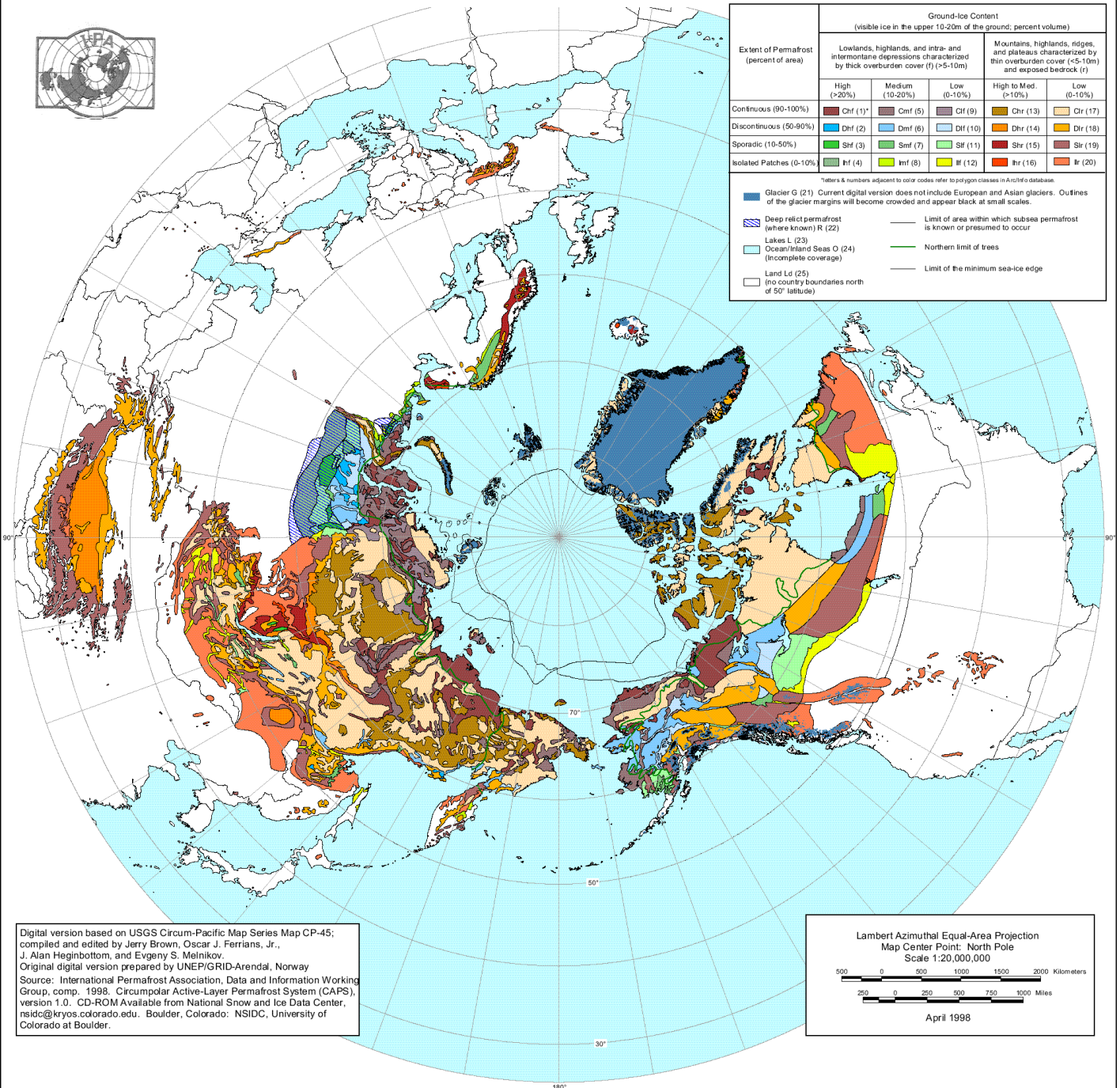

The active layer

CIRCUM-ARCTIC MAP OF PERMAFROST AND GROUND-ICE CONDITIONS



Extent of Permafrost (percent of area)	Ground-Ice Content (visible ice in the upper 10-20m of the ground; percent volume)				
	Lowlands, highlands, and intra- and intermontane depressions characterized by thick overburden cover (f) (>5-10m)			Mountains, highlands, ridges, and plateaus characterized by thin overburden cover (<5-10m) and exposed bedrock (r)	
	High (>20%)	Medium (10-20%)	Low (0-10%)	High to Med. (>10%)	Low (0-10%)
Continuous (90-100%)	Chf (1)*	Cmf (5)	Clf (9)	Chr (13)	Clr (17)
Discontinuous (50-90%)	Dhf (2)	Dmf (6)	Dlf (10)	Dhr (14)	Dlr (18)
Sporadic (10-50%)	Shf (3)	Smf (7)	Slf (11)	Shr (15)	Slr (19)
Isolated Patches (0-10%)	Ihf (4)	Imf (8)	Ilf (12)	Ihr (16)	Ilr (20)

*letters & numbers adjacent to color codes refer to polygon classes in Arc/Info database.

Glacier G (21) Current digital version does not include European and Asian glaciers. Outlines of the glacier margins will become crowded and appear black at small scales.

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 area within which subsea permafrost is known or presumed to occur

Northern limit of trees

Limit of the minimum sea-ice edge

Digital version based on USGS Circum-Pacific Map Series Map CP-45; compiled and edited by Jerry Brown, Oscar J. Ferrians, Jr., J. Alan Heginbottom, and Evgeny S. Melnikov.
Original digital version prepared by UNEP/GRID-Arendal, Norway
Source: International Permafrost Association, Data and Information Working Group, comp. 1998. Circumpolar Active-Layer Permafrost System (CAPS), version 1.0. CD-ROM Available from National Snow and Ice Data Center, nsidc@kryos.colorado.edu. Boulder, Colorado: NSIDC, University of Colorado at Boulder.

Lambert Azimuthal Equal-Area Projection
Map Center Point: North Pole
Scale 1:20,000,000

500 0 500 1000 1500 2000 Kilometers

250 0 250 500 750 1000 Miles

April 1998

The active layer:

IIn all periglacial areas there exists a surface layer of ground that freezes in winter and thaws in summer.

- If this layer overlies permafrost, this zone of annual freezing and thawing is called the active layer.

- Repeated freezing and thawing within the active layer often results in the formation of distinctive small-scale landforms and sedimentary structures at places where the active layer consists of unlitified sediments.

- The active layer generally is quite shallow (less than 50 cm) in the high arctic in the case of unlitified sediments. In bedrock and outside the high arctic the active layer thickness may well exceed 1.5 m.

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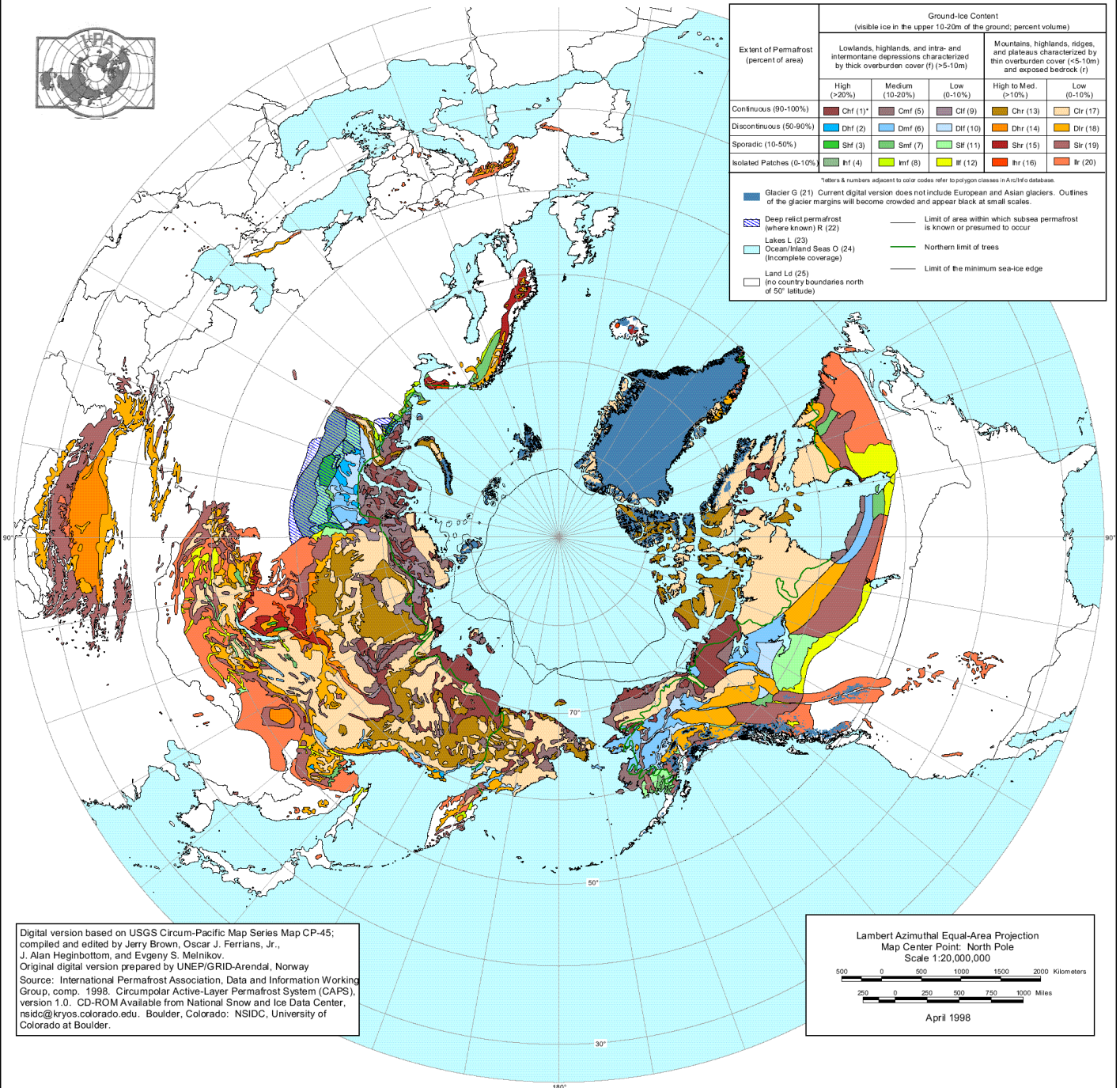

