Geomorphological significance of aggrading permafrost

Geomorphological significance of aggrading permafrost

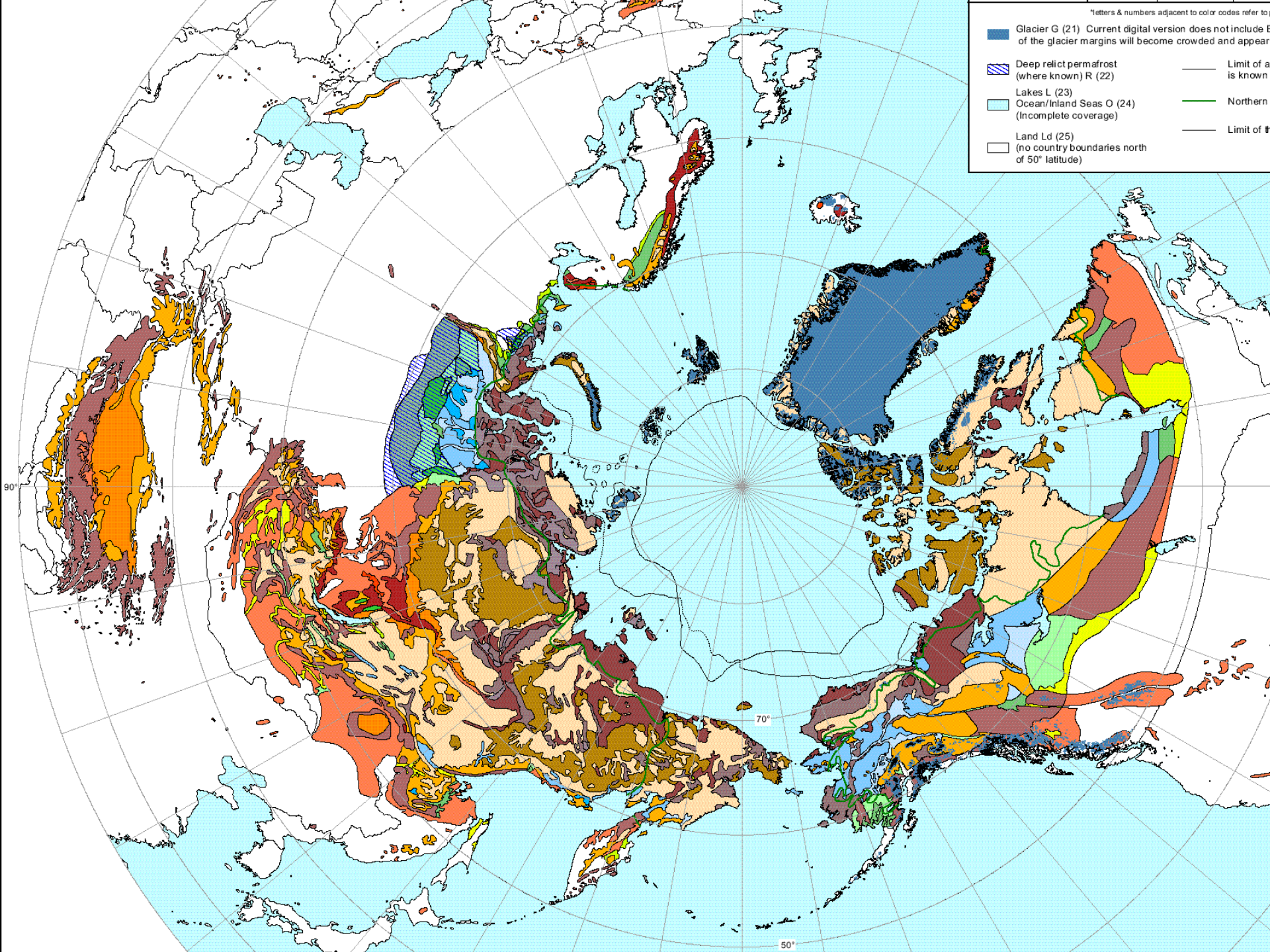
1: Aggrading versus degrading permafrost

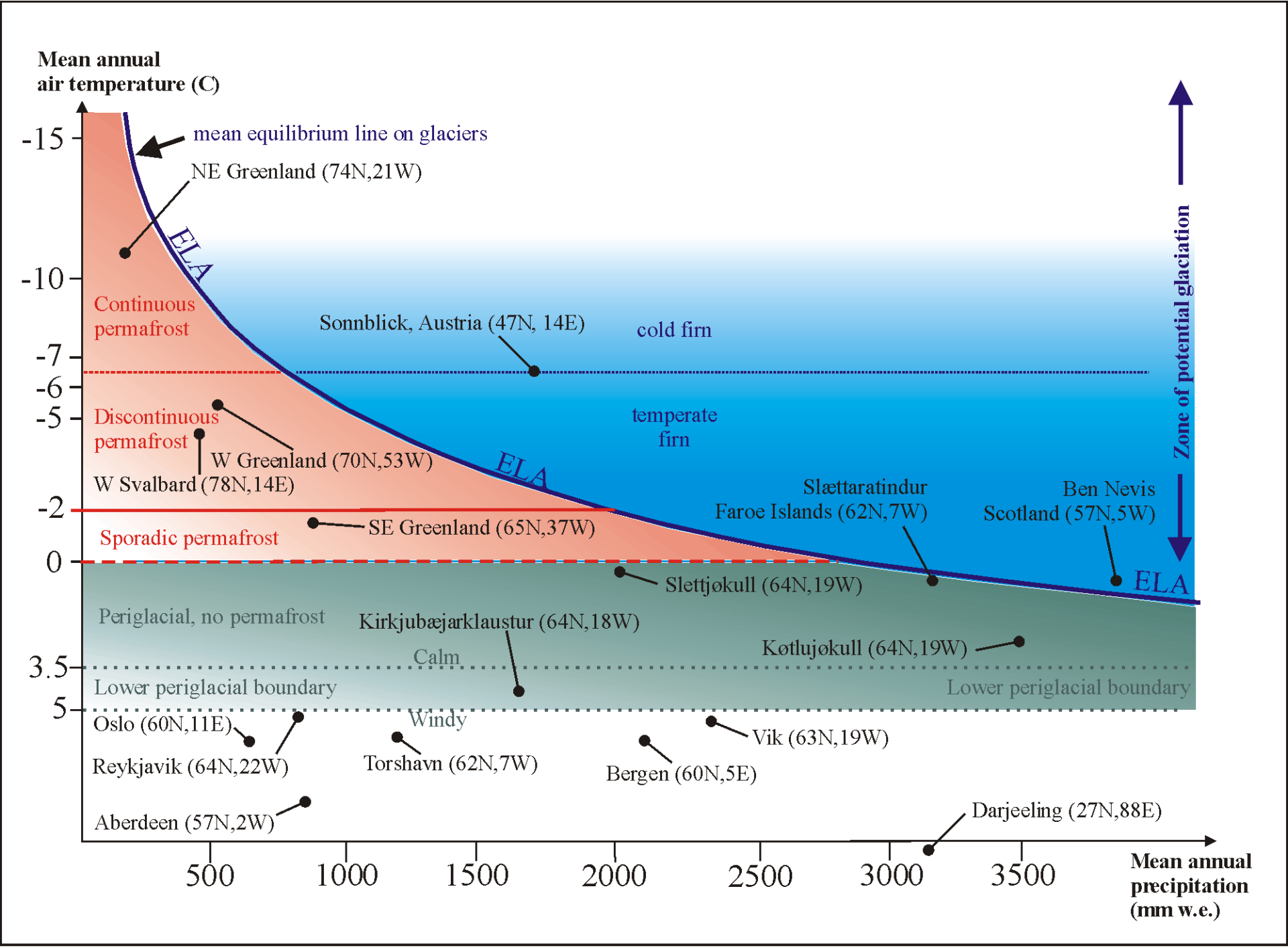
2: Aggrading permafrost; importance of avalanches

