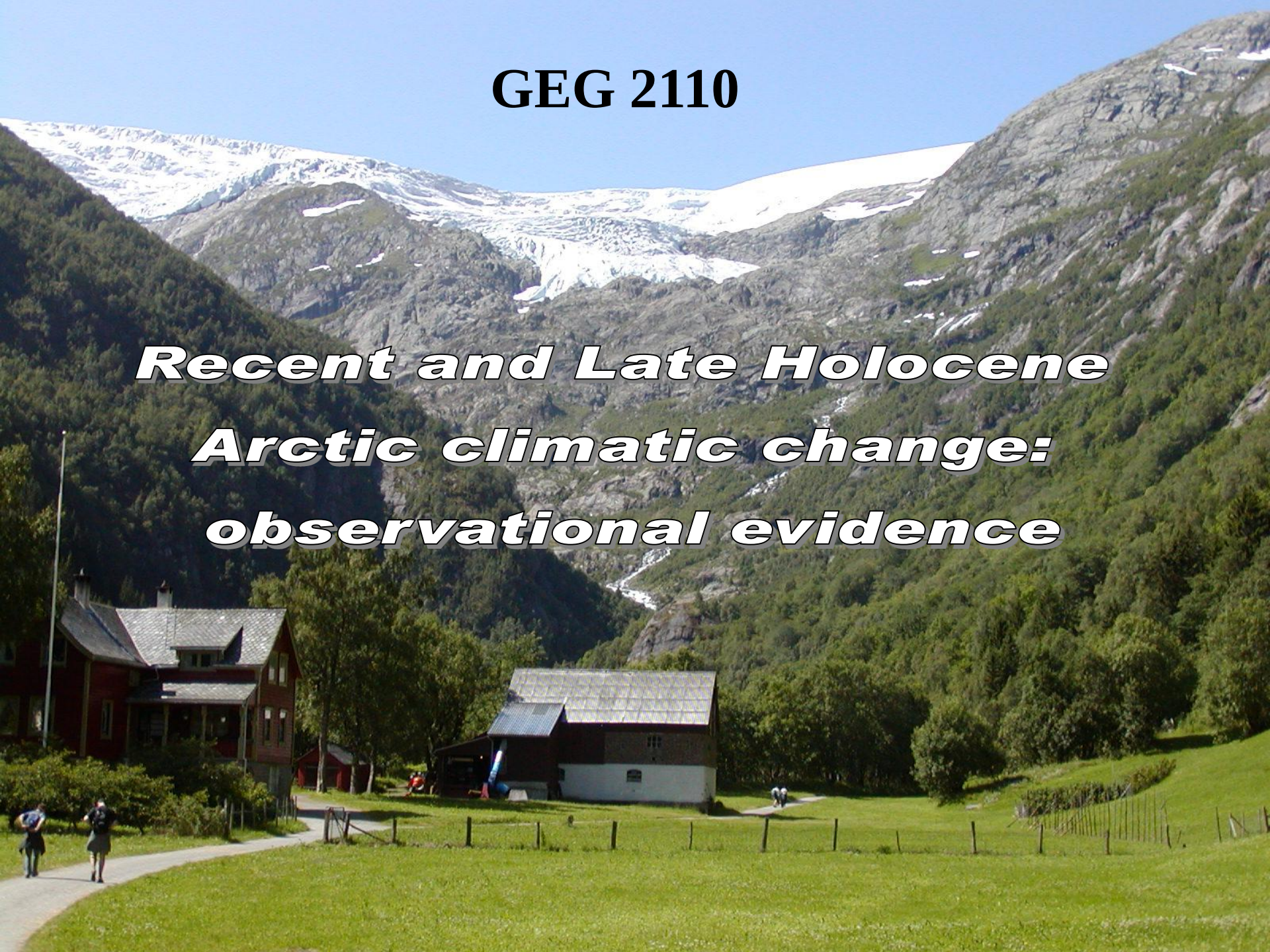
GEG 2110



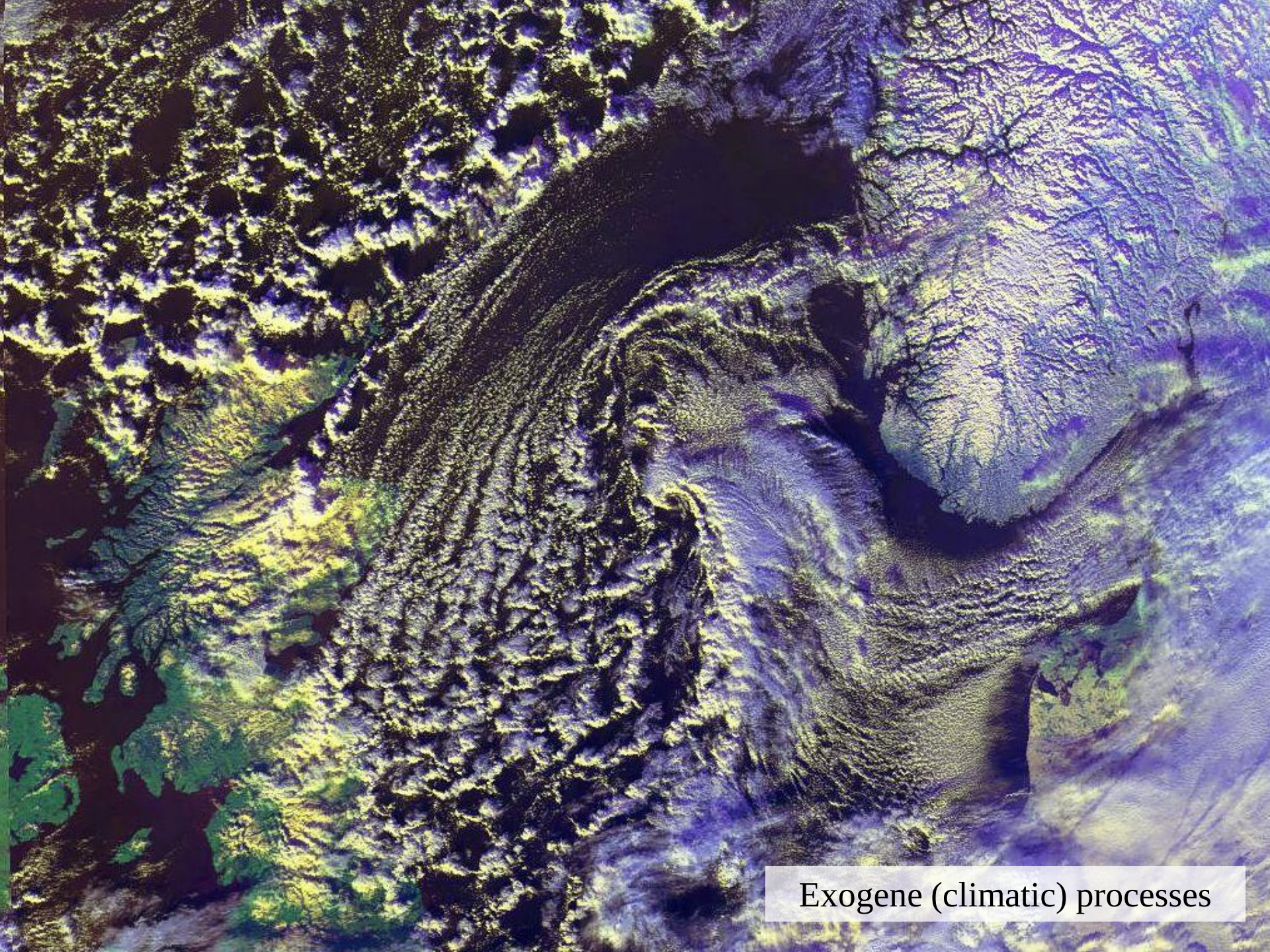
Recent and Late Holocene Arctic climatic change: observational evidence