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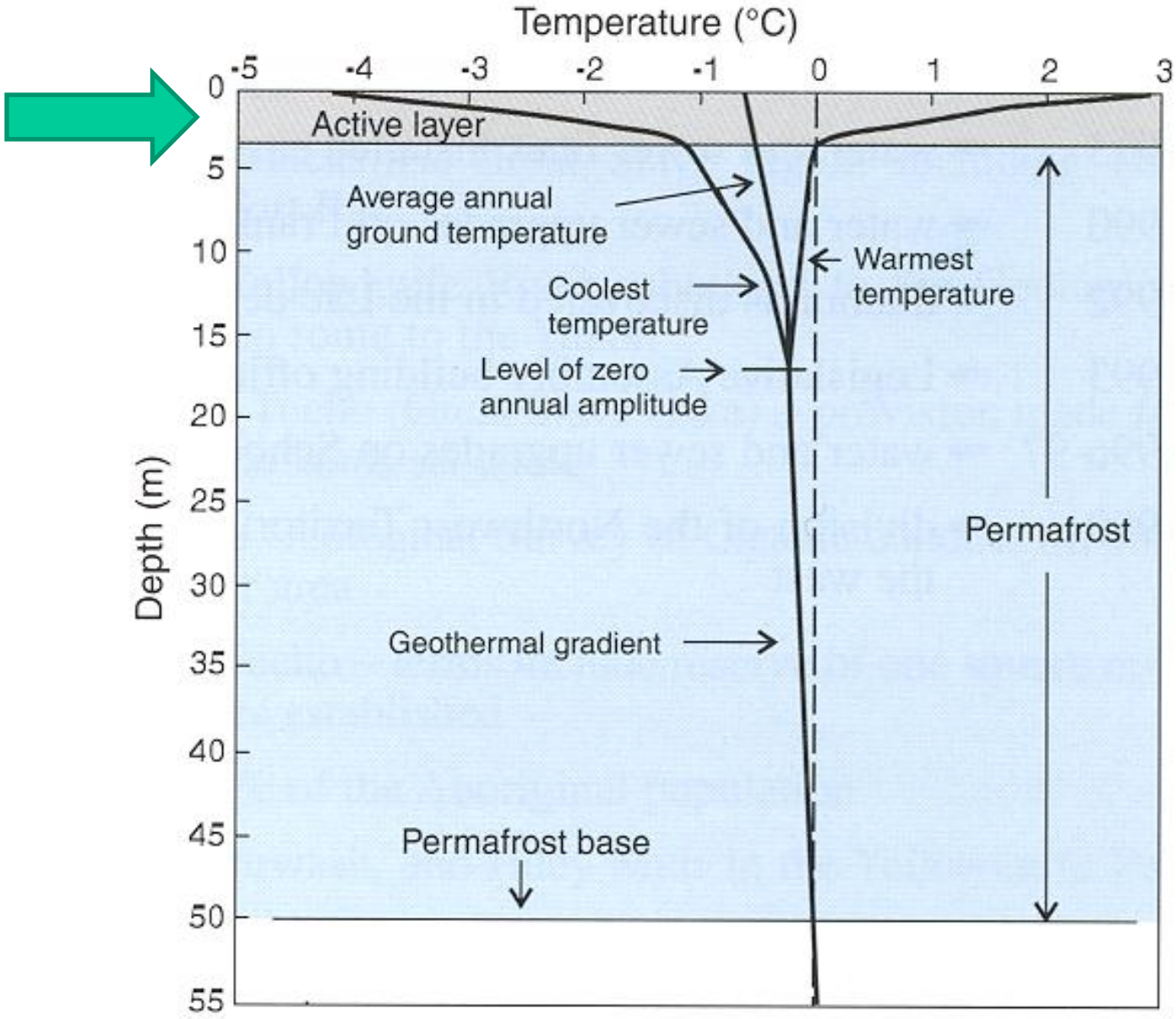
Lambert Azimuthal Equal-Area Projection
Map Center Point: North Pole
Scale 1:20,000,000

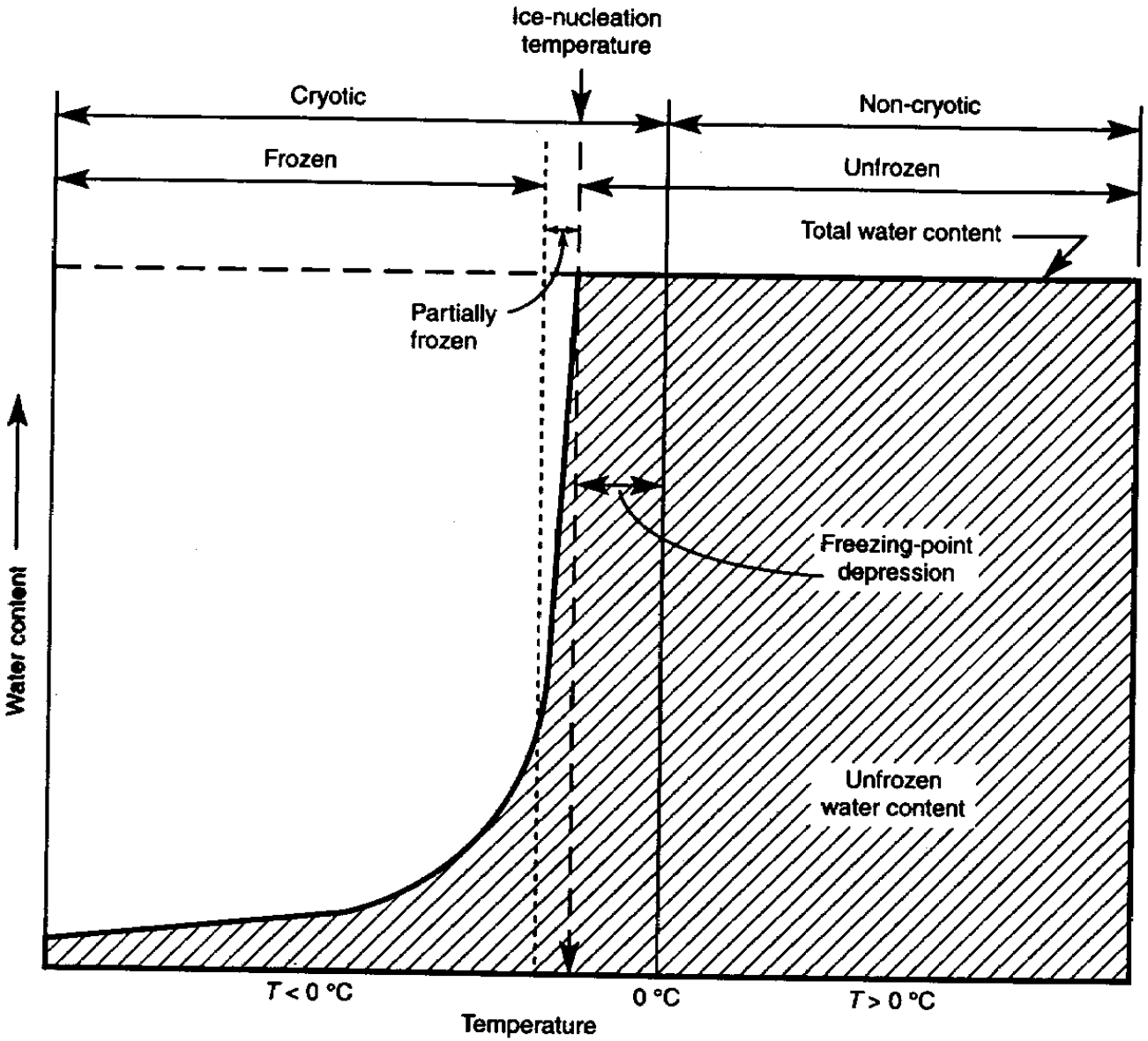
500 0 500 1000 1500 2000 Kilometers

250 0 250 500 750 1000 Miles

April 1998

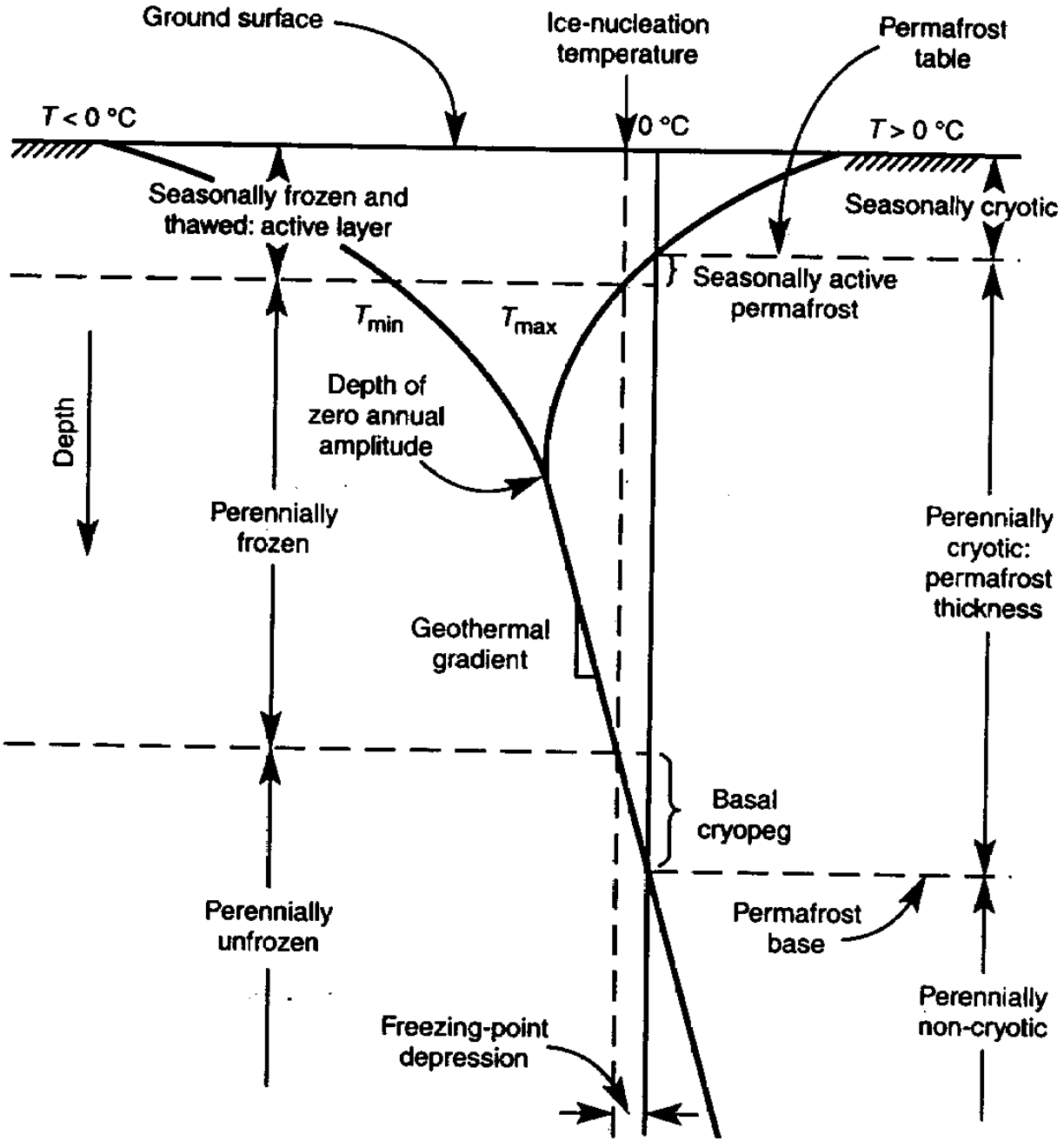

Temperature (°C)
-5
-4
-3
-2
-1
0
1
2
3
0
5
10
15
20
25
30
35
40
45
50
55
Depth (m)
Active layer
Average annual ground temperature
Coolest temperature
Level of zero annual amplitude
Warmest temperature
Permafrost
Geothermal gradient
Permafrost base

This is, however, a bit more complex….



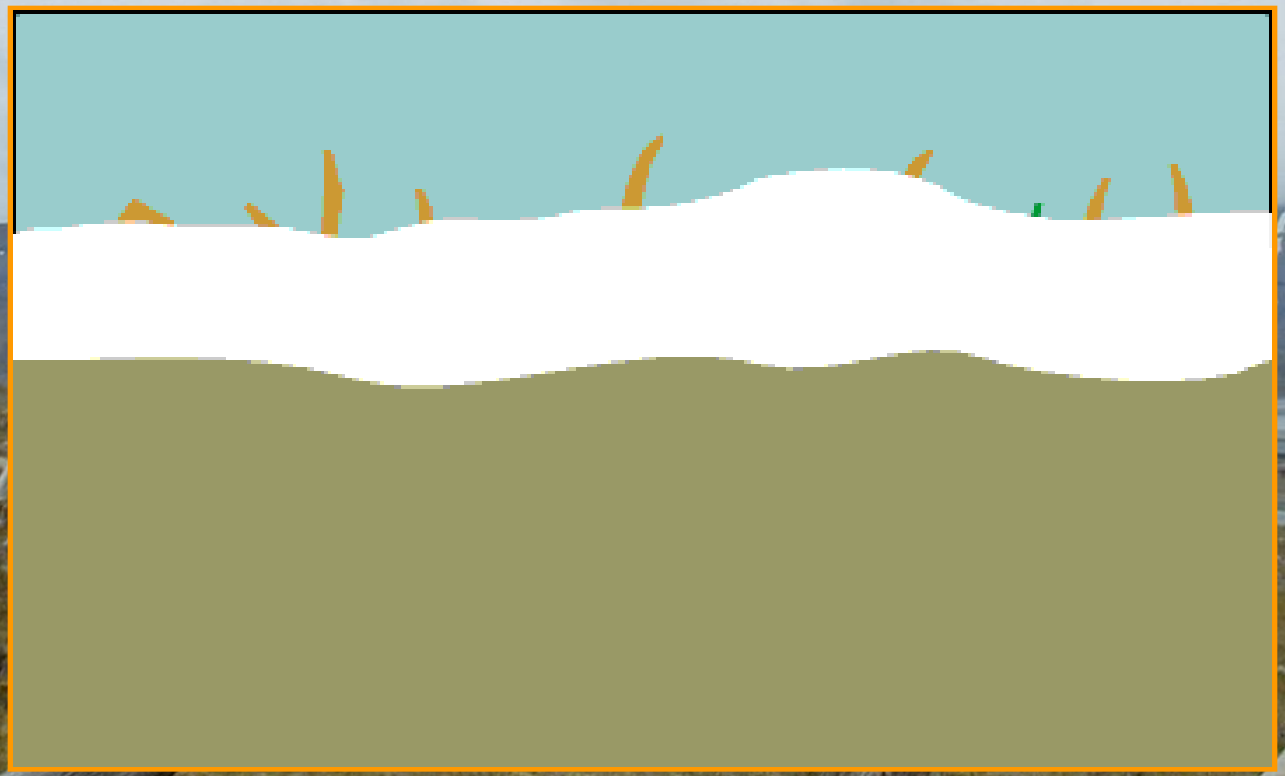
Terms used to describe the state of the water relative to ground temperature in soil materials subjected to freezing temperatures (modified from van Everdingen, 1985).

