Glaciological research of Estonian scientists on Svalbard 1974-2017

The changing Arctic

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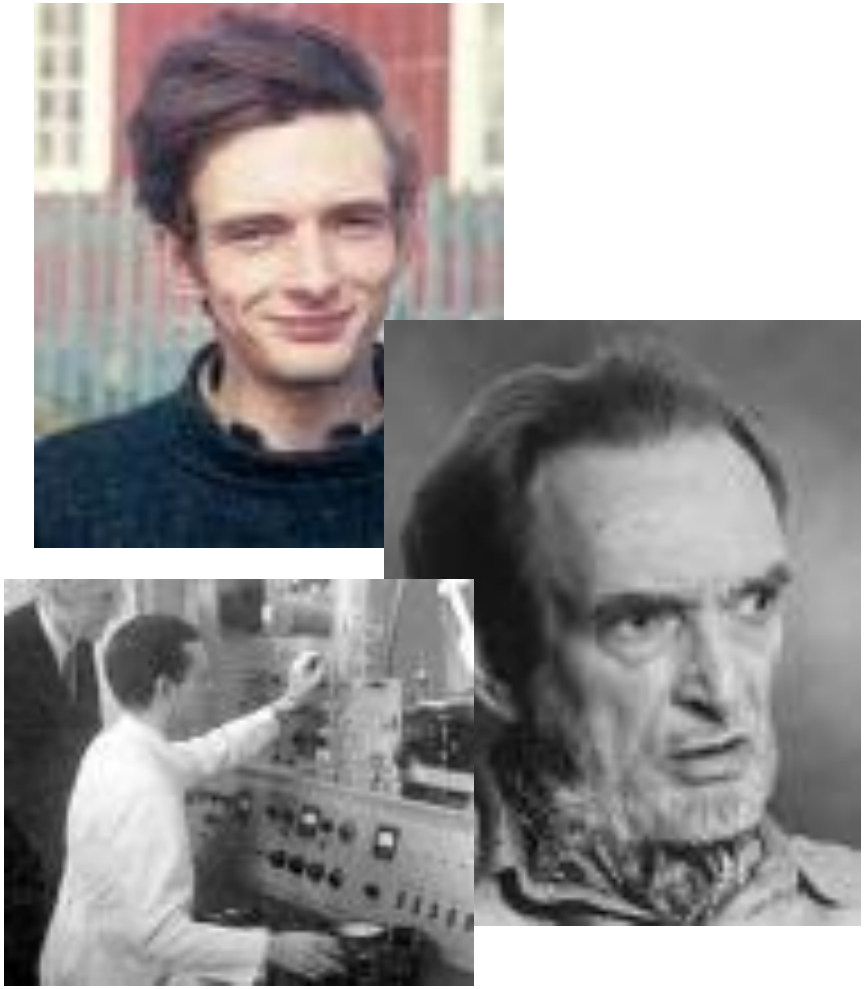
Norway-Estonia webinar
14.04.21

Introduction:

- Beginning of ice core science
- First drillings
- 1974 - “ice age“ in Estonia”
- Results
- Conclusions

At the beginning



- „Stable isotopes in precipitation“ (Tellus, 1964)
- Isotopic distribution in a Greenland iceberg(Nature,1960
- ^{32}Si ja ^{14}C in icebergs
- Ice core science

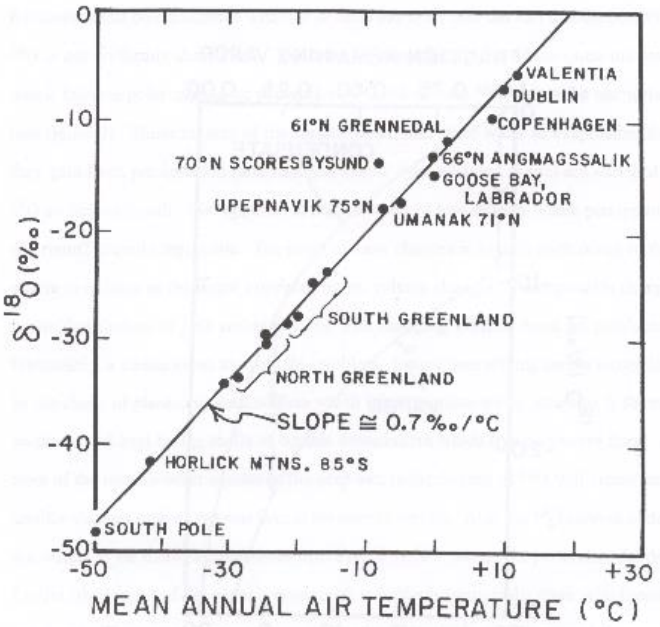


Figure 7. Observed $\delta^{18}O$ in average annual precipitation as a function of mean annual air temperature (Dansgaard, 1964). Note that all the points on this graph are for high latitudes (>45°). The $\delta^{18}O$ values are calculated as follows:

$$\delta^{18}O = \frac{^{18}O/^{16}O_{sample} - ^{18}O/^{16}O_{std.}}{^{18}O/^{16}O_{std.}} \times 1000$$

Glacier ice

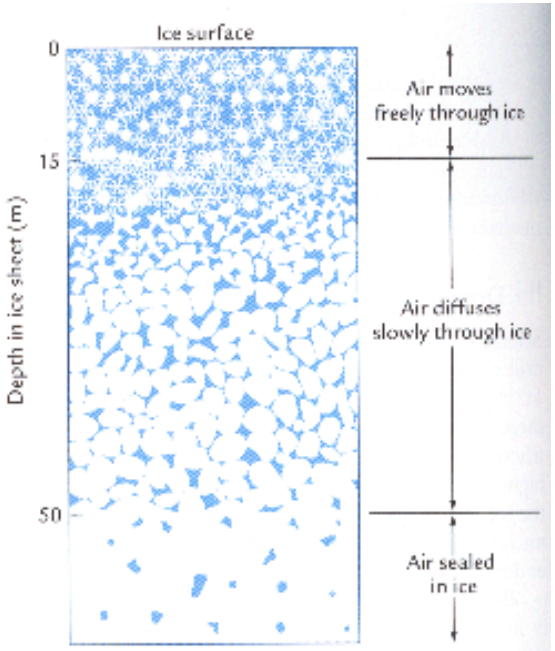
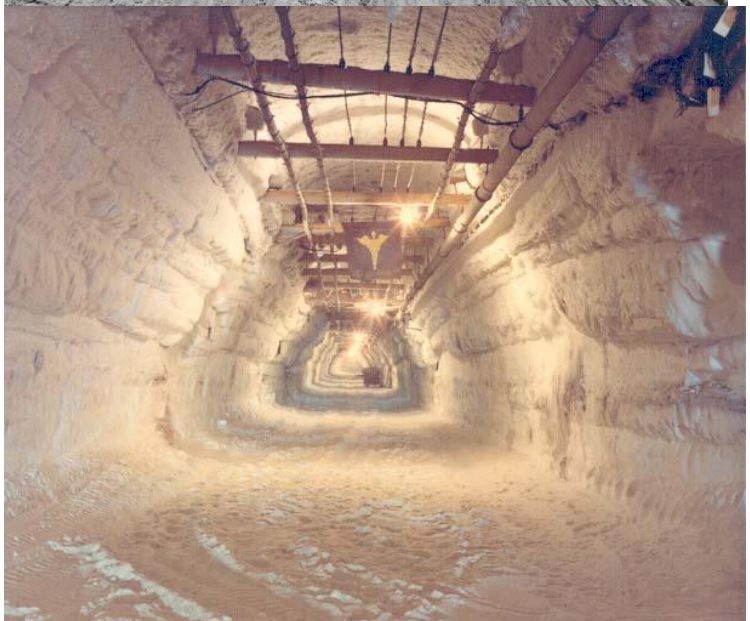


FIGURE 11-3 **Sintering: Sealing air bubbles in ice** Air moves freely through snow and ice in the upper 15 m of an ice sheet, but flow is increasingly restricted below this level. Bubbles of old air are eventually sealed off completely in ice 50 to 100 m below the surface. (Adapted from D. Raynaud, "The Ice Core Record of the Atmospheric Composition: A Summary, Chiefly of CO_2, CH_4 and O_2," in *Trace Gases in the Biosphere*, ed. B. Moore and D. Schimel [Boulder, Colo.: UCAR Office for Interdisciplinary Studies, 1992].)

