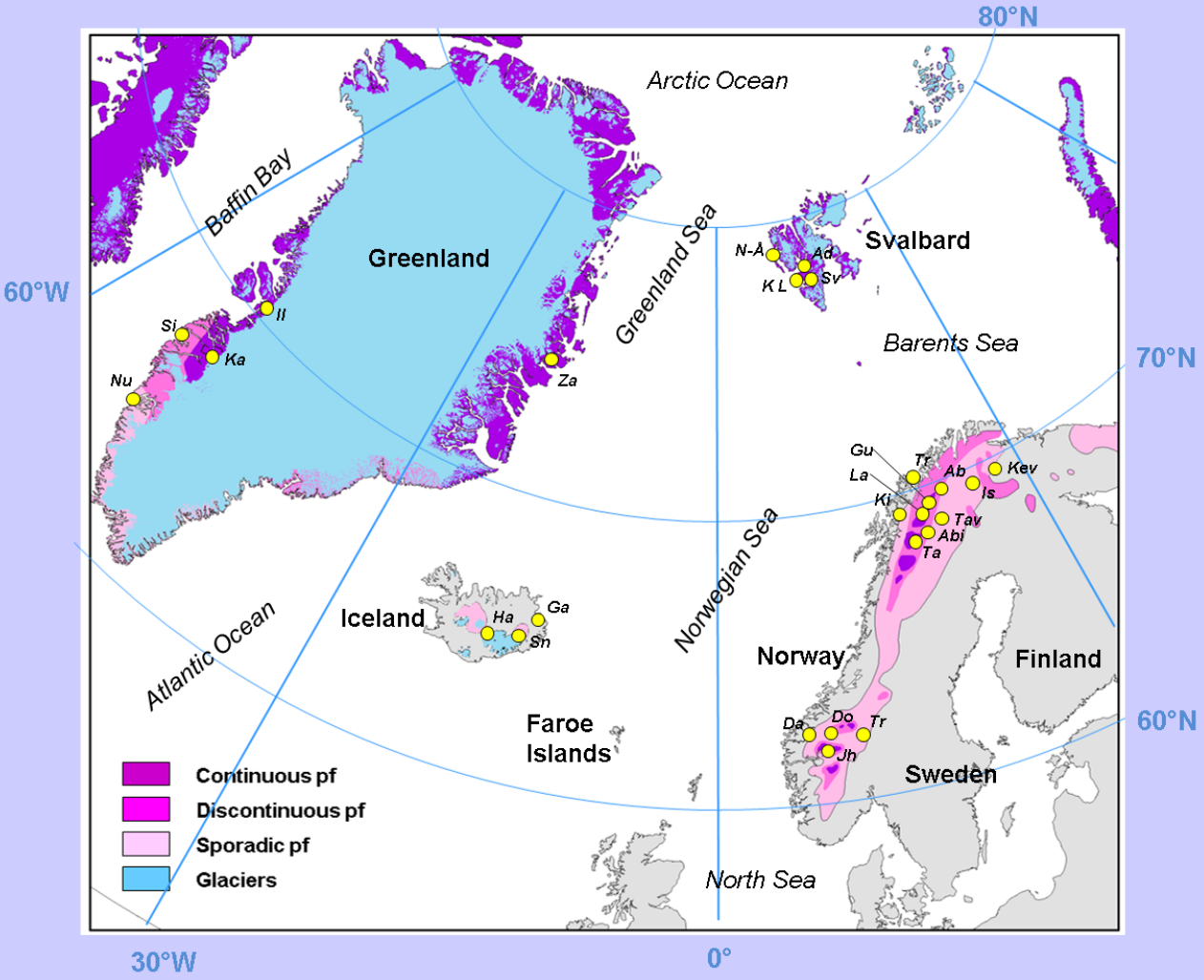
Permafrost in the Nordic area

with special focus on TSP NORWAY results



UNIS

The Thermal State of Permafrost in the Nordic area during IPY 2007-2009

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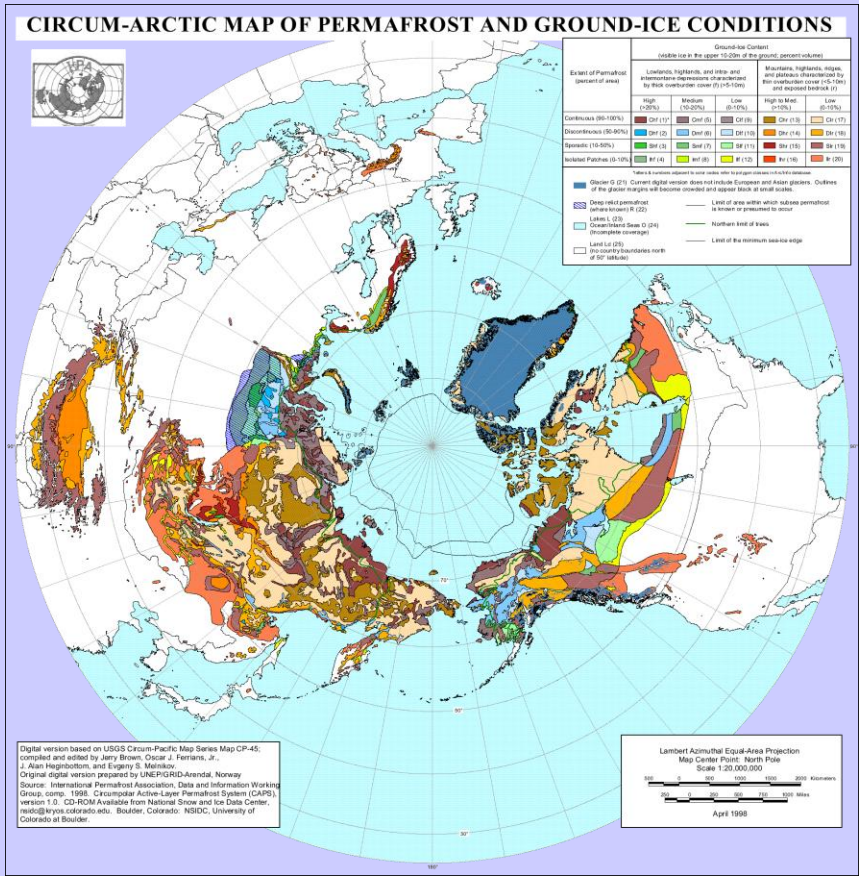
Ole Humlum, Uni. of Oslo & UNIS, Norway
Margareta Johansson, Uni. of Lund & Abisko Research Station, Sweden
Thomas Ingeman-Nielsen, Danish Tech. Uni. Denmark
Lene Kristensen, UNIS, Norway
Jan Hjort, Uni. Of Helsinki, Finland
Per Holmlund, Uni. Of Stockholm, Sweden
Britta Sannel, Uni. Of Stockholm, Sweden
Charlotte Sigsgaard, Uni. Of Copenhagen, Denmark
Jonas Åkerman, Uni. Of Lund, Sweden
Niels Foged, Danish Tech. Uni., Denmark
Lars H. Blikra, Åknes Early Warning Centre, Norway
Mark A. Pernosky, Asiaq, Greenland
Rune S. Ødegård, Gjøvik Uni. College, Norway



Measuring techniques

45 boreholes are made from sea level to 1800 m asl totalling 691 m !

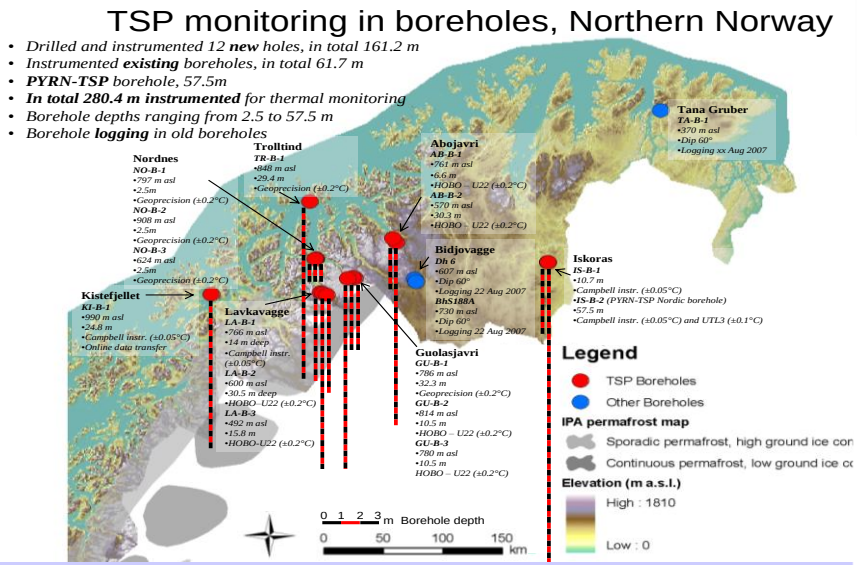
The 38 m deep borehole at the strandflat in Kapp Linne, Svalbard
(6 m sediment over bedrock)

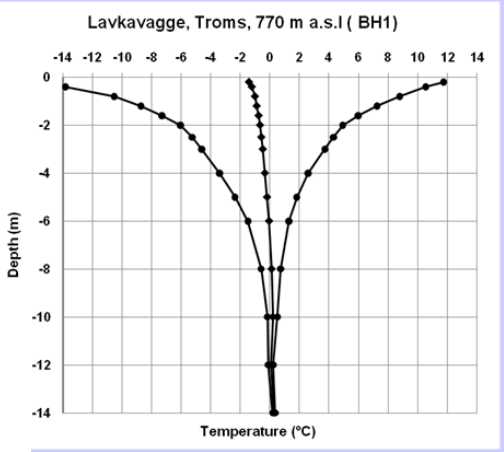
Hand coring in NE Greenland at Zackenberg Research Station

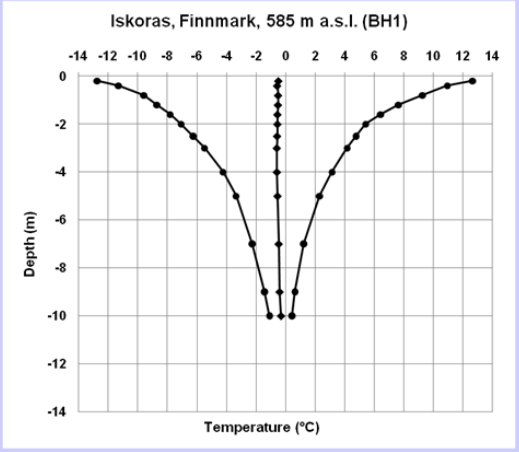
By UNIS students and researchers

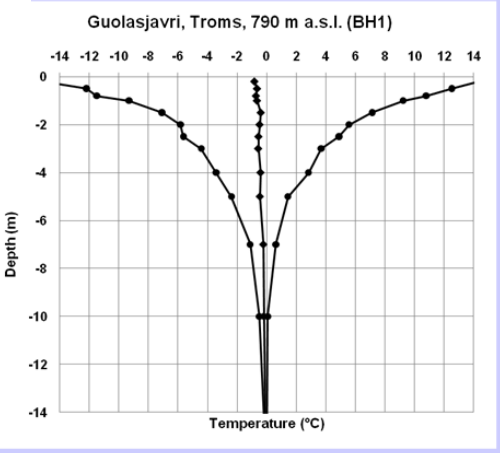
Short 3 m temperature string installation in borehole in Zackenberg, NE Greenland

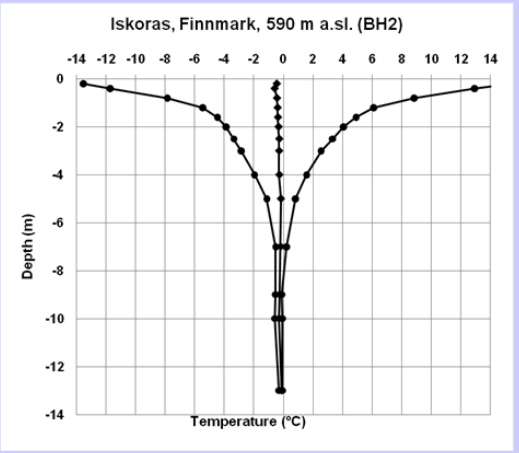
Permafrost snapshot from Northern Scandinavia: Minimum, mean and maximum temperatures 2007-2009

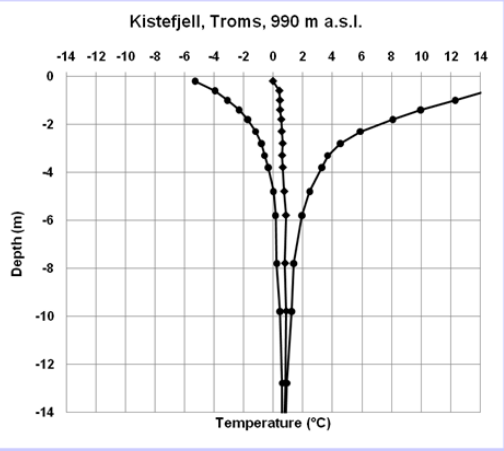


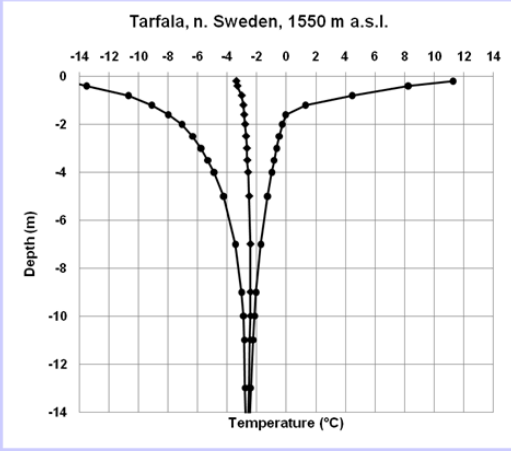








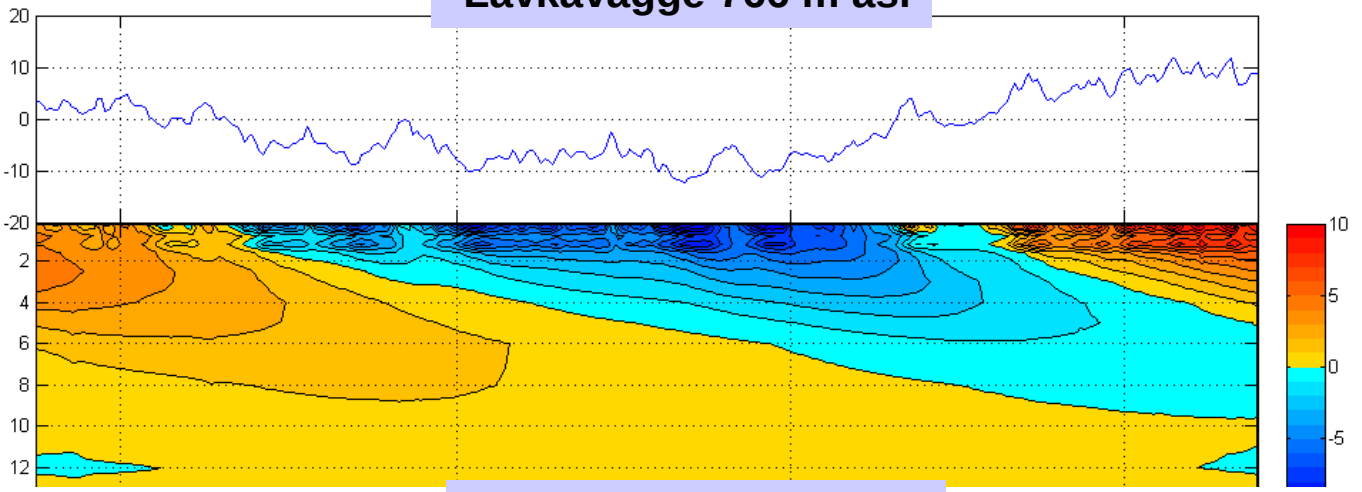




- Discontinuous permafrost regional limit from 1000 m asl in the west to 550 m asl in the eastern parts.
- Relatively warm permafrost, but colder at higher elevations entering the continuous permafrost zone
- 7-10 m thick active layers

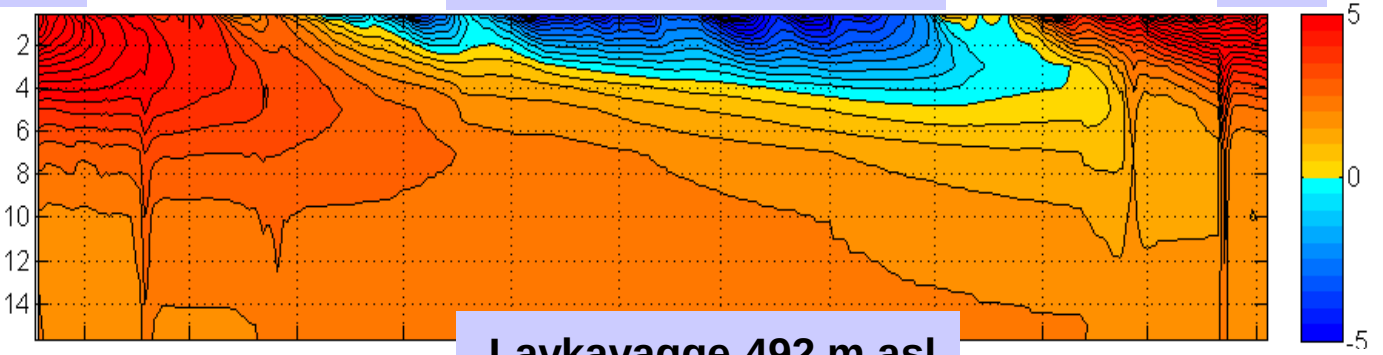
Troms: Lavkavagge (766 m a.s.l.)
Depth: 14.0 m
Borehole temperature monitoring
Automatic camera