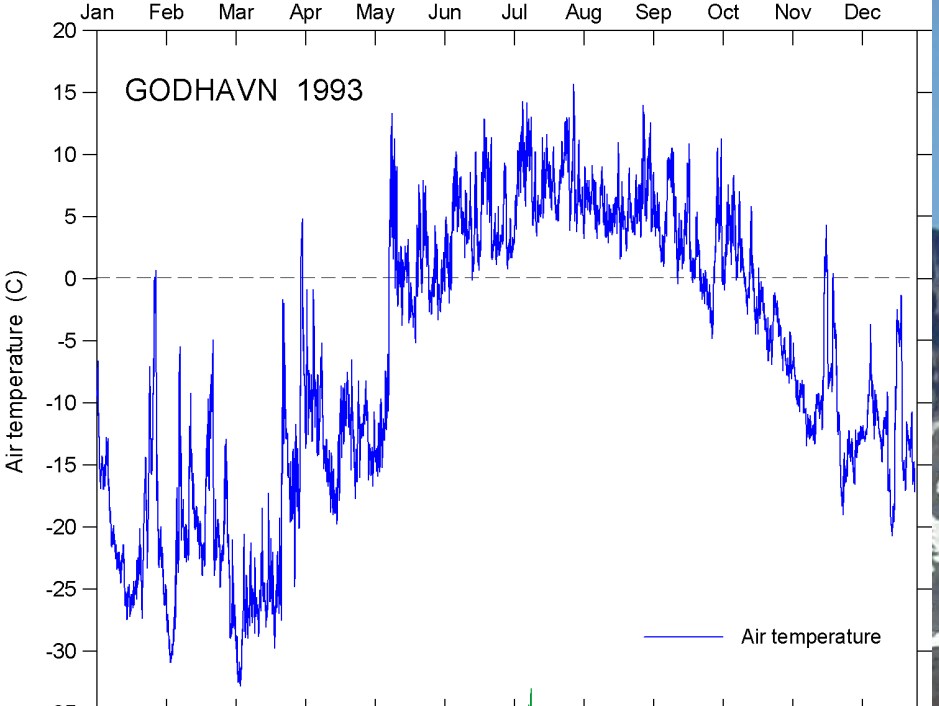
Two definitions of the active layer:



Temporal dynamics of the active layer

Seasonal changes in the active layer




Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
GODHAVN 1993
Air temperature (C)
Air temperature
Ground temperature (C)
- 005 cm; sediments
- 060 cm; sediments
- 175 cm; sediments
- 300 cm; bedrock


Active layer thawing
Non-conductive heat transfer during thawing
Zero-curtain effect during freezing

Coarse sediments and non-conductive heat transport

High ice/water content in the lower part of the active layer

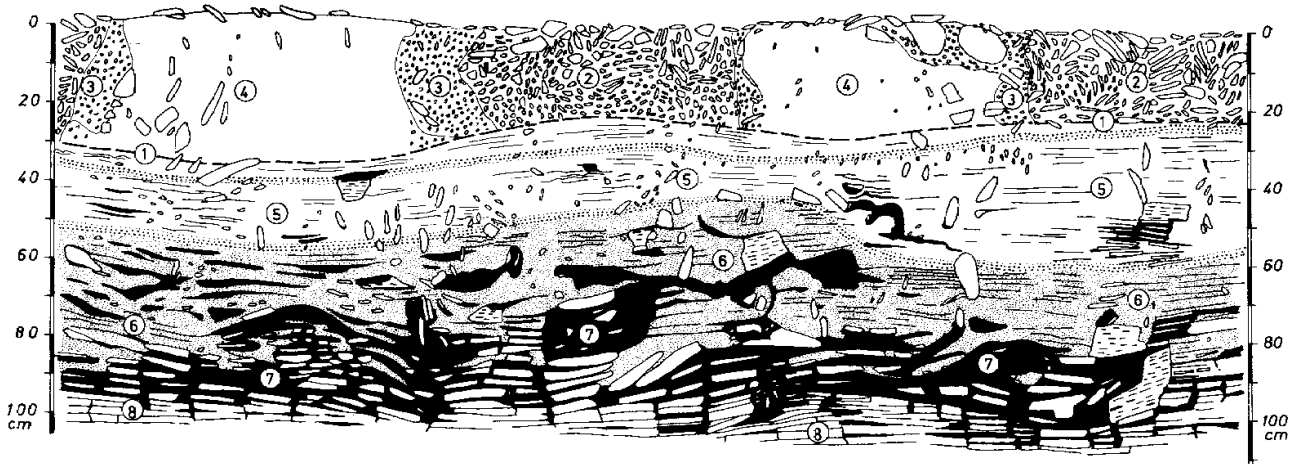
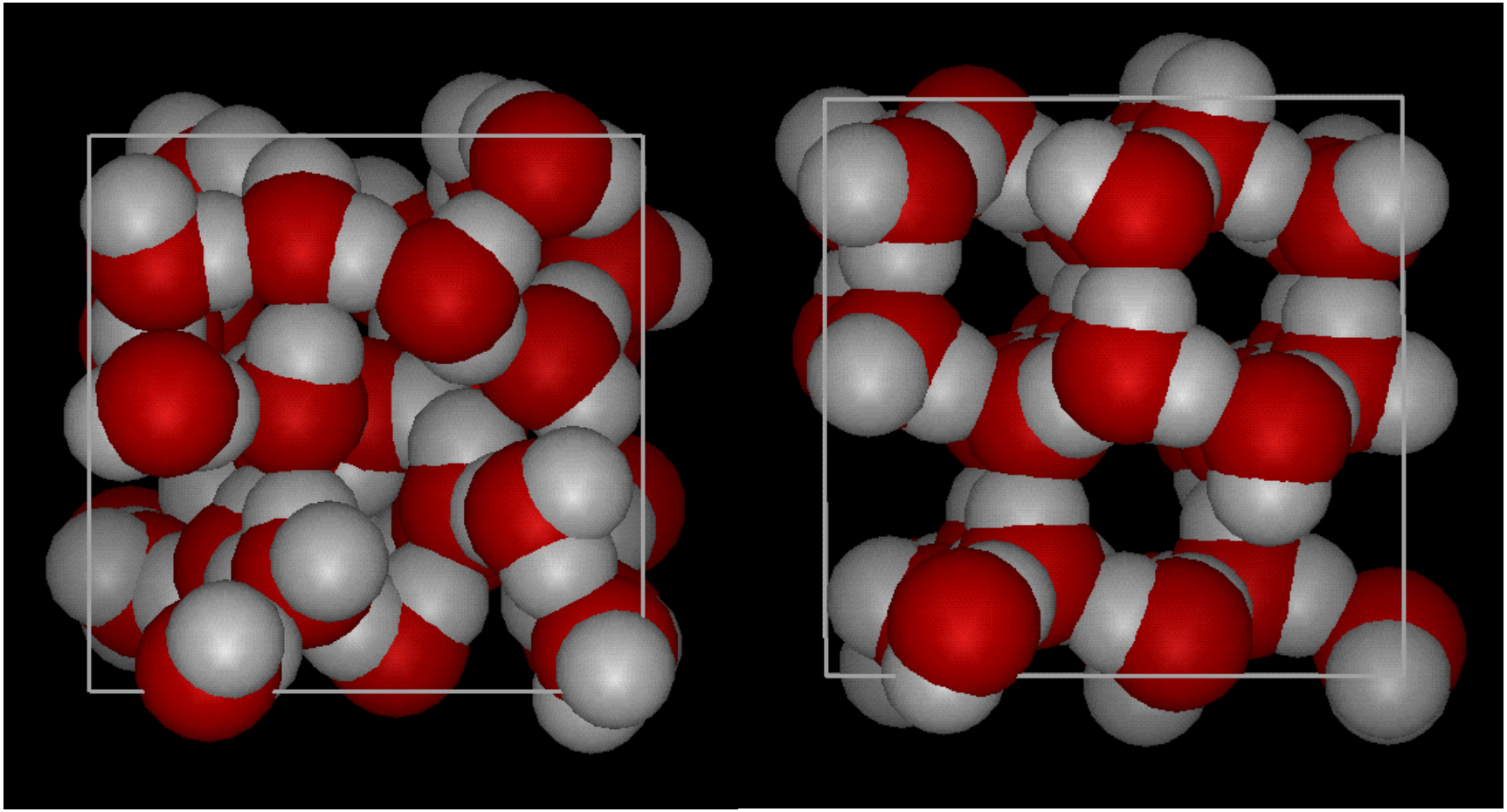


Fig. 23. Strukturboden und Eisrinde auf dem Hohenstaufen, 440 m. Basisgestein: triadische Plattenarkose, Grabung Krimhild I, 15. 7.1967 (Lage s. Fig. 20). 1 = Oberfläche des Dauerfrostbereichs. 2 = Grobschuttbeete im Kryoturbations-Strukturboden. 3 = Feinkiesmäntel um die Feinerdekerne. 4 = Feinerdekerne. 5 = Fossiler Auftauboden der postglazialen Wärmezeit, oberer grauer Horizont. Viel Feinmaterial, wenig Grobes, schmale Eislinsen. 6 = Desgl., unterer braun-grüner Horizont. Viel Humusbestandteile, einzelne Kiefernpollen, mehr Grobes, größere Eiskomplexe (schwarz). 7 = Eisrinde: völlig zerrüttete Trümmer des Anstehenden, von Bodeneismasse (schwarz) umhüllt. Nur im Oberteil noch etwas Feinstoff. 8 = Übergang von der Eisrinde zum ungestörten Anstehenden.