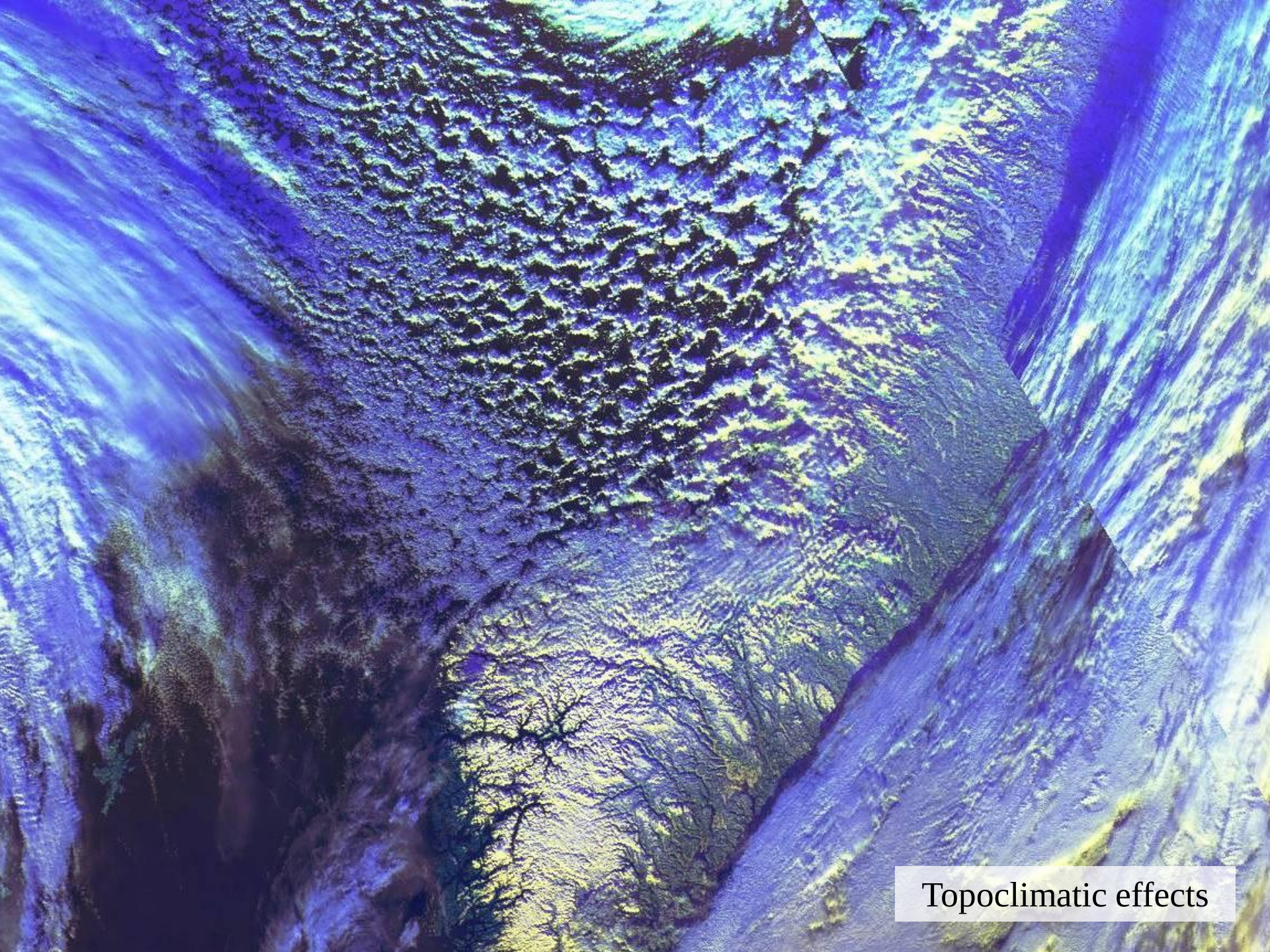
Recent and Late Holocene Arctic climatic change: observational evidence