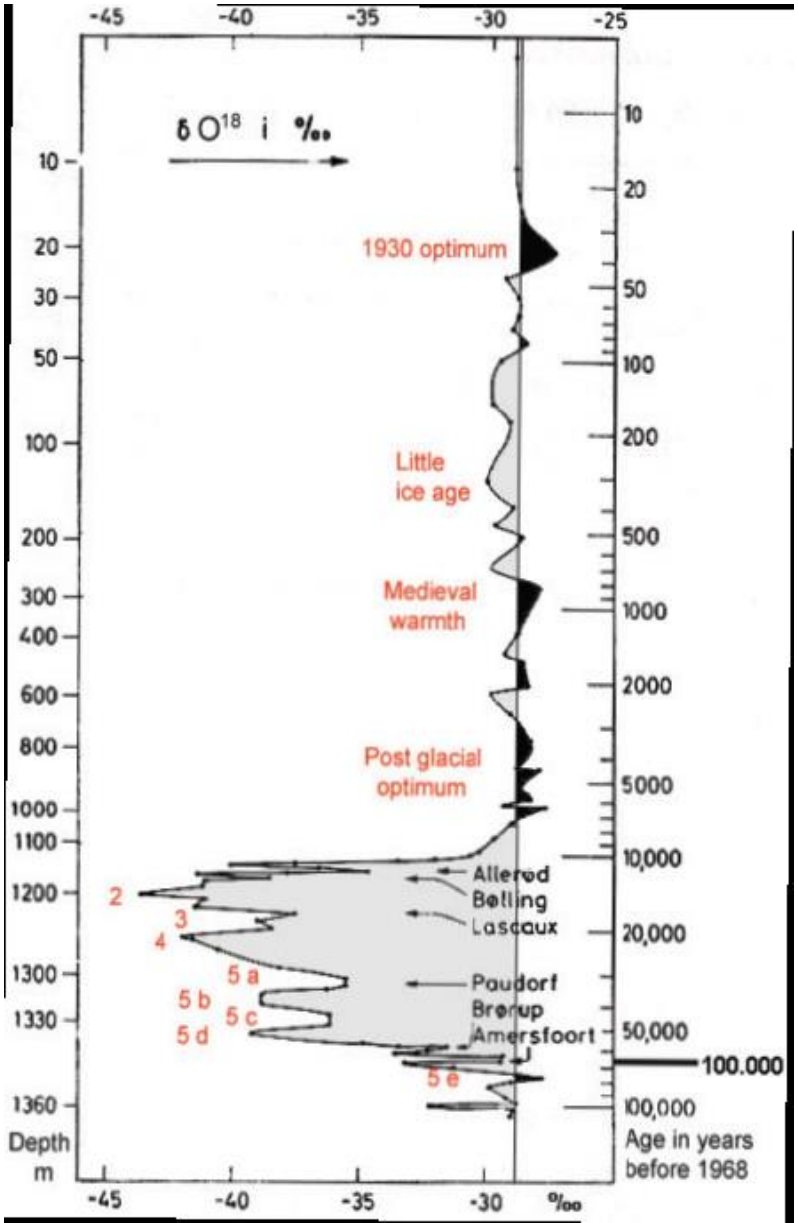
Three musceteers: Willi Dansgaard, Chester Langway & Hans Oeschger

Camp Century 1964-1966



Willi Dansgaard

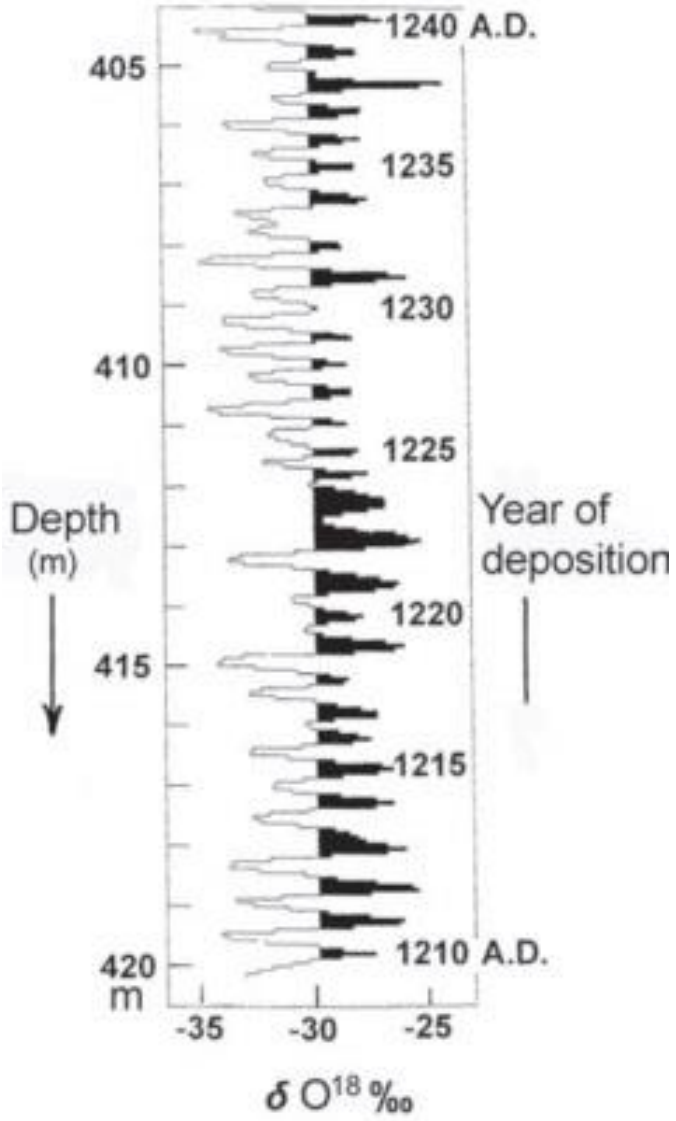
The first isotope profile (1968)