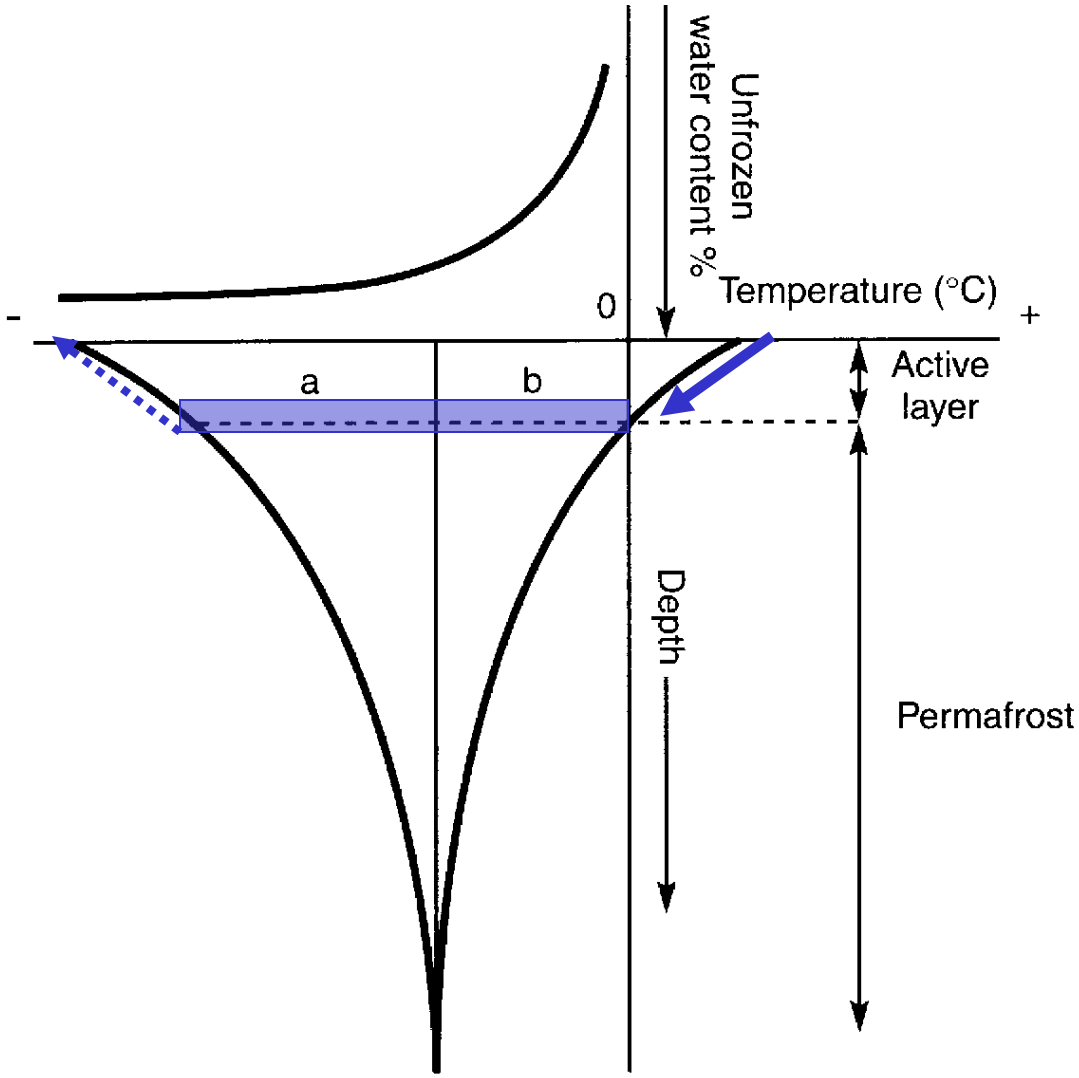
Liquid water

Ice



The **lattice structure of ice** also causes the about 9% volume expansion taking place when liquid water changes into solid ice.

High ice/water content in the lower part of the active layer



Frost weathering in the active layer

GEOMORPHOLOGICAL EFFECTS ON THE SLOPES OF LONGYEAR VALLEY, SPITSBERGEN, AFTER A HEAVY RAINSTORM IN JULY 1972

BY
STIG LARSSON

Department of Physical Geography, University of Uppsala

Lrsson, S., 1982: Geomorphological effects on the slopes of Longyear valley, Spitsbergen, after a heavy rainstorm in July 1972. *Geogr. Ann.* 64 A: 105–125.

ABSTRACT. The heavy rains of 10–11 July 1972 in Longyear valley, Spitsbergen were an extreme meteorological event Slides and debris flows corresponding to an average denudation of about 1 mm occurred in a small (6.8 km^2) catchment area. The debris mantle of slopes in the area investigated has a wide range of particle sizes, and drainage is normally good. Debris flows were not triggered by longlasting rains, but when rainfall intensity increased to values higher than 2 mm/hour, risk of failure was reached. Factors which encouraged debris slides and flows, in addition to the intense rainstorm, were a permafrost table, pre-existing depressions on hillsides and hillside steepness. Judging from the morphology on Longyear valleys slopes and nearby areas, the rapid and sporadic mass movements have a considerable effect upon evolution of slopes in the high arctic area.

1972. Morphological effects caused by heavy rainstorms were normally incorporated into descriptions of continuous processes.

The present report describes the morphological effects of a 1972 rainstorm on valley sideslopes in Longyear valley. The rains triggered many slides and debris flows (defined in more detail below) in the valley, causing damage to local service facilities (roads, pipe-lines for water, etc.). The aim of the present study is to present further details about active processes and factors involved in the triggering mechanism in this high arctic area.

Earlier reports by Thiedig and Kresling (1973) and Thiedig and Lehman (1973) discuss the meteorological and geological circumstances of

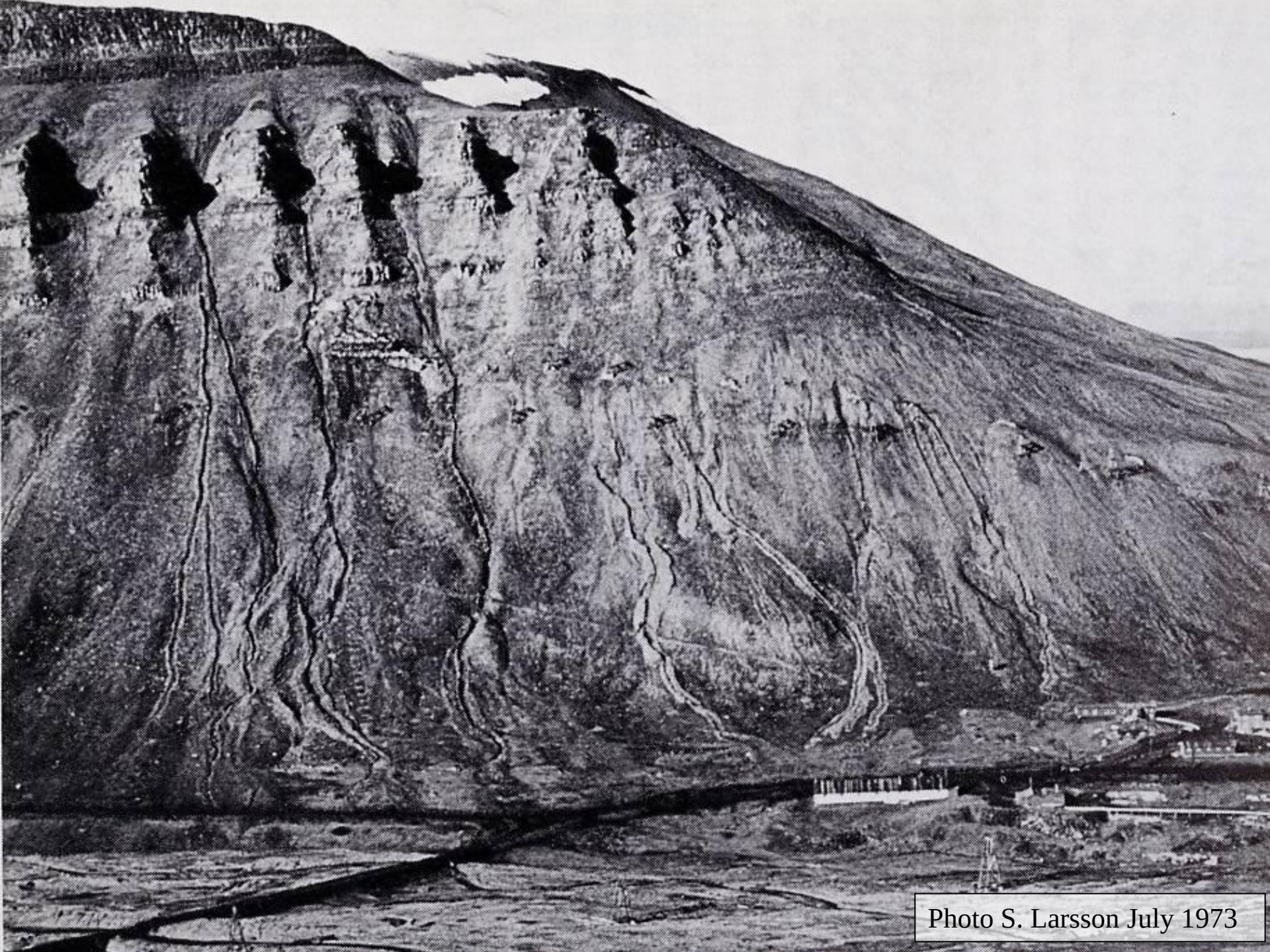
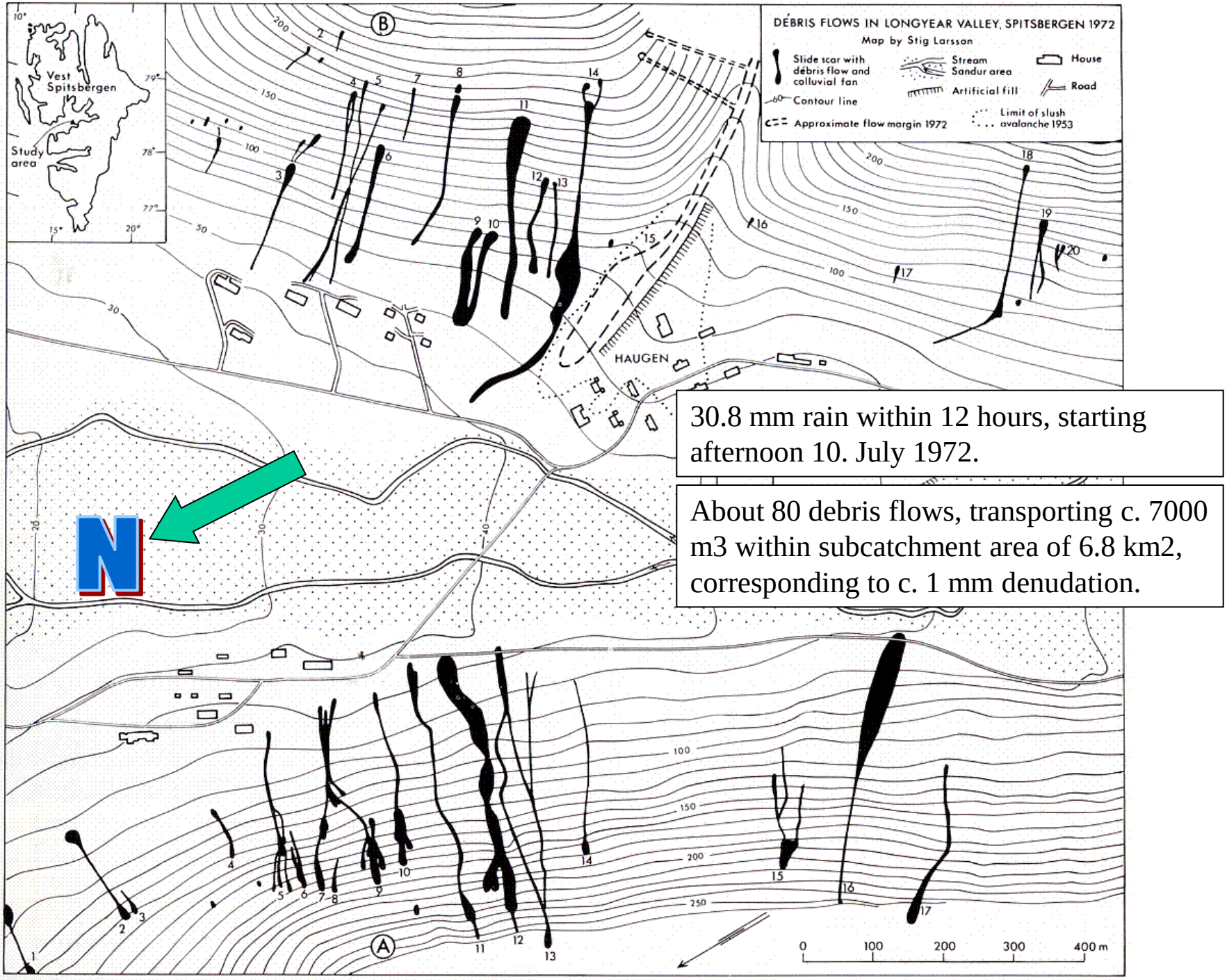


Photo S. Larsson July 1973



30.8 mm rain within 12 hours, starting afternoon 10. July 1972.

About 80 debris flows, transporting c. 7000 m3 within subcatchment area of 6.8 km2, corresponding to c. 1 mm denudation.

