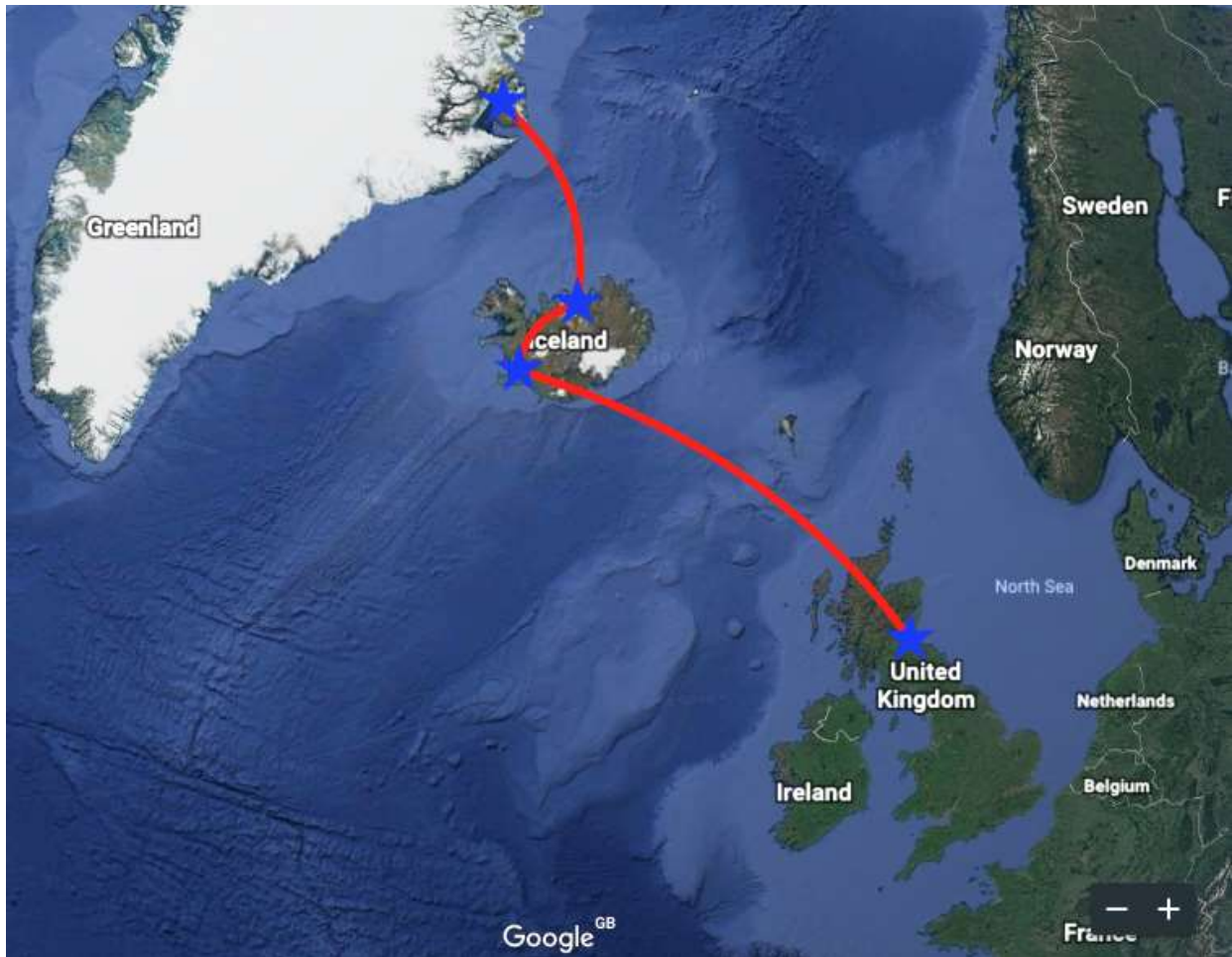
## GETTING THERE:

Getting to Constable Point is fairly straightforward, despite its high latitude and lack of proximity to any large population centres. Team Moskus flew from the U.K. to Keflavik airport in southwest Iceland, before spending the day driving north to Akureyri, on Iceland's north coast. Here we spent one night before flying out to Constable Point on a *Nordlys* plane.

Our flight was a private charter organised by *Tangent Expeditions Ltd*. The other passengers on the flight were also *Tangent* clients, travelling to Constable Point to compete in the annual 'Iceman' adventure race that *Tangent* run.

The temperature gradient that exists between Akureyri and Constable point is fairly exceptional. Throughout the year it averages 10° C, despite the locations being less than 600 kilometres apart. True to form, when we left Akureyri it was a balmy 9° C whereas in Greenland we were greeted by snowfall and temperatures of -5° C.

We were then due to be snowmobiled out to a hut known locally as the 'Red House', from where we would start the unsupported phase of our expedition. However, the weather was so abysmal that *Tangent's* team were unable to transport us for two days. In the meantime, we spent many hours holed up in our tent, enduring a prolonged and unpleasant blizzard as we acclimatised to life in the Arctic once again.



Our route to Constable Point, Greenland

### THE EXPEDITION PLAN:

As outlined at the start of this report, our expedition was planned to be an unsupported, five-week trip to Greenland with two distinct aims:

1. To summit at least two unclimbed peaks in the Stauning Alps mountain range
2. To conduct scientific research, including continuation of the work Thompson *et al.* started on the Roslin glacier, one of largest glaciers in the southern Stauning Alps.

Given our limited funding, and our desire to incorporate significant manhauling into the expedition, we concluded *Tangent's* snowmobile charge for a return trip to the Stauning Alps was a prudent place to save money. We resolved, therefore, to pulk most of the way there and to snowmobile most of the way back.



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Tangent agreed to drop us at a structure known as ‘The Red House’, from where we would commence the unsupported phase of our expedition. We then planned to pulk roughly 120 km northwest, into the Stauning Alps range. We had located a valley called *Gurreholm Dal*, which contained several sizeable glaciers and, allegedly, numerous unclimbed peaks. We budgeted a week for mountaineering in this locale, hoping to make at least two first ascents in that time, before returning to a food depot which we would have cached in *Schuchert Dal*.

Having resupplied at our depot, we would then ski north for two days to the Roslin glacier, where we would spend a week locating the ablation stakes left in the ice by Molly Thompson and her team. After this time we would return to a ruined trappers’ hut known as *Gurreholm*, from where we would be picked up by *Tangent’s* snowmobiles and taken back to Constable Point.