Lavkavagge 766 m asl

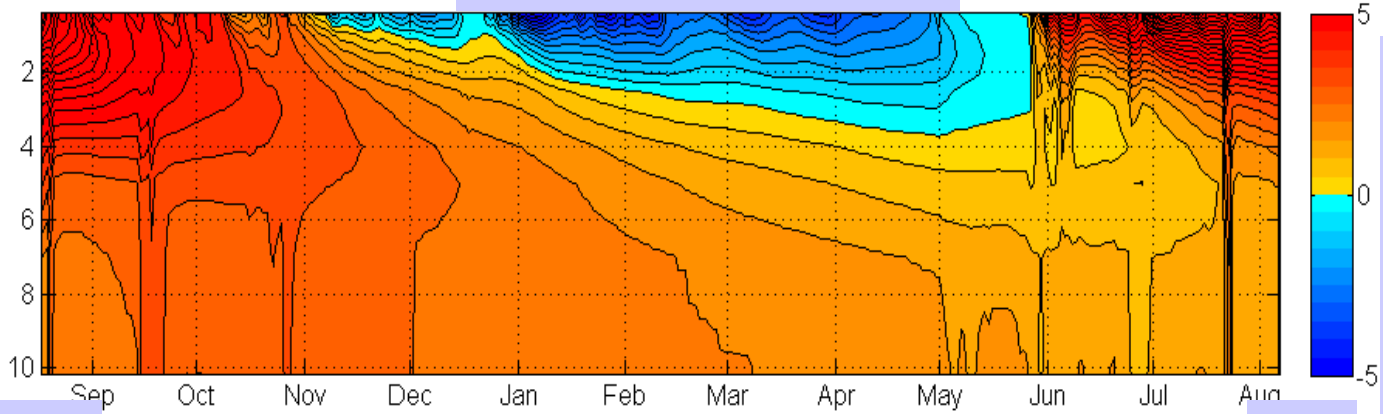


2007 2008

Lavkavagge 600 m asl



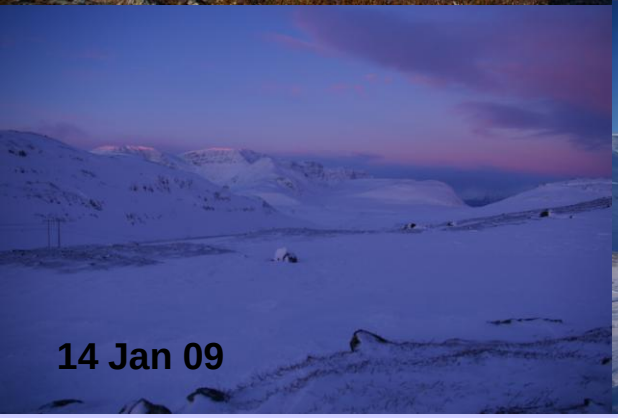
Lavkavagge 492 m asl



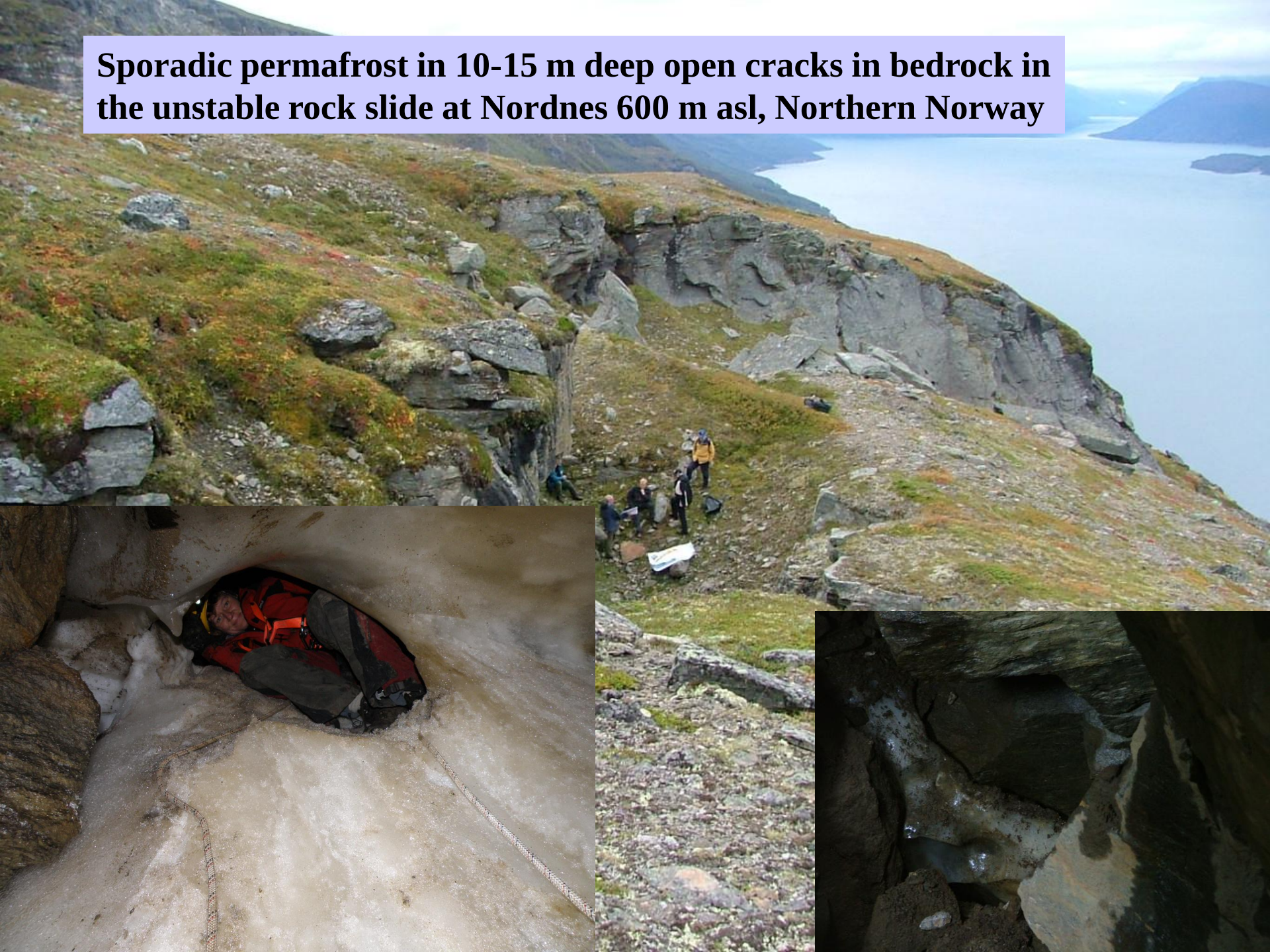
2007 2008

Snow cover influence

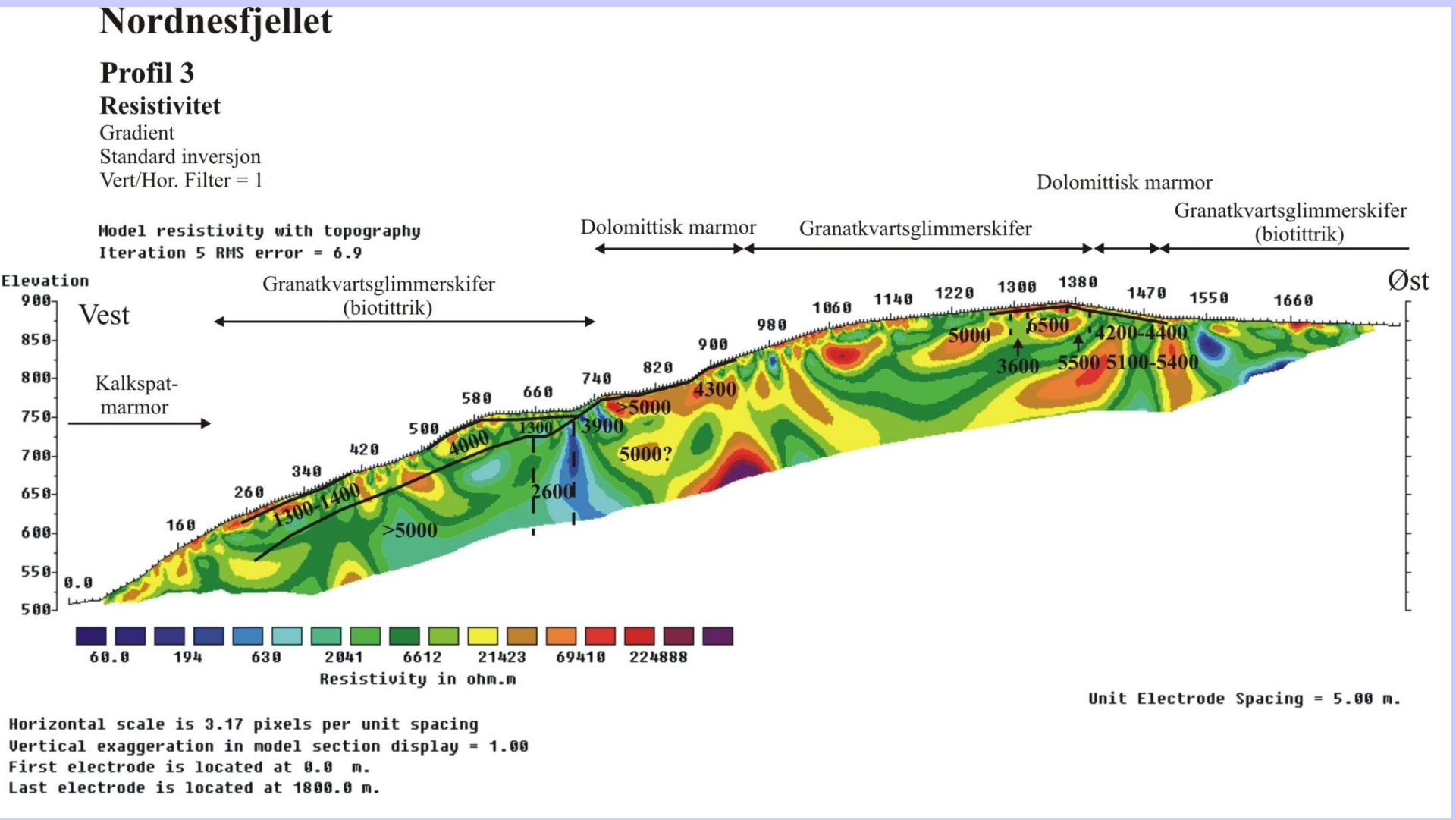
The snow cover monitoring using automatic cameras - at the Lavkavagge 766 m borehole



Sporadic permafrost in 10-15 m deep open cracks in bedrock in the unstable rock slide at Nordnes 600 m asl, Northern Norway

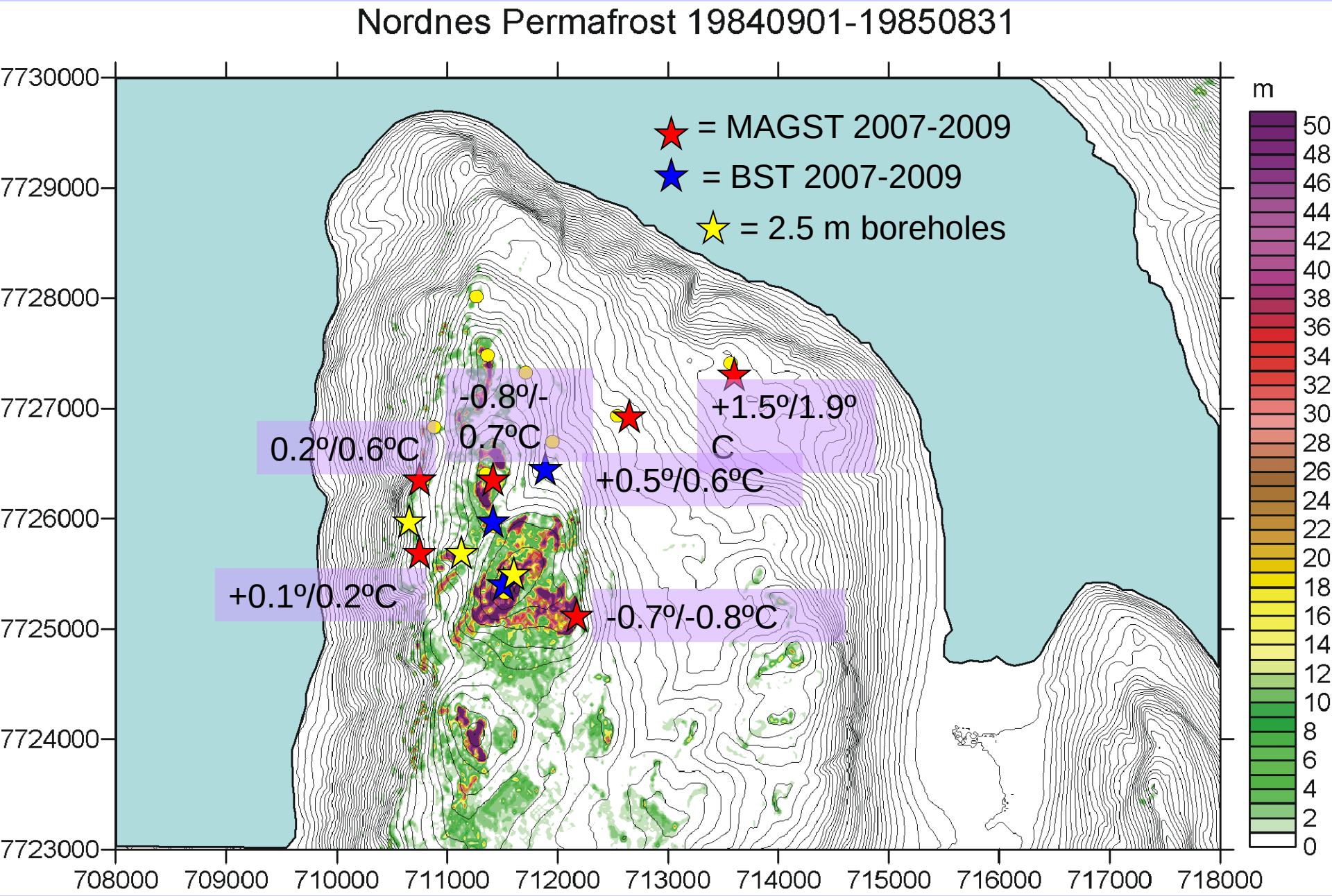


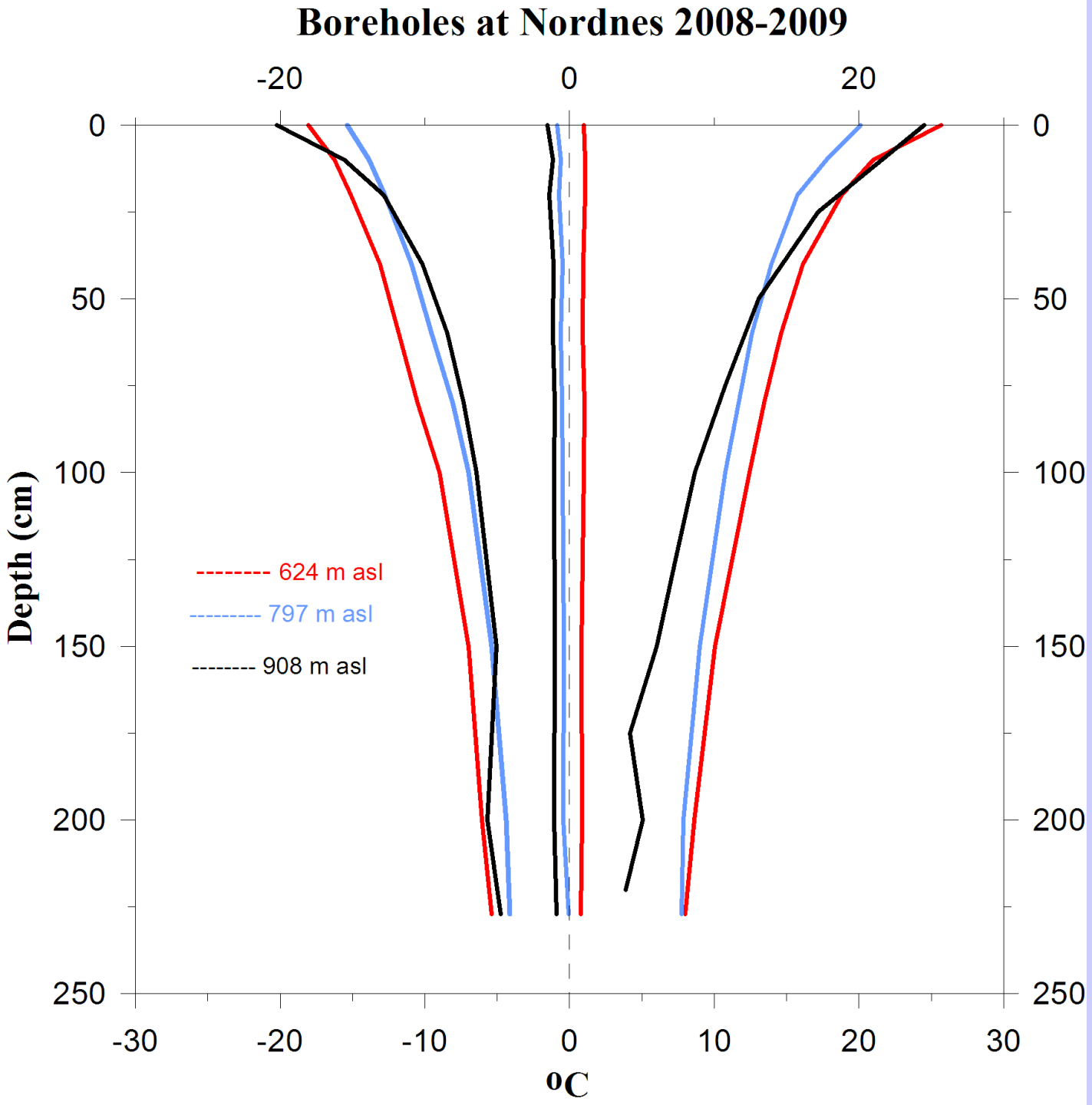
Nordnes undersøkelser

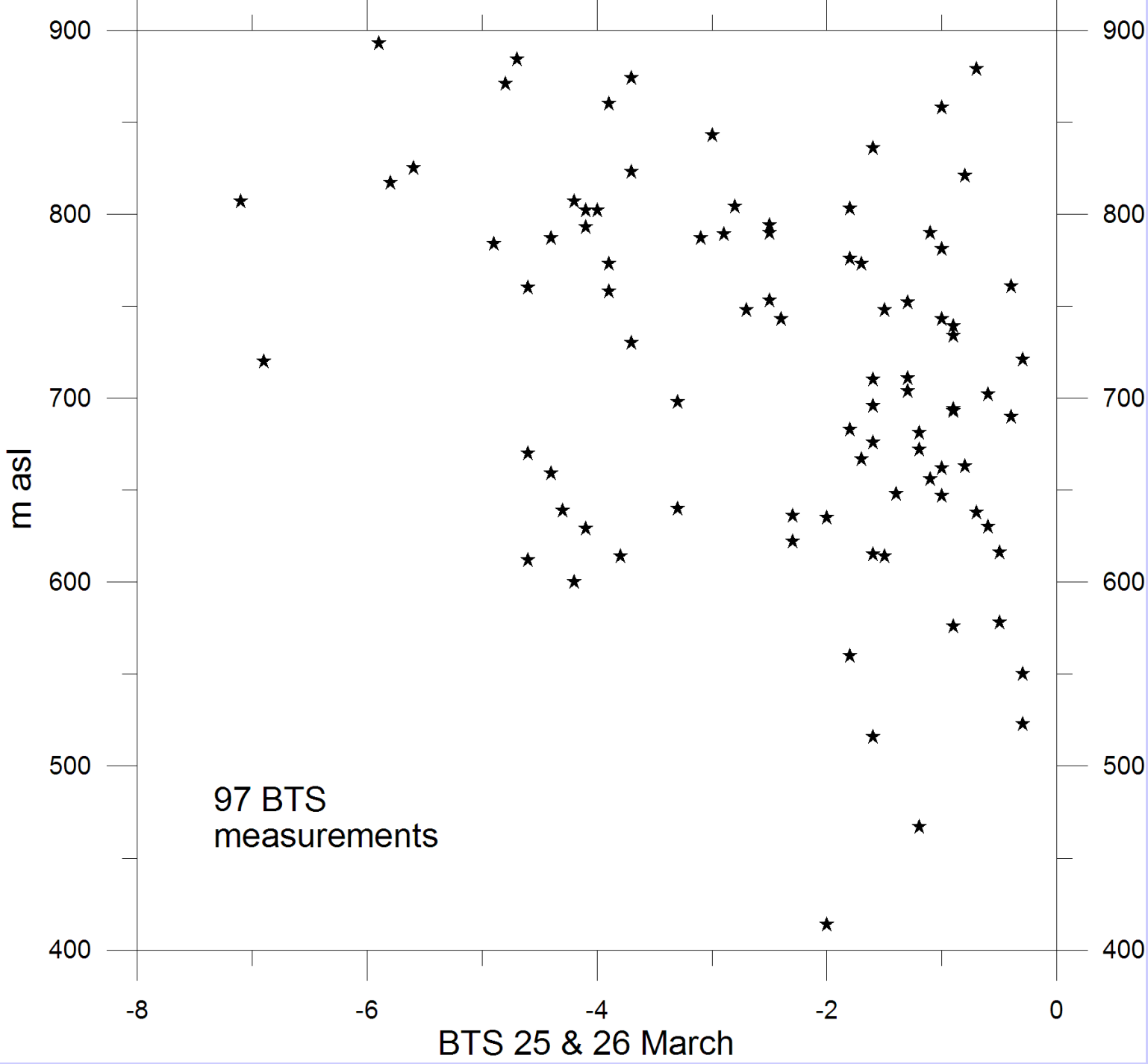


2D resistivity indicates depths to unstable rock is more than 150 m

Seismics show low velocity above 40 m, but with vertical zones with low velocities

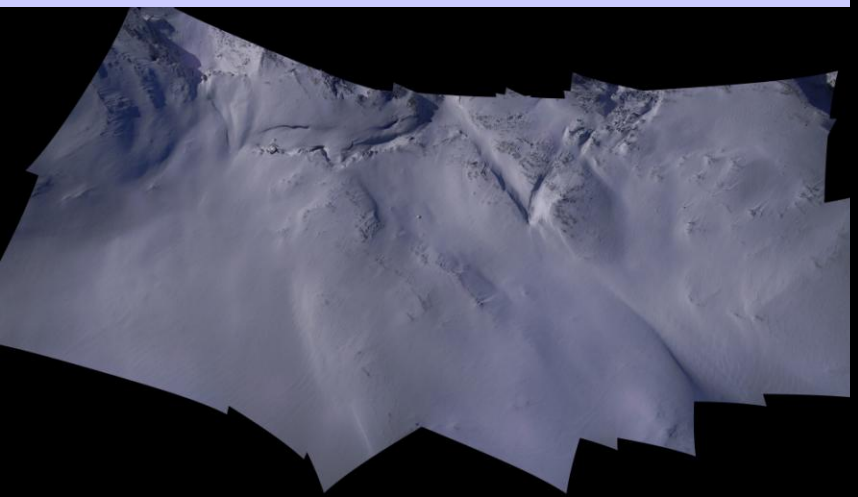

Nordnes Permafrost 19840901-19850831
= MAGST 2007-2009
= BST 2007-2009
= 2.5 m boreholes
-0.8º/-0.7ºC
0.2º/0.6ºC
+1.5º/1.9ºC
+0.5º/0.6ºC
+0.1º/0.2ºC
-0.7º/-0.8ºC
m
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
7730000
7729000
7728000
7727000
7726000
7725000
7724000
7723000
708000
709000
710000
711000
712000
713000
714000
715000
716000
717000
718000

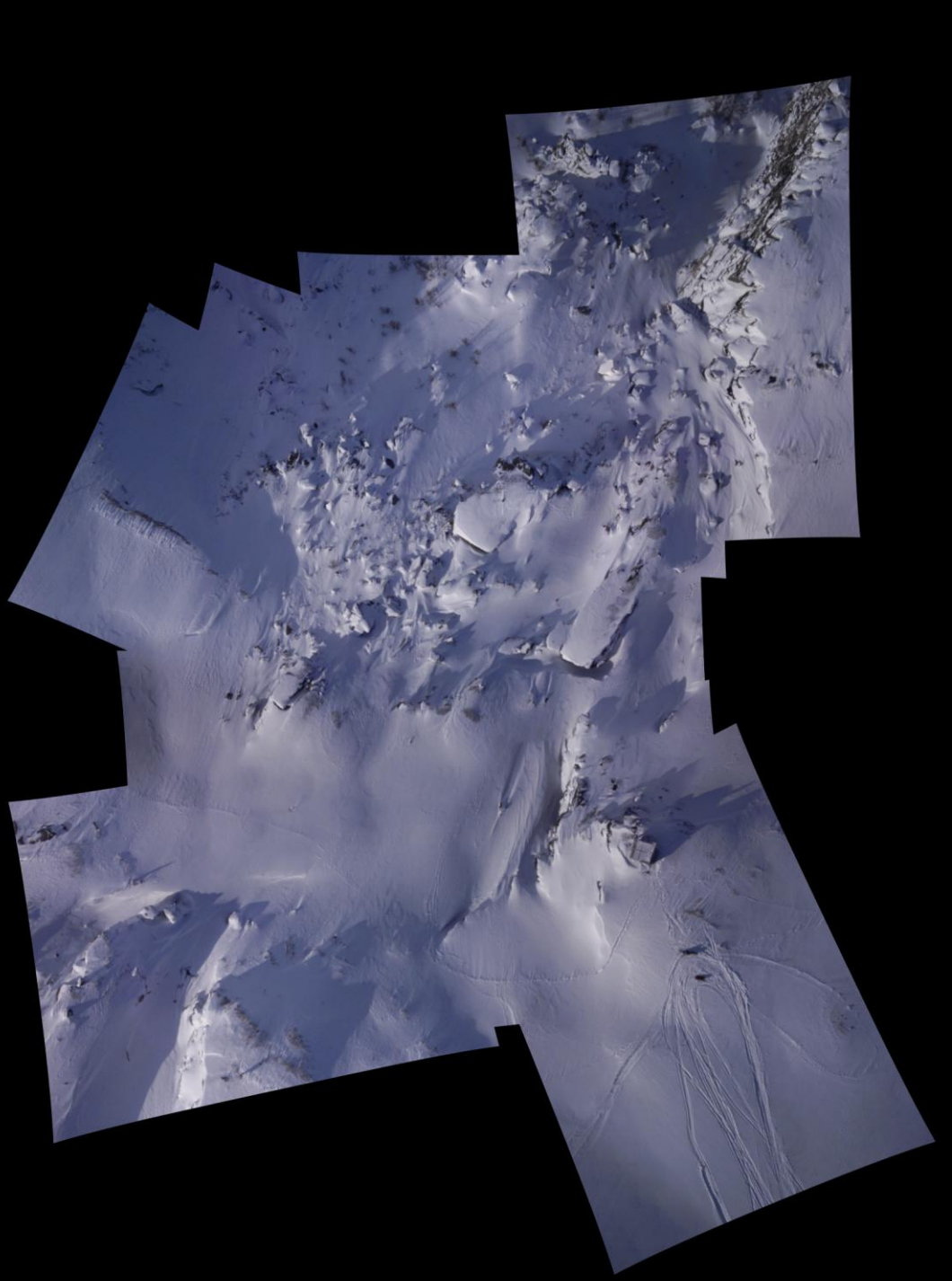

Boreholes at Nordnes 2008-2009
-20
0
20
0
50
100
150
200
250
Depth (cm)
-------- 624 m asl
-------- 797 m asl
-------- 908 m asl
-30
-20
-10
0
10
20
30
°C