CALM

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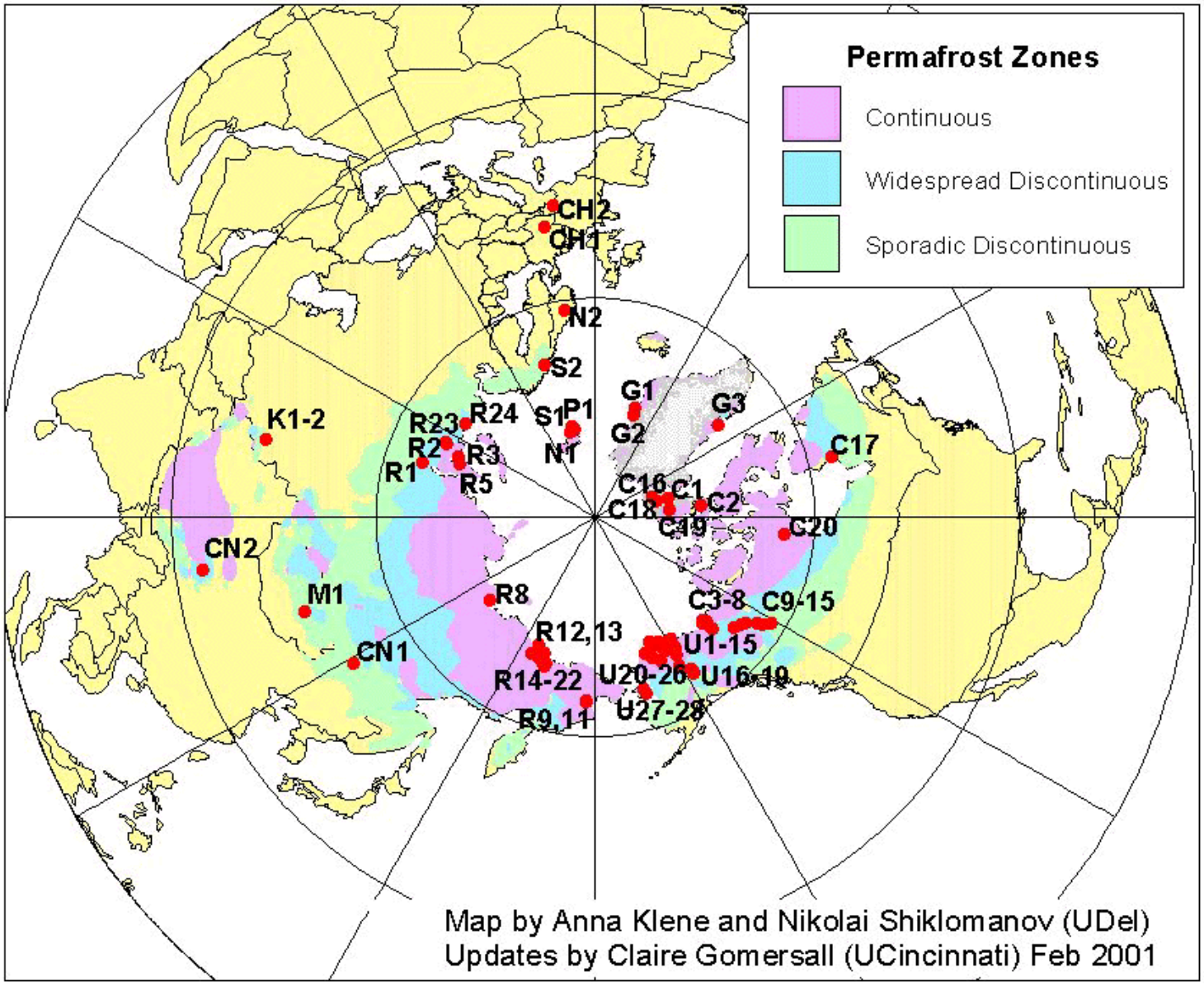
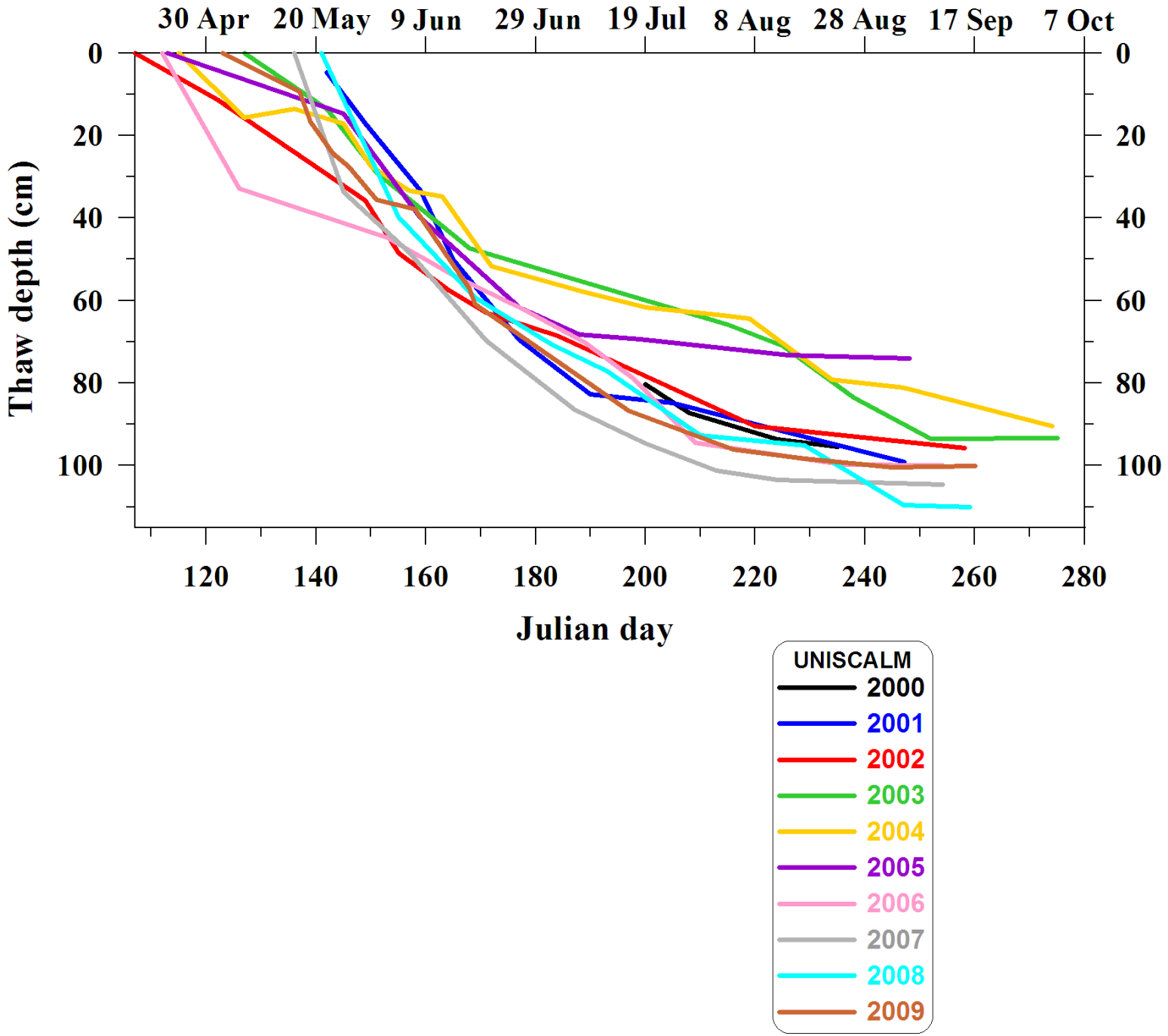
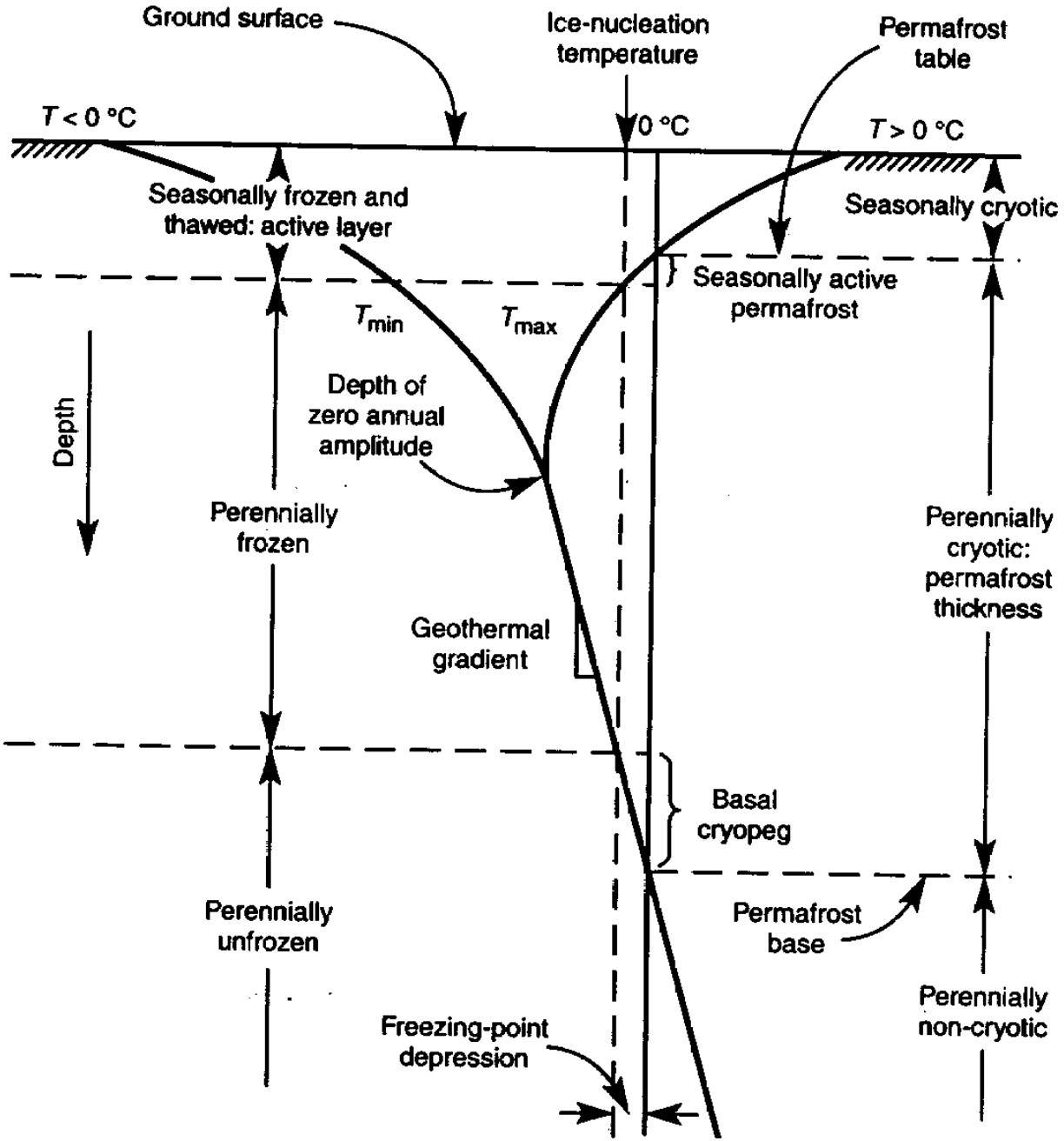
Circum Polar Active Layer Monitoring