The breakdown of our plan in terms of specific dates was thus\*:

- **April 15<sup>th</sup>**: Leo Carew joins Matt Hay in Keflavik, Iceland
- **April 16<sup>th</sup>**: Drive from Keflavik to Akureyri
- **April 17<sup>th</sup>**: [1] Fly from Akureyri, Iceland to Constable Point, Greenland
- **April 18<sup>th</sup>**: [2] Snowmobile to ‘The Red House’
- **April 19<sup>th</sup> to 28<sup>th</sup>**: [3] Pulk from ‘The Red House’ to *Gurreholm Dal*, caching food en route in *Schuchert Dal*
- **April 28<sup>th</sup> to May 4<sup>th</sup>**: [4] Mountaineering in *Gurreholm Dal*
- **May 4<sup>th</sup> to 6<sup>th</sup>**: Ski to Roslin Glacier via food depot in *Schuchert Dal*
- **May 6<sup>th</sup> to 13<sup>th</sup>**: [5] Science work on the Roslin Glacier
- **May 13<sup>th</sup> to 15<sup>th</sup>**: [6] Ski from the Roslin Glacier to *Gurreholm Hut*
- **May 15<sup>th</sup>**: [7] Snowmobile to Constable Point
- **May 15<sup>th</sup> to 22<sup>nd</sup>**: Contingency days, to be used for recreation, cultural visits to Ittoqqortoormiit and packing
- **May 22<sup>nd</sup>**: Fly from Constable Point, Greenland to Akureyri, Iceland

\*Where numbers have been inserted, they correspond to the image of our expedition plan on the next page.





Annotated Google image of the region, illustrating our original expedition plan





The Red House – A former space observatory and the start of our unsupported phase

## THE EXPEDITION:

### OVERVIEW:

Team Moskus' expedition can be broken down into three distinct phases, each of which will be covered in turn:

- i) Pulking Phase – Jameson Land
- ii) Mountaineering Phase – Stauning Alps
- iii) Science Phase – Liverpool Land

Already apparent from the mention of Liverpool Land is the fact that our expedition plan was substantially modified *in situ*, mostly due to the weather we encountered. The blizzard that kept us tent bound for our first few days in Greenland turned out to be a harbinger of what was to come; after an initial spell of clear, sunny conditions, Team Moskus were plagued by frequent snowfall, low cloud and bouts of strong wind.

**i) Pulking Phase – Jameson Land:**

The unsupported phase of our expedition began at a curious structure known as ‘The Red House’. This building allegedly used to be a space observatory but, after fulfilling its purpose elsewhere, ended up in Jameson Land. Here it has become a useful landmark, frequently visited by Inuit hunting parties who rest overnight at the Red House on their way to and from the plains of Jameson Land, where they hunt Musk Oxen.

We arrived on the 19<sup>th</sup> April to find the hut empty. We were grateful for its stove, which we used to dry out all the kit that had become wet during the blizzard. Early the next morning we set off, pulking up a col and trying to maintain a westerly bearing as we began our long trek to the Stauning Alps. Despite all of our training, the sheer weight of our pulks – roughly 100 kg – made it very challenging to ski uphill, even a modest gradient reduced our speed considerably.

Consequently we decided to change tack, following natural gullies and river beds down towards the coast of Scoresbysund Fjord, before skiing northwest along the flatter sea ice towards the Stauning Alps.



During this phase of the expedition we lived by a routine; breaking camp each morning and then pulking for 5 or 6 one-hour segments, with a short break for food and fluid in-between each stint and a slightly longer break for lunch. We kept an eye on the distance we were covering, given our need to complete the c.120 km journey in 10 days or less and tended to make camp in the evening only once we were satisfied with our progress.

We enjoyed excellent weather during this long ski, but the hardship was not inconsiderable. Overnight temperatures often fell below  $-20^{\circ}$  C and the dry air caused chapped skin and chilblains. The inaccurate maps and great weight of our pulks combined to a fearsome physical, mental and navigational challenge. We were badly sunburnt – including inside our mouths and up our nostrils (!) – as the strong April sunshine reflected off the snow all around us. The effort of daily pulking took its toll as well, especially on Matt who began to struggle with his ski boots, which rubbed slightly, inducing painful ‘tailors bunions’ on both of his feet that further exacerbated the problem.

The terrain changed only slowly as we threaded our way towards the coast. Our first glimpse of the Stauning Alps came on the 21<sup>st</sup> April, when we finally broke free of the labyrinthine gullies we’d been stuck in and made it onto the plains above. On the same day we also came across our first herds of Musk Ox, which was a wonderful experience.

Once we reached the coast, we headed northwest across the sea ice, passing close to some of the colossal icebergs that remain marooned in Scoresbysund fjord during the winter. On the frozen sea we saw plenty of polar bear, Arctic fox and ermine tracks and came across several seals hauled out on the ice. The highlight, however, was the icebergs, which were spectacular!

We had our coldest night of the expedition ( $-24^{\circ}$  C) whilst on the sea ice, as katabatic flows from the surrounding mountains drained into the fjord with the cold air pooling and forming patches of freezing fog in places.

On April 25<sup>th</sup> we made it to the abandoned trapper hut at *Gurreholm*, an interesting (if slightly spooky) 1930s structure. It’s front door had been smashed in by a polar bear a while back and the cabin has since partially filled with snow. Despite this, many of the rooms remain well preserved, including one that contains a radio transmitting system many decades old.



Leo Carew, looking out over the plains of Jameson Land to Musk Oxen and distant Milne Land



Exploring one of the many icebergs marooned in the sea ice of Scoresbysund Fjord



Polar rev (Arctic fox) tracks leading to a nearby iceberg, Scoresbysund fjord

On April 27<sup>th</sup>, we dug a depot at point 71°23'32.6" N, 24°35'34.7" W and cached most of our food, as well as the equipment and fuel that we would not need for the mountaineering phase of the expedition. By the 28<sup>th</sup> we had set up camp deep into Gurreholm Dal, tired but ready to start our mountaineering phase on schedule, having made up for the time we lost during the initial blizzard.



**Pulking up the Gurreholm River as we headed into the Stauning Alps**

**ii) Mountaineering Phase – Gurreholm Dal, Stauning Alps:**

The settled weather that had characterized our pulking phase unfortunately gave way almost as soon as we arrived in the mountains. A disturbed, mild and snowy pattern took hold, with frequent fronts bringing copious precipitation and bouts of strong wind at times. This meteorological regime was not conducive to successful mountaineering, with an elevated avalanche risk and frequent hill fog. Unfortunately, it lasted for much of the remainder of our expedition.