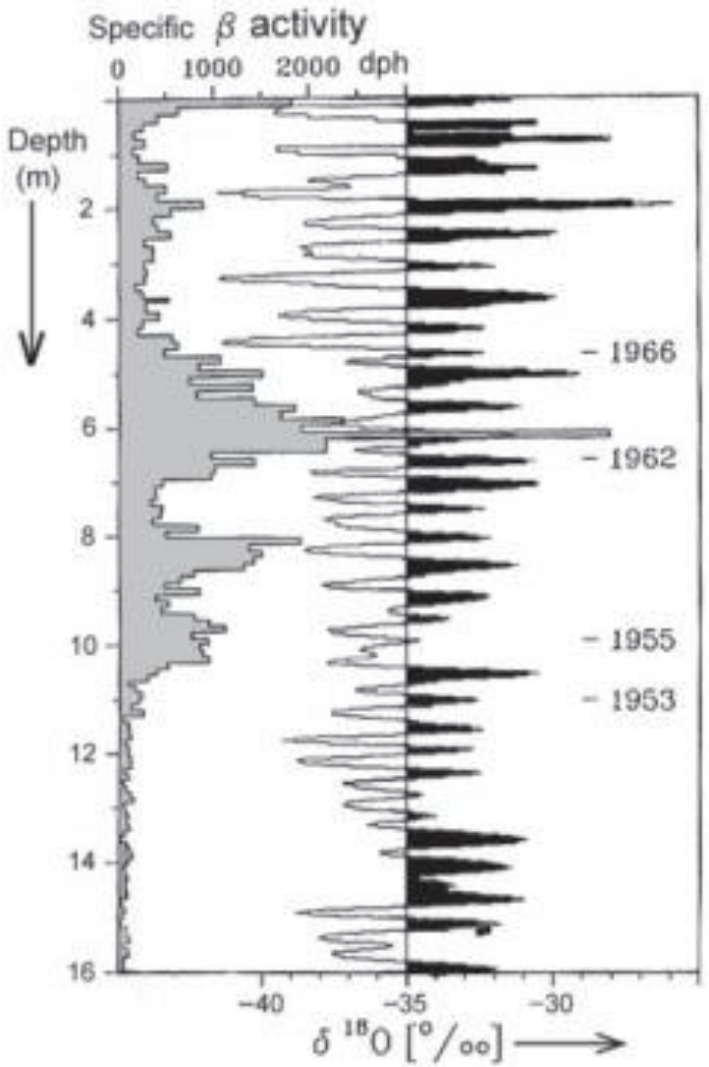


*The δ^{18}**O** profile along the Camp Century ice core plotted on a depth scale to the left and a preliminary logaritmic time scale to the right. The black and grey areas correspond to periods of Greenland temperatures higher and lower than today, respectively. The large grey area reflects the last glaciation. The time scale based on the simple sandwich model is correct, by and large, through the upper 85 % of the core, i.e. back to 14,000 years B.P. (before present). The heavy line in the lower right corner marks an age of 100,000 years according to a more advanced ice flow model*

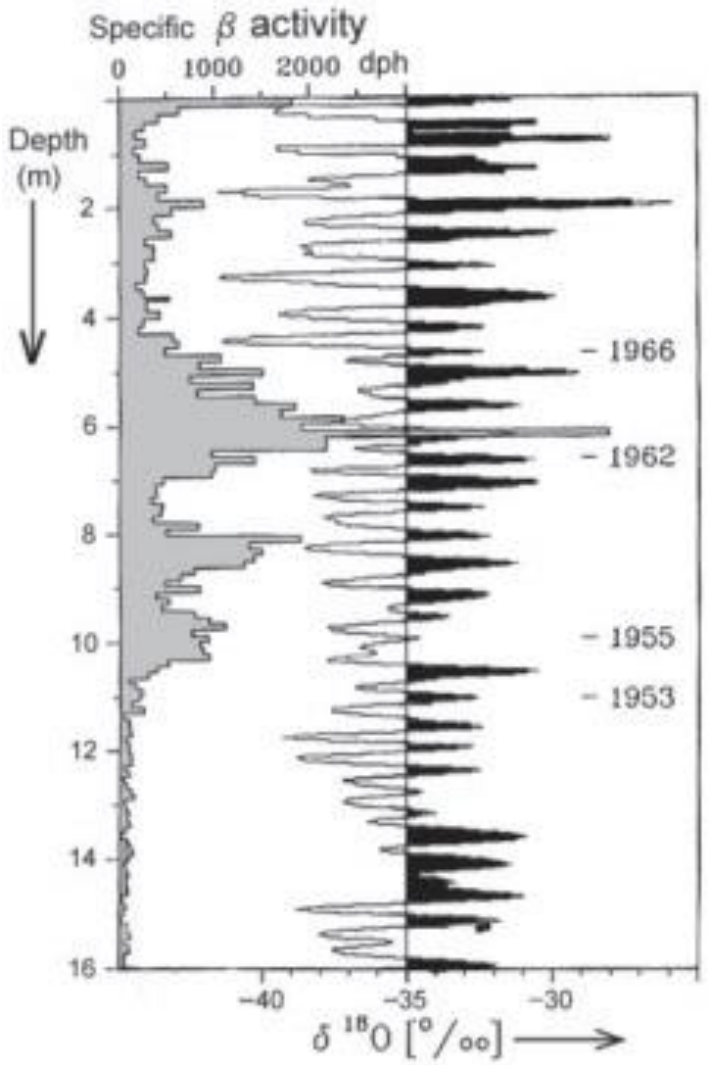
Dye 3 station in South-Greenland (1973)

Milcent (1974)





Crete (1974)

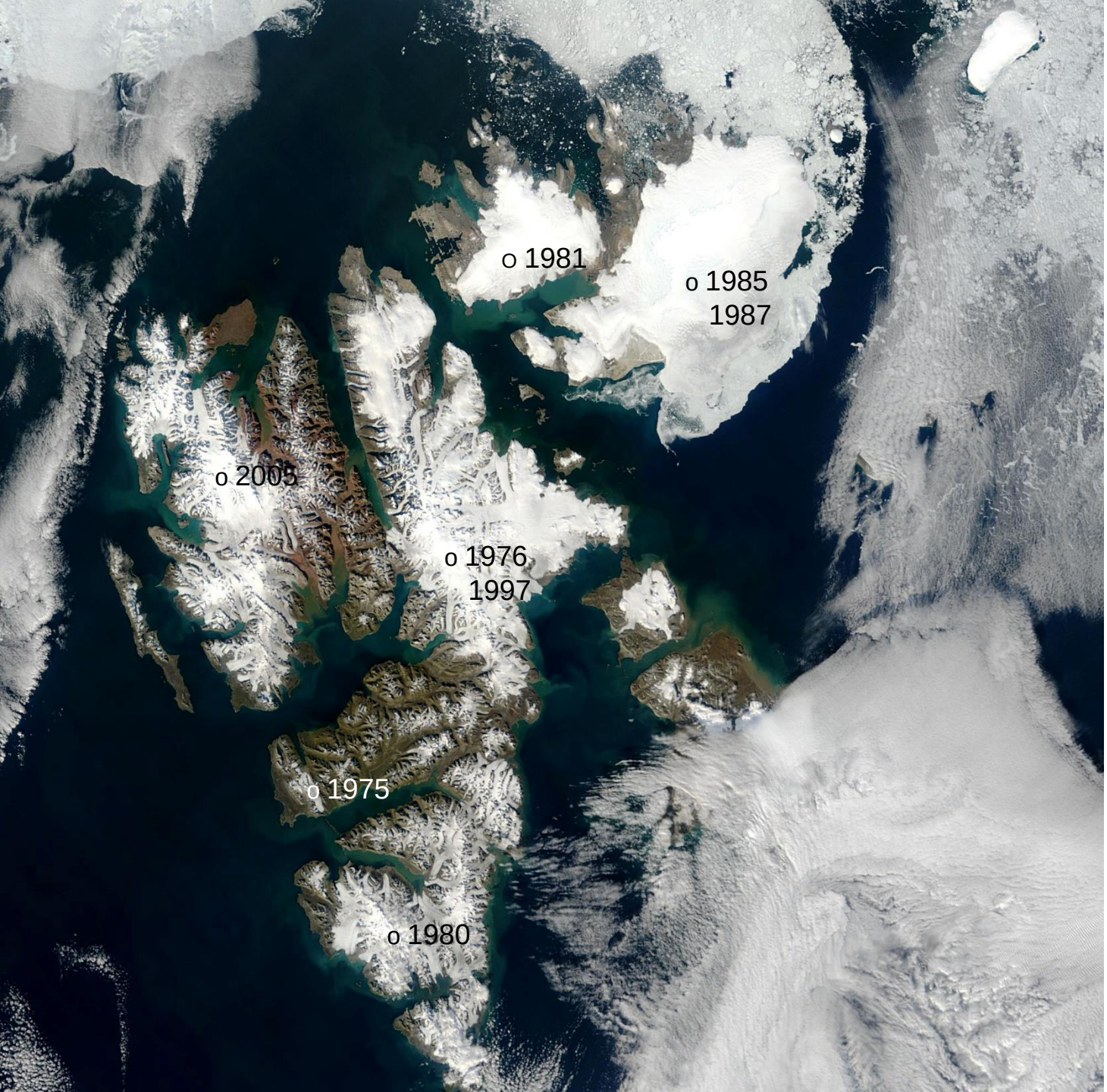


*β and δ^{18}**O** measurements along the upper 16 m of the Crête core from 1974. The seasonal cycles in the δ^{18}**O** curve to the right have decreasing amplitude downward, because the diffusion in the porous firn.However, the cycles are distinct enough for exact dating back to 1942.*

The grey shaded curve shows the specific β radioactivity profile: There is no trace of fall-out from the nuclear bombs in 1945, but the first hydrogen bombs in 1953-55 caused considerable radioactive fall-out on the inland ice, and so did the test series in 1958-59 and in the early 1960'es.