Circum-Polar Active Layer Monitoring (CALM) Network



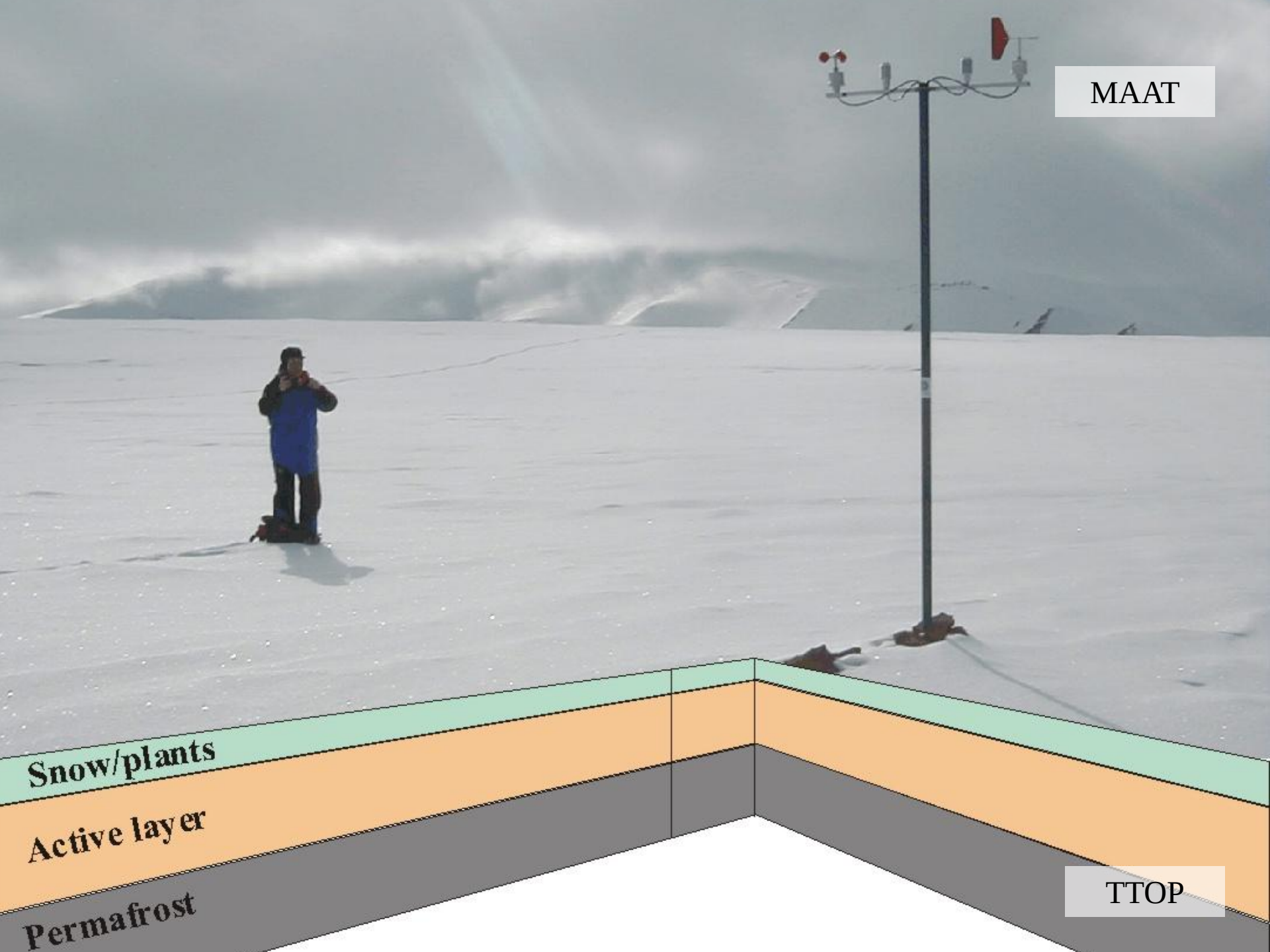

30 Apr
20 May
9 Jun
29 Jun
19 Jul
8 Aug
28 Aug
17 Sep
7 Oct
Thaw depth (cm)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
Julian day
UNISCALM
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009

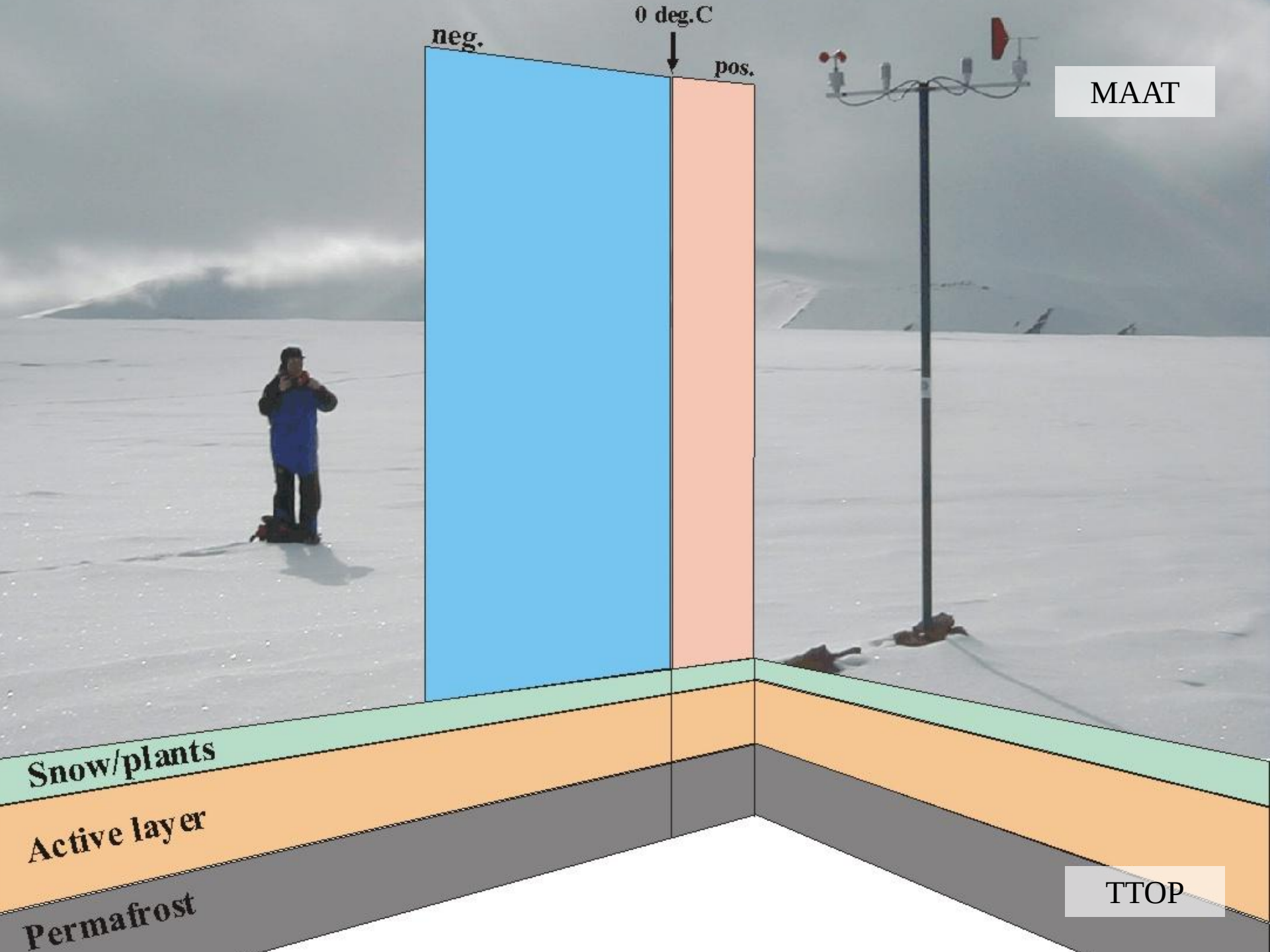
Two definitions of the active layer:

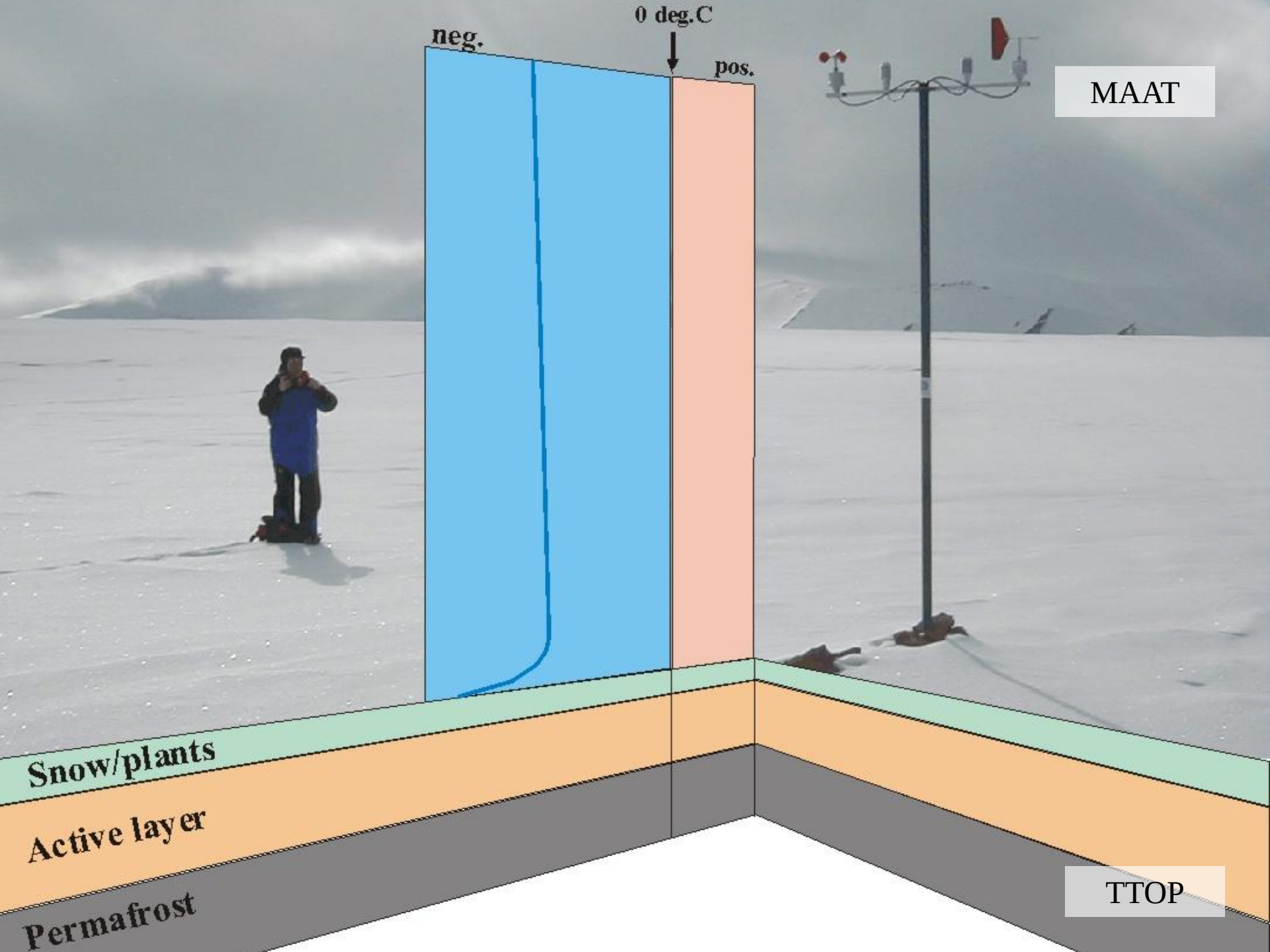


Active layer and permafrost: The relation between air temperature and ground temperature

Gruvefjellet meteorological station, central Spitsbergen, Svalbard, 18th May 2002