On April 29<sup>th</sup>, we skied a short recce up the valley to a height of c.700 m above sea level. The purpose of this excursion was to find a vantage point from which we could compare our map and reality. The two did not match especially well, due to the combination of the 100m contour lines on our maps, as well as plain inaccuracy.

We then lost three days to stormy conditions, with snow, mist and hill fog lasting all day on the 30<sup>th</sup> April, 1<sup>st</sup> May and 2<sup>nd</sup> May. Finally, clearer and cooler conditions moved in from the north and so, on the evening of the 2<sup>nd</sup>, we had our first attempt at a nearby summit. The mountain we

chose to ascend we later called *Fladtllysbjerg* ('the mountain of flat light') due to the poor contrast we experienced when climbing. We hoped it would be a summit to bag and also a useful vantage point for our route up a higher mountain further west, which we very much wished to climb.

We set off at 2100 local time and skinned up onto '*red-rock ridge*', a scoured seam of red arkose sandstone with several notable tors, which led west and then north up to the summit of '*Fladtllysbjerg*'. Unfortunately the final section of the ridge, up onto the peak itself, was exceptionally steep and loaded with fresh snow after the recent falls. We deemed the avalanche risk considerable and any further ascent reckless, reaching our highpoint at 1062m.

*'Fladtllysbjerg' (1161m) via 'Red-rock ridge'*

**Route Length:** 14 KM

**Net Altitude Gained:** 740m

**High Point:** 1,062m

**First Ascent:** No, unsuccessful first ascent with high point of 1062m reached

**Weather:** Mild at first, becoming colder and windier: -1 C at base, - 9 C at high point. Cloudy skies, with a few nearby summits obscured at times. Wind becoming northerly (15 to 20 knots) on the ridge.



One of the red sandstone tors on the ridge to *Fladtllysbjerg*





Returning home in a strong northerly wind, with Mt. Doom visible in the distance

After our unsuccessful attempt we then endured another day of snow on 3<sup>rd</sup> May. On 4<sup>th</sup> May, it was still snowing, but visibility was better and so we skied up and onto the Aries glacier the largest in *Gurreholm Dal*. With a beautiful ice cave at its snout, this glacier was well worth the visit. We also took the opportunity to dig a snow pit on the main body of ice (results in the science section) for future comparison with the Roslin glacier.

On the 5<sup>th</sup> May clearer weather encouraged us to attempt another first ascent attempt, this time on a beautiful twin-peaked mountain we referred to as '*Mt. Doom*'. Planning to set off at 2100 local time, we were distraught to watch cloud descend onto the summits soon after 1900. We resolved to wait for a few extra hours, relieved when the cloud finally dissipated around midnight. At 0100 on 6<sup>th</sup> May we set off up the valley towards the peak.



Annotated photo showing '*Mount Doom*' and our route up the '*Wolf's Ridge*' (in red)

It was a cold, gruelling but beautiful climb. We skied west up *Gurreholm Dal* before cutting up one of the steep-sided northern gullies and then onto the flank of a subsidiary mountain. Continuing west from here, we cut up the final '*Wolf's Ridge*' towards the higher, eastern summit. This final climb was exceptionally laborious, with deep, soft snow proving poor for step-cutting. Towards the summit, the ridge became extremely narrow, with cliffs on the northern side, and a steep, corniced slope on the other. This cornice was fractured in places, with evidence of recent avalanches that had triggered on the south facing slope all around us.

Less than 100 vertical metres from the summit, we reached an impasse – the route ahead was narrow and fractured, with a visible crown wall almost on the apex of the ridge itself. By this stage it was nearly 1000 local time, and the south-facing snow was softening readily in the sunshine. Having already negotiated an exposed section of the ridge, we were anxious to get back down that section before the snow deteriorated significantly as the temperature rose. This meant that any anchors we laid to get to the summit would have to be deployed quickly. However, the snow was of such atrocious quality that building a dependable anchor was not possible. Faced with the only remaining option of walking unprotected across the face of the slope below the crown wall, we decided to call time on our ascent. The likelihood and consequences of an accident were disastrous, particularly with the nearest rescue helicopter being hundreds of kilometres to the southeast.



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It was heart breaking to have come so close to the summit of such a fine mountain, but ultimately, we made the correct and safe decision in turning back. To continue would have been reckless.

**First Ascent of 'Mt. Doom' (1630m) via 'Wolf's Ridge'**  
N, 024° 53' 16.2" W

**Lat/Long:** 71° 36' 1.6"

**Net Altitude Gained:** 1455m

**Total Altitude Gained:** 1953m

**Route Length:** 31 KM

**First Ascent:** No, unsuccessful first attempt at a new route with high point of 1545m reached.

**Reason for retreat:** High avalanche risk on final section of route and snow too poor to build a quality anchor.

**Weather:** Clear and cold: -18 C at base, -12 C at summit, with little or no wind below 1,500m altitude.



Leo Carew taking in the sunrise en route to the 'Wolf's Ridge'



Annotated photo showing the summit of *Mt. Doom* and Team Moskus' high point

Despondent on the return journey after such an exhausting and fruitless effort, we decided to summit a nearby mountain, detouring slightly from our route back down to *Gurreholm Dal* to take in the peak, which we called '*Sugarlump*'.

While not the prize we were after, our ascent of '*Sugarlump*' gave us our first unclimbed mountain and something to build on. Its summit was the high point of a tract of ground to the east of our route up '*Mt. Doom*', but with sufficient prominence to be a separate mountain in its own right.

**First Ascent of '*Sugarlump Mountain*' (1167m)**

50' 09.6" W

**Lat/Long: 71° 34' 34.7" N, 024°**



Annotated photo showing the summit of ‘*Sugarlump*’ mountain (1167m) from the ‘*Wolf’s Ridge*’

Having pulled the trigger on a summit attempt, Team Moskus needed to rest and also to reassess. It was now the 6<sup>th</sup> May and if we had been able to stick to our original itinerary, we would have already been camped on the Roslin glacier by this date. After some deliberation we decided that we should make one more mountaineering effort, to get a second first ascent and complete at least one of our two expedition objectives. We had been warned by Alistair Everett – the glaciologist on Molly Thompson’s team – that locating their ablation stakes on the Roslin glacier would be extremely difficult as they were likely to be buried beneath the snowpack, locked into a moving glacier and without any material which might have been easily detected through snow (they were made out of bamboo). Having consulted with local experts, we were also concerned that high rates of ablation on the Roslin might have melted out the stakes altogether. Thus, the risk of abandoning our mountaineering objective, only to then fail at our scientific one, was significant.