1974 - “ice age“ in Estonia”

- Svalbard
- Polar-Ural
- Severnaja Zemlya
- Antarctica
- Kamchatka
- Siberia
- Arctic Canada



1975
Gronfjordbreen-
Fridtjovbreen

1976 Lomonosovfonna

1980 Amundsenisen

1981 Vestfonna

1985 Austfonna

1987 Austfonna

Kotlyakov et al, QSR

1997 Lomonosovfonna

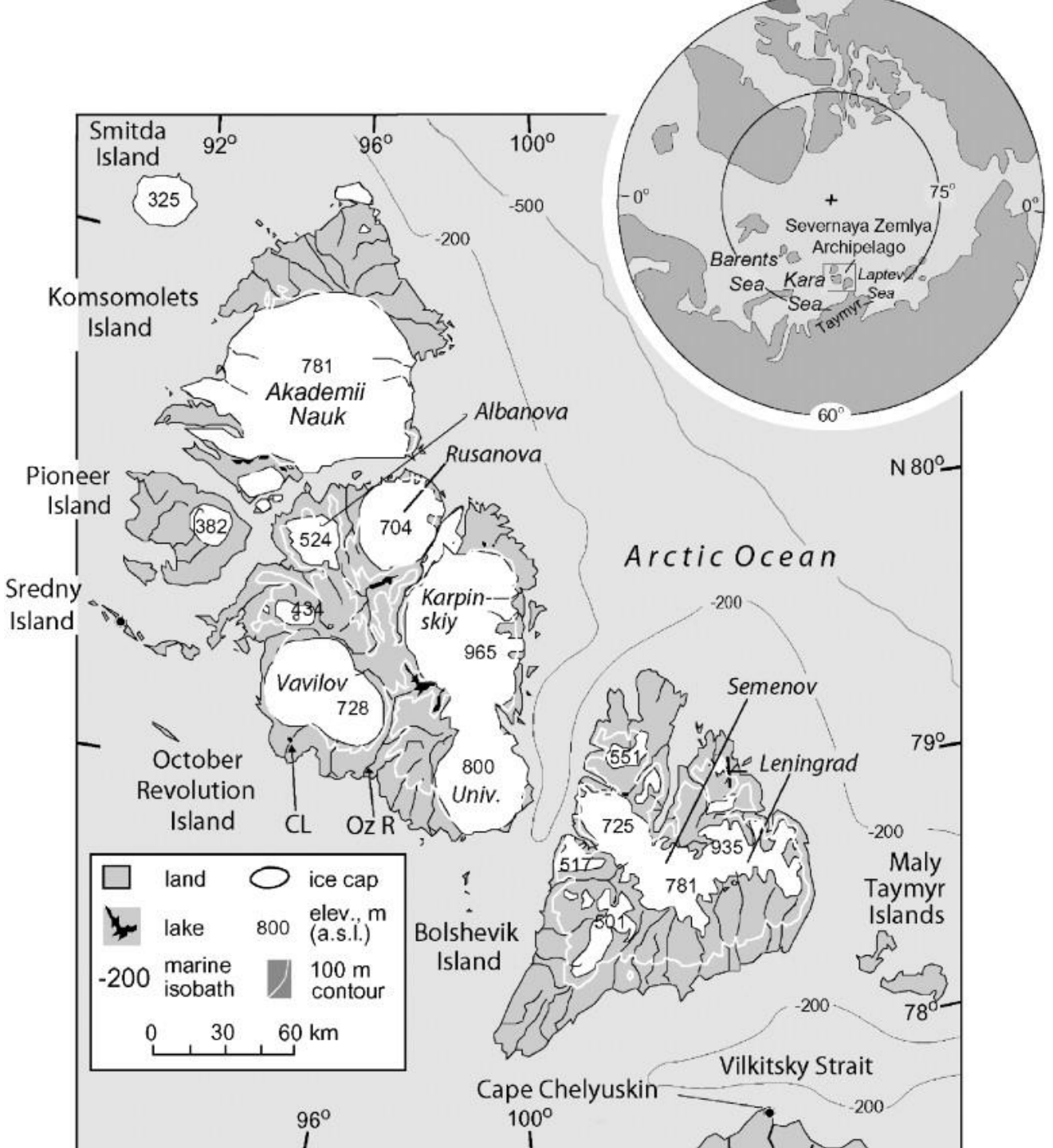
2005 Holtedahlfonna


СССР 21121
АЭРОФЛОТ


Grönfjordbreen

Lomonosovfonna 1976

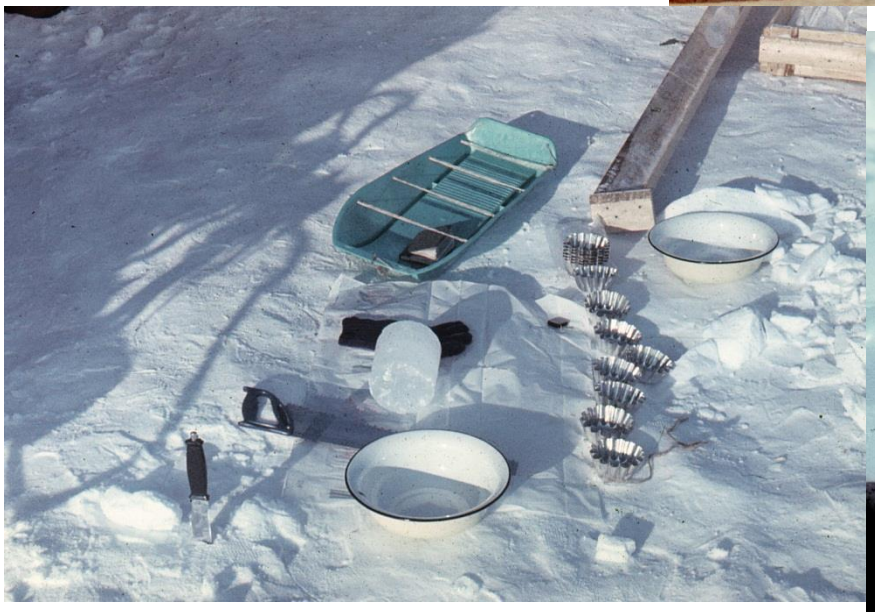
Lomonosovfonna 1976

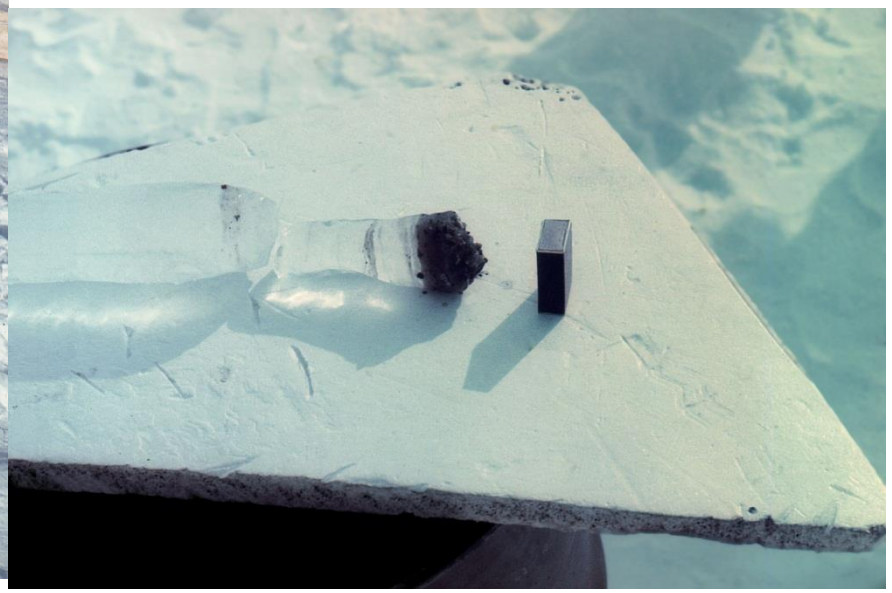

Smitda Island
92°
96°
100°
325
-500
-200
Komsomolets Island
781
Akademii Nauk
Albanova
Rusanova
Pioneer Island
382
524
704
Sredny Island
434
Karpin-skiy
965
Vavilov
728
October Revolution Island
CL
Oz R
800
Univ.
Arctic Ocean
N 80°
Semenov
551
Leningrad
79°
725
935
517
781
501
Bolshevik Island
Maly Taymyr Islands
78°
land
ice cap
lake
800
elev., m (a.s.l.)
-200
marine isobath