1: Evidence for past and present climate change

2: Instrumental records of climatic variations

3: Geohazards, geomorphological processes and climate change


Exogene (climatic) processes


Topoclimatic effects


Effects related to topography

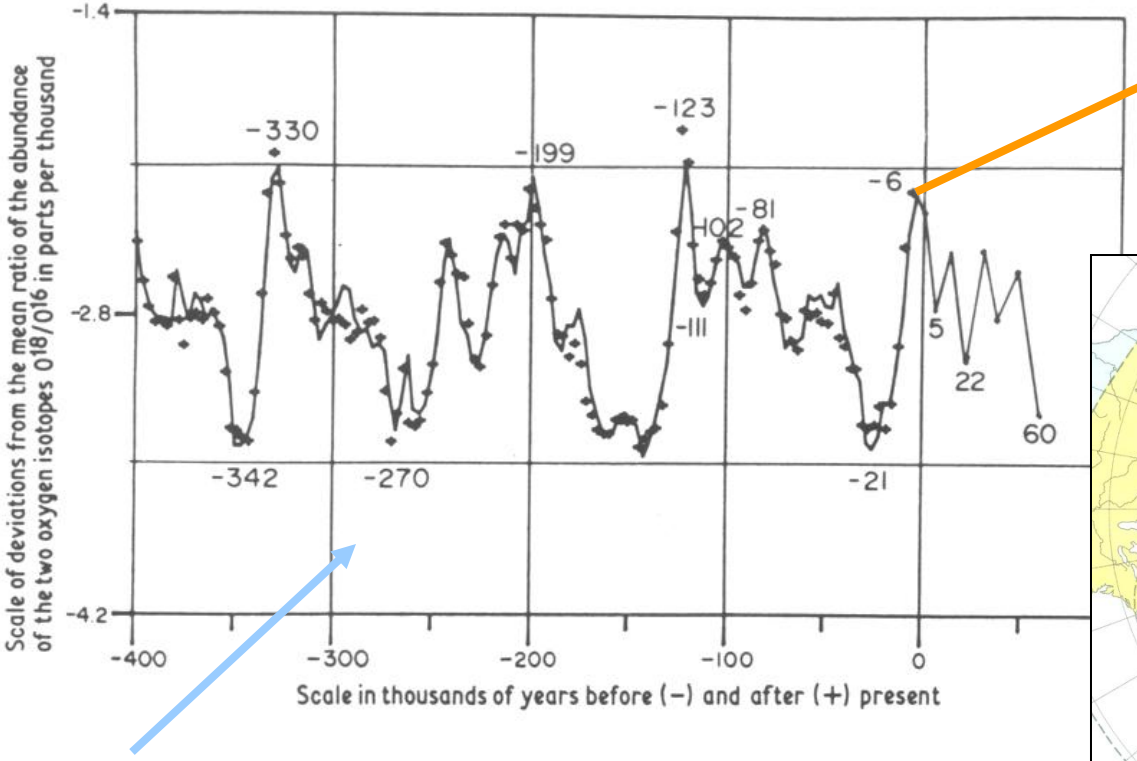

Effects related to surface characteristics


Summer versus winter

Climate in a longer perspective

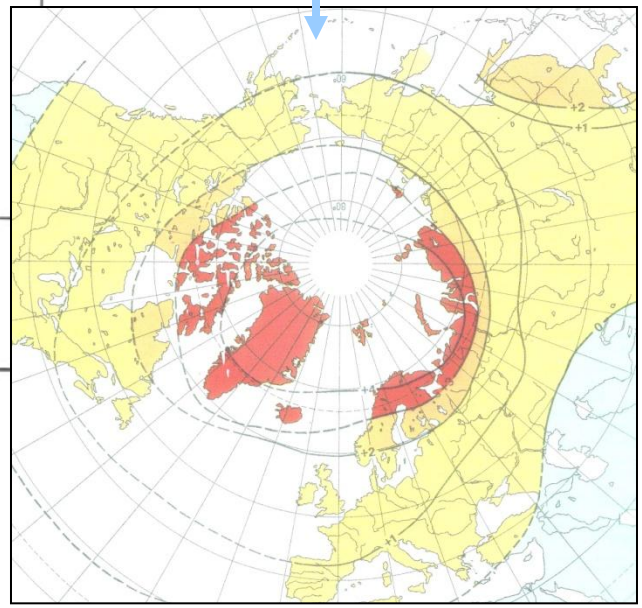
The Holocene:

The Holocene (the last 11.500 calendar years), can roughly be characterized by a climatic optimum during the first part of the interglacial followed by a deteriorating climate ever since, apparently controlled by orbital parameters. Superimposed on this is a millennial-scale climate variability, global in nature, but pronounced in the North Atlantic region, with a mean pacing of 1374 502 years. This signal is, however, not a strictly periodic signal and cannot yet be related to any known physical process.