Ultimately, we decided it was better to secure the one objective that we knew was within our grasp. However, this meant a two-day ski trip, to the depot and back, in order to resupply with food and fuel. We set off for *Schuchert Dal* on the evening of the 7<sup>th</sup> May, travelling through the night when the snow was cooler and drier. The freezing temperatures also limited our break time between stints of pulking, as we quickly got cold and impatient to be on the move again.



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Our food cache was easy to find thanks mostly to an Arctic fox, which had attempted to burrow down to our supplies. Happily, we had had the foresight to cover the top snow-layer with anti-bear pepper spray and this had clearly deterred the fox, whose digging had ceased at the depth of the contaminated snow. By enlarging the fox's hole we found our buried kit. Incidentally, the fox proved a far more reliable locator than our GPS, which was out by over a metre!

Having resupplied, we pulked back up *Gurreholm Dal* the next evening, pitching camp on the southern side of the valley this time, directly below our next target: a broad, glaciated peak that dominated the valley's south-eastern skyline.



*Mountain camp mark two, on the southern side of Gurreholm Dal*

At 2100 on the 9<sup>th</sup> May we set off on our third attempt at a first ascent. Our weather forecast from home had warned of a savage storm coming in at 1000 the following morning, so we knew that we had to take advantage of the brief weather window and work quickly.

We skinned up a steep slope and onto a broad ridge, which peaked above an interesting corrie we called '*The Superbowl*'. After this the ridge dropped down to a col before ascending a steep and extensive ridge onto the glaciated plateau of the mountain. This part of the climb was exposed

and challenging, with deep, soft snow once again hindering our progress. Fortunately, at the crucial moment the conditions were conducive to anchor building and so we were able to scale a tricky cornice and top out on the plateau. From here, it was a race against the weather as we skied nearly 5 km southwest to the summit itself, conscious all the while of the clouds amassing on the eastern horizon.

Having reached the summit we returned via a different route, along the eastern side of a large corrie, avoiding the very steep ridge we had ascended. This lengthened our excursion but was much safer. We made it back to our tent by 1000 on the 10<sup>th</sup> May, with a second first ascent under our belts!

**First Ascent of ‘Bjørnsskulderfjell’ (1620 m)**

**Lat/Long:** 71° 30’ 23.6” N, 025°

01’ 42.1” W

**Net Altitude Gained:** 1301m

**Total Altitude Gained:** 1821m

**Route Length:** 24 KM

**First Ascent:** Yes, successful.

**Weather:** Clear and cold: -2 C at base, -12 C at the summit, with light easterly winds.



(Left) Matthew Hay approaching a cornice at the top of the steep ridge up ‘Bjørnsskulderfjell’

(Right) Matthew Hay climbing the steep ridge en route to the glaciated plateau below the







Leo Carew on the summit of '*Bjørnsskulderfjell*', the 'Shoulder of the Bear' (1620m)



Annotated photo showing our route to the summit (not visible in this image)

Our triumph was short-lived, however, with a planned satellite phone call to *Tangent* the next day resulting in an evacuation from the Stauning Alps. This was a real hammer blow to our scientific effort as it precluded the possibility of Team Moskus even visiting the Roslin glacier during the five days we had remaining.

*Tangent* were concerned that an incoming storm would scour the snowmobile route of its snow, jeopardising the feasibility of our agreed rendezvous at *Gurreholm Hut* on the 15<sup>th</sup> May. Given their local knowledge, Team Moskus felt compelled to trust *Tangent's* judgement and so broke camp, pulking through the night to meet the snowmobiles near *Gurreholm* early on the 12<sup>th</sup> May.

The return to Constable Point took the rest of that day, though the weather was fantastic and we were treated to excellent views of snow buntings, geese and musk oxen.



Team Moskus awaiting collection on the coast of Scoresbysund Fjord

*Tangent Expeditions and the Mountaineering History of the Scoresbysund Region – A Note to Climbers:*

Aforementioned in the planning section was a problem we had with *Tangent Expeditions Ltd.* regarding the mountaineering advice they gave us. When homing in on *Gurreholm Dal* and the Aries Glacier as a likely location for our expedition, Team Moskus sent Paul Walker an email asking for information on unclimbed peaks in that locale.

Below is the response we received:

*“On 14 Jan 2018, at 18:21, Paul Walker <[paul@tangent-expeditions.co.uk](mailto:paul@tangent-expeditions.co.uk)> wrote:*

*Subject: Aries Glacier ascents*

*Hi Matt, Leo,*

*Most of the peaks around the Aries Glacier will probably be unclimbed. The attached is a summary of all expeditions that I am aware of up until 1996. The only ones since then that I am aware of are some of our own trips which were further south, and then Molly Thompson’s [in 2017]...”*

Of note is the fact that the email doesn't detail any expeditions post-1996 that visited the area in question, with Paul mentioning that *Tangent's* trips had taken place further south and that Molly Thompson's team, who visited the Roslin and Bjørnbo glaciers, were the only other group he was aware of.

Due to our own research, Team Moskus believe that we were aware of all the pre-2008 expeditions to the Stauning Alps. The only gap in our knowledge was the decade from then until 2018. With Paul's assurances, though, we were confident that the mountains we had identified as unclimbed in *Gurreholm Dal* were indeed unclimbed.

Once we had returned to Constable Point on the 12<sup>th</sup> May, however, we chatted to Paul about our expedition and he mentioned that he actually knew of two trips to *Gurreholm Dal* since 2014, which *Tangent* had been involved with. He then showed us the reports from these trips and we were devastated to realize that 'Mount Doom' had already been climbed. More than this, it had been climbed by both expeditions, with the second team falsely believing it was their first ascent as well! Below are the annotated maps from both expeditions, in 2014 and 2016:



Annotated map from the 2014 expedition



Annotated map from the 2016 expedition

Team Moskus' understanding, therefore, is that both the 2016 expedition and our own attempted to climb Mt. Doom because we mistakenly believed it to be unclimbed. Admittedly, our route up the 'Wolf's Ridge' was different (and therefore new), but the salient fact is that both expeditions climbed the peak under a false assumption. Quite why Paul Walker withheld this information from the two groups is unclear; our gut instinct is that his mistake was accidental, born out of poor administration rather than anything conscious.