100 m contour
0
30
60 km
Vilkitsky Strait
Cape Chelyuskin
96°
100°
0°
75°
Severnaya Zemlya Archipelago
Barents Sea
Kara Sea
Laptev Sea
Taymyr
60°

Severnaja Zemlya 1979

Methods

Sampling





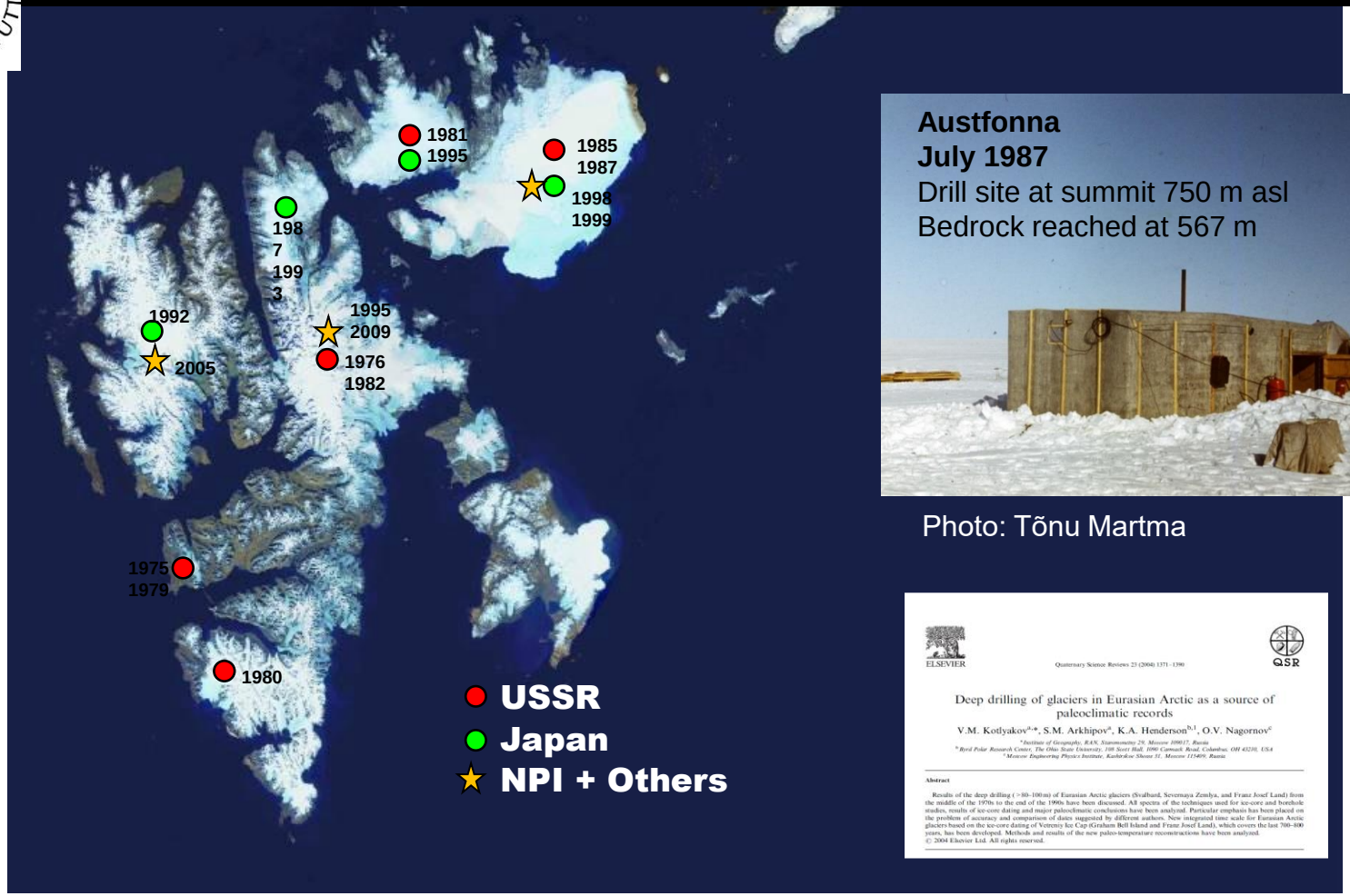

Amundsenisen 1980

Austfonna 1985

“Austfonna crying”

(Aftenposten, 04.09.2009)

Svalbard ice core drillings 1975-2009



Austfonna
July 1987
Drill site at summit 750 m asl
Bedrock reached at 567 m

Photo: Tõnu Martma

ELSEVIER

Quaternary Science Reviews 23 (2004) 1371–1390

QSR

Deep drilling of glaciers in Eurasian Arctic as a source of paleoclimatic records

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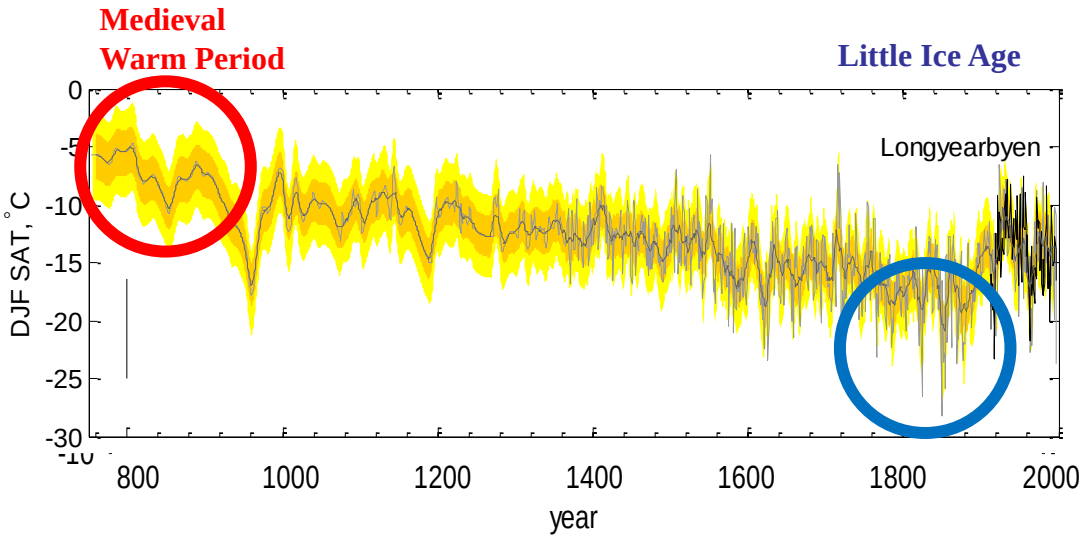
[b] Byrd Polar Research Center, The Ohio State University, 108 Scott Hall, 1090 Carmack Road, Columbus, OH 43210, USA
[c] Moscow Engineering Physics Institute, Kashirskoe Shosse 31, Moscow 115409, Russia