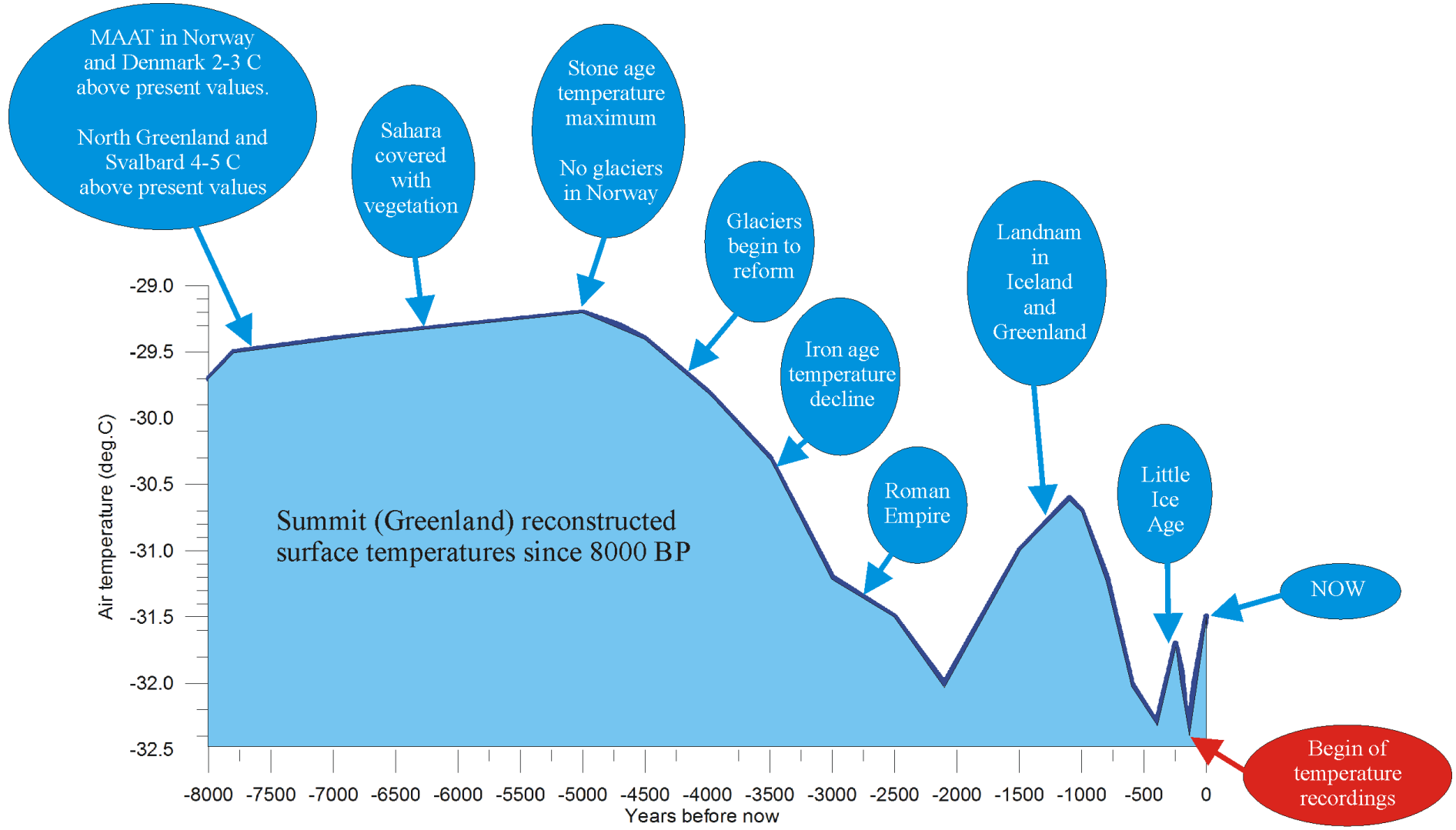


Long-term variations of global temperatures and orbital parameters over the past 400,000 years and calculation for the next 60,000 years. Crosses indicate oxygen isotope measurements from deep ocean cores (Berger, 1980).