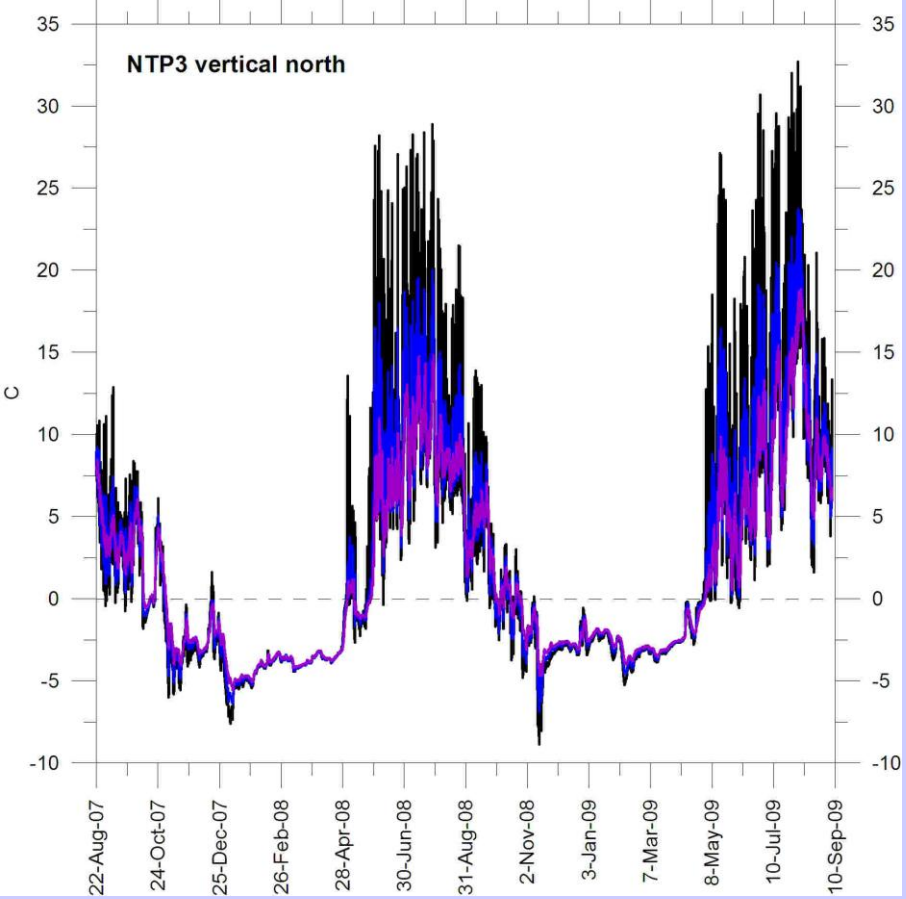


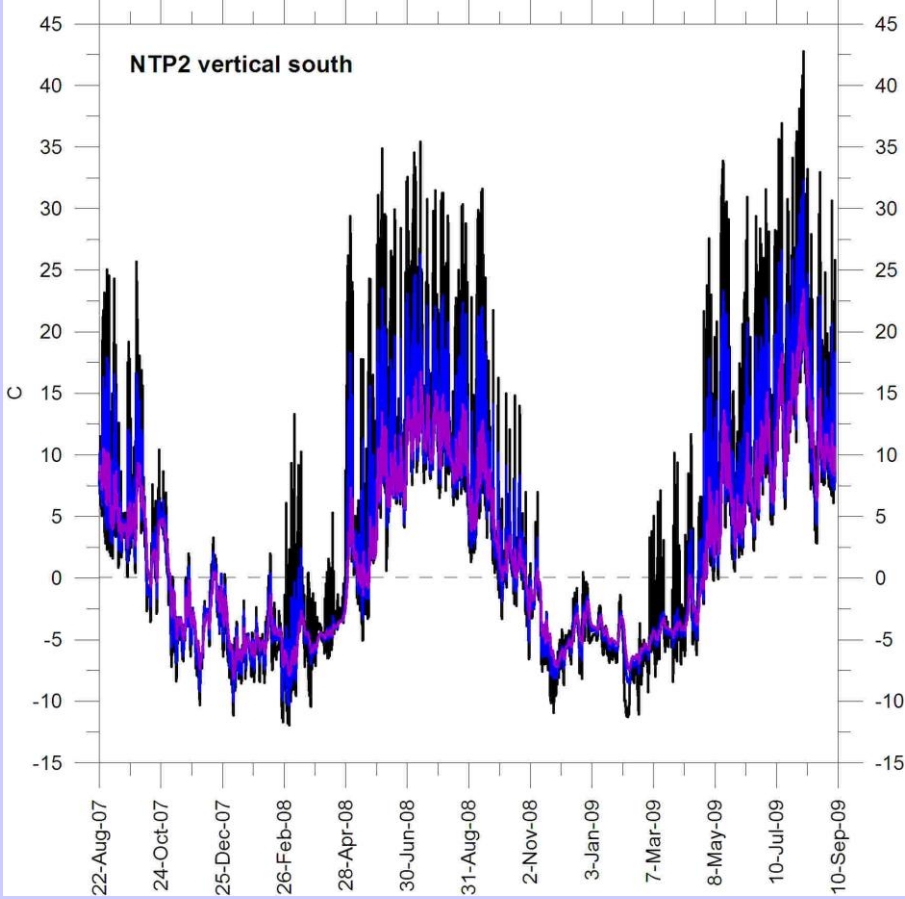
Nordnes
BTS
Campaign
March 2009

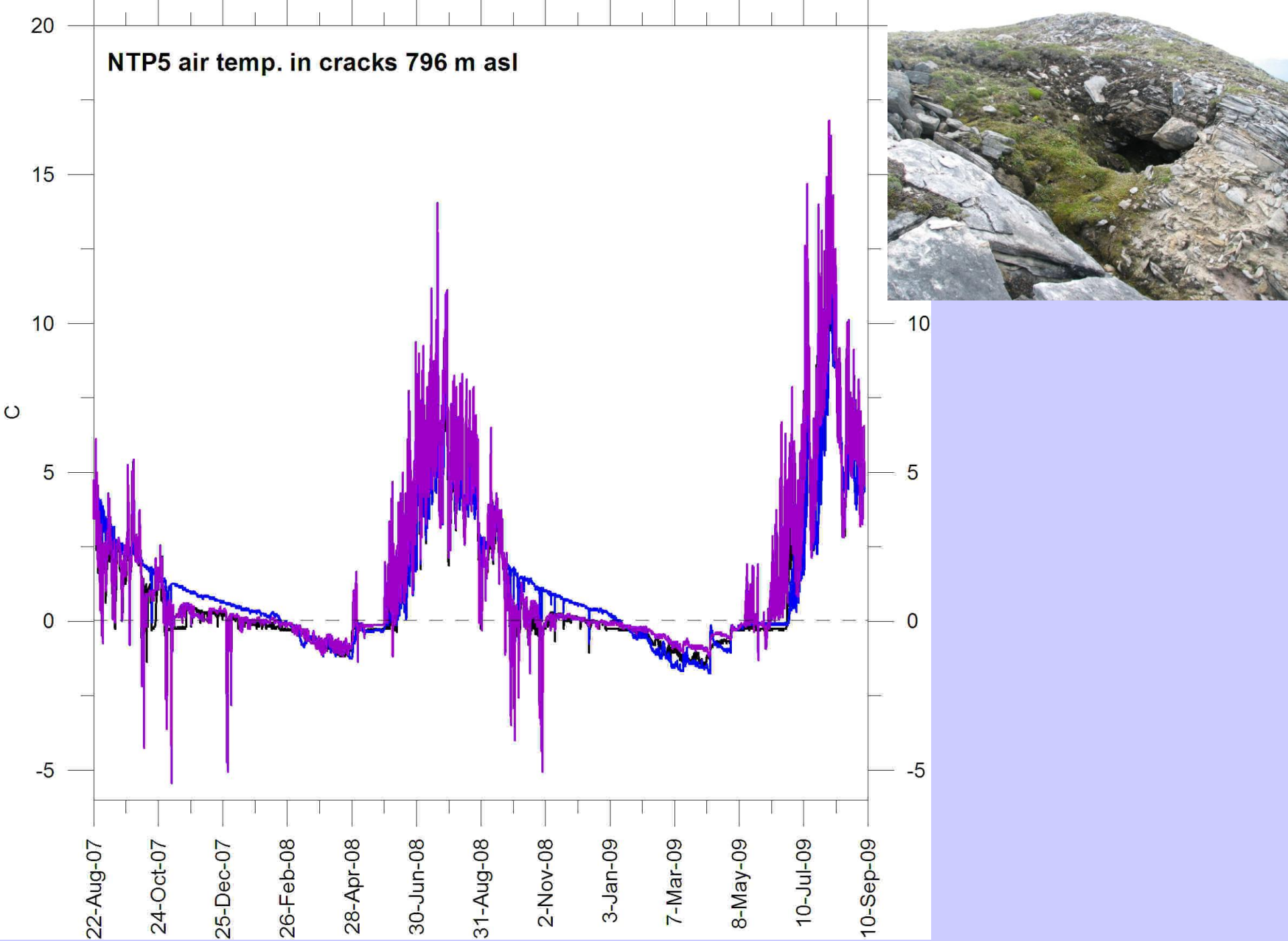
Snow cover data from UAV
Kolibri Geoservices
www.geokolibri.com

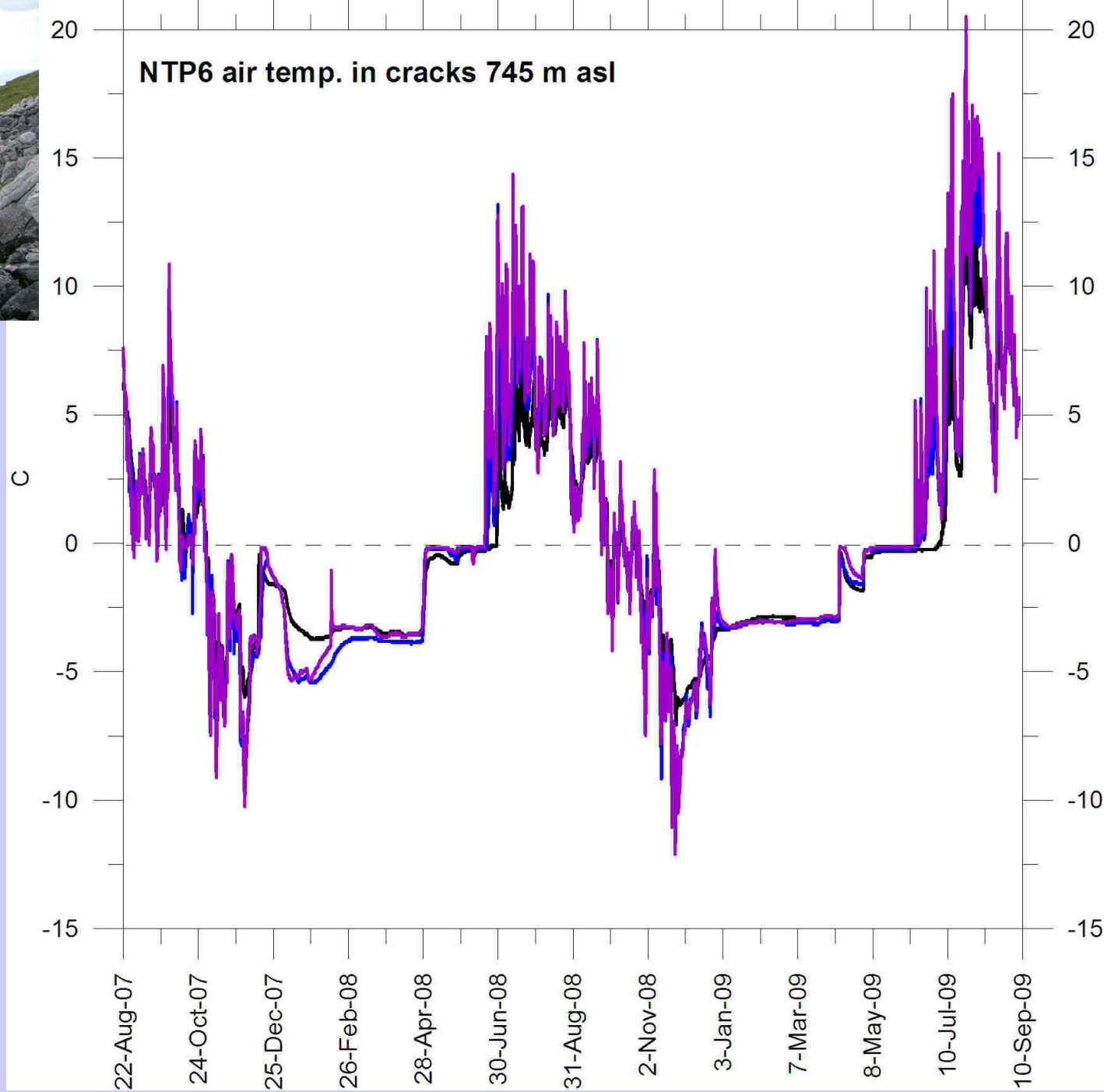




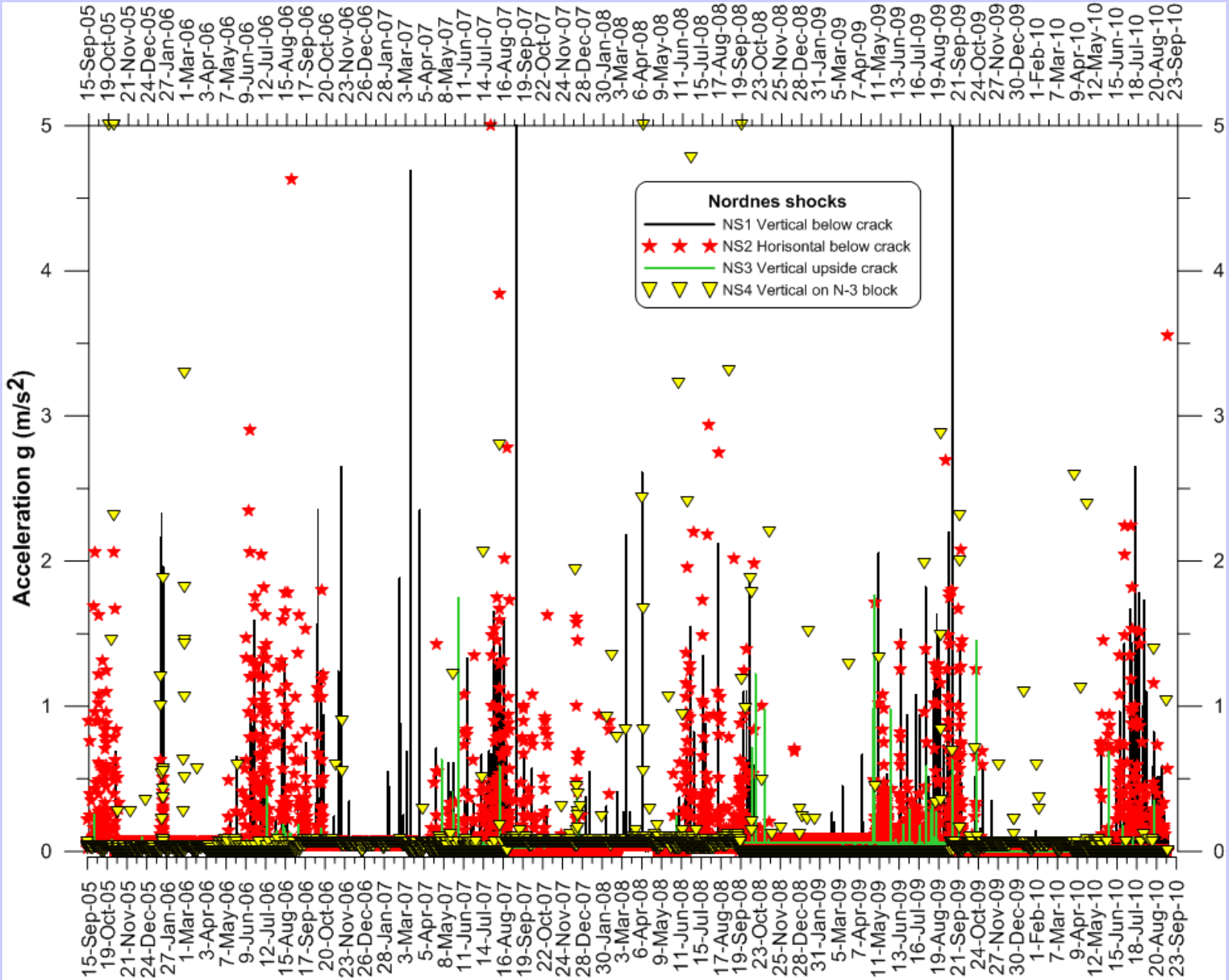

NTP3 vertical north
C
35
30
25
20
15
10
5
0
-5
-10
22-Aug-07
24-Oct-07
25-Dec-07
26-Feb-08
28-Apr-08
30-Jun-08
31-Aug-08
2-Nov-08
3-Jan-09
7-Mar-09
8-May-09
10-Jul-09
10-Sep-09

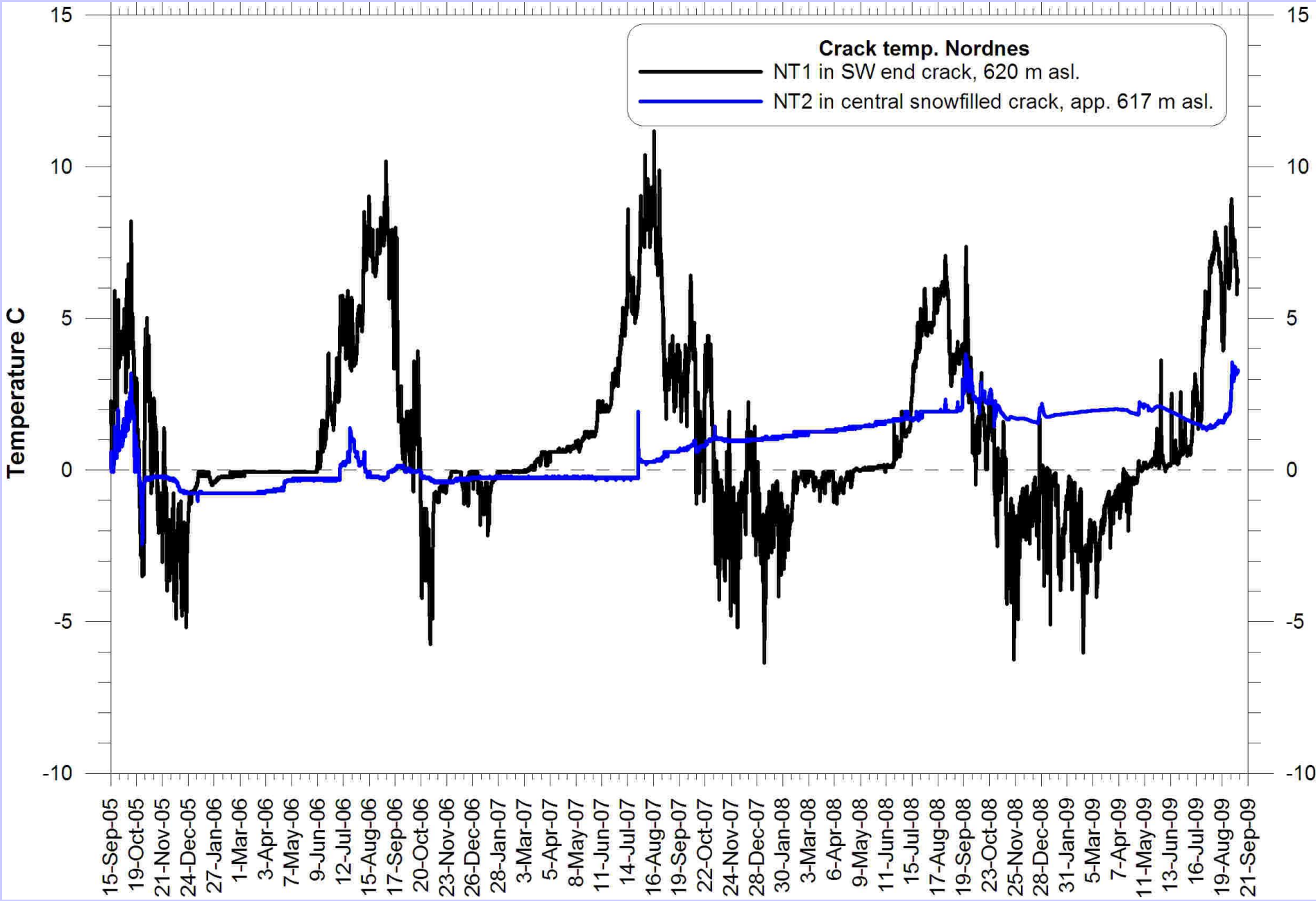

NTP2 vertical south
C
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
22-Aug-07
24-Oct-07
25-Dec-07
26-Feb-08
28-Apr-08
30-Jun-08
31-Aug-08
2-Nov-08
3-Jan-09
7-Mar-09
8-May-09
10-Jul-09
10-Sep-09