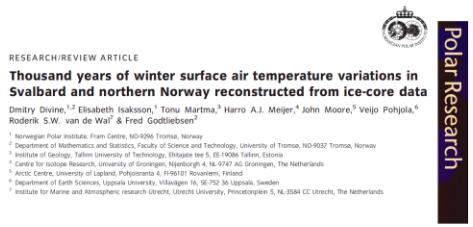
Abstract

Results of the deep drilling (>80–100 m) of Eurasian Arctic glaciers (Svalbard, Severnaya Zemlya, and Franz Josef Land) from the middle of the 1970s to the end of the 1990s have been discussed. All spectra of the techniques used for ice-core and borehole studies, results of ice-core dating and major paleoclimatic conclusions have been analyzed. Particular emphasis has been placed on the problem of accuracy and comparison of dates suggested by different authors. New integrated time scale for Eurasian Arctic glaciers based on the ice-core dating of Vetreny Ice Cap (Graham Bell Island and Franz Josef Land), which covers the last 700–800 years, has been developed. Methods and results of the new paleo-temperature reconstructions have been analyzed.

Winter temperature reconstruction

using $\delta^{18}O$ from ice cores and instrumental records

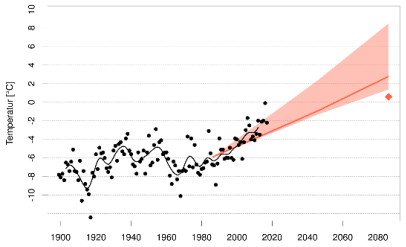



RESEARCH/REVIEW ARTICLE

Thousand years of winter surface air temperature variations in Svalbard and northern Norway reconstructed from ice-core data

Dmitry Divine,[1,2] Elisabeth Isaksson,[1] Tonu Martma,[3] Harro A.J. Meijer,[4] John Moore,[5] Veijo Pohjola,[6] Roderik S.W. van de Wal[7] & Fred Godtliebsen[2]

Polar Research

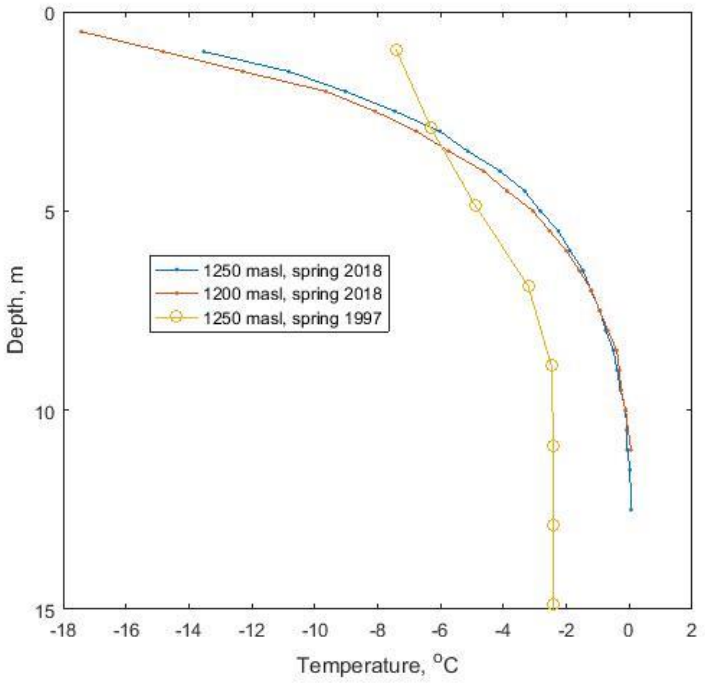


Svalbard is already 4°C warmer (7.3°C during winter) than 50 years ago (Hanssen-Bauer et al., 2019).

- **Winters were about 4 degrees colder during the mid-1800 (peak of the LIA) than during the 1900s.**
- **Winters during the early part of the Viking era (MWP) was at least as warm as winters during the late 1900s.**

Increased impact of melt also at higher elevations

Lomonosovfonna snow pack temperatures 1200 m asl



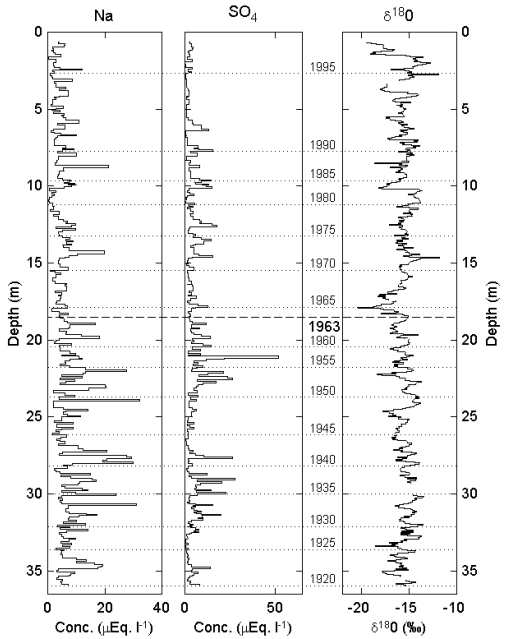
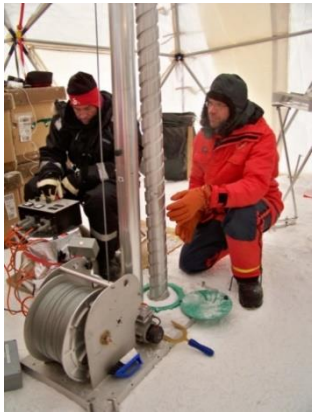


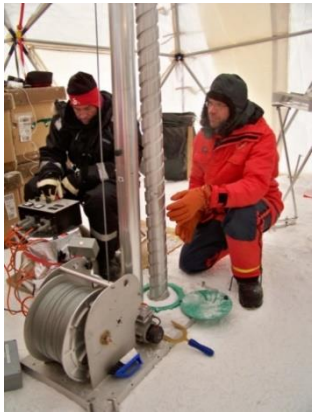
Figure from Sergey Marchenko

Four sampling sites at different elevations



- Lomonosovfonna: 1250 masl
- Holtedahlfonna: 1150 masl
- Austfonna: 740 masl
- Kongsvegen: 700 masl