However, our willingness to extend *Tangent* the benefit of the doubt was tested shortly after Team Moskus' return to the U.K., when a BBC producer who was part of a crew coming to Scoresbysund fjord in June 2018 got in touch. She asked Matthew for his advice on the region and on snow conditions in the Stauning Alps, sharing with him the first ascents that the BBC expedition were targeting for their documentary.

Of the five peaks that the BBC had earmarked in the Stauning Alps, Matthew knew that three were already climbed (and named: *Pevensey Fjeld*, *Kilvrough Fjeld* and *Snekuppel*) by John Hunt's expedition in the 1960s – the information being freely available on the Geological Survey of Denmark's website. After enquiring who had recommended these mountains to the BBC crew, Matthew learnt that it was, once again, Paul Walker.

As stated earlier, Team Moskus enjoyed working with *Tangent* while we were in Greenland and found them to be very hospitable and friendly. It does seem, however, that they are entirely unreliable suppliers of mountaineering information. **To avoid experiencing a similar disappointment to us, we recommend that any future expeditions targeting first ascents do not rely on *Tangent* for an accurate understanding of the region's mountaineering history!**

**iii) Science Phase – Bjerring-Pedersons Glacier, Liverpool Land:**

Once back at Constable Point, Team Moskus were stormbound for a further two days, with the blizzard peaking on the 14<sup>th</sup> May. While this was frustrating, it provided us with time to reconfigure the scientific element of our expedition. Originally, we had had three aims, which were:

- i) Locate and measure the ablation stakes, which Molly Thompson's team had drilled into the Roslin glacier
- ii) Dig snow-pits in the Stauning Alps to ascertain the depth, temperature and density of the winter snowpack
- iii) Photograph the current extent of any glaciers we visited or camped on

Given our failure to reach the Roslin glacier, we were clearly going to be unable to achieve our first aim. However, we had managed to dig a snow pit on the Aries glacier as well as photographing the extent of three glaciers in *Gurreholm Dal*. Building on this, we decided to dig further snow-pits on the *Bjerring-Pedersons* glacier in Liverpool Land, siting one of these

on a comparable aspect to the Roslin glacier and another on the opposite aspect, though at a similar elevation.



Annotated photograph showing the extent of three glaciers in upper *Gurreholm Dal*, May 2018

Getting to the *Bjerring-Pedersons* was straightforward; a quick trip across the still frozen Hurry Fjord and then a short but steep ski up the western side of the glacier. We made a campsite near the apex of the glacier, on the coastward side. This would serve as our base for the duration of our time in Liverpool Land, until our final return to Constable Point began on the 19<sup>th</sup> May.

On the 15<sup>th</sup> May we dug our first snow-pit at an altitude of 525 metres above sea level, on a similar westerly aspect to that of the Roslin glacier. The depth of snow on the glacier was astonishing. Even accounting for the pit's proximity to the coast, there was much more snow than we had expected. Molly Thompson's team had dug ten pits the previous spring, down to the surface of the Roslin Glacier, and none of their pits was deeper than 185cm. By contrast the snowpack at our site on *Bjerring-Pedersons* glacier was in excess of 350cm, nearly twice as deep!



(Left) Matthew Hay digging a snow pit on the *Bjerring-Pedersons* glacier.

Both team members took it in turns to dig.

The other obvious difference in our snow pits, both on the Aries and the *Bjerring-Pedersons* glaciers was the temperature – none of our values were much below  $-7^{\circ}\text{C}$ , compared with typical values between  $-9$  and  $-15^{\circ}\text{C}$  the previous year.

While the ambient air temperature heavily influences the top 20 cm of the snowpack, the lower layers tend to be insulated from short-term fluctuations, thereby providing an indication of the air temperature around the time they were buried by further snowfall. The lack of cold temperatures in the snowpack during 2018 is likely the result of an abnormally mild winter in the Scoresbysund region of eastern Greenland, both in comparison to 2017 and the climatic average. It is also possible that a highly unusual rainfall event in February contributed to the warmer temperatures in the snowpack, as liquid water percolated down through the snow during the midwinter thaw.

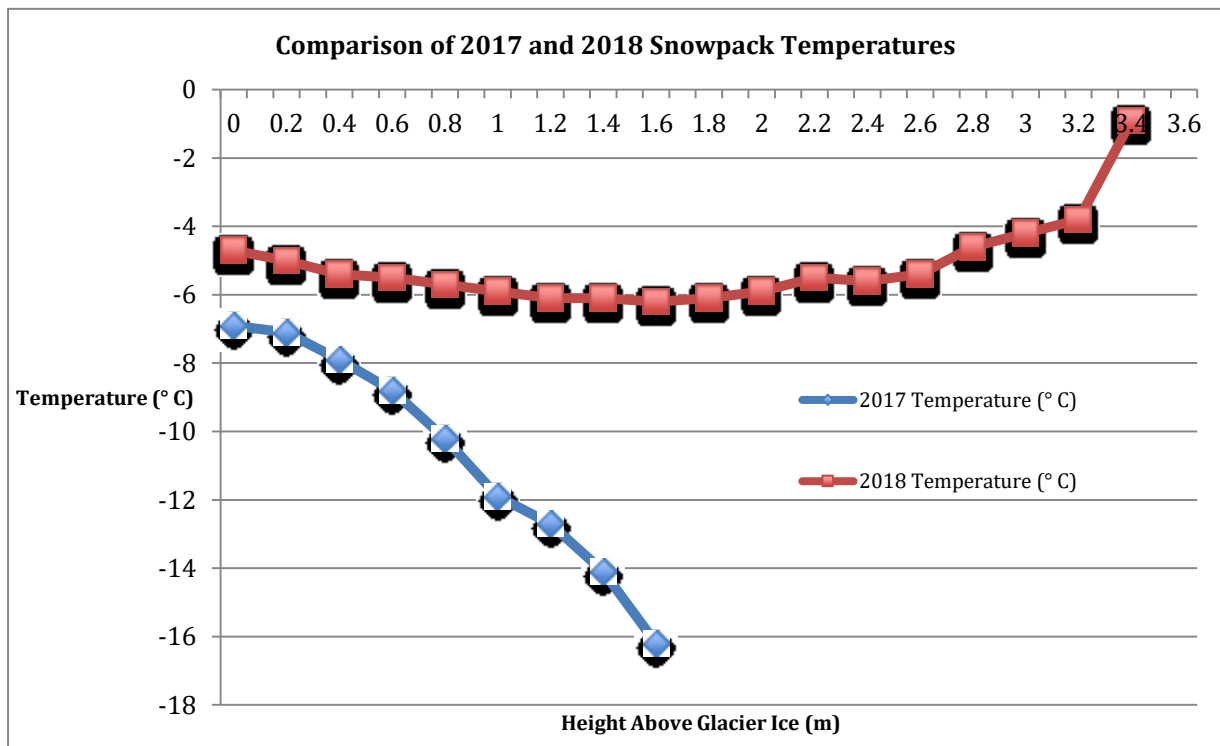
The 2017-2018 winter's mild temperatures are also linked to the season's large volume of snowfall, both being the result of easterly winds dominating the local weather pattern bringing warm, maritime airmasses and frequent frontal precipitation in off the North