NTP5 air temp. in cracks 796 m asl
20
15
10
5
0
-5
C
10
5
0
-5
22-Aug-07
24-Oct-07
25-Dec-07
26-Feb-08
28-Apr-08
30-Jun-08
31-Aug-08
2-Nov-08
3-Jan-09
7-Mar-09
8-May-09
10-Jul-09
10-Sep-09

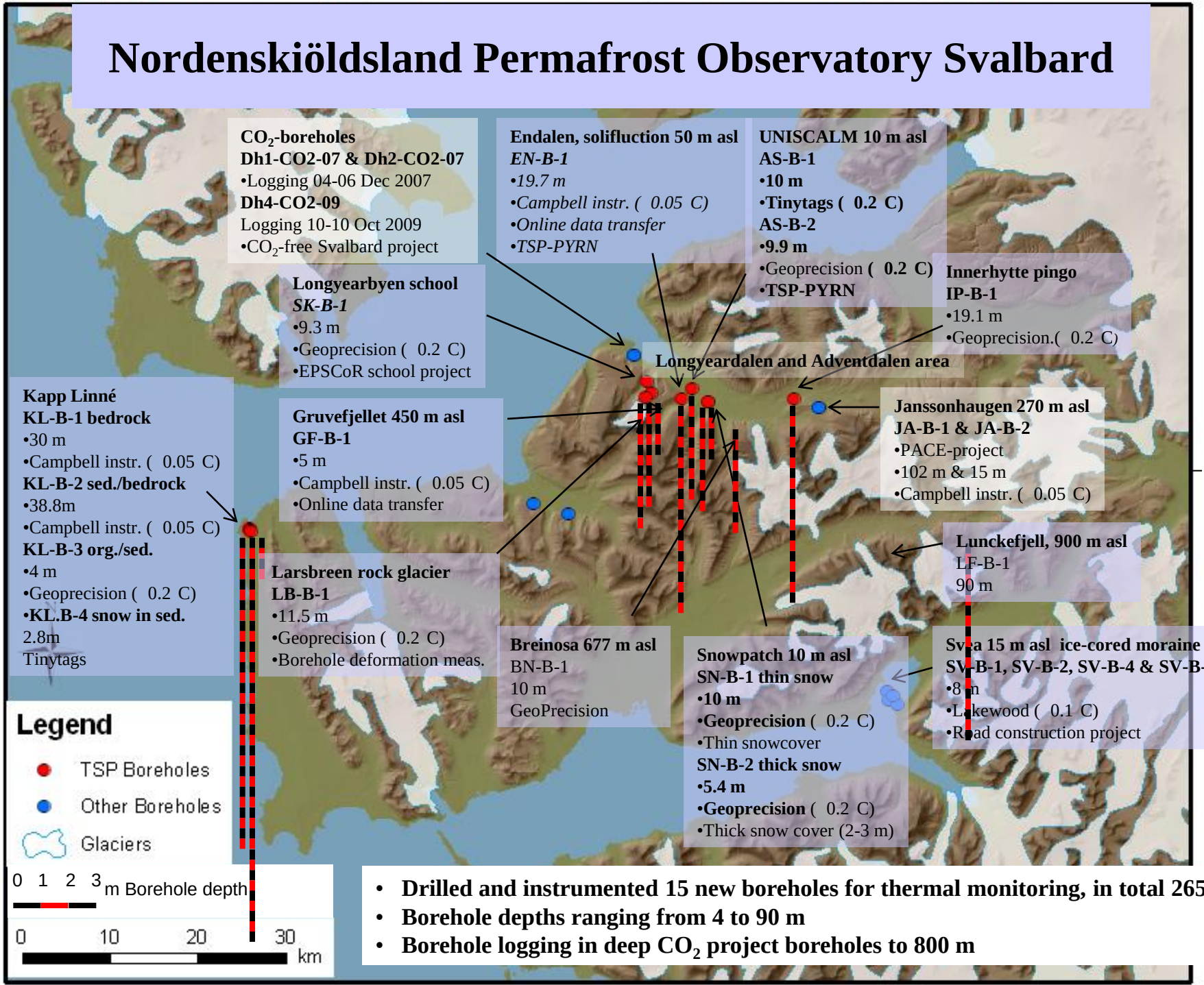

NTP6 air temp. in cracks 745 m asl
C
20
15
10
5
0
-5
-10
-15
22-Aug-07
24-Oct-07
25-Dec-07
26-Feb-08
28-Apr-08
30-Jun-08
31-Aug-08
2-Nov-08
3-Jan-09
7-Mar-09
8-May-09
10-Jul-09
10-Sep-09

Shock logger Tinytag data from Nordnes 2005-2010

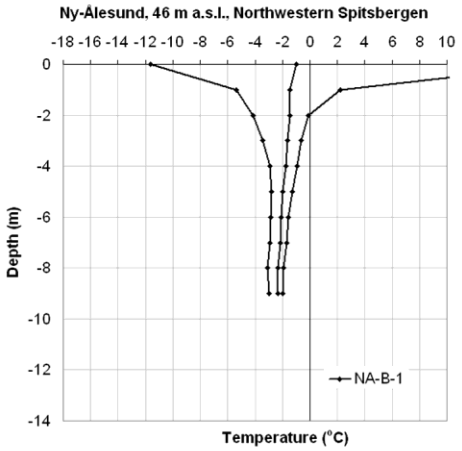


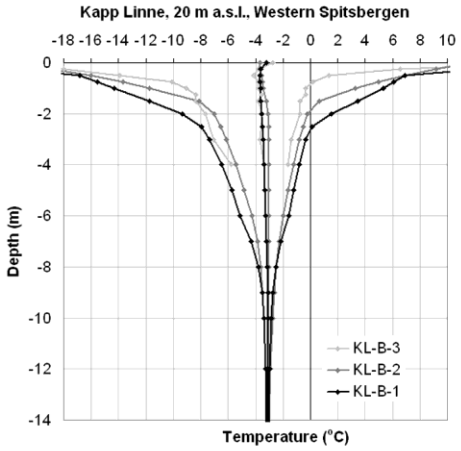

Crack temp. Nordnes
NT1 in SW end crack, 620 m asl.
NT2 in central snowfilled crack, app. 617 m asl.
Temperature C
15
10
5
0
-5
-10
15-Sep-05
19-Oct-05
21-Nov-05
24-Dec-05
27-Jan-06
1-Mar-06
3-Apr-06
7-May-06
9-Jun-06
12-Jul-06
15-Aug-06
17-Sep-06
20-Oct-06
23-Nov-06
26-Dec-06
28-Jan-07
3-Mar-07
5-Apr-07
8-May-07
11-Jun-07
14-Jul-07
16-Aug-07
19-Sep-07
22-Oct-07
24-Nov-07
28-Dec-07
30-Jan-08
3-Mar-08
6-Apr-08
9-May-08
11-Jun-08
15-Jul-08
17-Aug-08
19-Sep-08
23-Oct-08
25-Nov-08
28-Dec-08
31-Jan-09
5-Mar-09
7-Apr-09
11-May-09
13-Jun-09
16-Jul-09
19-Aug-09
21-Sep-09

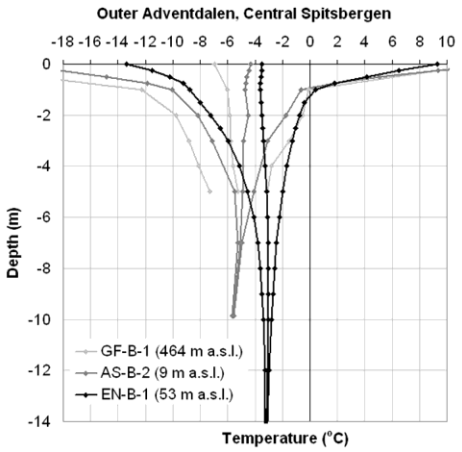
Nordenskiöldsland Permafrost Observatory Svalbard

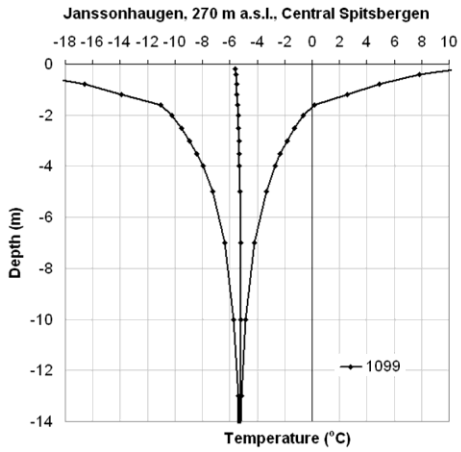


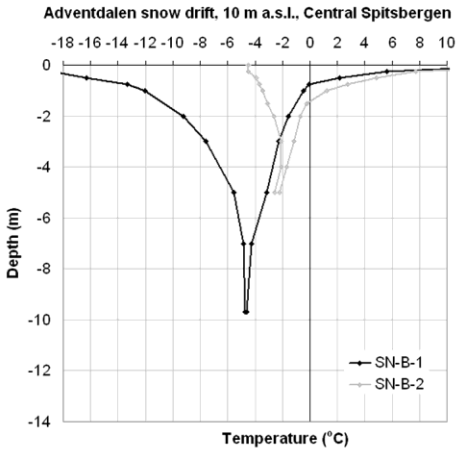
- **Drilled and instrumented 15 new boreholes for thermal monitoring, in total 265.5 m**
- **Borehole depths ranging from 4 to 90 m**
- **Borehole logging in deep CO_2 project boreholes to 800 m**

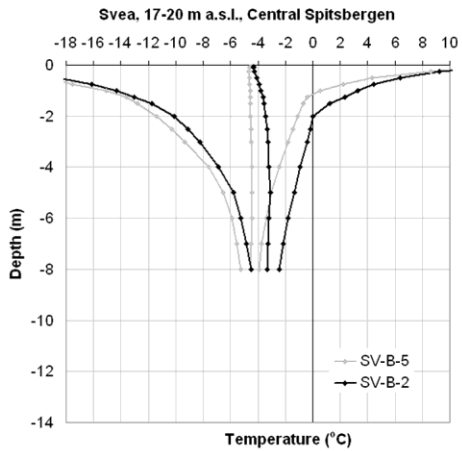








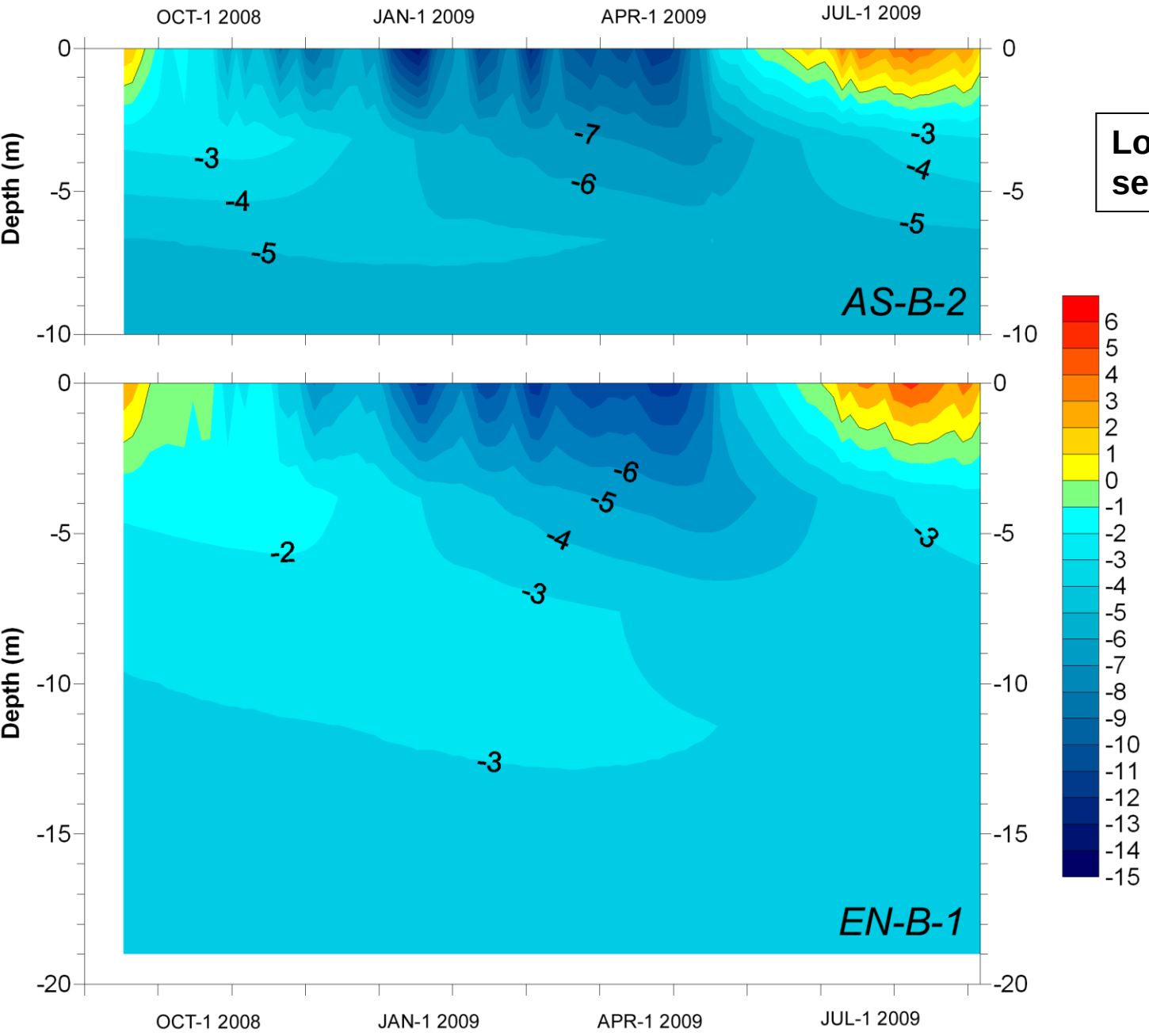




Permafrost thermal state in Svalbard 2008-2009: Minimum, mean and maximum temperatures

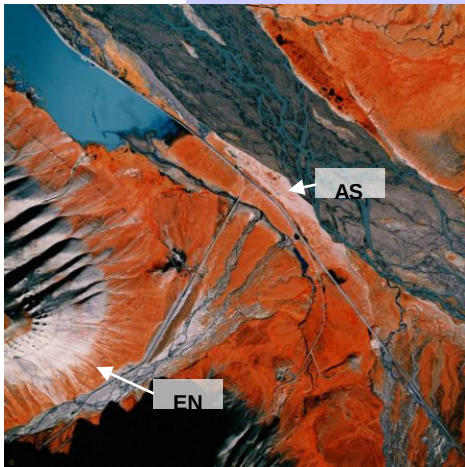
- Boreholes in sediment and bedrock and different landforms
- Continuous permafrost from -2.3ºC on the west coast to -5.6ºC in central areas
- Active layer 0.8 to 2.5 m

Two boreholes in Adventdalen 500 m apart

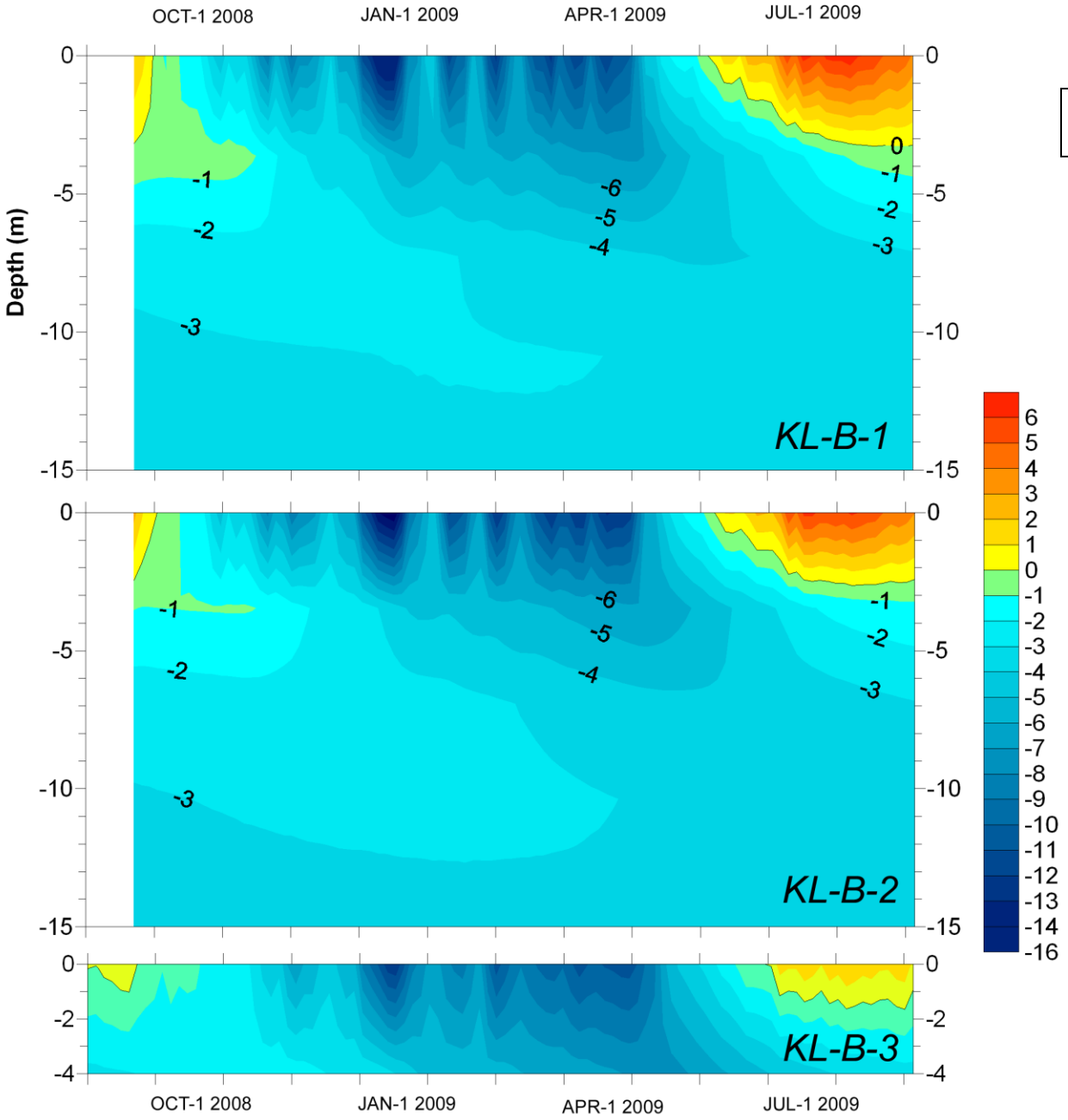


Loess terrace, sediments

Solifluction sheet, 7 m sediment over bedrock



Three boreholes on the strandflat at Kapp Linne 300 m apart



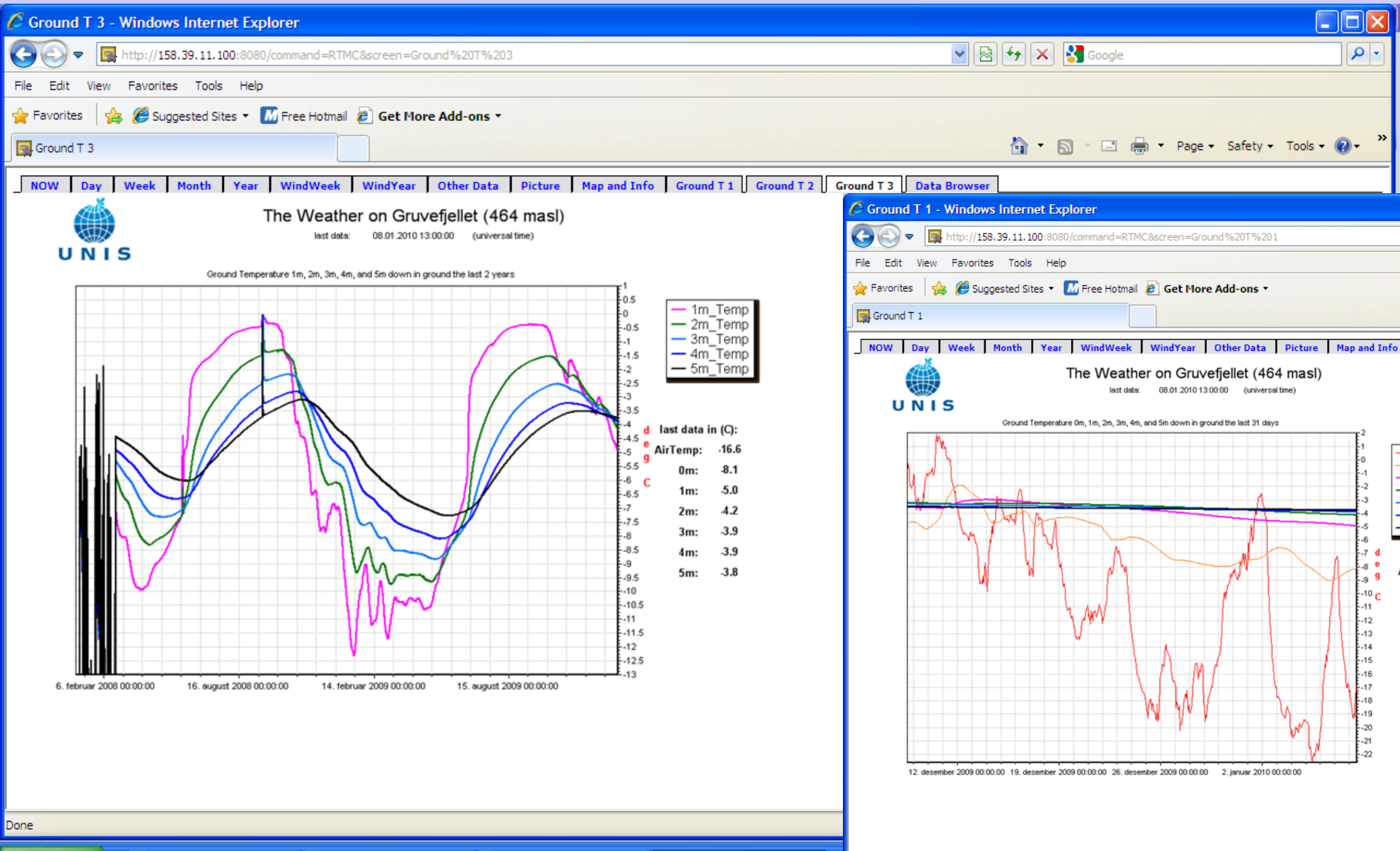
Bedrock

6 m littoral sediment over bedrock

40 cm organic mat. over littoral sediment

Online permafrost temperatures

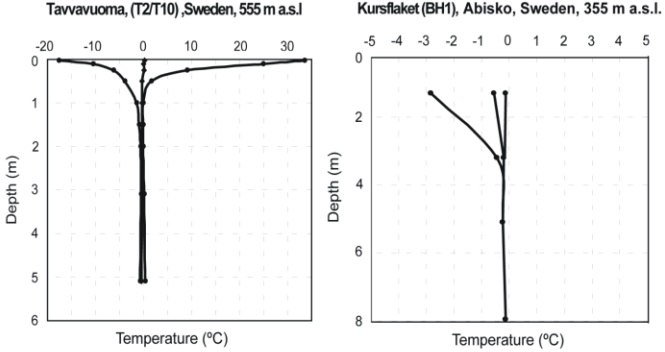
via www.unis.no – weather

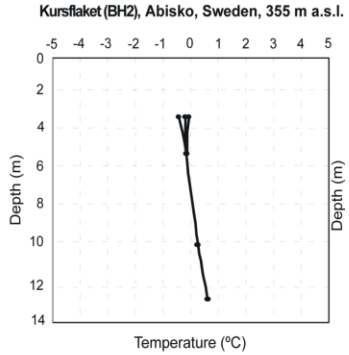


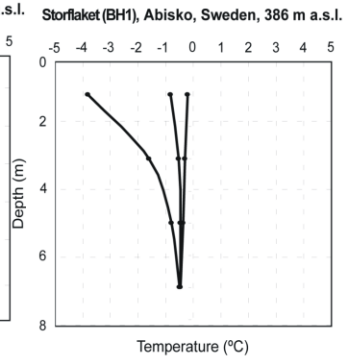
Sporadic permafrost in palsa and peat plateau in Sweden and Finland