Four sampling sites at different elevations



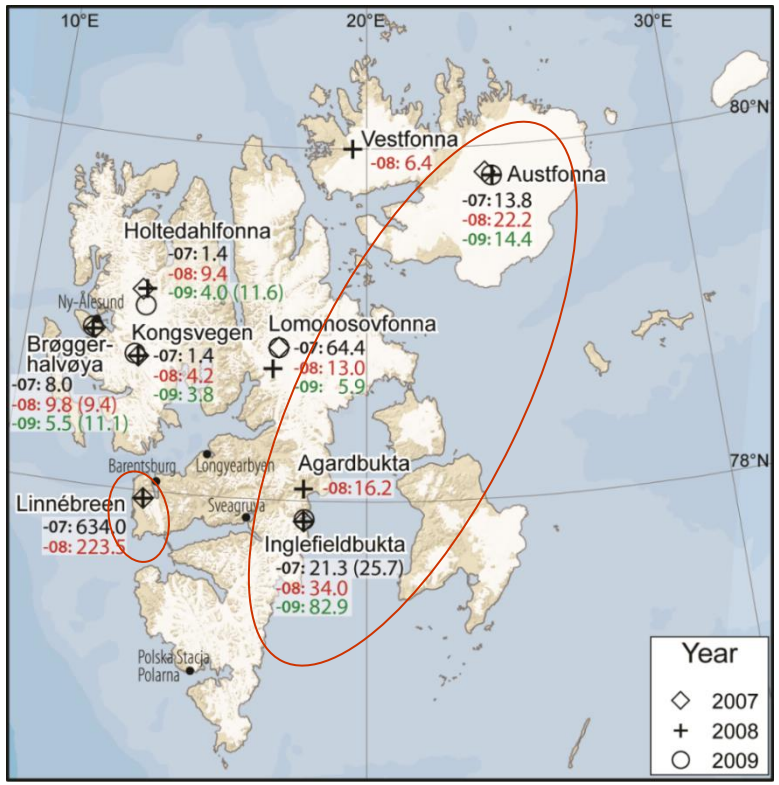
- Lomonosovfonna: 1250 masl
- Holtedahlfonna: 1150 masl
- Austfonna: 740 masl
- Kongsvegen: 700 masl

The “dirt “…..

Black carbon

Spatial variability in winter snow 2007-2009

BC might change the albedo of the snow and enhance melt




JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES, VOL. 118, 1–14, doi:10.1002/2013JD019886, 2013

Elemental carbon measurements in European Arctic snow packs

S. Forsström,[1] E. Isaksson,[1] R. B. Skeie,[2] J. Ström,[3] C. A. Pedersen,[1] S. R. Hudson,[1] T. K. Berntsen,[2,4] H. Lihavainen,[5] F. Godtliebsen,[1,6] and S. Gerland[1]


JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 114, D19112, doi:10.1029/2008JD011480, 2009

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Elemental carbon distribution in Svalbard snow

S. Forsström,[1] J. Ström,[1,2] C. A. Pedersen,[1] E. Isaksson,[1] and S. Gerland[1]

Black Carbon Lomonosovfonna

SP2 method

Atmos. Chem. Phys., 18, 12777–12795, 2018
https://doi.org/10.5194/acp-18-12777-2018

Atmospheric Chemistry and Physics
EGU

An 800-year high-resolution black carbon ice core record from Lomonosovfonna, Svalbard

Dmitri Osmont[1,2,3], Isabel A. Wendl[1,2,3], Loïc Schmidely[2,4], Michael Sigl[1,2], Carmen P. Vega[5,a], Elisabeth Isaksson[6], and Margit Schwikowski[1,2,3]

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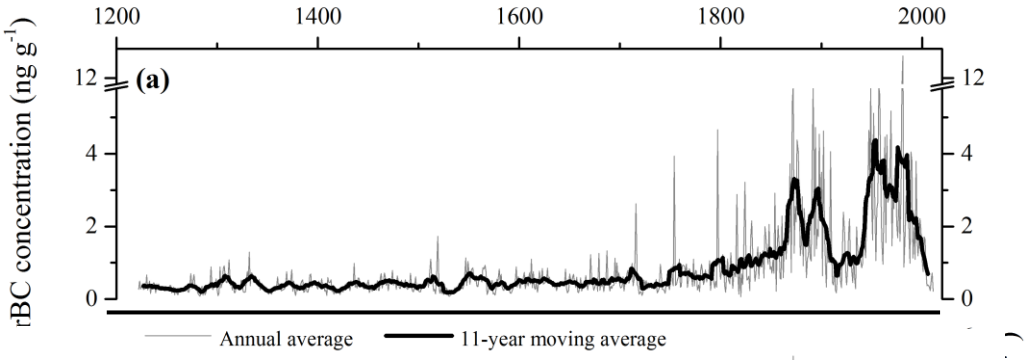
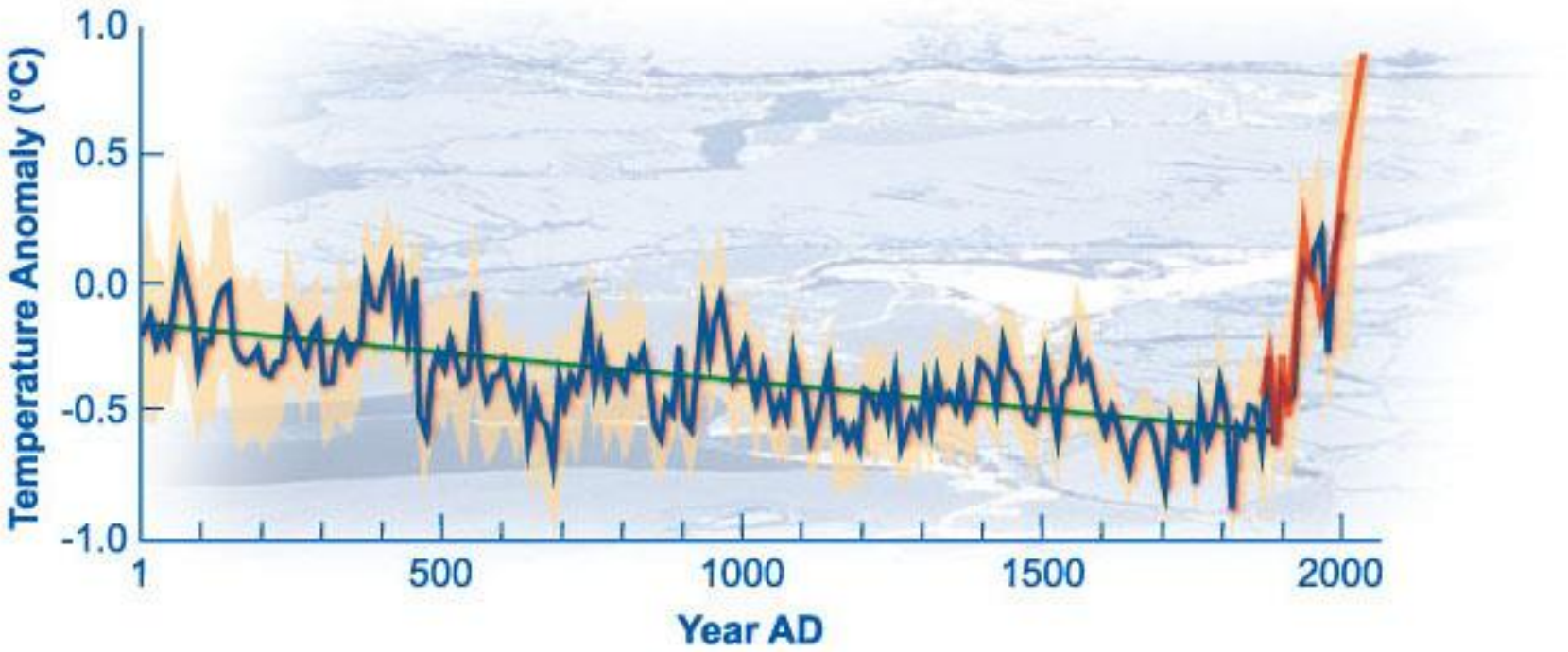