3: Deformation of aggrading permafrost

4: Rock glaciers; types and terminology

5: Rock glaciers; geomorphic significance


*letters & numbers adjacent to color codes refer to
Glacier G (21) Current digital version does not include E
of the glacier margins will become crowded and appear
Deep relict permafrost
(where known) R (22)
Lakes L (23)
Ocean/Inland Seas O (24)
(Incomplete coverage)
Land Ld (25)
(no country boundaries north
of 50° latitude)
Limit of a
is known
Northern
Limit of th
90°
70°
50°


Mean annual
air temperature (C)
-15
-10
-7
-6
-5
-2
0
3.5
5
mean equilibrium line on glaciers
NE Greenland (74N,21W)
ELA
Continuous
permafrost
Sonnblick, Austria (47N, 14E)
cold firn
Discontinuous
permafrost
W Greenland (70N,53W)
W Svalbard (78N,14E)
temperate
firn
ELA
Slættaratindur
Faroe Islands (62N,7W)
Ben Nevis
Scotland (57N,5W)
Zone of potential glaciation
Sporadic permafrost
SE Greenland (65N,37W)
Slettjøkull (64N,19W)
ELA
Periglacial, no permafrost
Kirkjubæjarklaustur (64N,18W)
Køtlujøkull (64N,19W)
Calm
Lower periglacial boundary
Lower periglacial boundary
Windy
Oslo (60N,11E)
Reykjavik (64N,22W)
Torshavn (62N,7W)
Vik (63N,19W)
Bergen (60N,5E)
Aberdeen (57N,2W)
Darjeeling (27N,88E)
500
1000
1500
2000
2500
3000
3500
Mean annual
precipitation
(mm w.e.)

Ole Humlum

Permafrost and climate change

- Models assume a stable terrain surface
- Importance of geomorphological processes such as erosion and deposition is usually ignored

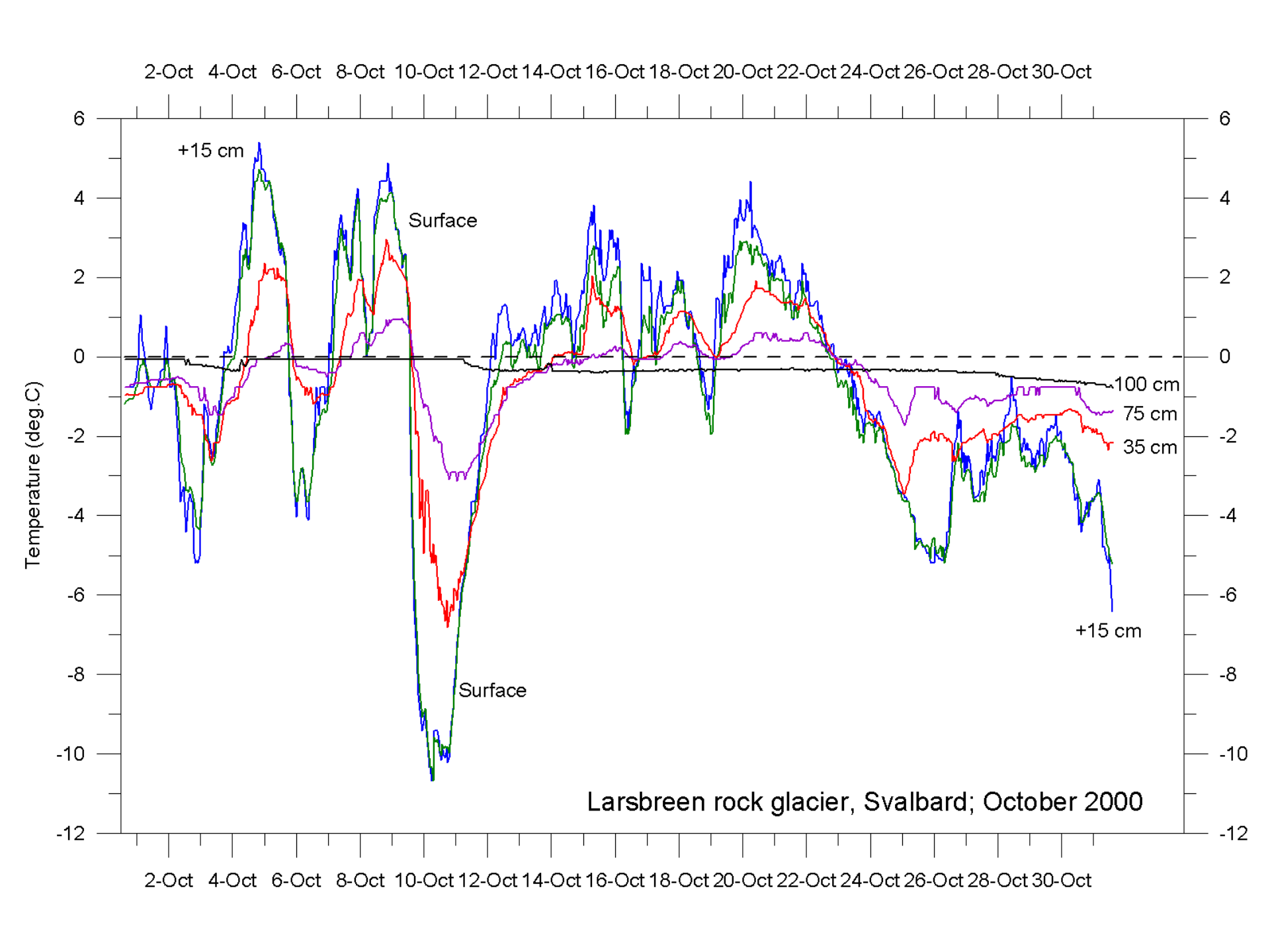
Coarse debris; the Balch ventilation effect:

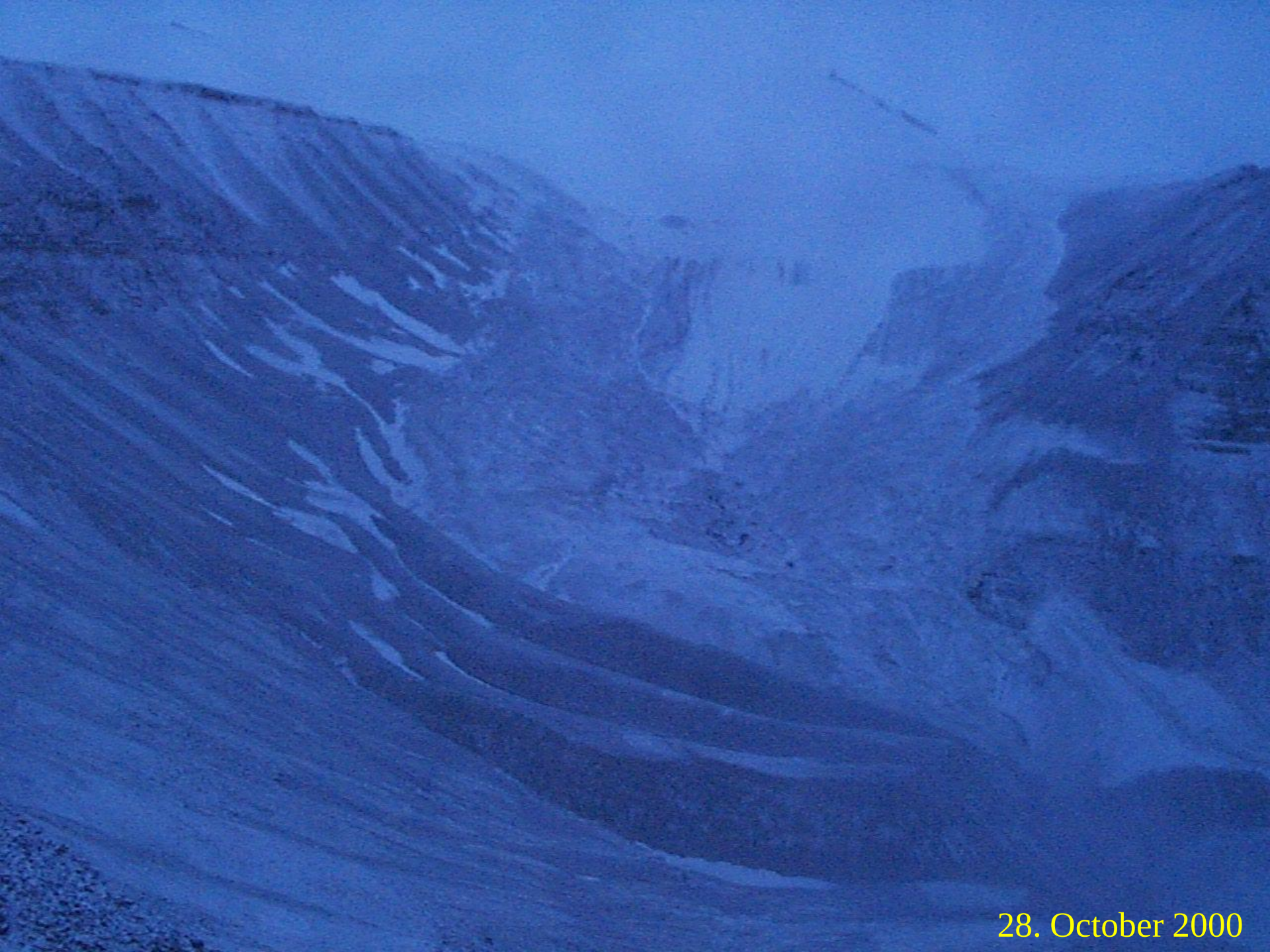

Cold air accumulation
= Balch ventilation

Examples of temperature variations in coarse debris:

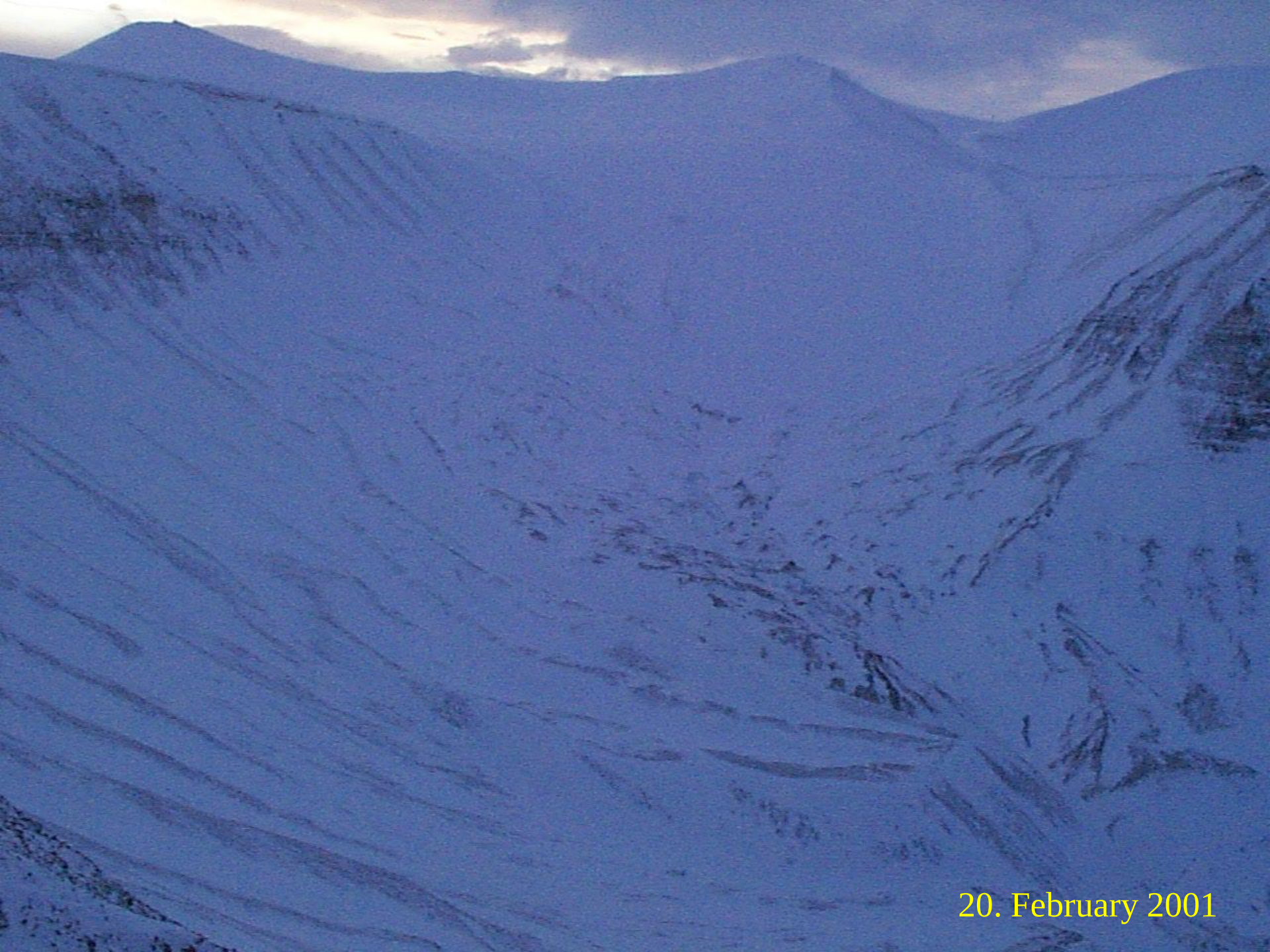
Larsbreen, central Spitsbergen


3. October 2000


2-Oct 4-Oct 6-Oct 8-Oct 10-Oct 12-Oct 14-Oct 16-Oct 18-Oct 20-Oct 22-Oct 24-Oct 26-Oct 28-Oct 30-Oct
6
4
2
0
-2
-4
-6
-8
-10
-12
Temperature (deg.C)
+15 cm
Surface
Surface
100 cm
75 cm
35 cm
+15 cm
Larsbreen rock glacier, Svalbard; October 2000