Atlantic ocean. Being further inland, one would expect the Stauning Alps to receive less snowfall from such a meteorological setup and, indeed, our snow pit on the Aries glacier was 60 cm shallower than its Liverpool Land counterpart.

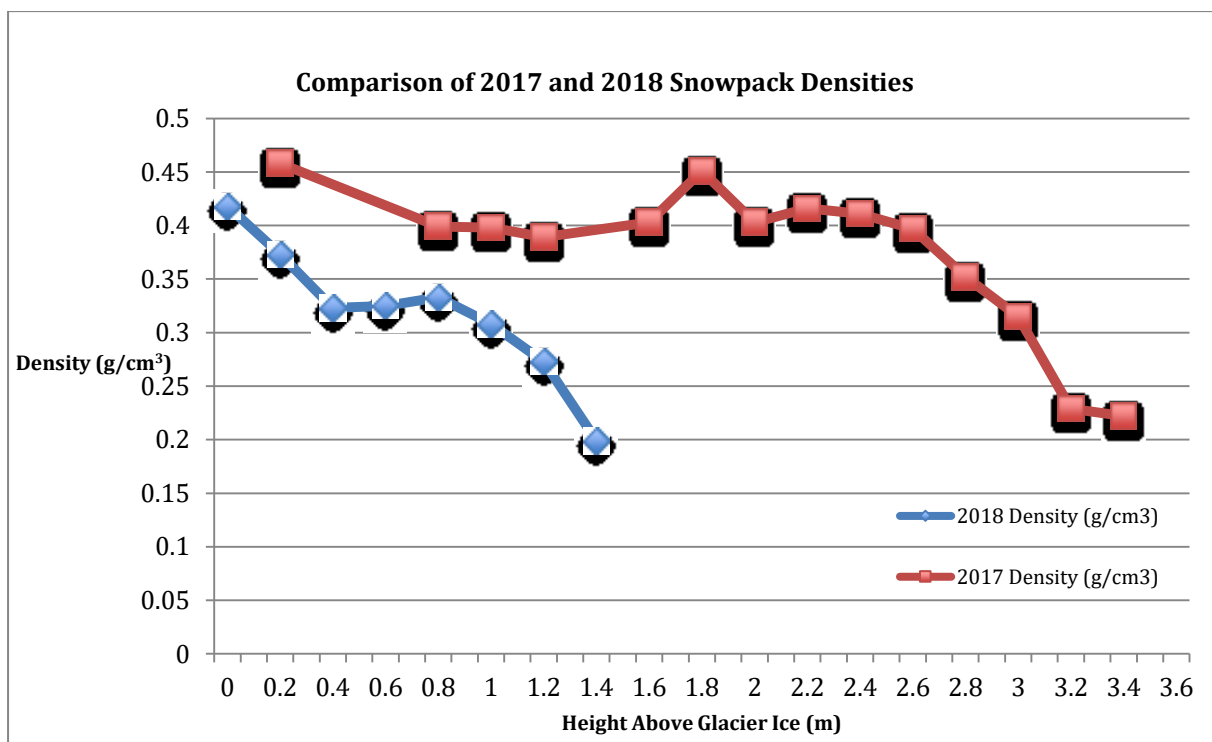
Interestingly, it seems that climate change is in part responsible for this shift in winter weather conditions. Milder temperatures, increased snowfall near the east coast and decreased sea ice are all part of the global warming signal in this part of Greenland. Scoresbysund fjord freezes up on average one month later than it did even twenty years ago, with the thaw setting in a week or two earlier as well. While this rate of change is not unusual in the 'High Arctic', it is still dramatic. It seems likely that the region will breach a climatic tipping point in the next few decades, beyond which its ecology may be altered irreparably.

**Comparison of Snowpack Temperatures and Densities:**

Below are two graphs comparing the temperature and density profiles from one of our snow pits on the *Bjerring-Pedersons* glacier with snow pit #4 from the Thompson expedition. The latter was chosen for comparison because it was dug at a comparable aspect and altitude to our pit, being less than 50 metres higher in elevation. The raw data for our snow pits can be found in the appendices of this report.







On both the above graphs, the '0' on the X-axis corresponds to the glacier ice, i.e. the base of the snowpack. Immediately clear is the vastly increased depth of snow during 2018, as well as the milder temperatures within the snowpack. The density of the snow also seems to be generally greater in the 2018 snowpack, though this is most likely the result of a greater volume (and weight) of snow sitting on top of any given layer, compressing it from above. It is possible that milder temperatures and the dramatic midwinter thaw contributed to greater consolidation of the snow as well.

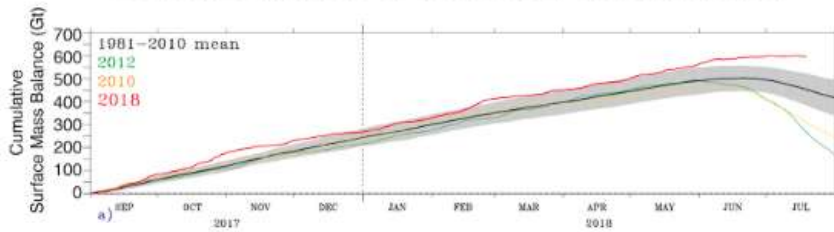
**2018 Winter Snowfall in Context:**

Team Moskus repeatedly came across anecdotal accounts of exceptional winter snowfall during the 2017-2018 winter season. However, apart from comparison with the data from Molly Thompson's expedition the year before, we had little scientific evidence to help us put the conditions in context. Consequently, on our return from Greenland we sought out data from the U.S.A's 'National Snow and Ice Data Centre' [NSIDC] to get a more scientific perspective on the season's snowfall.<sup>1</sup>