MAAT
Snow/plants
Active layer
Permafrost
TTOP


0 deg.C
neg.
pos.
MAAT
Snow/plants
Active layer
Permafrost
TTOP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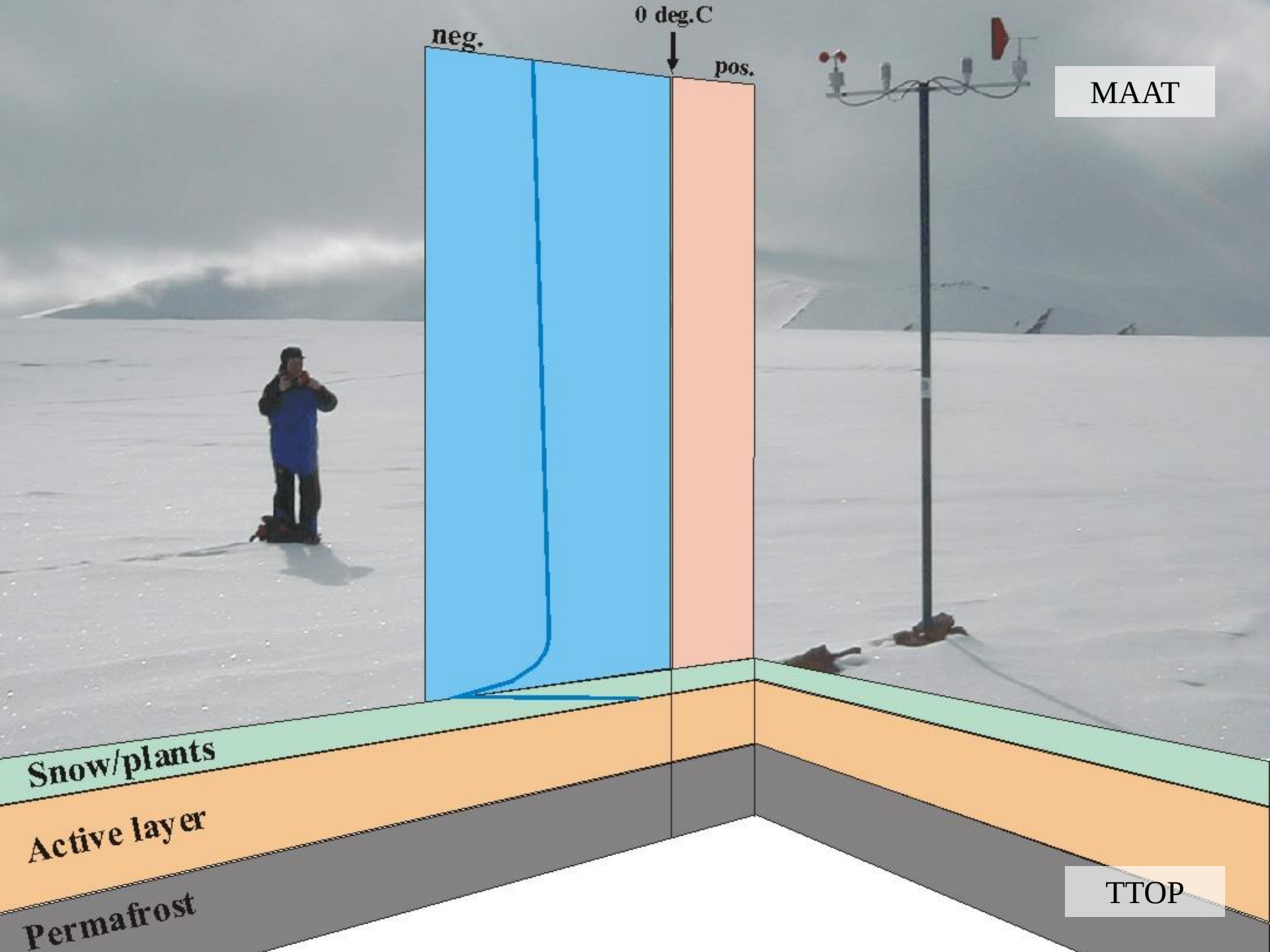
0 deg.C
neg.
pos.
MAAT
Snow/plants
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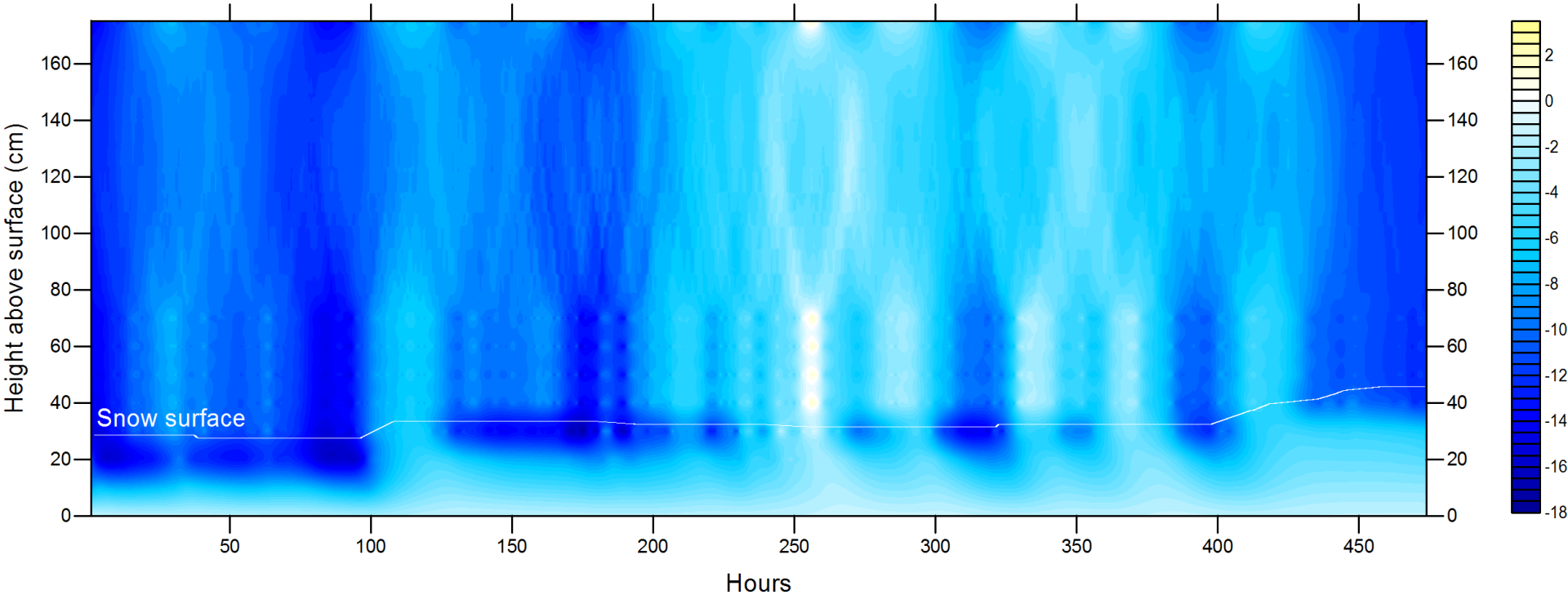
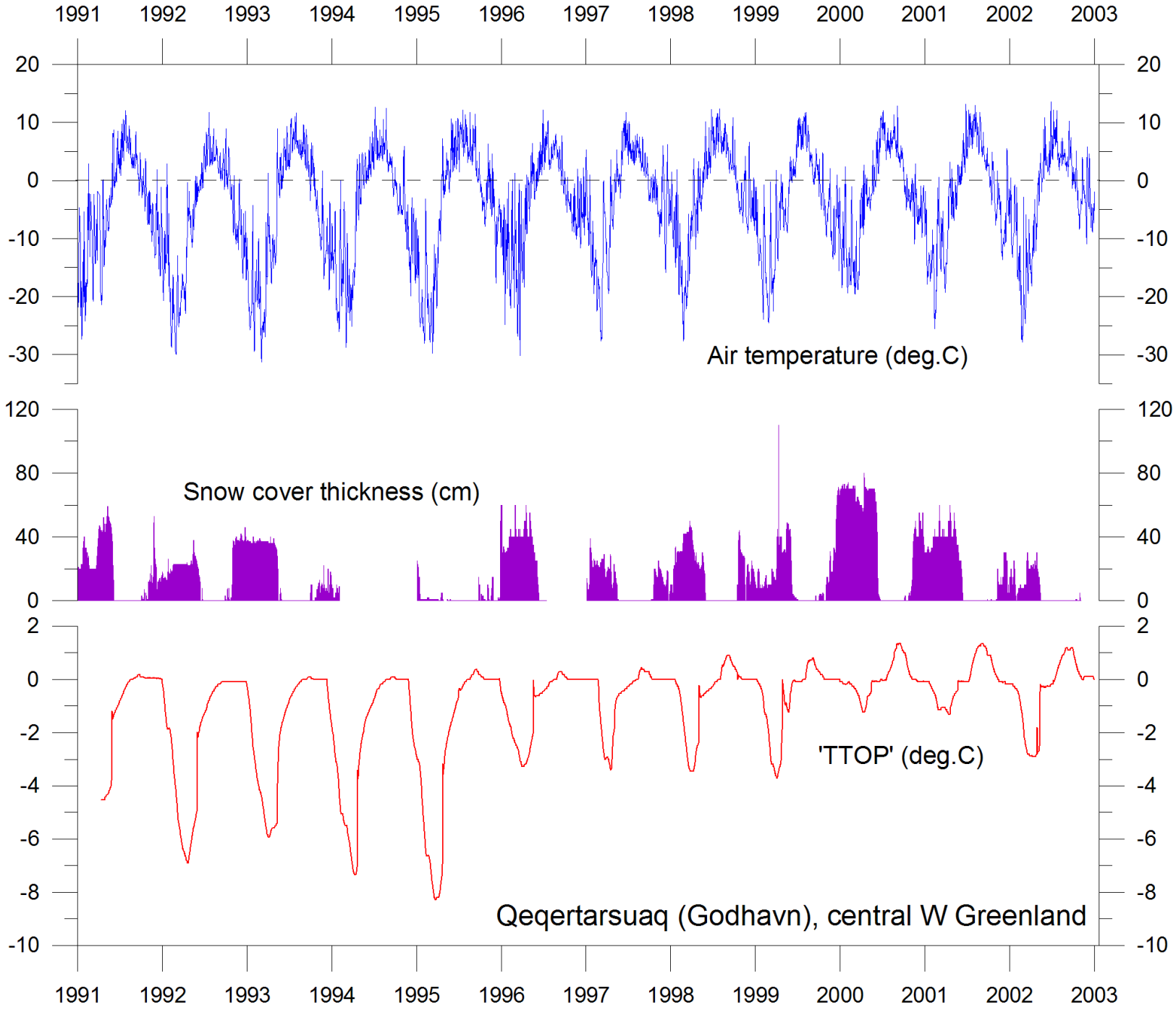
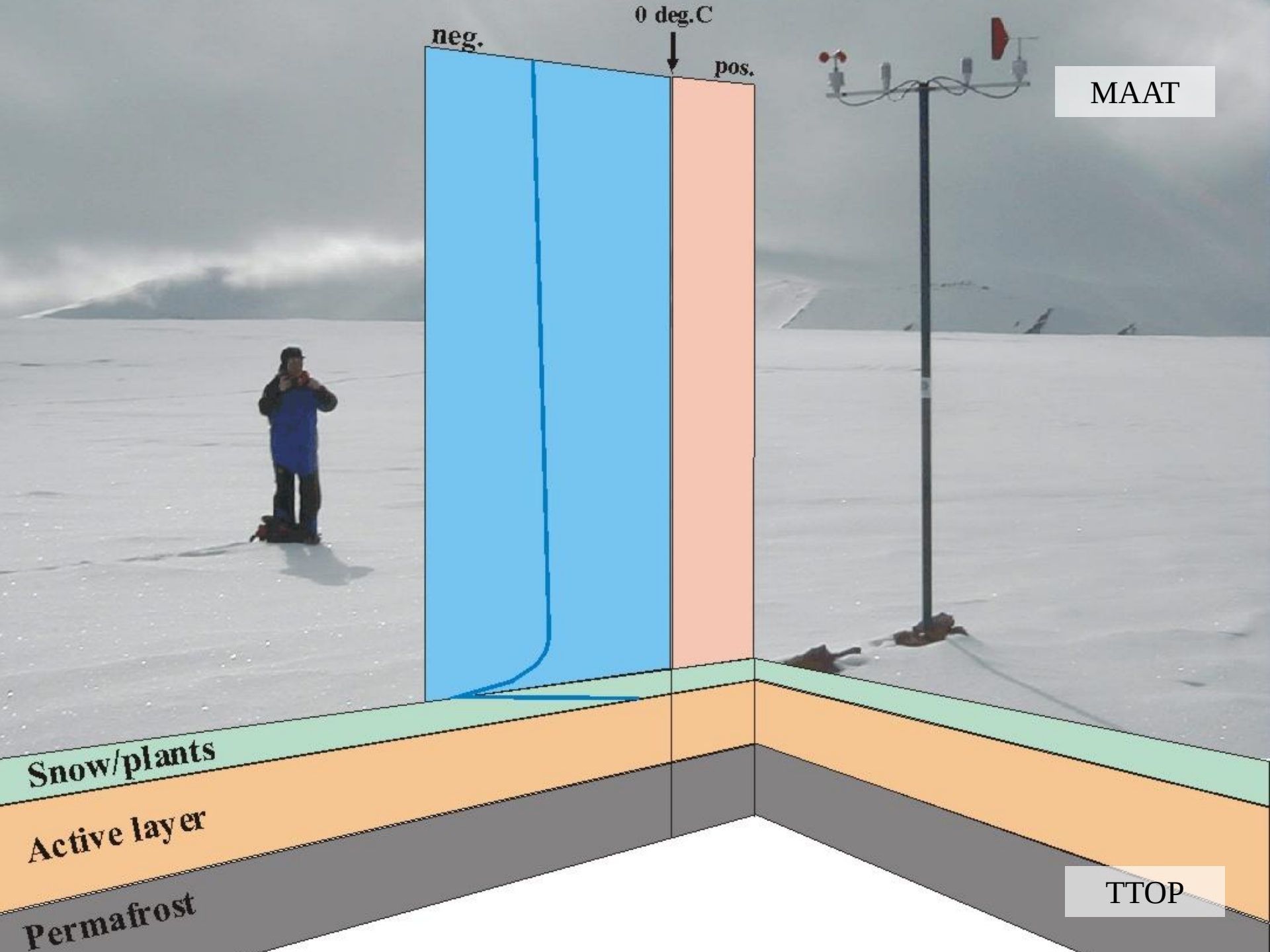
Air temperature and ground temperature