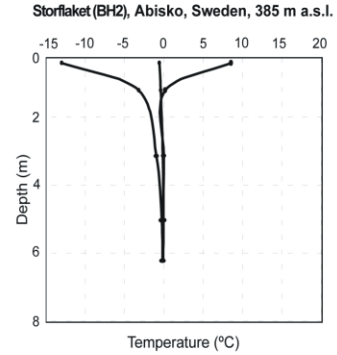
- Occuring 300-550 m asl
- Warm and thin permafrost in organic-rich peat

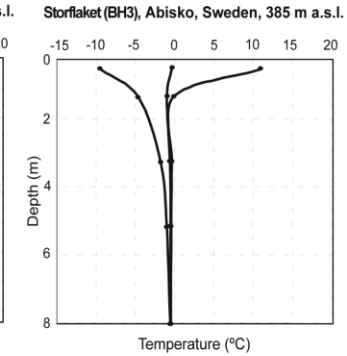
Thermokarst lake, Tavvavuoma, Sweden (68ºN) 555 m asl

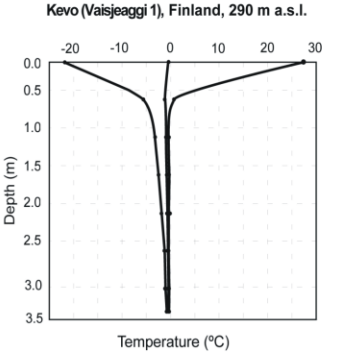






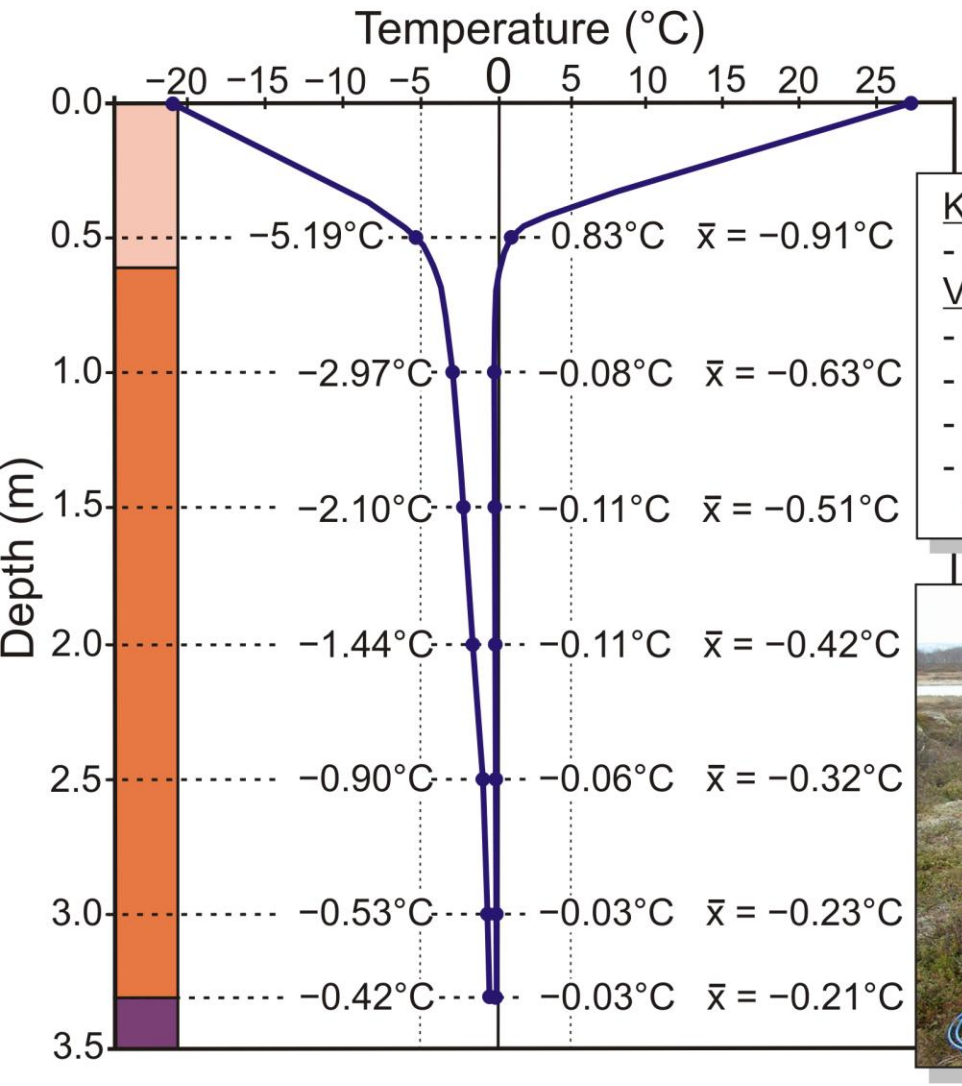






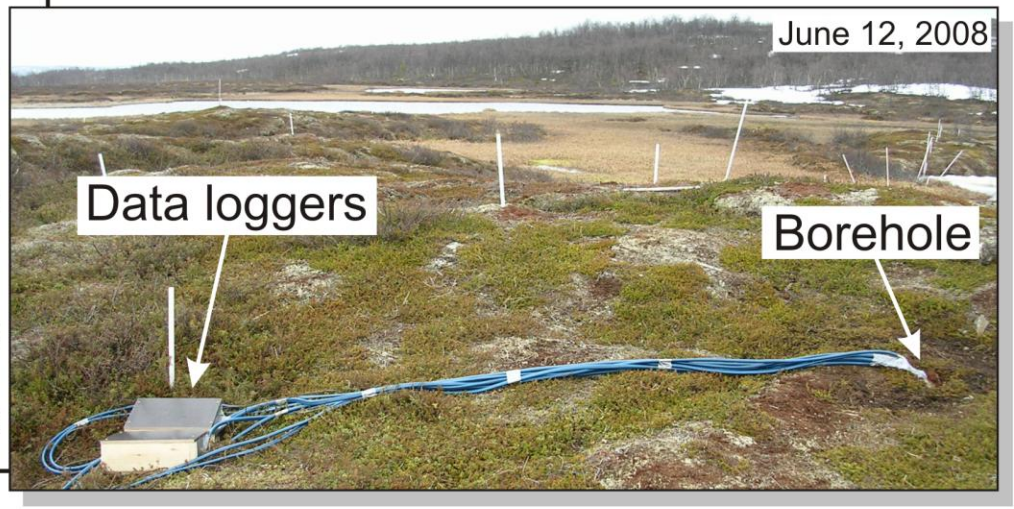

Palsas around Kevo research station, Finland

Vaisjeaggi permafrost monitoring site, Kevo, Finland



Kevo Meteorological Station (107 m a.s.l.)
- MAAT[1] = −1.7°C; precipitation[1] = 414 mm

Vaisjeaggi palsa mire (290 m a.s.l.)
- MAAT[2] = −2.7°C; MAT[3] = −1.0°C; MGST[3] = −0.6°C
- FDD[3] = −1437; TDD[3] = 1082
- Mean ALT[4] = 61 cm
- Mean maximum snow depth[5]: palsa surface = <20 cm, fen area = 40–70 cm



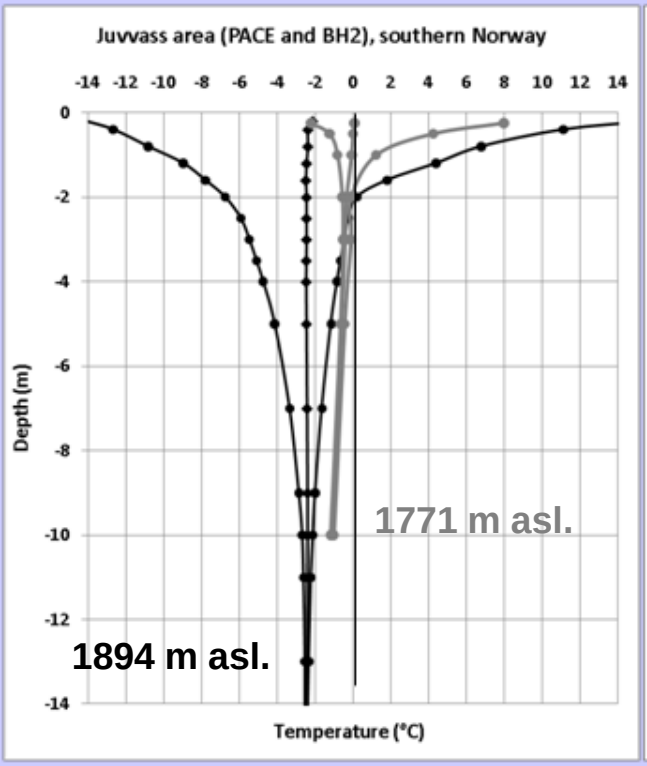
Active layer (peat) Permafrost (peat) Permafrost (till)

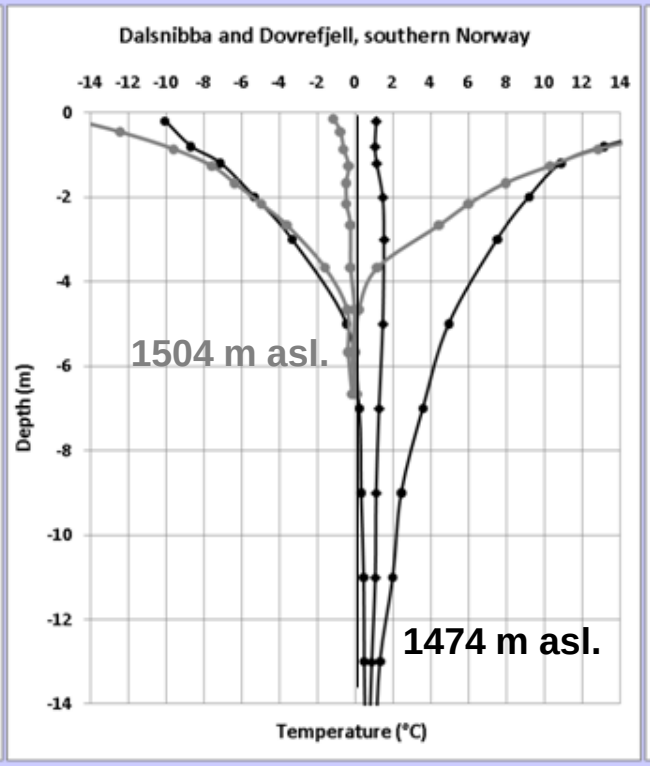

Palsa in Neiden, Finnmark, N Norway

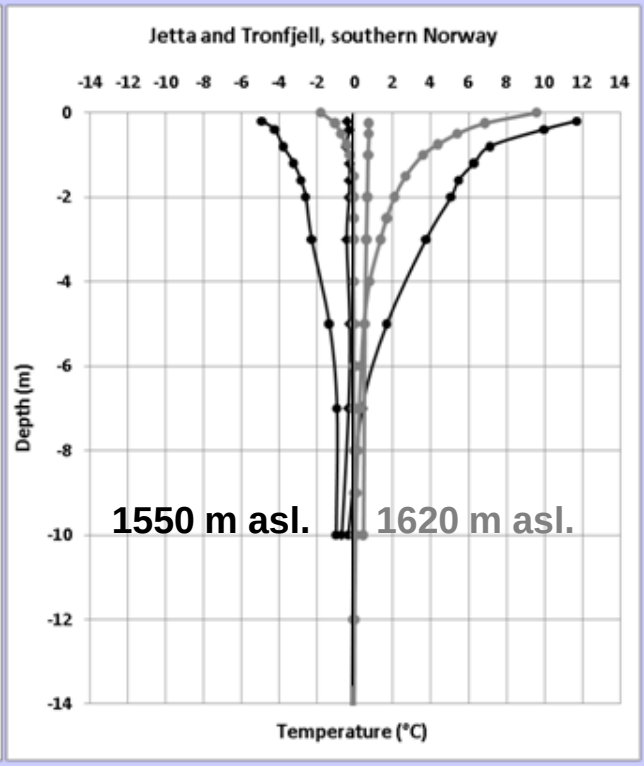

Palsa in Karlebotn, Finnmark, N Norway, almost at sea level


Panasonic

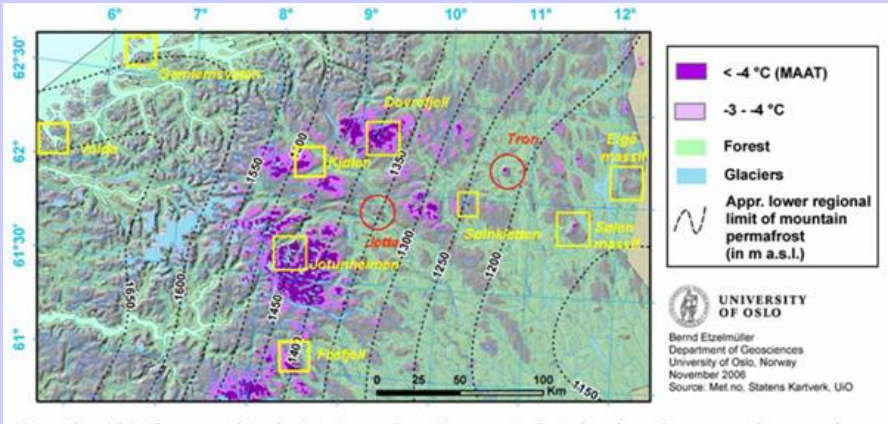
Permafrost annual thermal snapshot in southern Norway 2008-2009



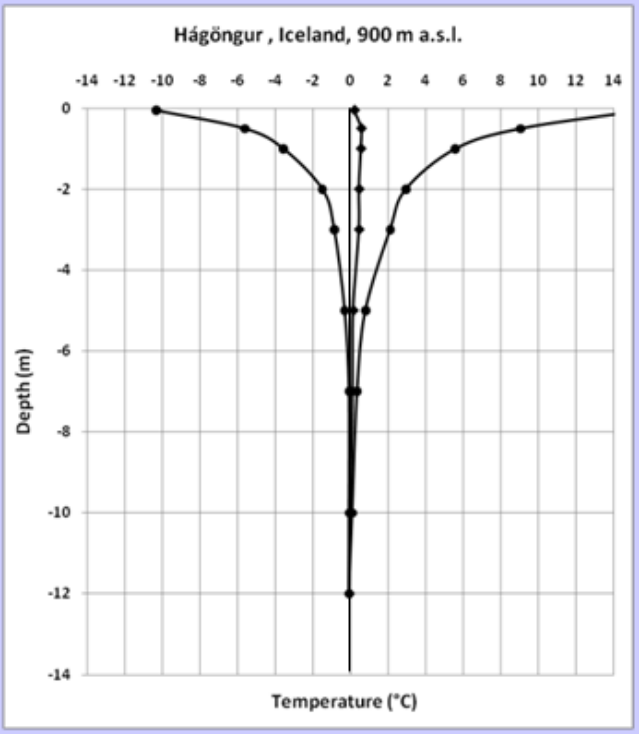


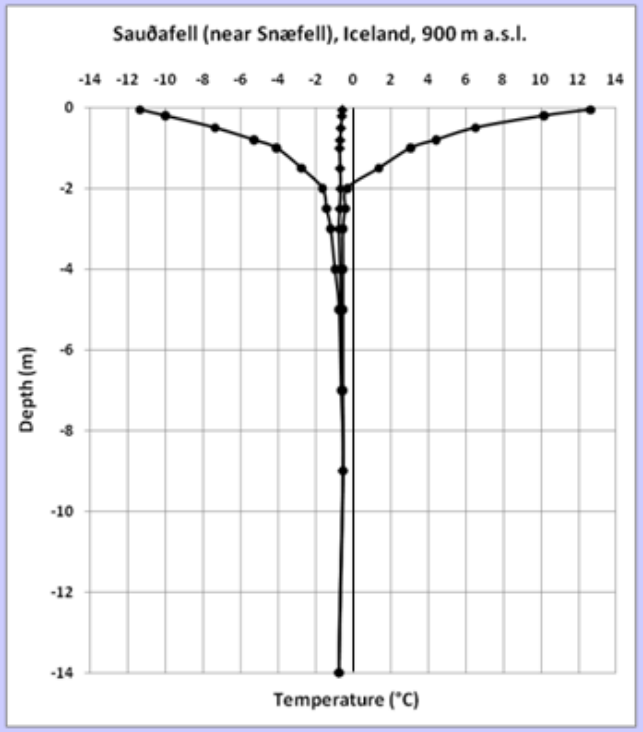


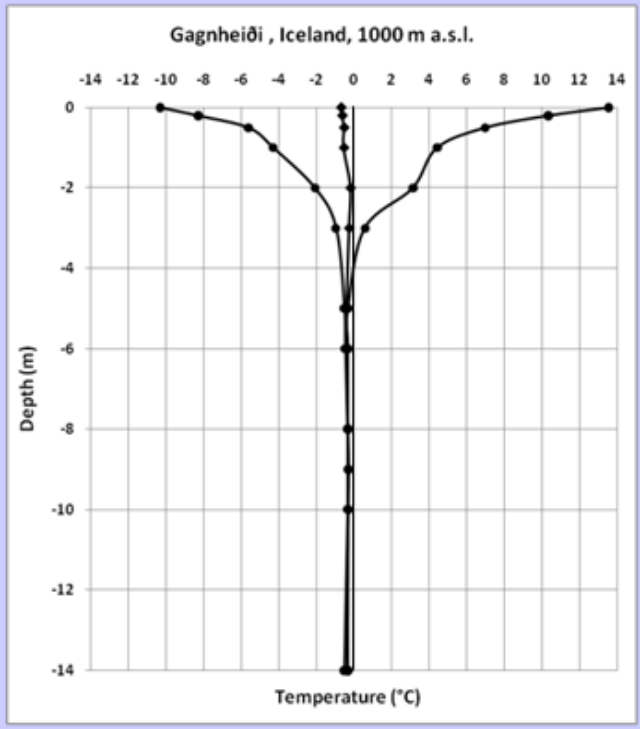
- All measured in bedrock
- Altitudinal permafrost temperature gradients: -2.5ºC at 1900 m asl to -0.3ºC at 1500 m asl
- Thick active layers 2-10 m



Permafrost thermal snapshot in Iceland 2007-2009



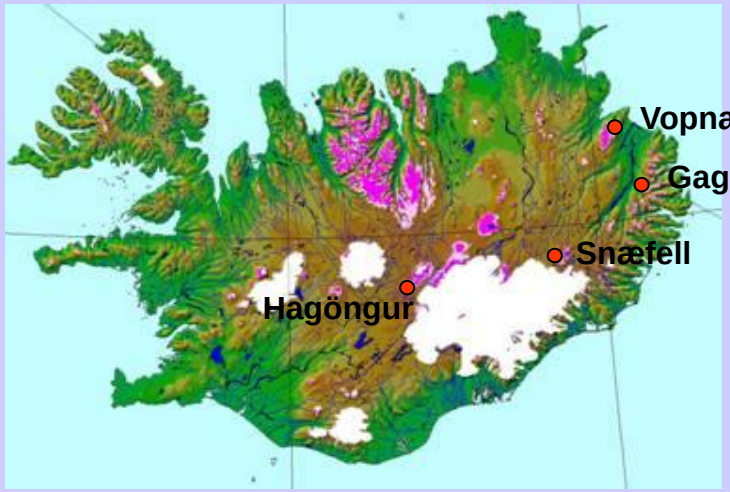




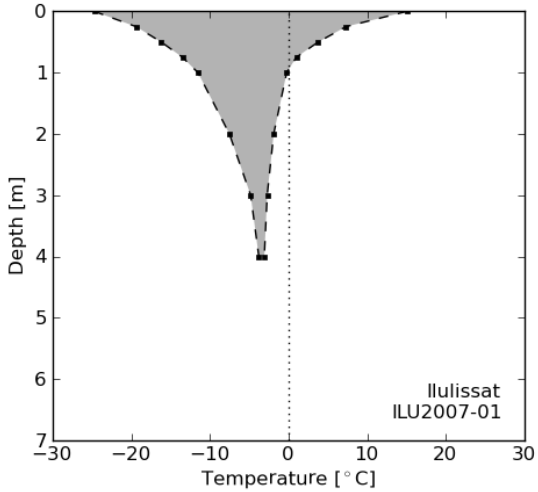
- Measured in bedrock with sediment cover

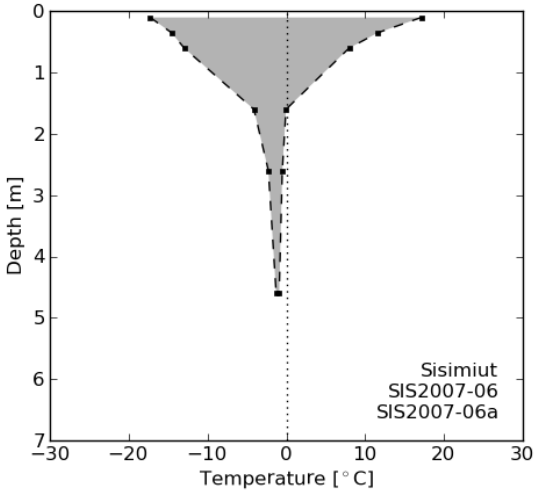
- Permafrost warm and discontinuous /sporadic.