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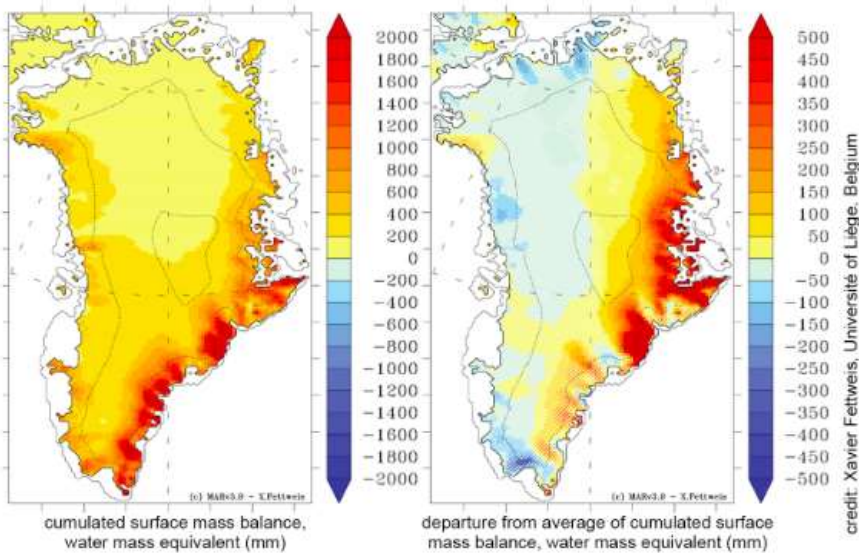
<sup>1</sup> <https://nsidc.org/greenland-today/2018/07/2018-melt-season-half-time-assessment/>

### Model Estimates of Net Snow Accumulation



### Change in Ice Thickness

September 1, 2017 to July 8, 2018



### NSIDC charts showing the relative and absolute change in ice thickness

Greenland.

The right hand of the two charts illustrates how extreme the snowfall accumulation was, relative to the climatic average, during the 2017-2018 season.

Team Moskus, therefore, are confident that our snow pits were not anomalous but instead indicative of the regional situation after an unusually snowy autumn, winter and spring.

### Science Phase – Concluding Remarks:

The NSIDC use data from weather models to calculate snowfall accumulation and melt rates across Greenland's glaciers and ice sheet.

Their diagram, on the left, shows the Scoresbysund region at the centre of an area of exceptional increases in the surface mass balances of ice sheets and glaciers in the east and southeast of



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There is an admirable idea percolating through mountaineering circles at the moment about the value of conducting so-called ‘citizen science’ in remote wildernesses, as part of a sporting adventure. The ethos behind this is both logical and commendable, given that mountaineers are often climbing in far-flung and inaccessible parts of the planet where environmental changes are hard to observe and measure. However, as Team Moskus experienced, in practise it is often challenging for an unsupported expedition to do genuinely useful science without significant specialist equipment, and more time than an unsupported, mixed-objective expedition typically allows.

In Greenland, the one technology that may soon change this is the drone. Although they are expensive and can be difficult to charge and fly in polar climates, drones offer the means to map and photograph glaciers quickly and precisely. Many mountaineers may find use for them in filming and photographing their sporting exploits too.

The other work that seems both straightforward and valuable is simply photographing glaciers and their environs while in the field. These visual records not only provide a different perspective to satellite-derived images, they can become powerful aids when attempting to illustrate climatic and environmental changes in a region. It may be more powerful to envisage glacial retreat from a human viewpoint, on the ground, rather than a slightly abstract image shot from space. Human photographs also show changes in vegetation, river levels and snow patches, which may not be easily detectable from satellites and that, again, add a level of detail, which makes the visible changes more apparent.

However, we argue the most important task for any Greenland expedition is to make themselves and others aware of the speed of climate change in the Arctic. We are witnessing rapid and irreversible changes across all the northern regions of our planet and it is vital that we impress the consequences of these upon everyone our expeditions touch. By forging personal and emotional connections between the Arctic and those people far removed from it, we may give them some stake in and understanding of the future of this region. Although these ties may be small, it seems the most plausible way to make people care about this distant part of the planet, and demand the change that is required.



Leo Carew faces up to an iceberg, frozen into the Greenland Sea off Liverpool Land

## POLAR BEARS:

Polar bears (*Ursus maritimus*) were much on our mind during the Moskus Expedition. We saw frequent evidence of them and had one encounter, while up on the *Bjerring Pedersons* glacier in Liverpool Land. Thankfully, our meeting with the Arctic's top predator was benign, with the bear seemingly uninterested in us. Nonetheless it was a wonderful experience for Team Moskus, with the large male lingering most of a day in our locale.

We can only speculate as to why the bear travelled up onto the glacier from the coast. It walked east and then north about 500 metres from our campsite before resting for several hours in the afternoon sunshine. After its nap, the bear then climbed a steep slope up to a col and over into the next valley. We believe that it was resting while it waited for the sun to set, so that it could ascend the slope once the snow had refrozen and the avalanche risk was reduced.

The take home message, however, is to always be alert to the possibility of bear encounters, even when in mountainous/glaciated terrain or a long way from the coast. Other climbers we met told us of polar bears visiting their campsites at altitudes of over 2,000 metres in the



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Watkins Range, so it is prudent to keep ones guard up for the entirety of any expedition to this part of Greenland, especially as sea ice cover continues to reduce in the future.



Leo Carew photographs the fresh bear tracks on the *Bjerring Pedersons* glacier



(Left) Matthew Hay's ski boot inside the polar bear footprint for scale

(Right) The polar bear wakes up, having rested for most of the afternoon on the glacier.



(Below) The polar bear climbing a steep slope on



## CONCLUSION – LESSONS LEARNT AND THANKS:

We began our return to Constable Point on the 19<sup>th</sup> May, in anticipation of another storm on the 20<sup>th</sup> being likely to slow our progress. By this time, Leo's ski had suffered an unfortunate break, with the back third snapping off. Using gorilla tape, the remains of a shortbread tin and some tent pegs he was able to splint the ski back together, but its ability to glide was severely reduced, which slowed our pace slightly.

By the evening of the 19<sup>th</sup> we had made it to the mouth of *Sødal*, just 12 kilometres from Constable Point. As expected, we were then stormbound in our tent on the 20<sup>th</sup>, completing the journey across Hurry fjord on the 21<sup>st</sup>. We flew back to Iceland on the 22<sup>nd</sup> and the U.K. on the 24<sup>th</sup>.