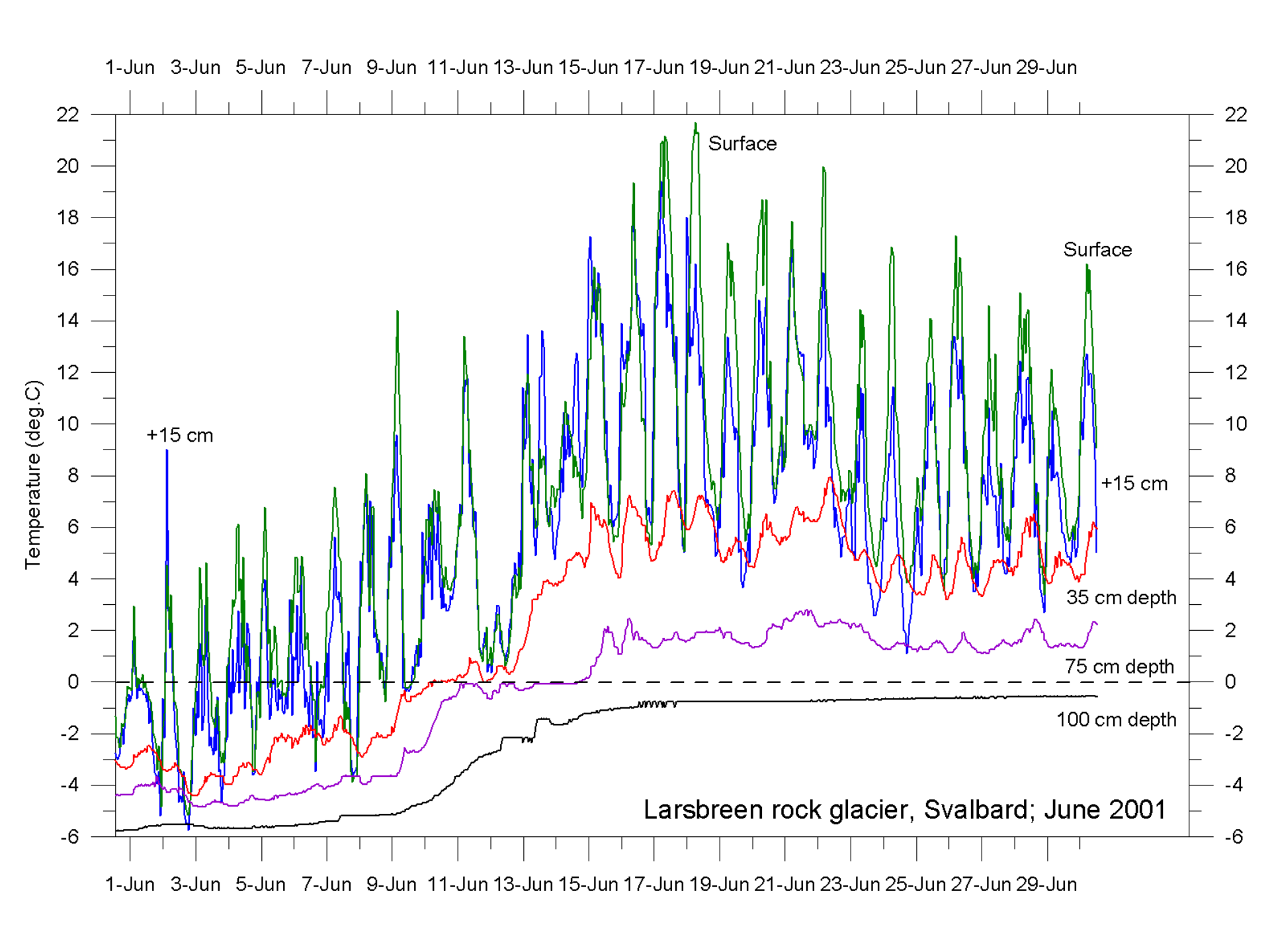

28. October 2000


5. February 2001

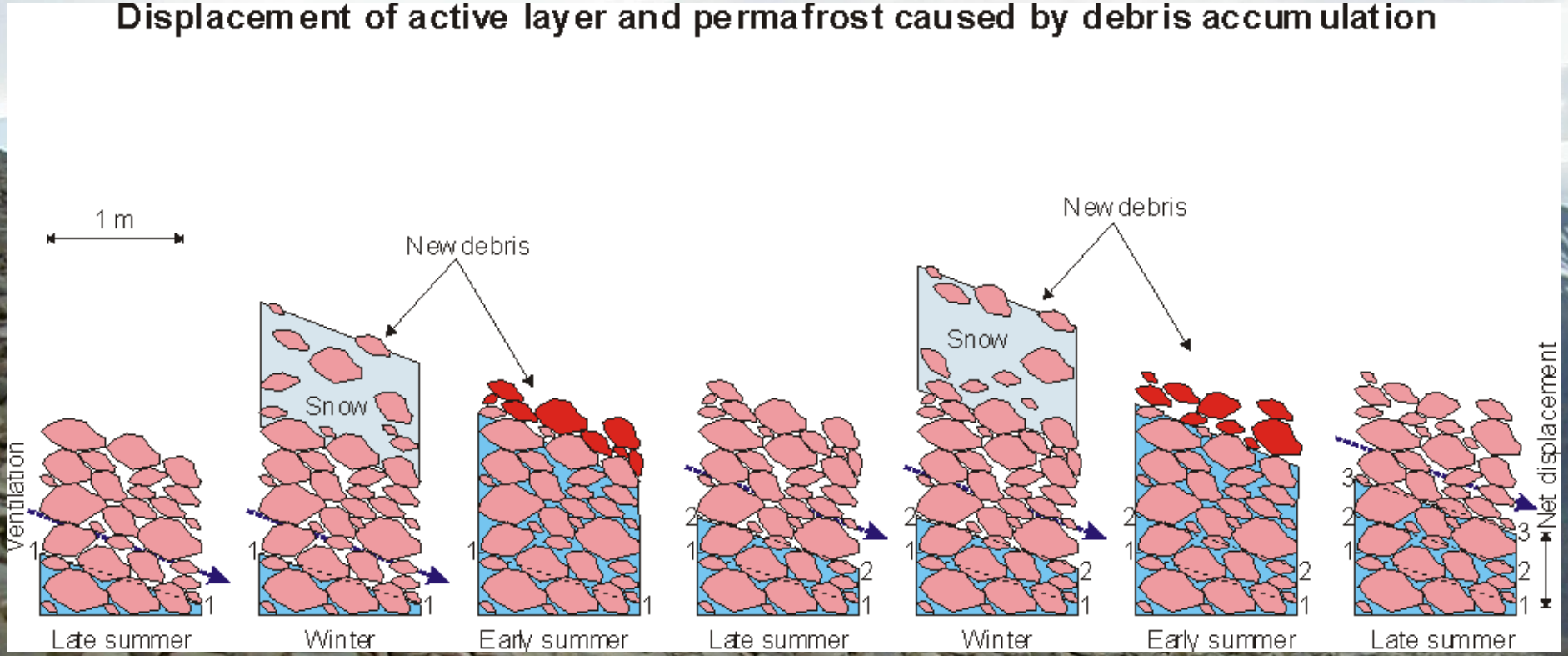

20. February 2001


3. June 2001

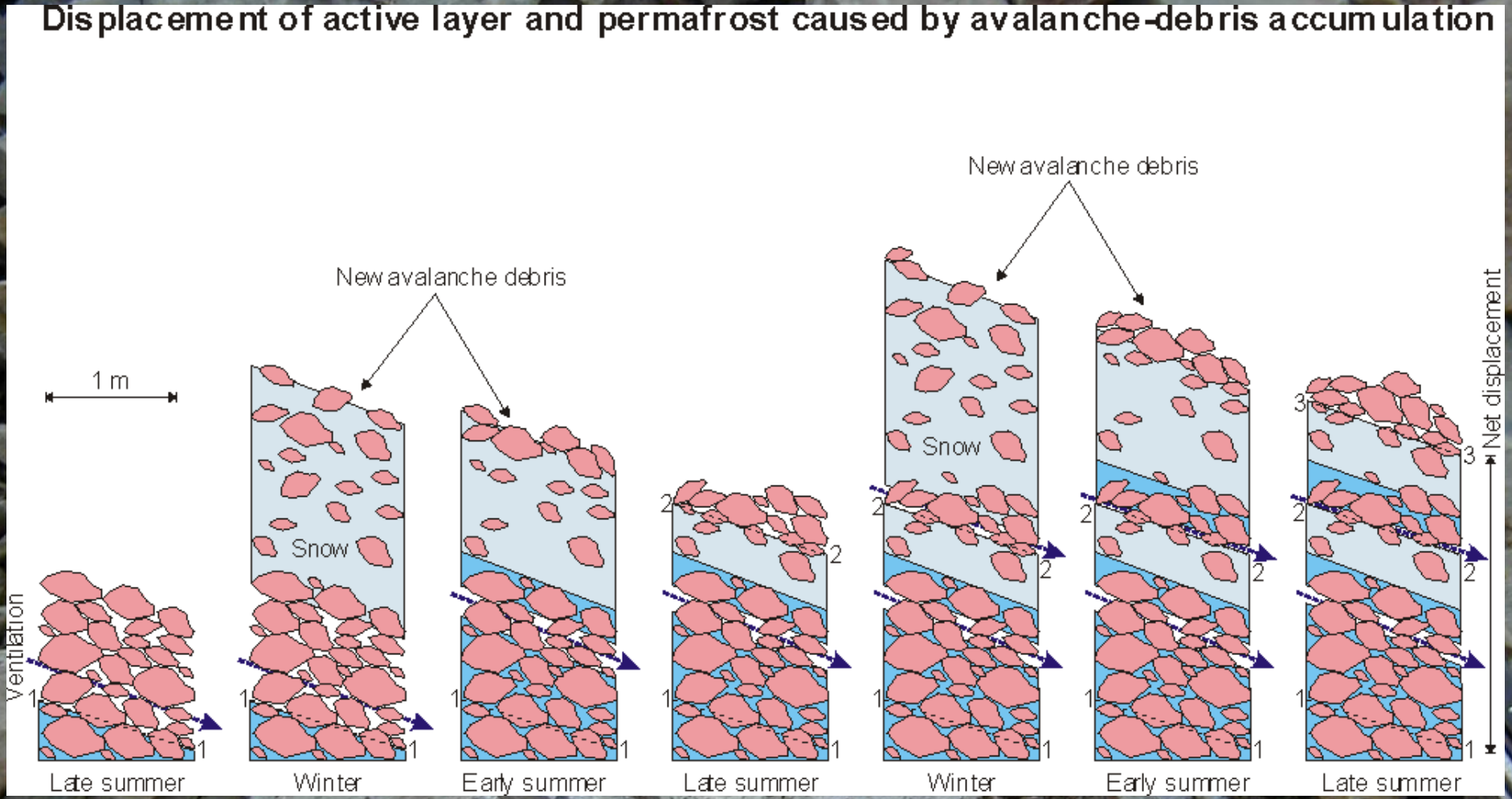

27.June 2001


1-Jun 3-Jun 5-Jun 7-Jun 9-Jun 11-Jun 13-Jun 15-Jun 17-Jun 19-Jun 21-Jun 23-Jun 25-Jun 27-Jun 29-Jun
22 20 18 16 14 12 10 8 6 4 2 0 -2 -4 -6