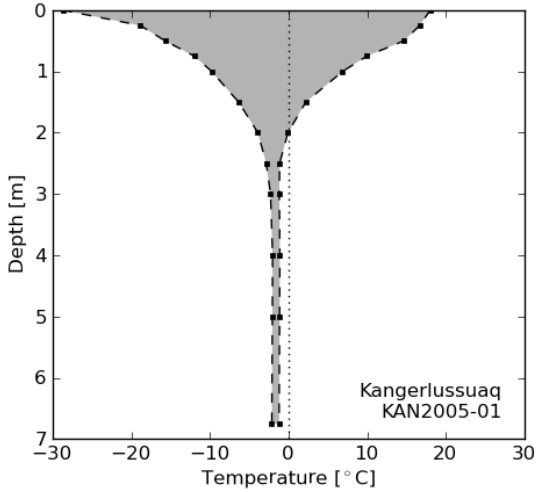
- Active layer thicknesses: 2-4 m.

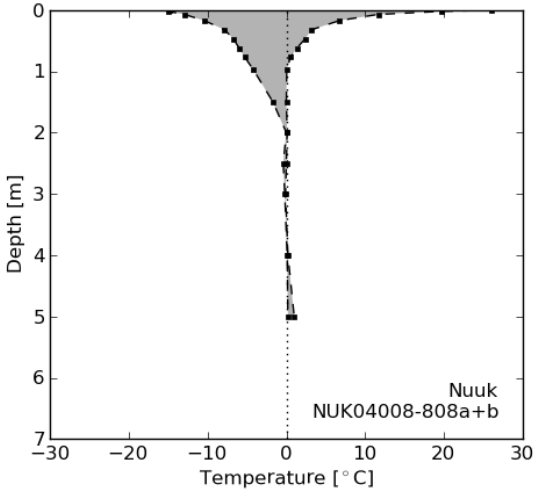


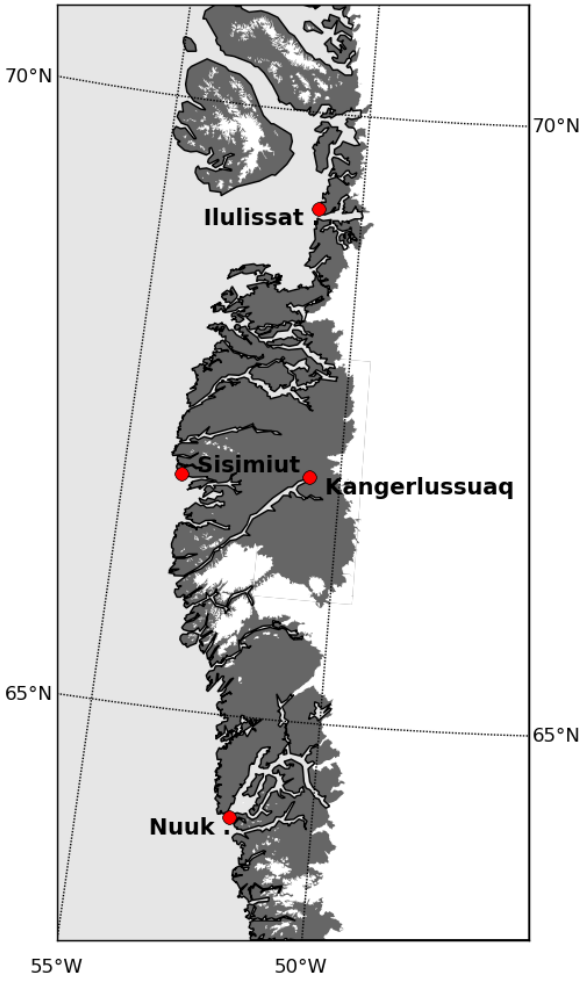
Permafrost snapshot in western Greenland 2008-2009





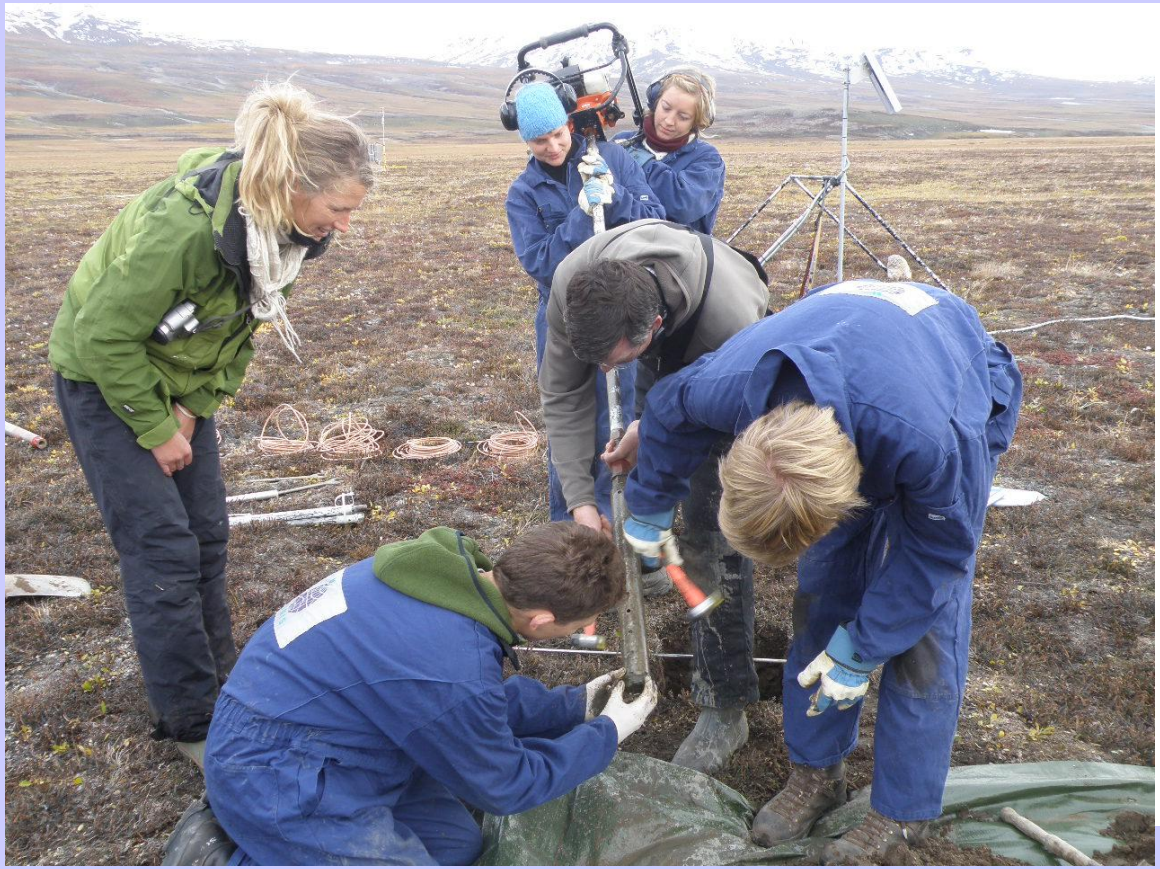


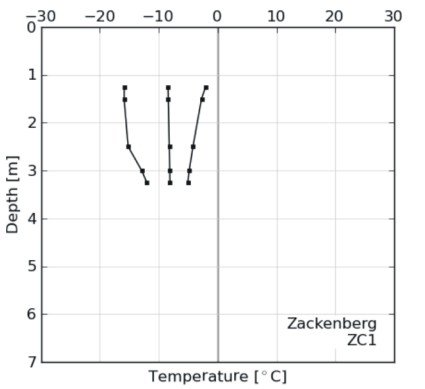




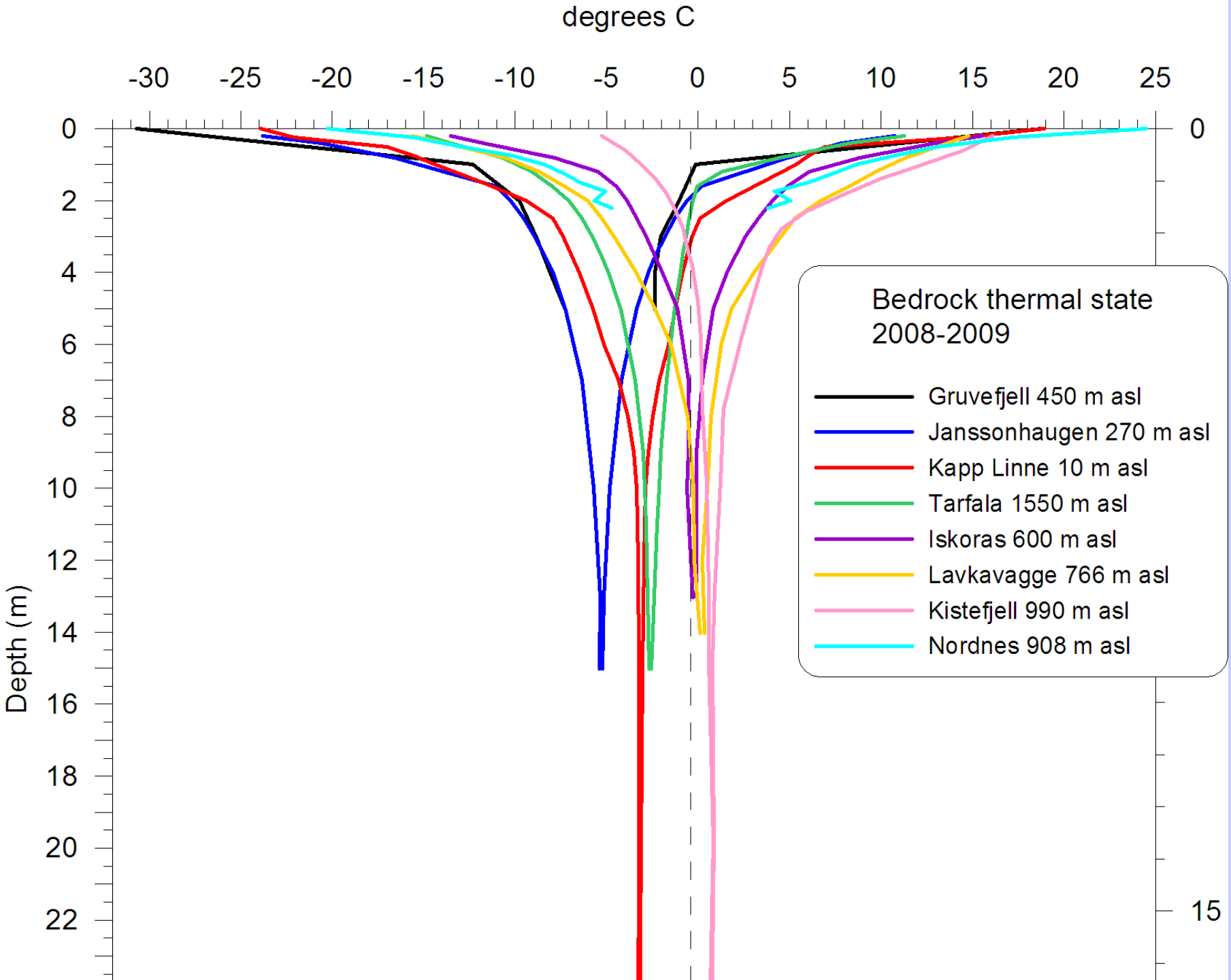
- All boreholes in sediment
- All boreholes 25 to 50 m asl
- Discontinuos / sporadic warm permafrost -3ºC to 0.2ºC
- Active layer thickness: 0.9-1.8 m

Permafrost thermal snapshot in eastern Greenland 2008-2009

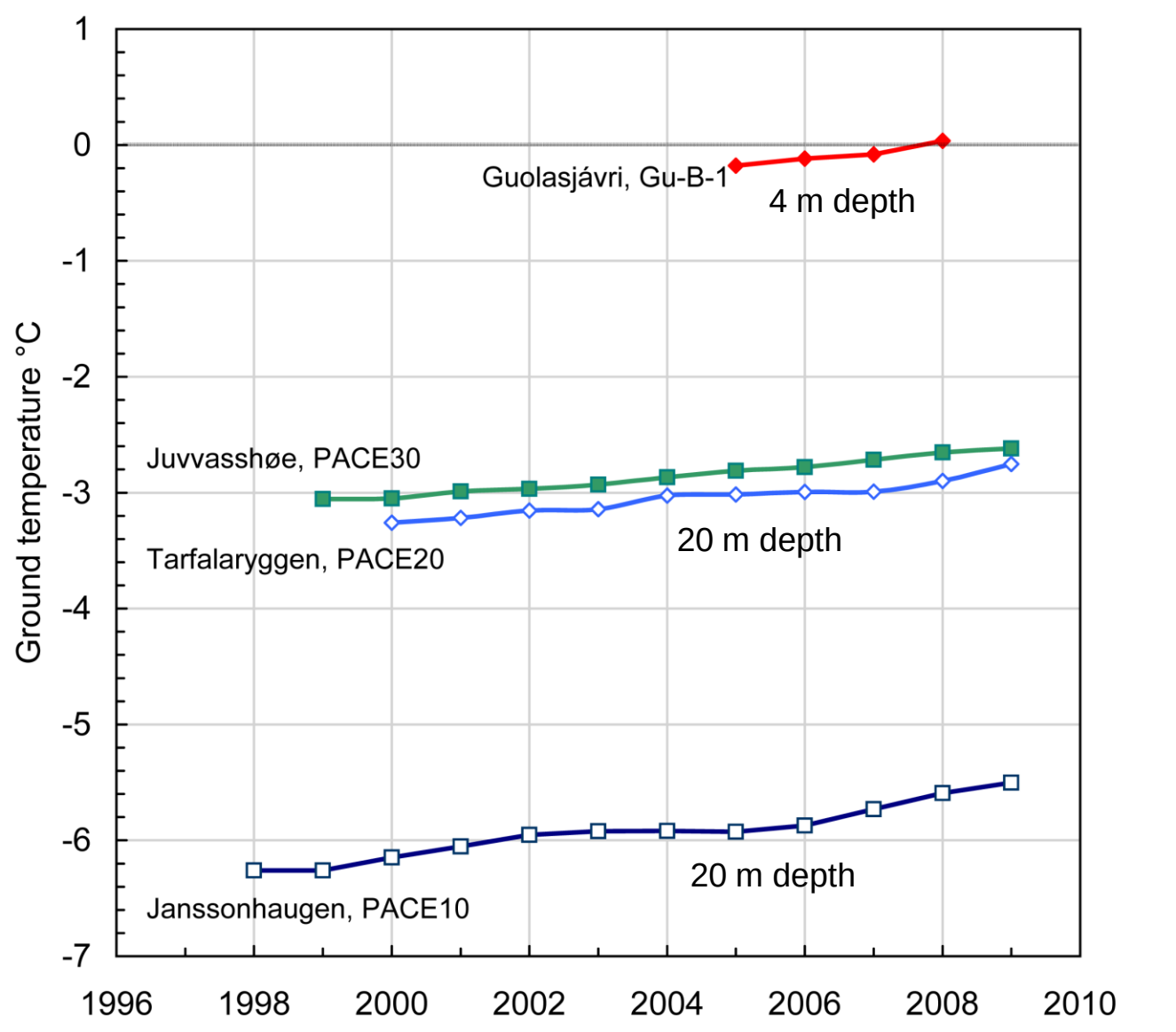




- 3 m boreholes in sediments (severe instrumentation problems)
- Continuous cold permafrost -8ºC, coldest permafrost temperature in the Nordic area !
- Active layer thickness 0.8 m


degrees C
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
0
2
4
6
8
10
12
14
16
18
20
22
Depth (m)
0
15
Bedrock thermal state
2008-2009
Gruvefjell 450 m asl
Janssonhaugen 270 m asl
Kapp Linne 10 m asl
Tarfala 1550 m asl
Iskoras 600 m asl
Lavkavagge 766 m asl
Kistefjell 990 m asl
Nordnes 908 m asl

Long-term permafrost temperatures in the Nordic area – mainly from the PACE EU project