1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
20
10
0
-10
-20
-30
Air temperature (deg.C)
120
80
40
0
Snow cover thickness (cm)
2
0
-2
-4
-6
-8
-10
'TTOP' (deg.C)
Qeqertarsuaq (Godhavn), central W Greenland


0 deg.C
neg.
pos.
MAAT
Snow/plants
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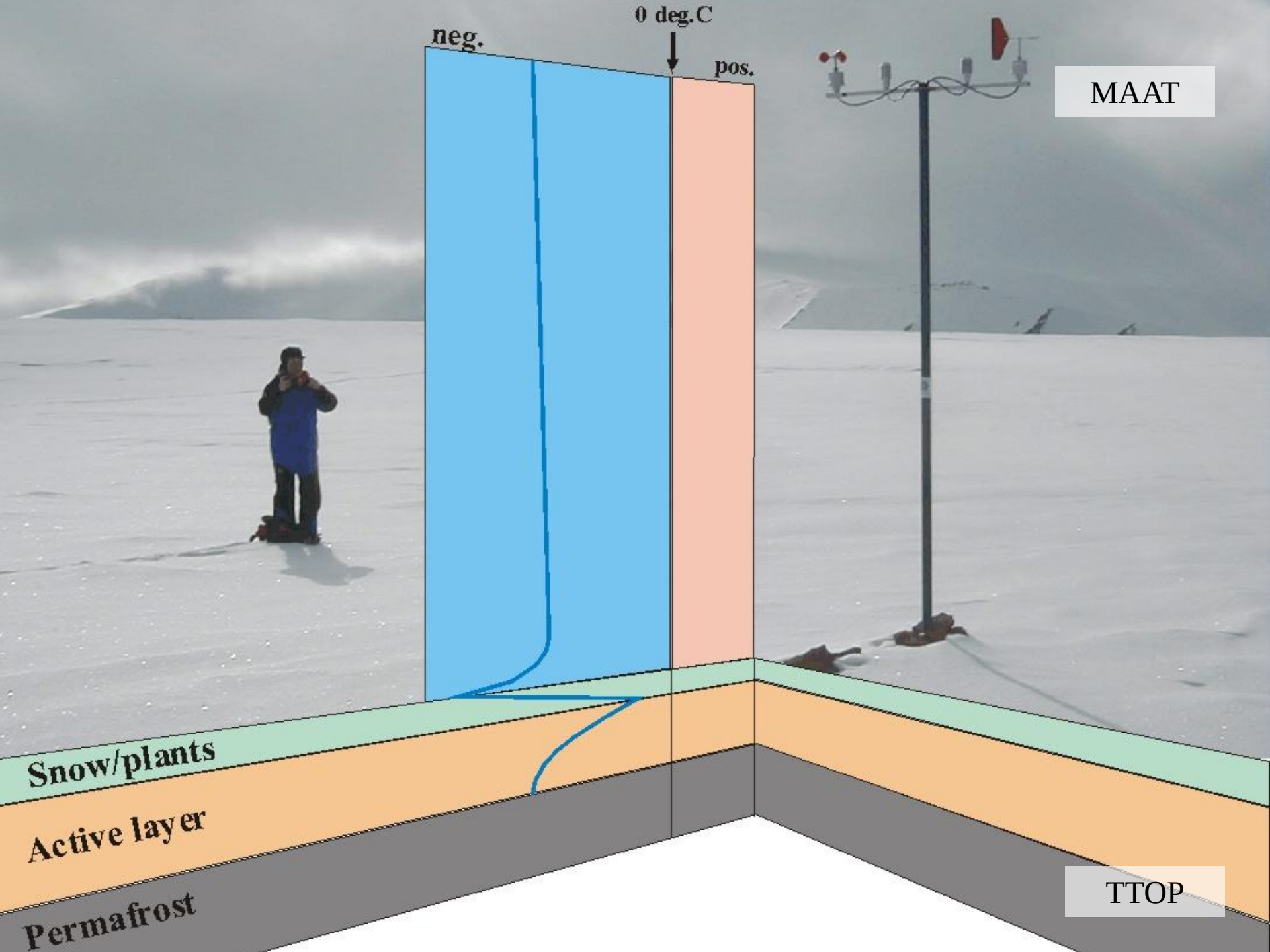
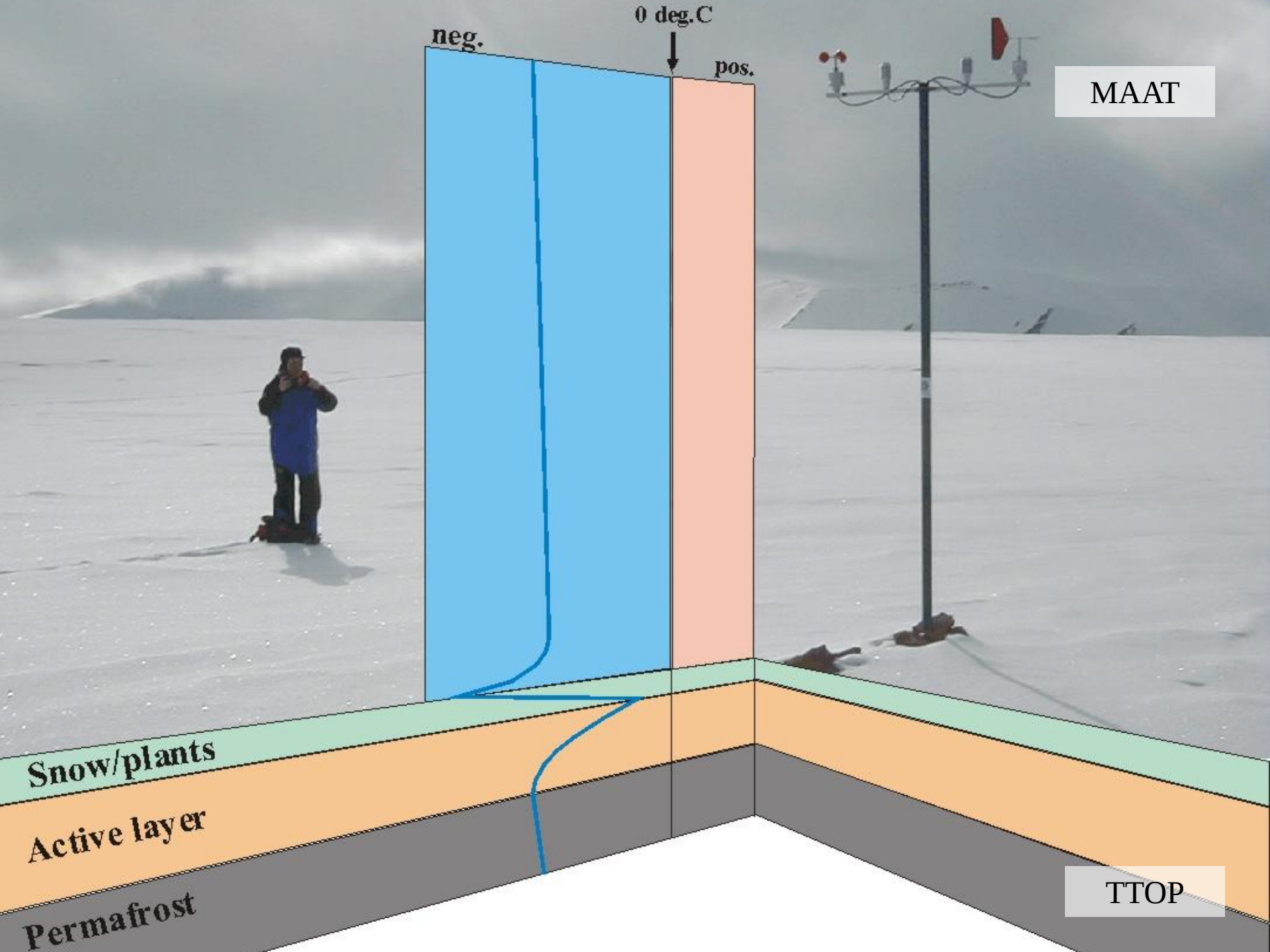

0 deg.C
neg.
pos.
MAAT
Snow/plants
Active layer
Permafrost
TTOP


0 deg.C
neg.
pos.
MAAT
Snow/plants
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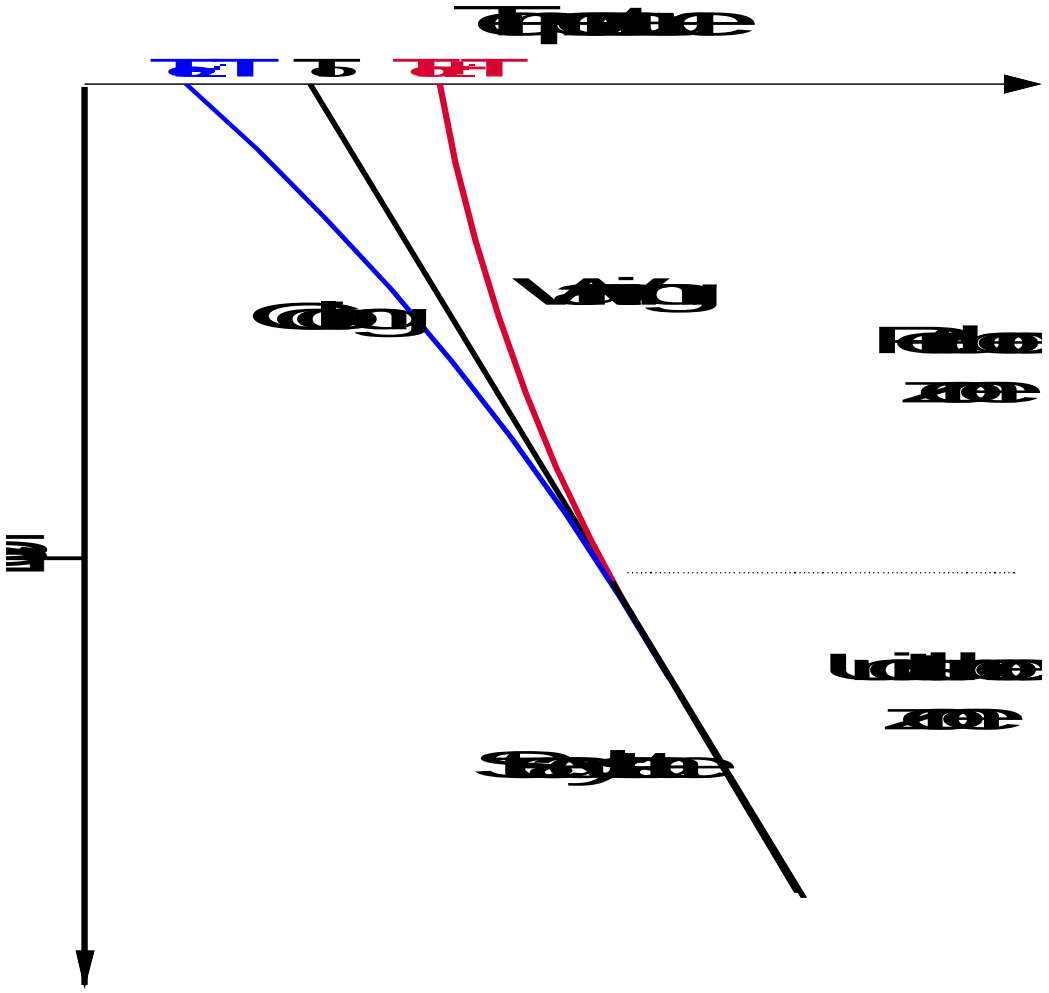
TTOP

Permafrost and climate: A somewhat complicated relation

- Geothermic response to changes in temperature (TTOP)



Next time:
Soil creep and
bedrock weathering processes