Temperature (deg.C)
Surface
Surface
+15 cm
+15 cm
35 cm depth
75 cm depth
100 cm depth
Larsbreen rock glacier, Svalbard; June 2001

Aggrading permafrost; geomorphic processes:

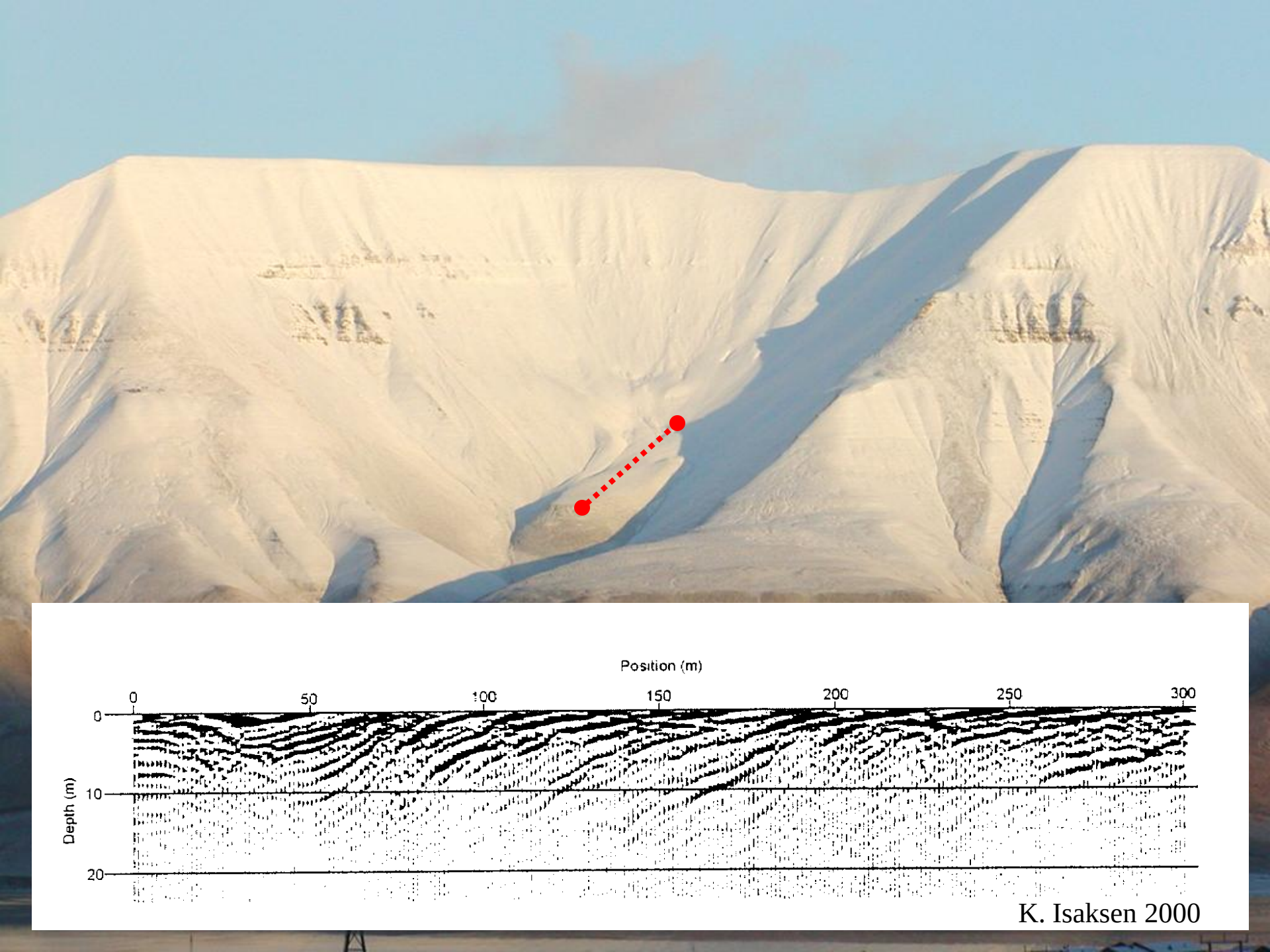


Annual permafrost net growth rate: 0-5 cm



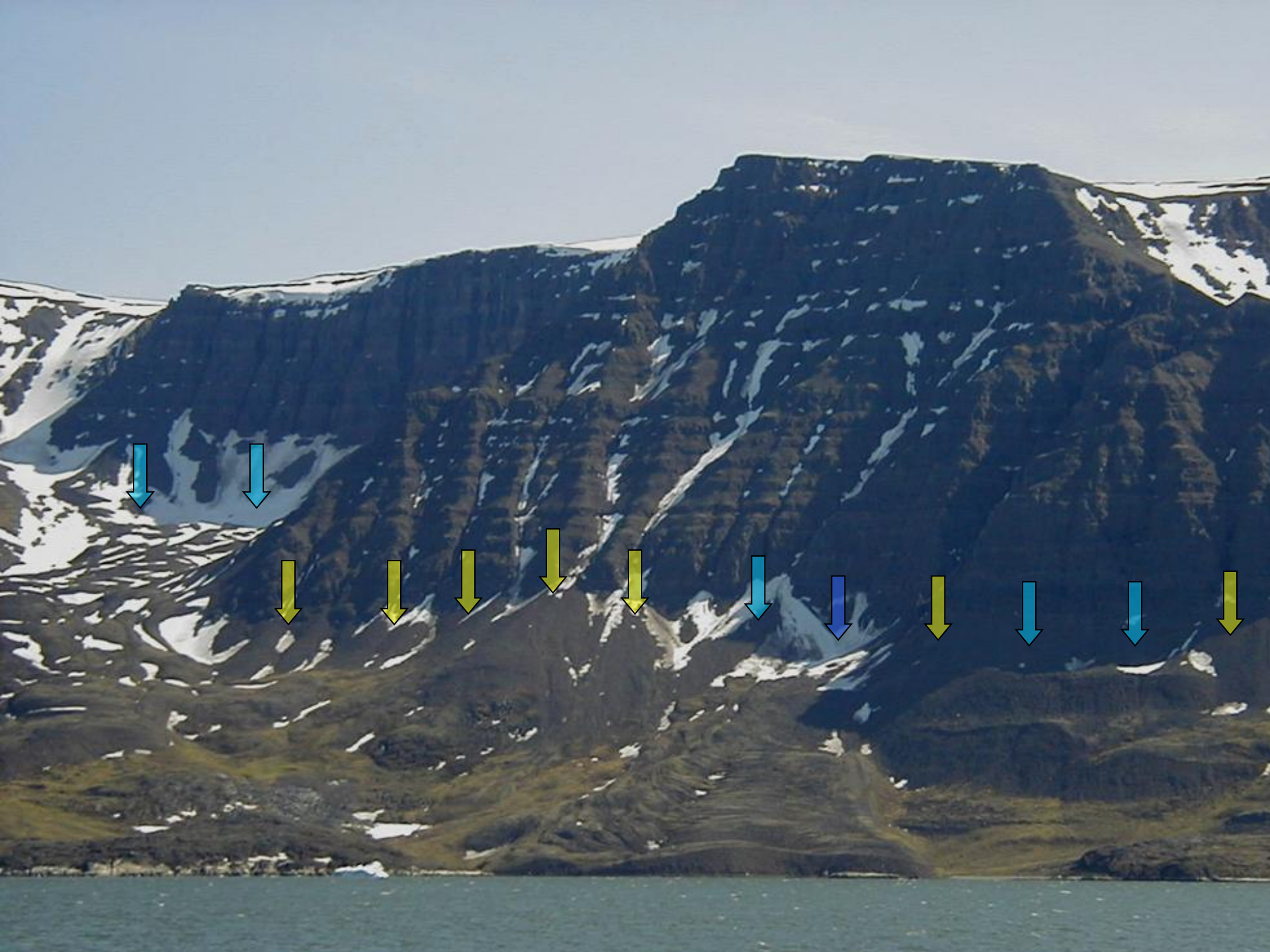
Annual permafrost net growth rate: 0-100 cm