Overall, the expedition had been a tough but enriching experience for Team Moskus. We returned healthy and unharmed, none the worse for our five weeks in a tent together. It was with a mixture of sadness and relief that we left the Arctic, our beautiful home since mid-April.

On our final night, however, both of us were delighted when an Arctic fox decided to trot right past our tent. For so much of our expedition these hardy little mammals had been ever-present yet utterly elusive, barking out of sight or visiting our campsite while we slept. To finally see one in the flesh and have it look us in the eye seemed a fitting last encounter, a salute from the Greenlandic wilderness.

### **Lessons Learnt:**

Future expeditions will glean a lot about the Scoresbysund region from this report. However, Team Moskus have three insights we wish to emphasise, which will believe will stand future trips in good stead. These are:

- i) Consider carefully the relative benefits of a Nordic mountain-ski setup versus an alpine touring-ski setup
- ii) Take a solar panel and big battery for charging electronics – iPods and Kindles make storm days much better
- iii) Take more whisky (or whatever your preferred alcoholic drink is...) – we ran out far too soon!



Scoresbysund fjord, from the window of a Twin Otter aircraft on the way back to Iceland

**And finally...a few more 'Thank You's':**

Both Matthew and Leo remain immensely grateful to everyone who helped us to make this expedition a reality. We want to reiterate our thanks to our financial backers and our sponsors. Also to Anna Weguelin, who tirelessly kept track of our progress and disseminated news amongst our friends and family so tactfully. Rachel Dobbs was brilliant at making the expedition more real for those at home by using social media to keep everyone updated, and our families' constant love and support meant everything to us.

We realise the emotional toll that expeditions of this nature take on those closest to us and cannot thank our loved ones enough for their patience and understanding. It was an immense privilege to spend so much time in the Arctic this year, an experience Team Moskus will carry with them for the rest of their lives.





## APPENDICES

### FINANCIAL STATEMENT:

**Breakdown of finances:**

**COSTS**

Description	Comment	Amount
Freight Shipment (120 KG)	<i>Tangent Expeditions Ltd.</i>	£1,000.00
Flights to Iceland	Iceland Air	£290.00
Flights to Greenland	<i>Tangent Expeditions Ltd.</i>	£3,000.00
Equipment Hire (e.g. pulks)	<i>Tangent Expeditions Ltd.</i>	£295.00
Stove Fuel (15 L)	<i>Tangent Expeditions Ltd.</i>	£175.00
Snowmobile Transport	<i>Tangent Expeditions Ltd.</i>	£6,650.00
Insurance	<i>Tangent Expeditions Ltd.</i>	£3,000.00
Permitting and Firearms	<i>Tangent Expeditions Ltd.</i>	£450.00
Food and Medical Supplies		£410.00
Misc. (Planning /Administration)	Incl. 'Avalanche training course'	£930.00
<b>TOTAL</b>		£16,200.00

**INCOME**

Description	Comment	Amount
The Arctic Club Award	Gino Watkins Memorial Trust	£4,000.00
The Scottish Arctic Club	SAC Expedition Fund	£1,000.00
The Mount Everest Foundation	The Mount Everest Foundation	£2,000.00
Scottish Mountaineering Trust	SMT Expedition Grant	£1,000.00
British Mountaineering Council	BMC International Committee	£200.00
Expedition Team Contributions	Team Moskus' Personal Savings	£8,000.00
<b>TOTAL</b>		£16,200.00

**SNOWPIT DATA TABLES:**

**Aries Snow Pit #1:**

**Temperature = 0.0 ° C,**

**Altitude = 752 m**

**Latitude: 71° 34' 09.9" N**

**Longitude: 24° 57' 34.5" W**

<b>Height Above Ice (m)</b>	<b>Temperature (°C)</b>	<b>Density (g/cm<sup>3</sup>)</b>
0	-	-
0.1	-7.0	0.145
0.2	-7.0	0.252
0.3	-7.2	0.453
0.4	-7.3	0.407
0.5	-7.3	0.305
0.6	-7.3	0.370
0.7	-7.3	0.351
0.8	-7.3	0.344
0.9	-7.3	0.392
1.0	-7.2	0.375
1.1	-7.3	0.437



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1.2	-7.2	0.452
1.3	-7.4	0.433
1.4	-7.3	0.355
1.5	-7.3	0.388
1.6	-7.1	0.394
1.7	-7.1	0.360
1.8	-7.0	0.432
1.9	-6.8	-
2.0	-6.8	-
2.1	-6.8	0.348
2.2	-6.8	0.375
2.3	-6.8	0.301
2.4	-6.7	0.274
2.5	-6.2	0.205
2.6	-5.8	0.323
2.7	-4.1	0.265
2.8	AIR	AIR

**Bjerring Pedersons Pit #1:      Temperature = +1.1 ° C dropping to -1.4 ° C,      Altitude  
= 525 m**



**GRNLND 2018**

**Latitude: 70° 44' 31.7" N**

**Longitude: 22° 01' 43.9" W**

Height Above Ice (m)	Temperature (°C)	Density (g/cm <sup>3</sup> )
0	-4.7	-
0.2	-5.0	0.458
0.4	-5.4	-
0.6	-5.5	-
0.8	-5.7	0.399
1.0	-5.9	0.398
1.2	-6.1	0.389
1.6	-6.1	-
1.8	-6.2	0.403
2.0	-6.1	0.451
2.2	-5.9	0.403
2.4	-5.5	0.411
2.6	-5.6	0.397
2.8	-5.4	0.352
3.0	-4.6	0.315
3.2	-4.2	0.229
3.4	-3.8	0.220
3.6	-0.9	-

**Bjerring Pedersons Pit #2:      Temperature = +0.2 ° C,**

**Altitude = 408 m**

**Latitude: 70° 44' 30.9" N**

**Longitude: 22° 07' 07.0" W**

Height Above Ice (m)	Temperature (°C)	Density (g/cm <sup>3</sup> )*
0	-6.3	-
0.2	-6.3	-
0.4	-6.4	-



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0.6	-6.5	-
0.8	-6.5	-
1.0	-6.3	-
1.2	-6.2	-
1.6	-5.9	-
1.8	-5.6	-
2.0	-5.1	-
2.2	-4.1	-
2.4	-2.6	-
2.6	-0.6	-
2.8	AIR	-

\*Density cutter unable to penetrate snowpack in this location