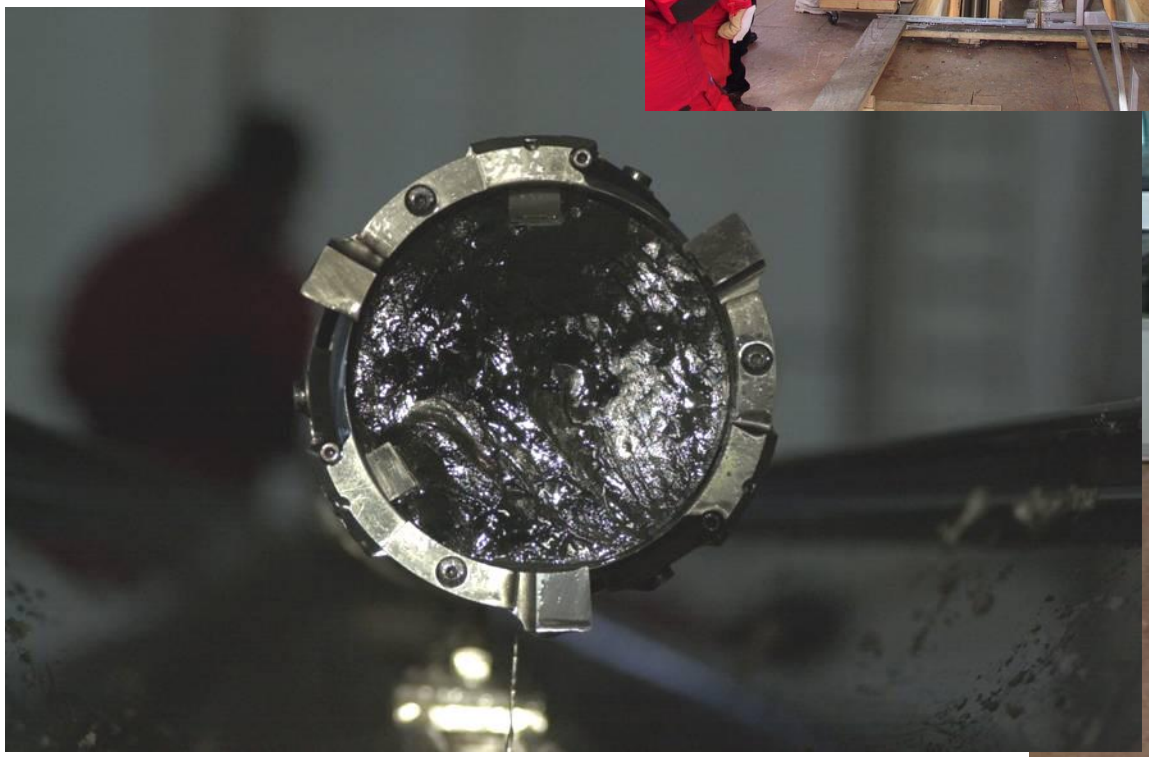
- Clear anthropogenic signal from 1860, earlier than Greenland
- Economic growth after WWII
- Recent decrease in accordance with atmospheric measurements
- Preindustrial part of the record reflects biomass burning

Recent Arctic warming(II)

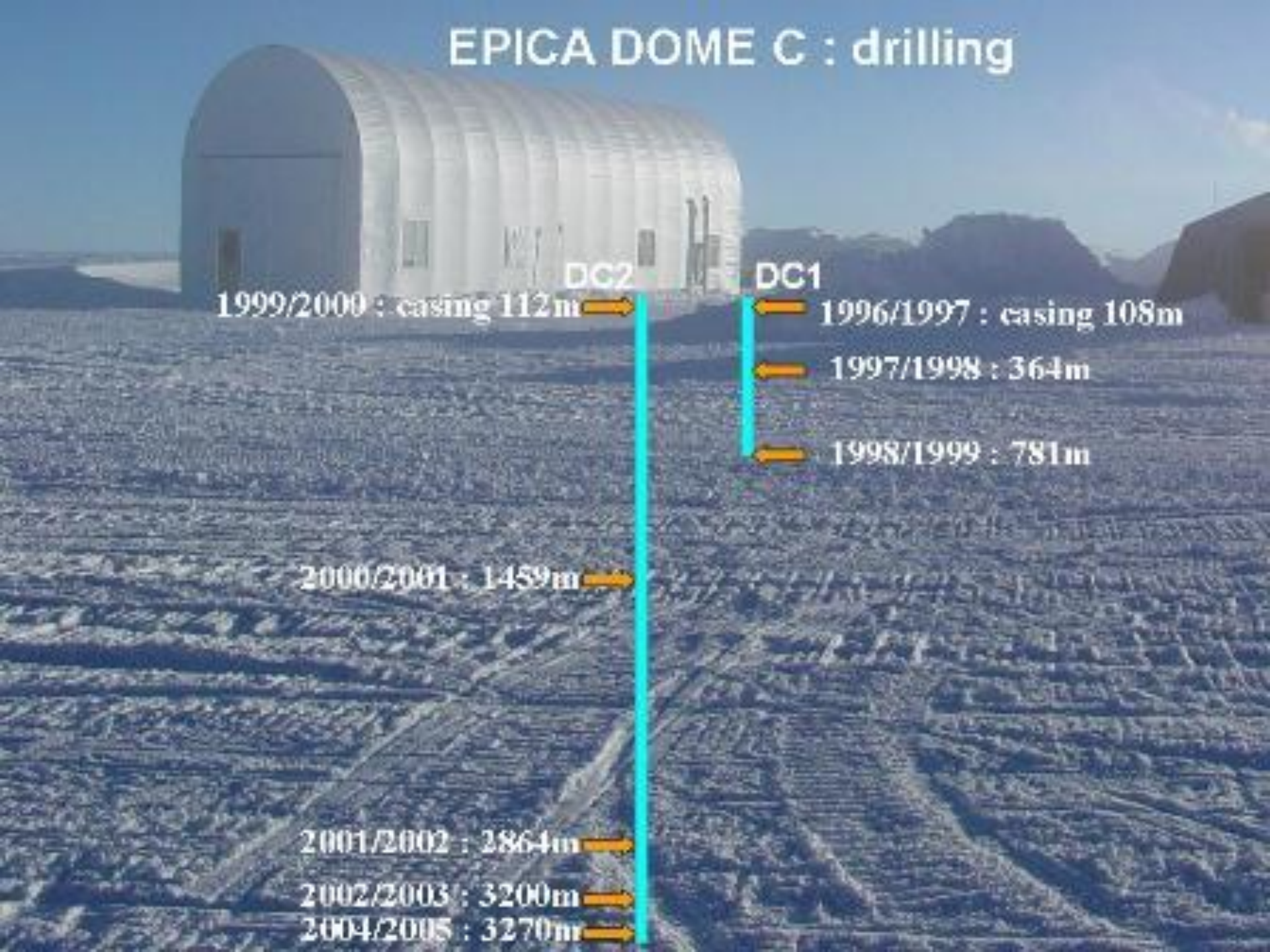
Kaufman et al.Science 325,2009



Ice Core Drilling



Showcase of European Research and Technology


EPICA DOME C : drilling
DC2
DC1
1999/2000 : casing 112m
1996/1997 : casing 108m
1997/1998 : 364m
1998/1999 : 781m
2000/2001 : 1459m
2001/2002 : 2864m
2002/2003 : 3200m
2004/2005 : 3270m

Conclusions

- Recent warming reverses long- term Arctic cooling
- The last decades of the past millennium are characterized again by warm temperatuures that seem to be unprecedented in the context of the last 1600 years

Thank you!

Acknowledgements
We want to thank all the people in Norway , in Russia and in Estonia who in various ways helped to make these ice-coring projects possible. Logistical support came from NPI in Longyearbyen, Ny Ålesund and financial support came from Norwegian Polar Institute, The Norwegian Research Council andThe Estonian Research Council. Special thanks to Elisabeth Isakssson(NPI) and Tõnu Martma(IGTUT)