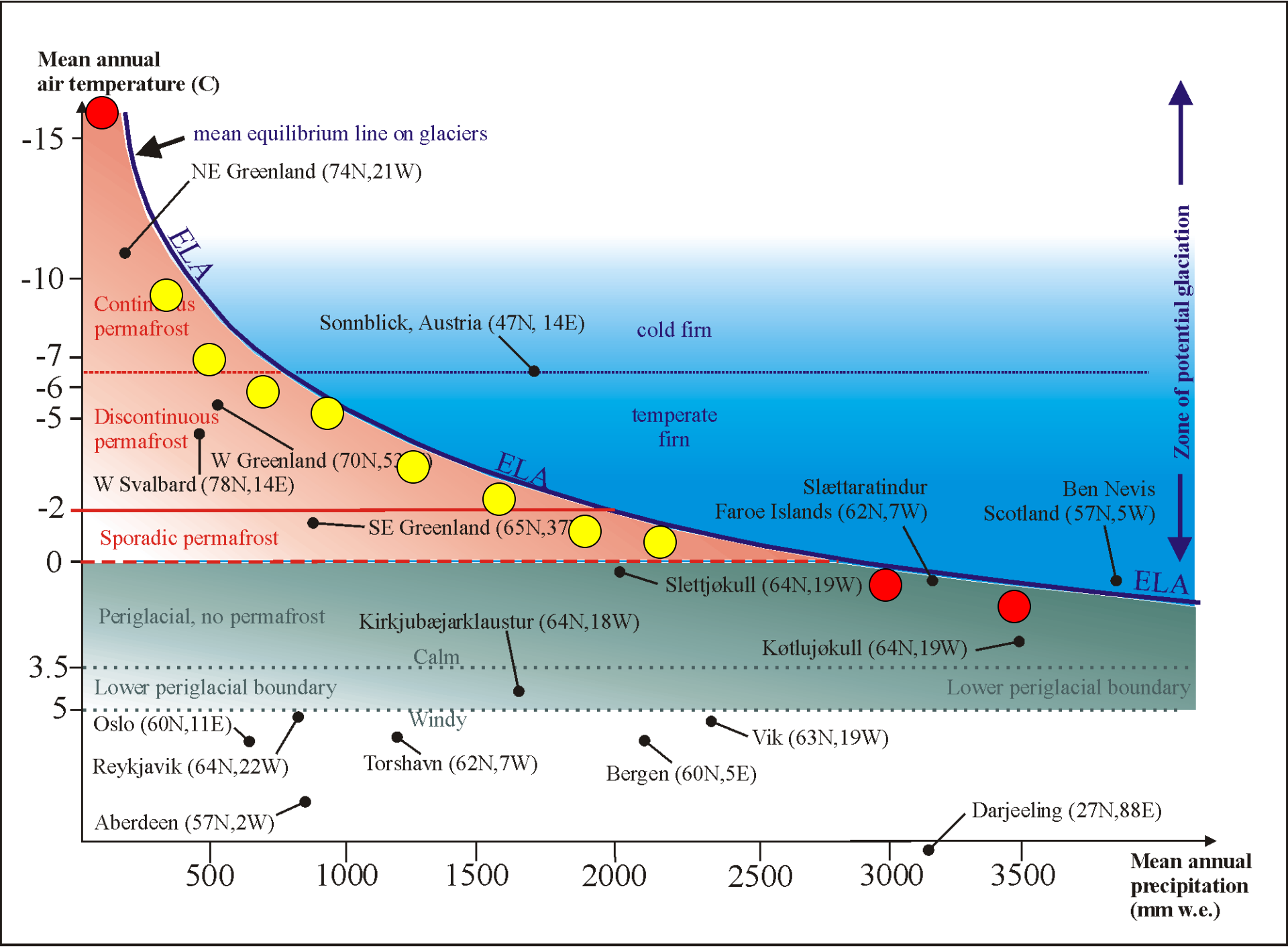
...and mass balance is positive...



K. Isaksen 2000


Oxygen delta 18-O values:
-10.97 to –17.47
No fractionation. Precipitation mainly between –2 and –10 deg.C.