Circumarctic permafrost temperature series

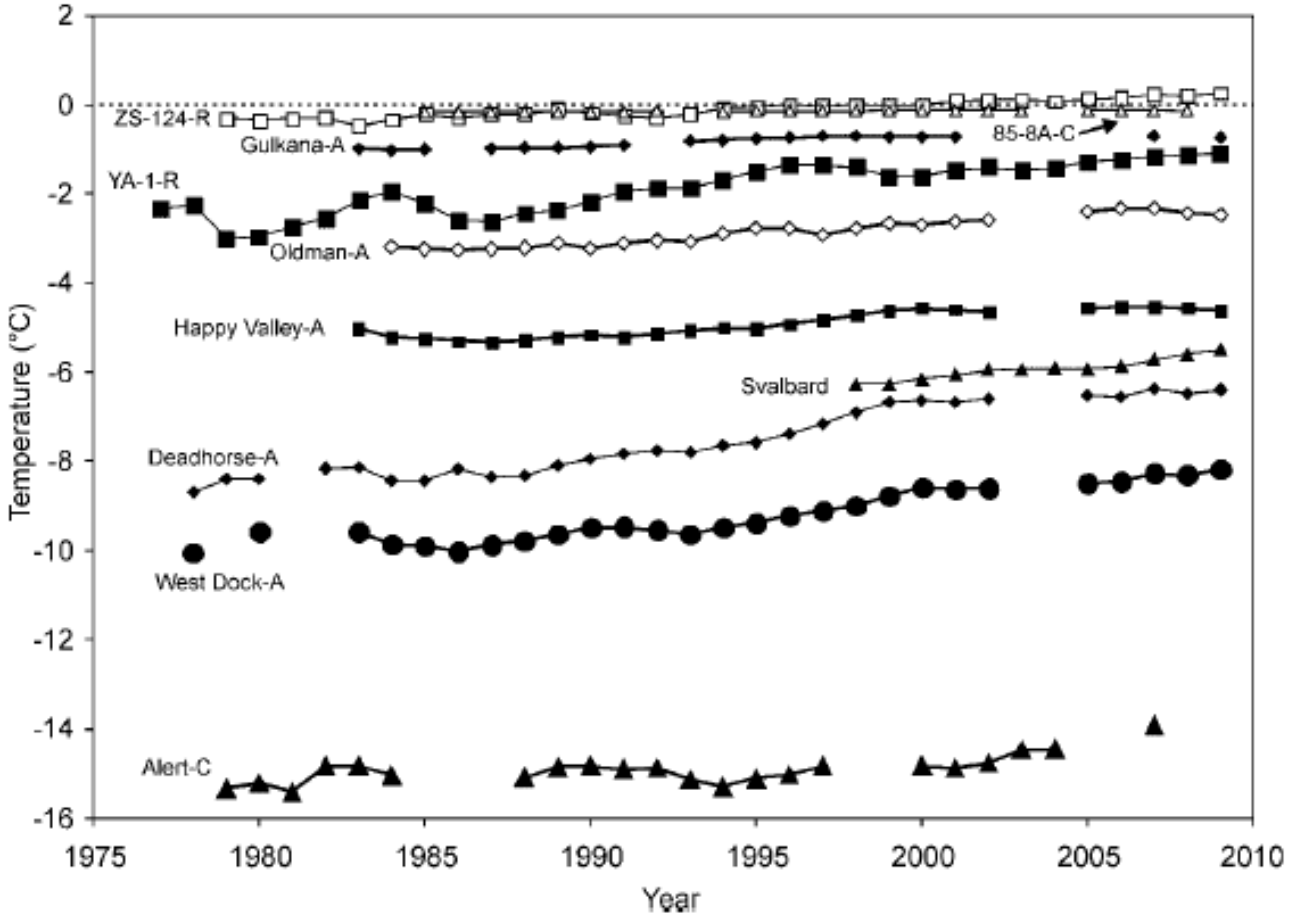
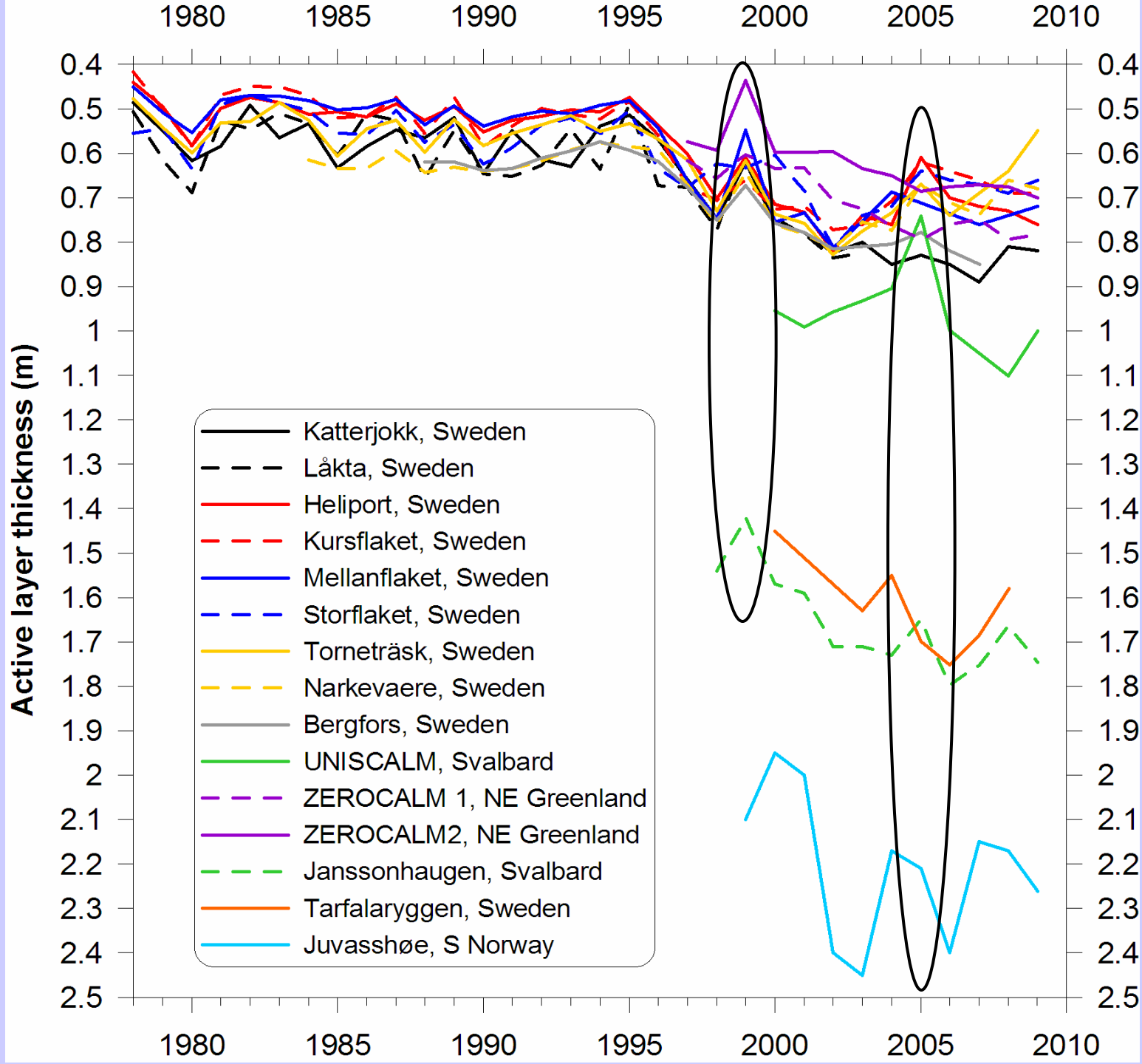


Figure 3 Time series of mean annual ground temperatures at depths between 10 and 20 m for boreholes throughout the circumpolar northern permafrost regions. Data sources for North American, Russian and Nordic sites are Smith *et al.* (2010), Romanovsky *et al.* (2010) and Christiansen *et al.* (2010) respectively. C, Canadian site; A, Alaskan site; R, Russian site. The Svalbard site is Janssonhaugen, which is also called PACE-10 (Isaksen *et al.*, 2007). Measurement depth for Russian boreholes and 85-8A is 10 m, Gulkana, Oldman and Alert are 15 m, and 20 m for all other boreholes. Coordinates for borehole locations are: ZS-124 – 67.4°N 63.4°E; 85-8A – 61.6°N 121.1°W; Gulkana – 62.2°N 145.5°W; YA-1 – 67.5°N 64°E; Oldman – 66.4°N 150.6°W; Happy Valley – 69.1°N 148.8°W; Svalbard – 78.2°N 16.5°E; Deadhorse –70.2°N 148.5°W; West Dock – 70.4°N 148.5°W; Alert – 82.5°N 62.4°W.

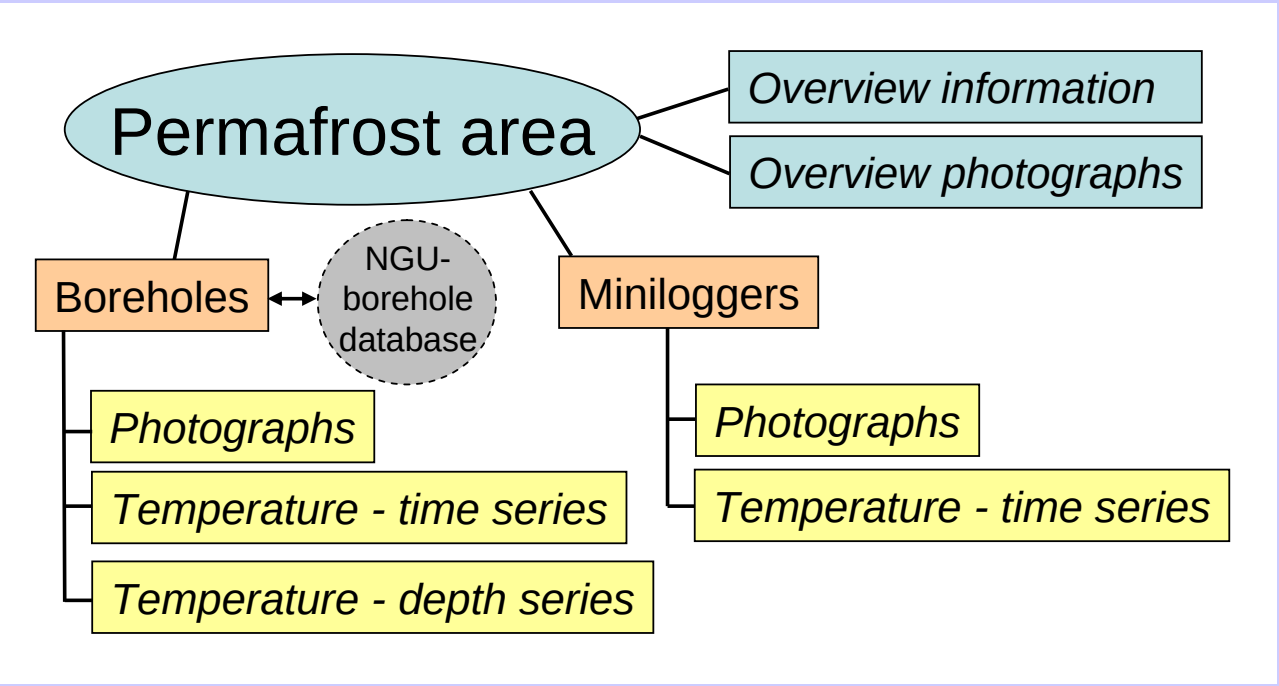
(Romanovsky et al., 2010)

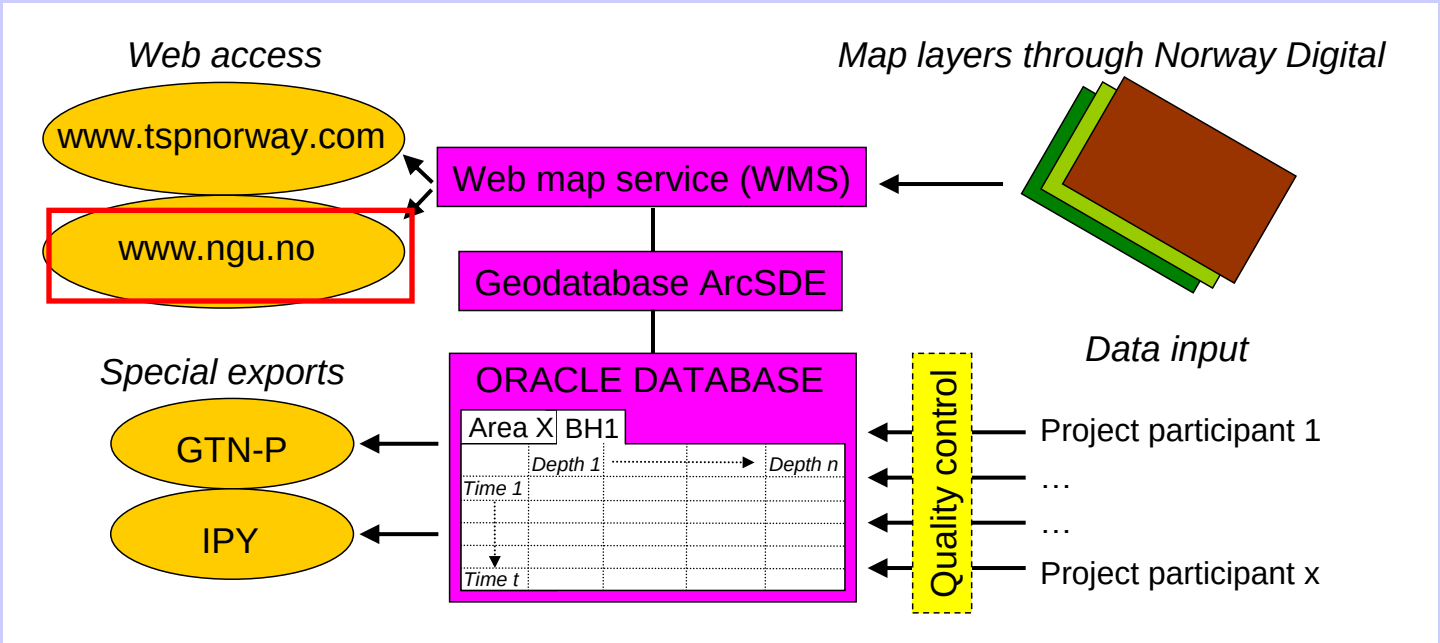


Some summers with same reaction to the overall climate variation
1999

Some summers with regional differences, thinning in Swedish and Svalbard sites while thicker in Greenlandic sites
2005

NORPERM = Norwegian Permafrost Database





Conclusions and perspectives

- Large areas with permafrost temperatures close to 0ºC

- Warmest permafrost temperatures at sea level in Svalbard same as in in the higher parts of the mountains in mainland Scandinavia

- Significantly warmer permafrost in Svalbard compared to NE Greenland

- Warm sporadic permafrost in organic-rich peat deposits –palsas, peat plateau below the regional permafrost limits

- Potential for better permafrost modelling and then to produce a first detailed Nordic permafrost map

- Need for a common Nordic permafrost database.
  The Norwegian permafrost database, NORPERM could be expanded.
  Data to be included in the Global Terrestial Network for Permafrost GTN-P

- Future use as baseline for assessments of changes in a Nordic Permafrost Observatory, potentially as part of SAON, SIOS and other relevant arctic networks.

Permafrost Thermal State in the Polar Northern Hemisphere during the International Polar Year 2007–2009: a Synthesis

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[2] Geological Survey of Canada, Natural Resources Canada, Ottawa, Ontario, Canada
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The Thermal State of Permafrost in the Nordic Area during the International Polar Year 2007–2009

H. H. Christiansen,[1,2]* *B. Etzelmüller,*[2] *K. Isaksen,*[3] *H. Juliussen,*[1] *H. Farbrot,*[2] *O. Humlum,*[1,2] *M. Johansson,*[4,5] *T. Ingeman-Nielsen,*[6] *L. Kristensen,*[1] *J. Hjort,*[7] *P. Holmlund,*[8] *A. B. K. Sannel,*[8] *C. Sigsgaard,*[9] *H. J. Åkerman,*[4] *N. Foged,*[6] *L. H. Blikra,*[10] *M. A. Pernosky*[11] *and R. S. Ødegård*[12]

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[11] Asiaq, Greenland Survey, Nuuk, Greenland
[12] Gjøvik University College, Norway

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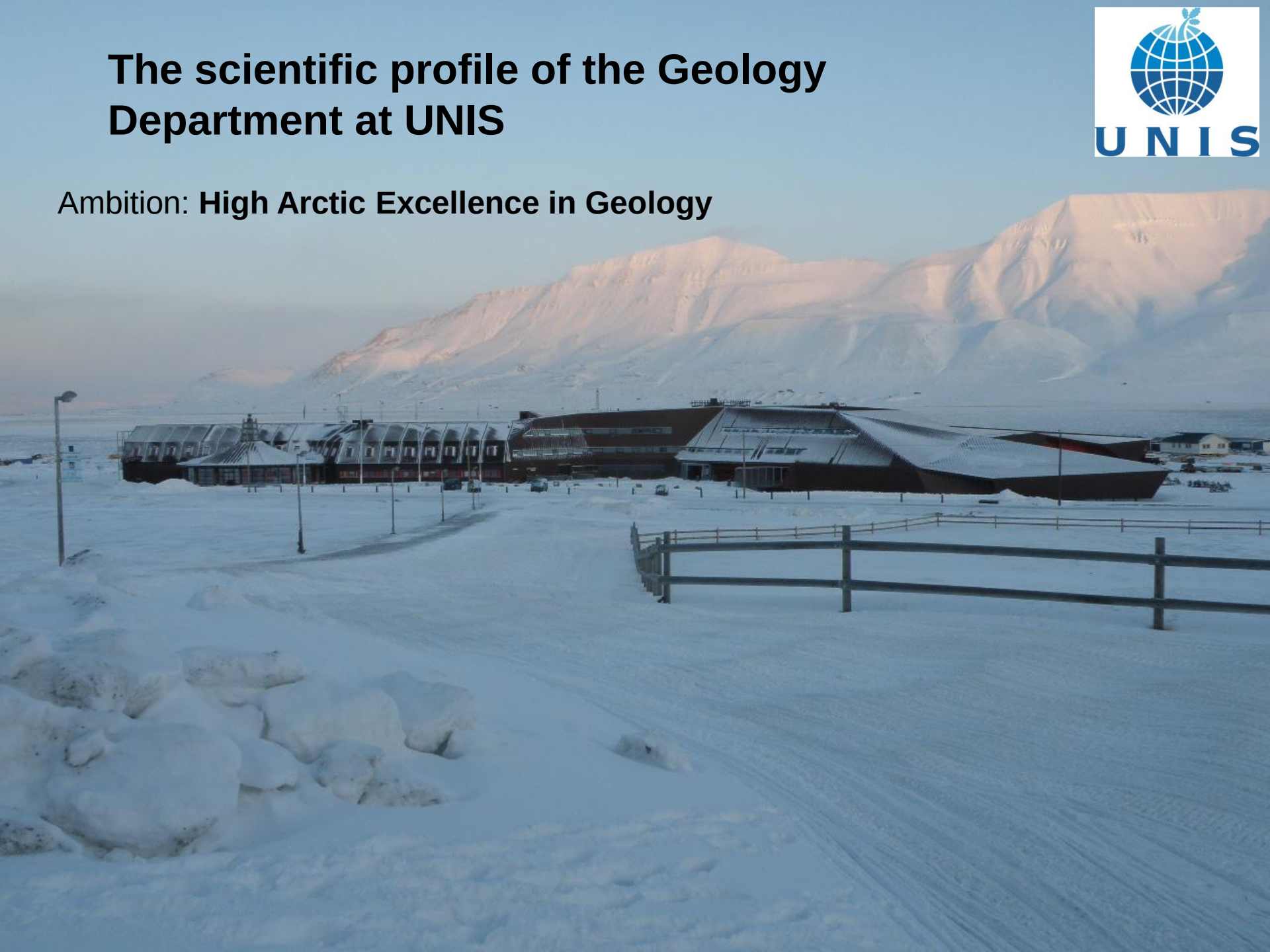
Published online in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/ppp.687

The scientific profile of the Geology Department at UNIS

Ambition: **High Arctic Excellence in Geology**



Geology Department
November 2010

BEDROCK

CRYOSPHERE

QUATERNARY

Tectonics and structural Geology

Alvar Braathen

Sedimentology

Maria Jensen

Petroleum Geology

William H-Hansen, UiB

Per T Osmundsen NGU

Snorre Olaussen

Marine Geology

Riko Noormets

vacant

Quaternary Geology

Anne Hormes

Olafur Ingolfsson, UiIsland

Glaciology and glacial geomorphology

Doug Benn

Ole Humlum,UiO
Andy Hodson, UiSheffield
Bo Elberling, UiKøbenhavn 5%

Permafrost and periglacial geomorphology

Hanne H. Christiansen

AG-209
The Tectonic and Sedimentary History of Svalbard 15 ECTS

AG-213
Fossils of Svalbard
5 ECTS

AG-211
Arctic Marine Geology
15 ECTS

AG-210
The Quaternary History of Svalbard
15 ECTS

AG-212
Holocene and Modern Climate Changes
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10 ECTS

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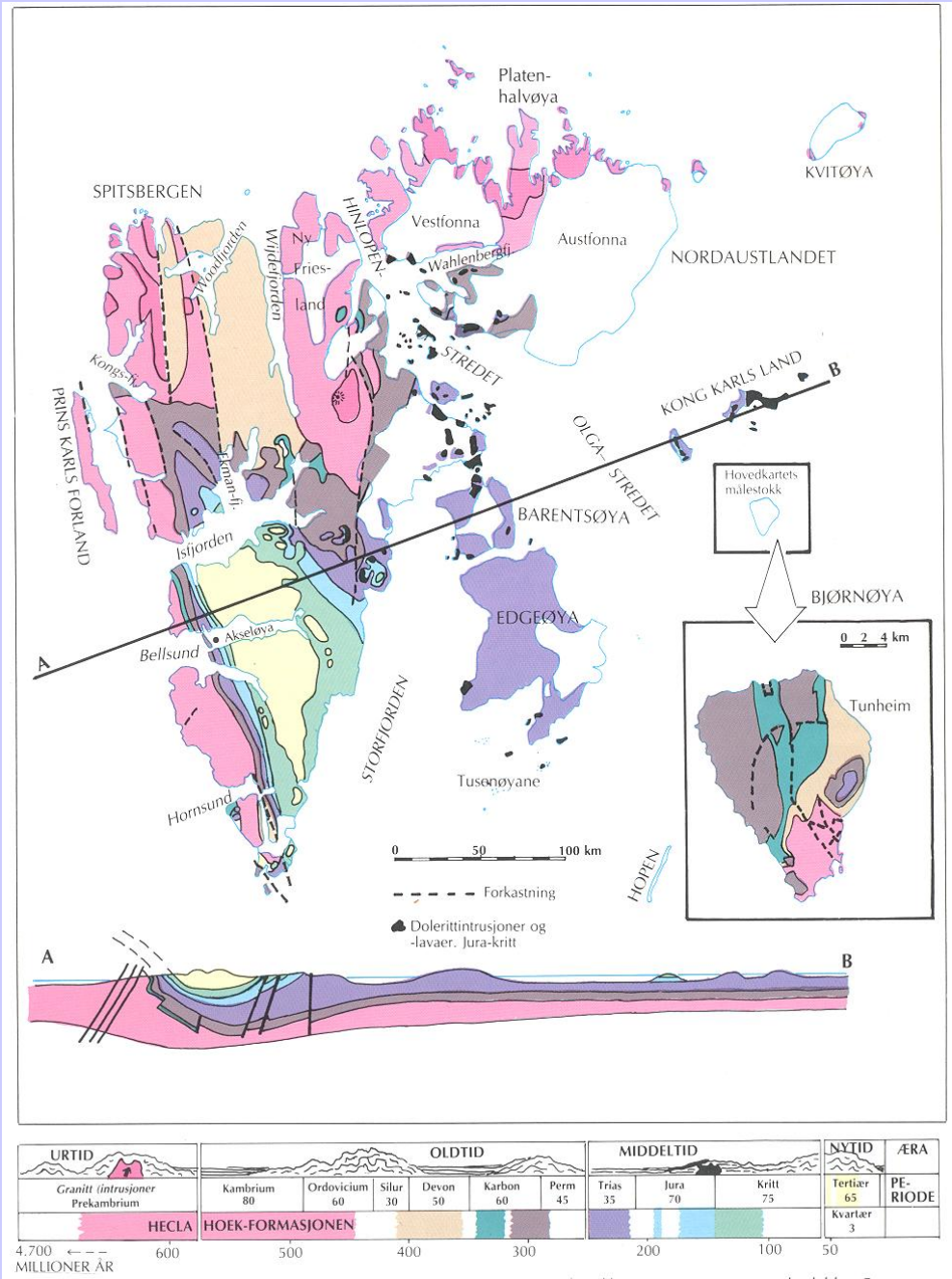
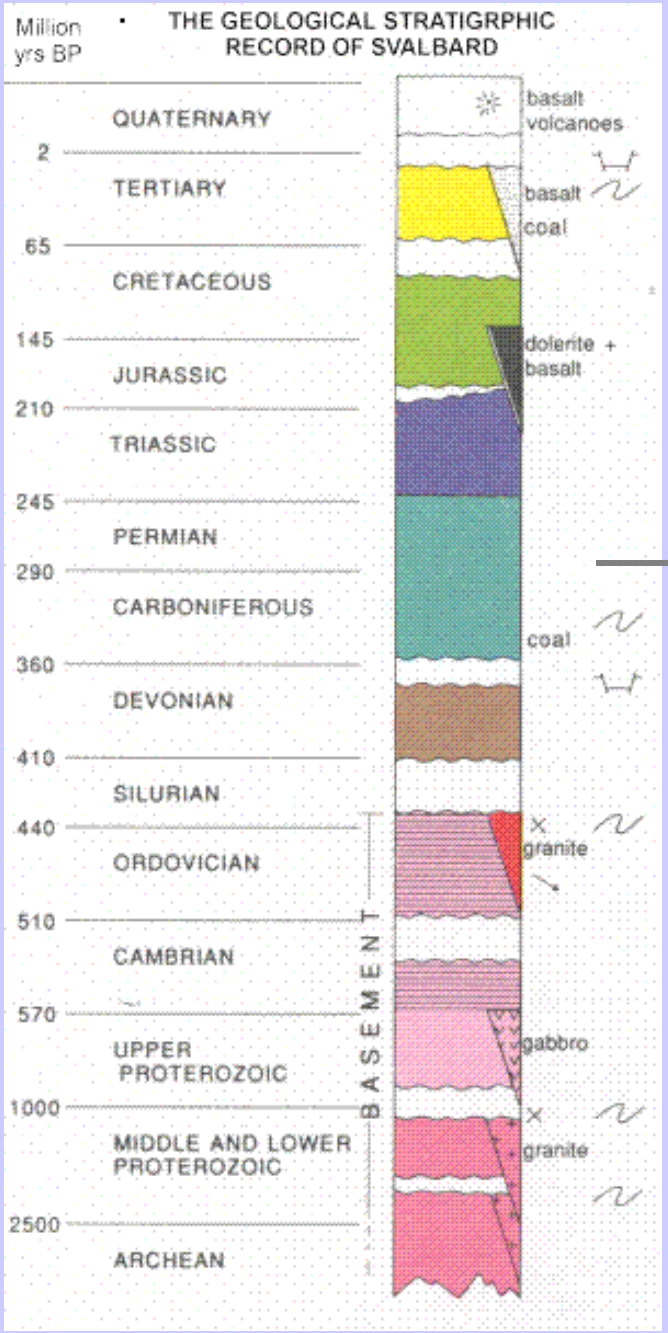
Holocene and recent climate change in the high Arctic Svalbard landscape10 ECTS