Mean annual
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-15
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-7
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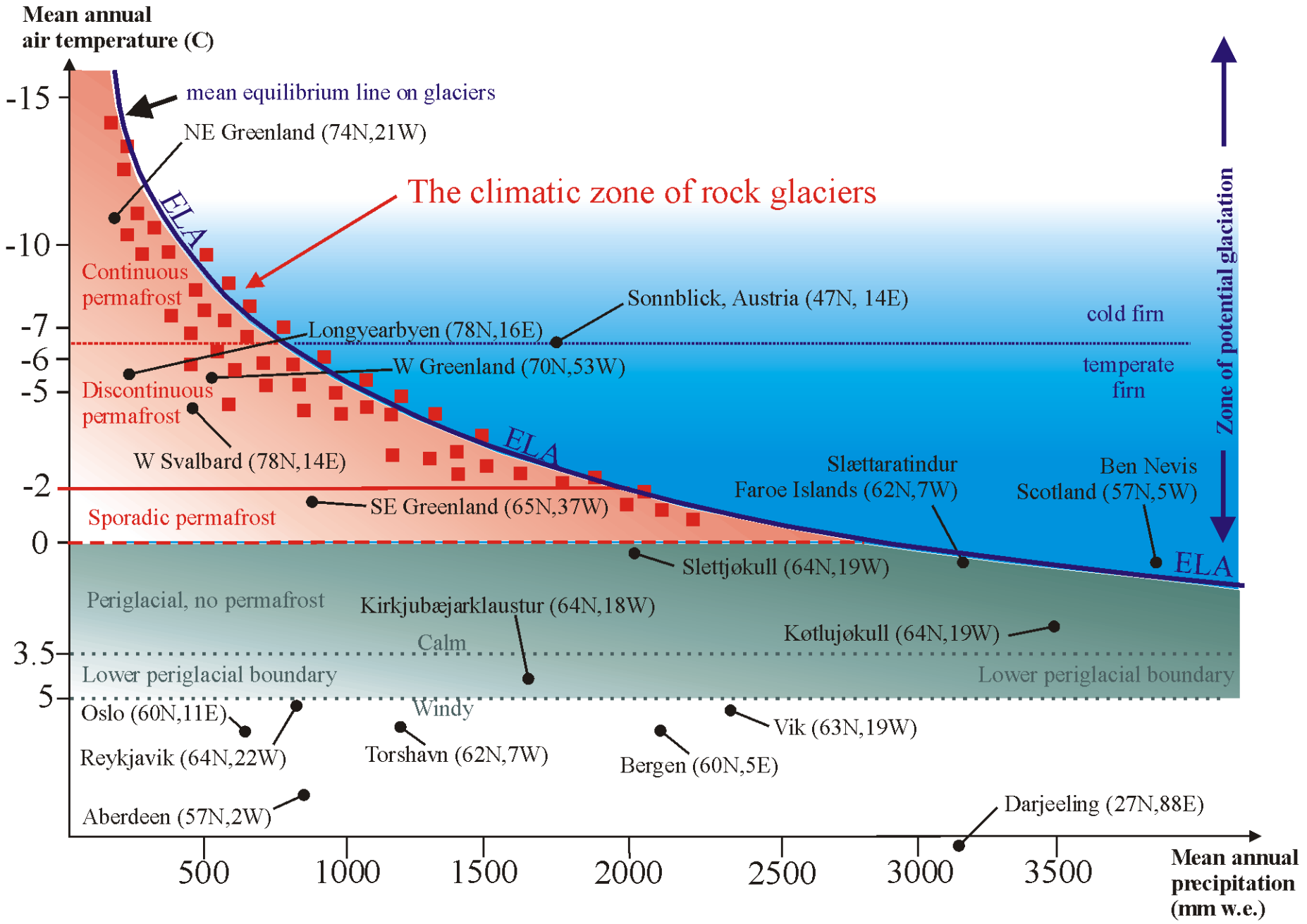
-5
-2
0
3.5
5
mean equilibrium line on glaciers
NE Greenland (74N,21W)
ELA
Continuous
permafrost
Discontinuous
permafrost
W Svalbard (78N,14E)
W Greenland (70N,52
Sonnblick, Austria (47N, 14E)
cold firn
temperate
firn
ELA
SE Greenland (65N,37
Sporadic permafrost
Slettjøkull (64N,19W)
Slættaratindur
Faroe Islands (62N,7W)
Ben Nevis
Scotland (57N,5W)
ELA
Zone of potential glaciation
Periglacial, no permafrost
Kirkjubæjarklaustur (64N,18W)
Calm
Køtlujøkull (64N,19W)
Lower periglacial boundary
Lower periglacial boundary
Windy
Oslo (60N,11E)
Reykjavik (64N,22W)
Torshavn (62N,7W)
Bergen (60N,5E)
Vik (63N,19W)
Aberdeen (57N,2W)
Darjeeling (27N,88E)
500
1000
1500
2000
2500
3000
3500
Mean annual
precipitation
(mm w.e.)

Ole Humlum


Mean annual
air temperature (C)
-15
-10
-7
-6
-5
-2
0
3.5
5
mean equilibrium line on glaciers
NE Greenland (74N,21W)
ELA
The climatic zone of rock glaciers
Continuous
permafrost
Discontinuous
permafrost
Sporadic permafrost
Periglacial, no permafrost
Lower periglacial boundary
Longyearbyen (78N,16E)
W Greenland (70N,53W)
W Svalbard (78N,14E)
SE Greenland (65N,37W)
Sonnblick, Austria (47N, 14E)
cold firn
temperate
firn
Slættaratindur
Faroe Islands (62N,7W)
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500
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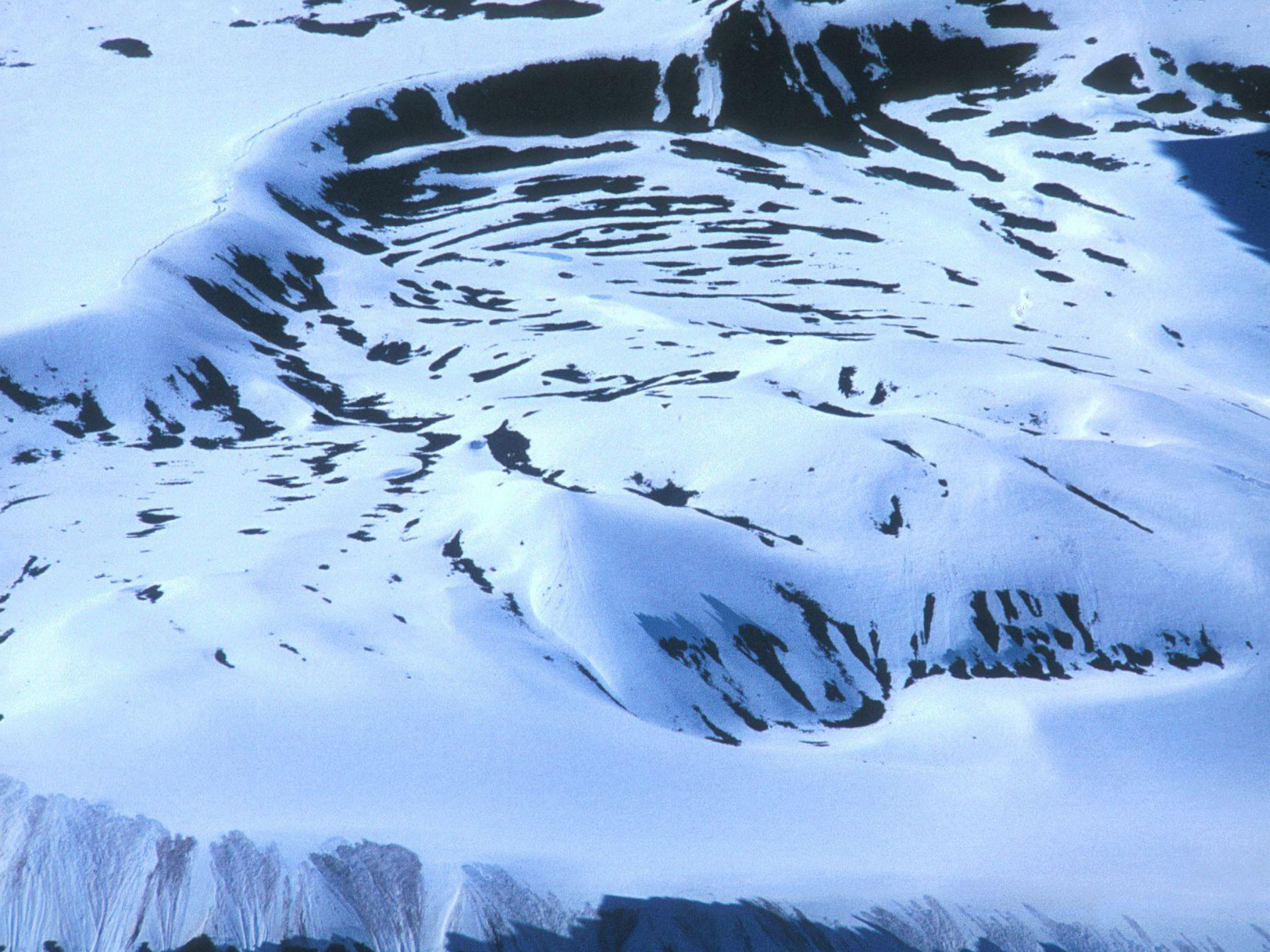
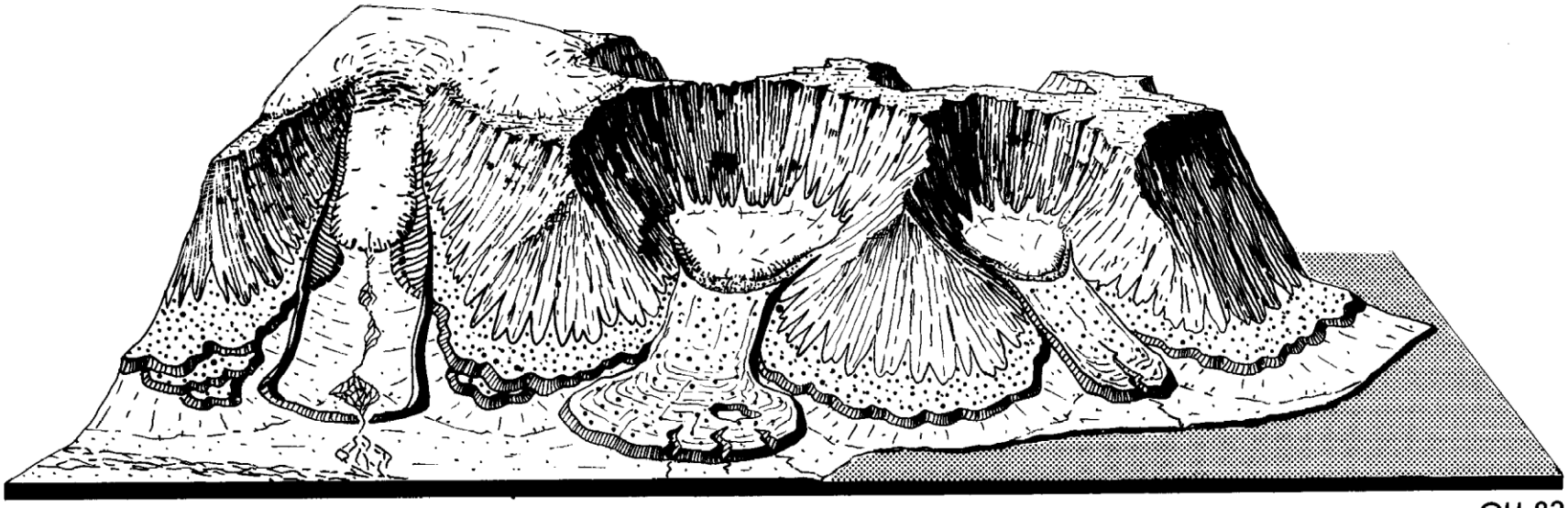
Mean annual
precipitation
(mm w.e.)