AG341 Geological constraints of CO2 sequestration

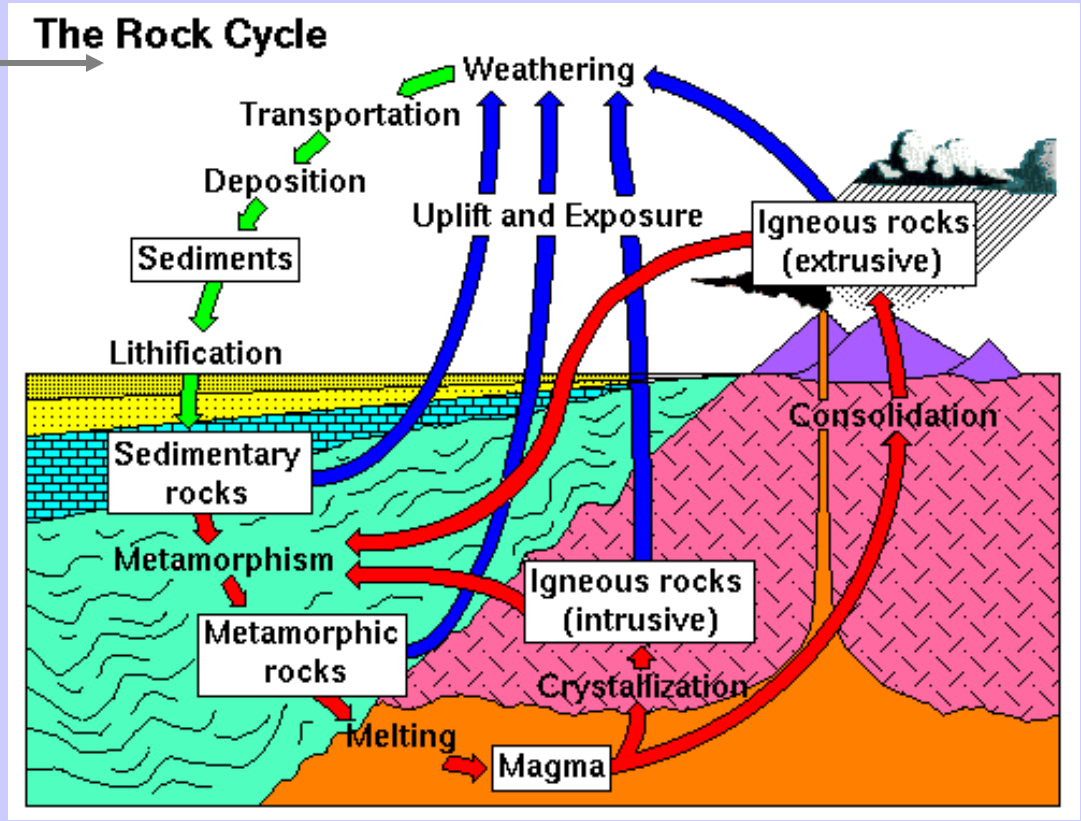
AG-340
Arctic Glaciers and landscapes

Bedrock and sedimentary geology over large parts of Svalbard

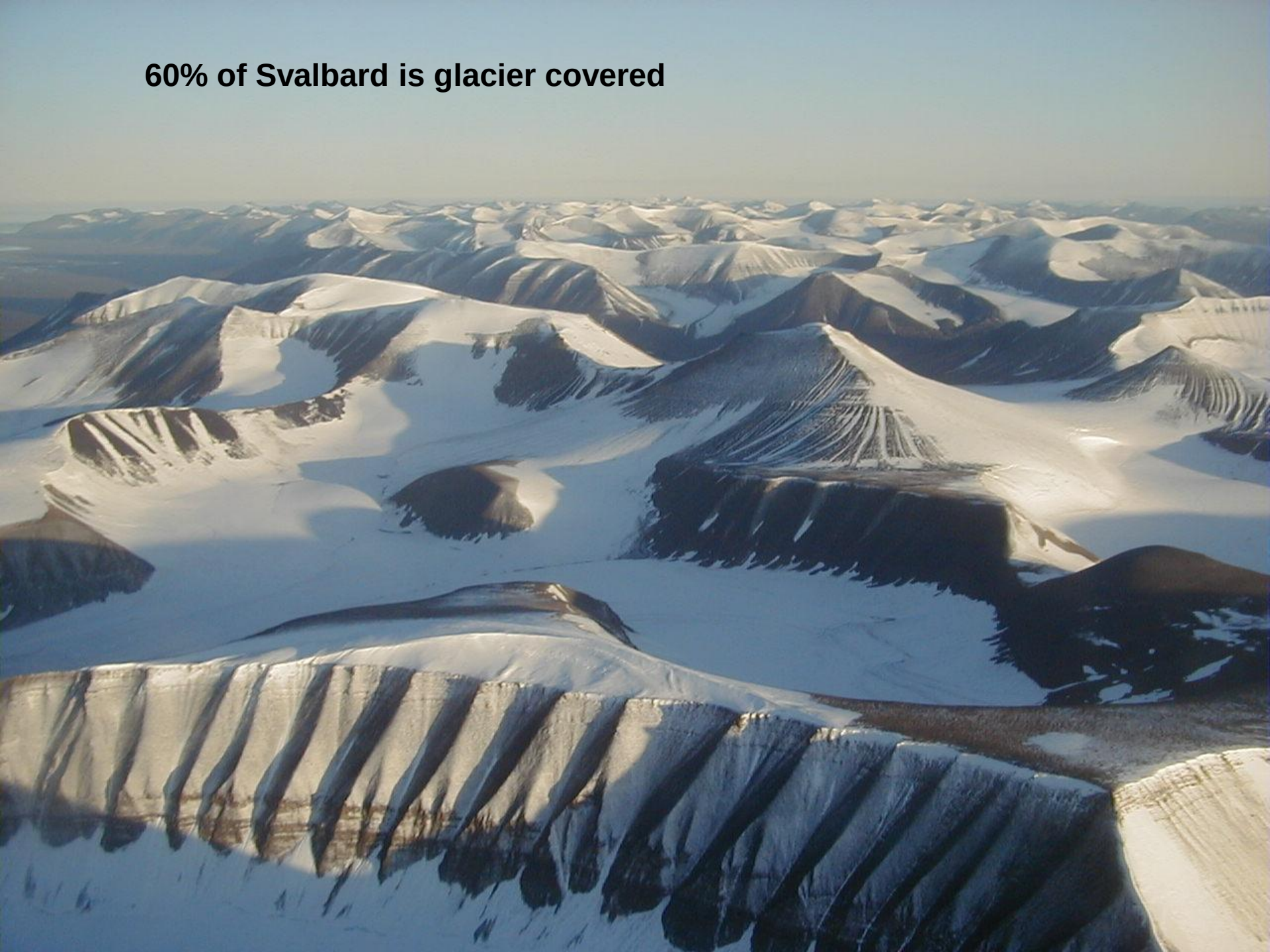




The Svalbard geology reflects repeated events of rock formations, tectonics and major environmental shifts through its long history



60% of Svalbard is glacier covered



GLACIODYN 2007 - 2010

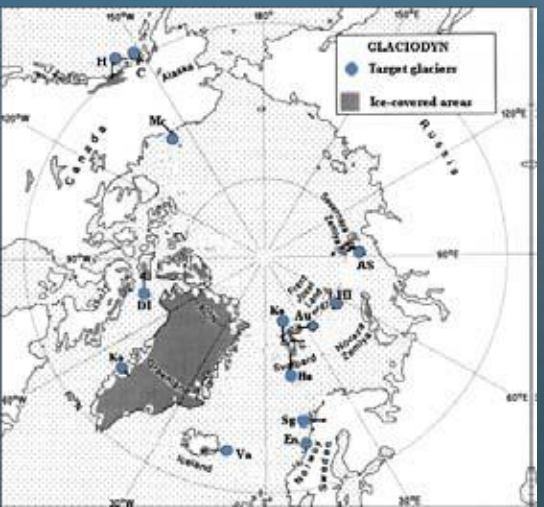
The dynamic response of Arctic glaciers to global warming

Field investigations – remote sensing – modeling

Mass budget – surface mass balance and dynamics (calving flux)

Main project goals

- **Calculate future changes in freshwater transport from glacier and thus improve the estimation of global sea level changes**
- **Understand how glacier dynamics respond to climatic changes**



GLACIODYN

Ph

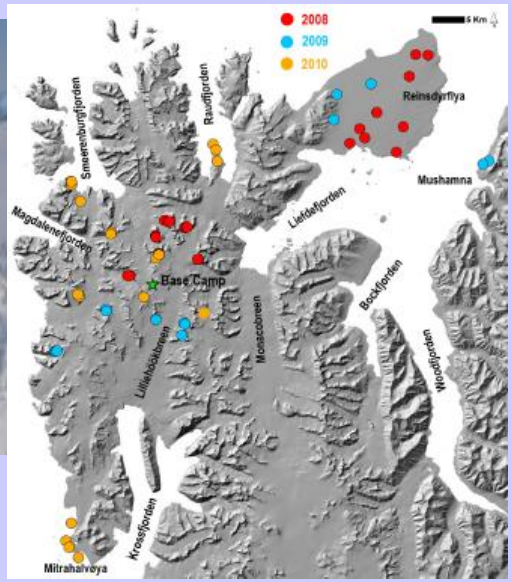
Kronebreen – calving processes

Pairs of time-lapse digital cameras:

**** High resolution***
velocity and strain records

ICEBOUND.no

Reconstruction of the last glacial Svalbard-Barents sea ice sheet.



Objectives

Reconstruct the former ice sheet geometry on Svalbard, to deliver new terrestrial data of the ice sheet development in the Svalbard region:

-) Mapping glacial trimlines in selected mountain areas

-) Dating trimlines by means of cosmogenic nuclides (CN) in order to constrain the vertical dimensions of the last ice sheet inland

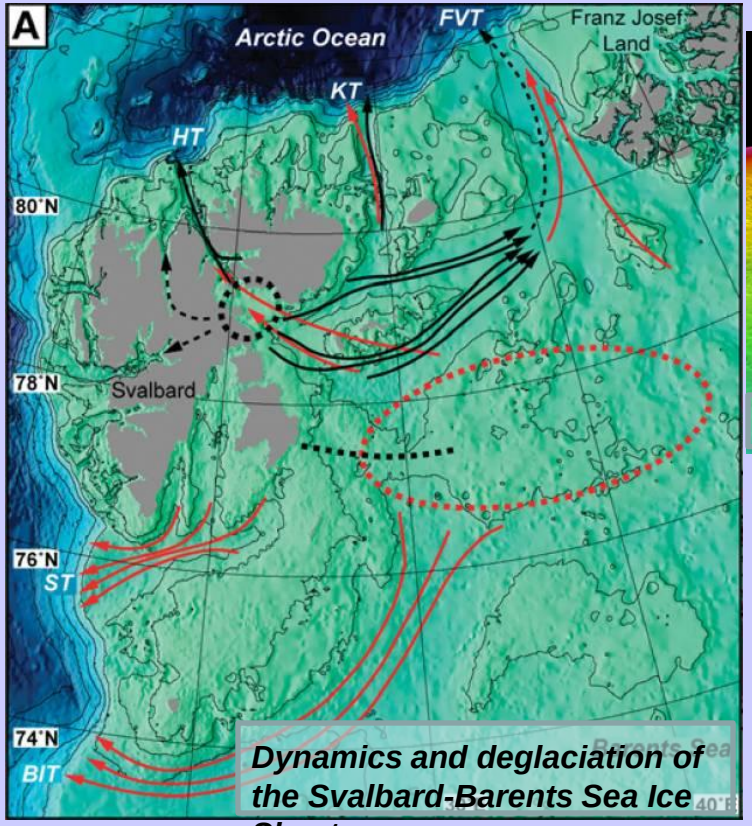
-) CN dating and bedrock source analysis of erratic boulders in order to constrain the age of deglaciation and ice flow directions during the late Weichselian

Marine Geology research focus:

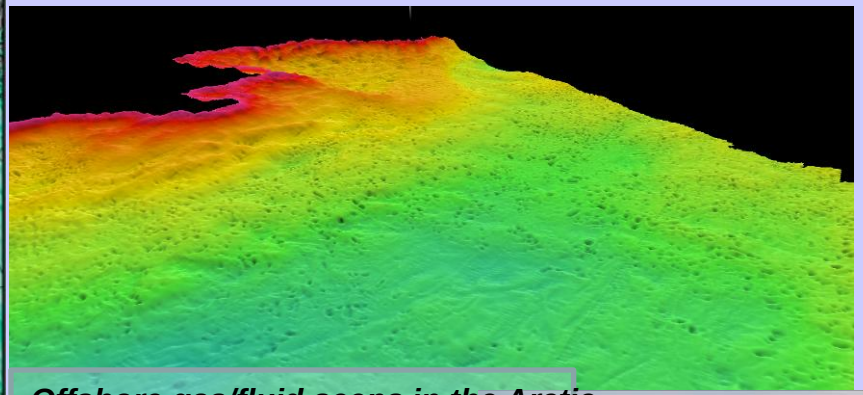
Dynamics and deglaciation history of the former marine-based Svalbard-Barents Sea Ice Sheet - implications for the stability of the West Antarctic Ice Sheet

Offshore gas/fluid seeps in Svalbard – origin, distribution, sedimentology and geochemistry

Holocene environmental change - implications of aeolian deposits in the marine sediments



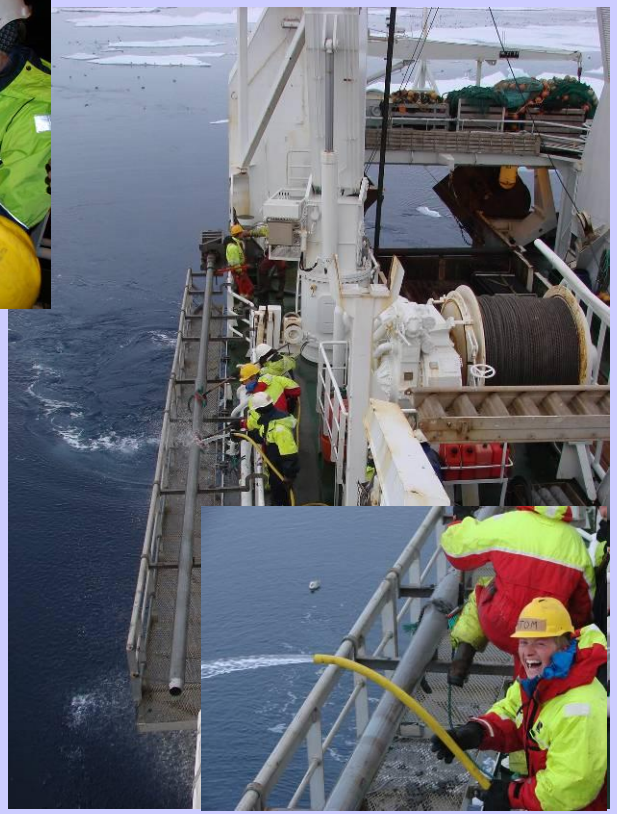
Dynamics and deglaciation of the Svalbard-Barents Sea Ice Sheet



Offshore gas/fluid seeps in the Arctic

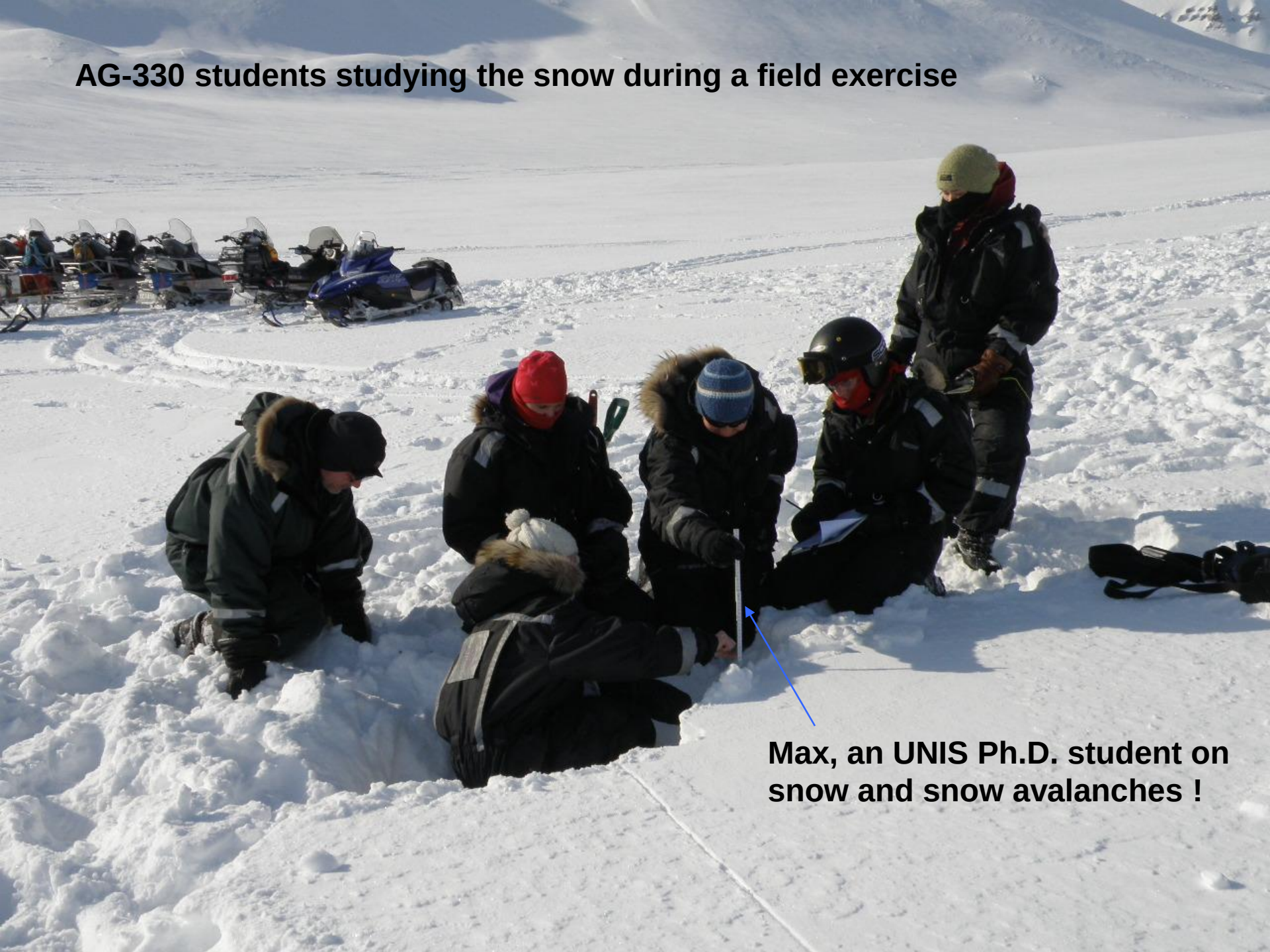
Aeolian deposits as a proxy for paleoclimate in the Arctic

Arctic marine geology cruise at UNIS



AG-330 Permafrost and Periglacial Environments


The very active Svalbard winter landscape
snow avalanches


AG-330 students studying the snow during a field exercise
Max, an UNIS Ph.D. student on snow and snow avalanches !

AG-330 students on excursion on snow mobiles

AG-330 has world class lecturers, working in different parts of the Arctic !

Master thesis possiblities combining fieldwork and supervision at UNIS with your home university – you still obtain your degree from your home university


So we look very much forward to seeing you at UNIS
to follow in the footsteps of many other coming arctic researchers
hanne.christiansen@unis.no
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