Ole Humlum



GREENLAND

ROCK GLACIER TYPES, DISKO

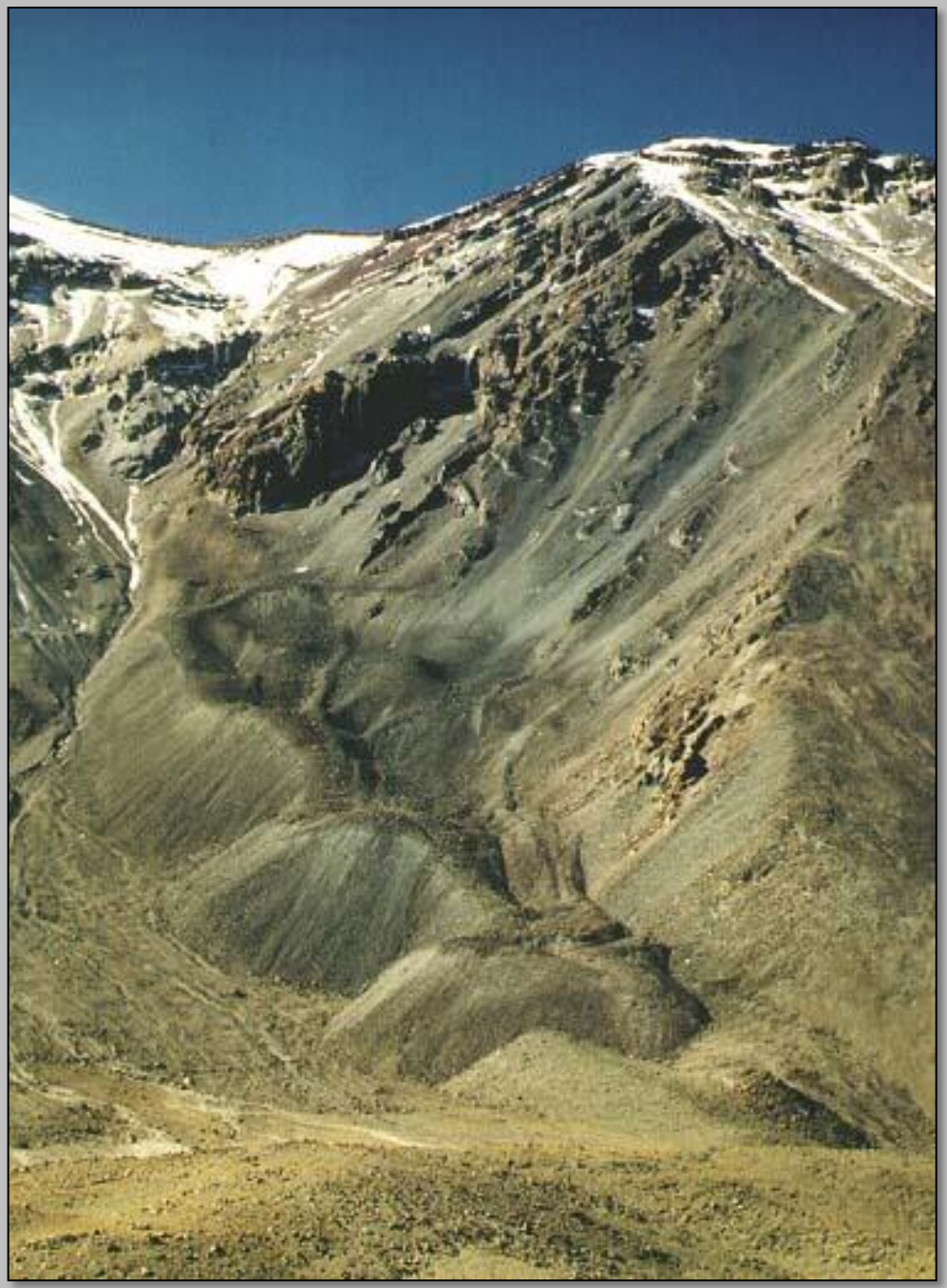


OH 82

AUSTRIA

ICELAND

NEW ZEALAND



CHILE

SCOTLAND

ROMANIA

The Holocene 8,6 (1998) pp. 631–658

Climatic signals recorded in snow avalanche-dominated colluvium in western Norway: depositional facies successions and pollen records

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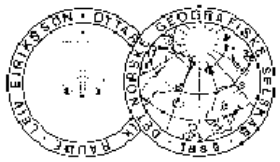
(Geological Survey of Norway, P.O. Box 3006, N-7002 Trondheim, Norway)

Received 26 February 1997; revised manuscript accepted 14 April 1998

Norsk geogr. Tidsskr. Vol. 54, 157–168. Oslo. ISSN 0029-1951

Glacier characteristics and sediment transfer system of Longyearbreen and Larsbreen, western Spitsbergen

BERND ETZELMÜLLER, RUNE STRAND ØDEGÅRD, GEIR VATNE, RØNNAUG SÆGROV MYSTERUD, TORE TONNING & JOHAN LUDVIG SOLLID



Etzelmüller, B., Ødegård, R. S., Vatne, G., Mysterud, R. S., Tonning, T. & Sollid, J. L. 2000. Glacier characteristics and sediment transfer system of Longyearbreen and Larsbreen, western Spitsbergen. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* Vol. 54, 157–168. Oslo. ISSN 0029-1951.

Two small high-Arctic glaciers (Longyearbreen and Larsbreen) on Svalbard (78°N 15°E) were studied with respect to glaciological and hydrological characteristics. Fieldwork during the melting season of 1993 and 1994 was coupled with digital map analysis based on high-resolution digital elevation models (DEM) to reveal the dynamics and temperature regime of small glaciers in a high-Arctic environment, and its relationship to the material transport and sedimentation of these glaciers. The study showed Longyearbreen and Larsbreen to be low activity glaciers, cold-based with temperate patches, and thus having a low potential of basal erosion. The transport of ions and suspended solids in the glacial meltwater implies storage of material in and around the glacier which comes into contact with the meltwater. The study suggests that small Arctic glaciers couple the slope system with the fluvial system and therefore build a highly effective denudation system. Small polythermal glaciers are therefore important in understanding Pleistocene and Holocene landform development in cold regions.

Keywords: *cold glaciers, DEM, GIS, high-Arctic glaciers, map analysis, sediment budget*

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