'Holocene climatic optimum'



Reconstructed mean annual air temperature (MAAT) at the Holocene climatic optimum

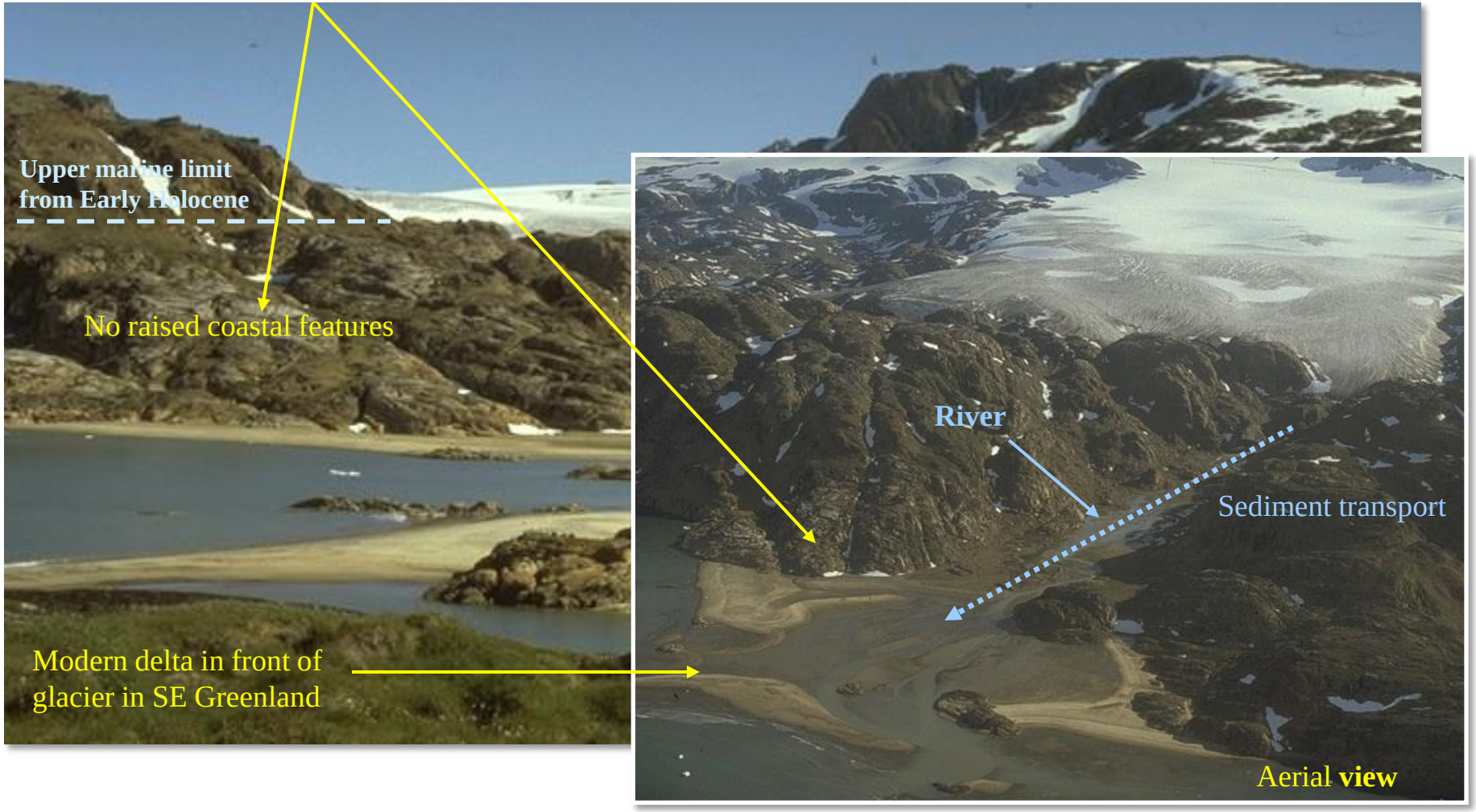

MAAT in Norway and Denmark 2-3 C above present values.
North Greenland and Svalbard 4-5 C above present values
Sahara covered with vegetation
Stone age temperature maximum
No glaciers in Norway
Glaciers begin to reform
Iron age temperature decline
Roman Empire
Landnam in Iceland and Greenland
Little Ice Age
NOW
Begin of temperature recordings
Summit (Greenland) reconstructed surface temperatures since 8000 BP
Air temperature (deg.C)
-29.0
-29.5
-30.0
-30.5
-31.0
-31.5
-32.0
-32.5
-8000 -7500 -7000 -6500 -6000 -5500 -5000 -4500 -4000 -3500 -3000 -2500 -2000 -1500 -1000 -500 0
Years before now

Geomorphology and sediments as evidence for climate change

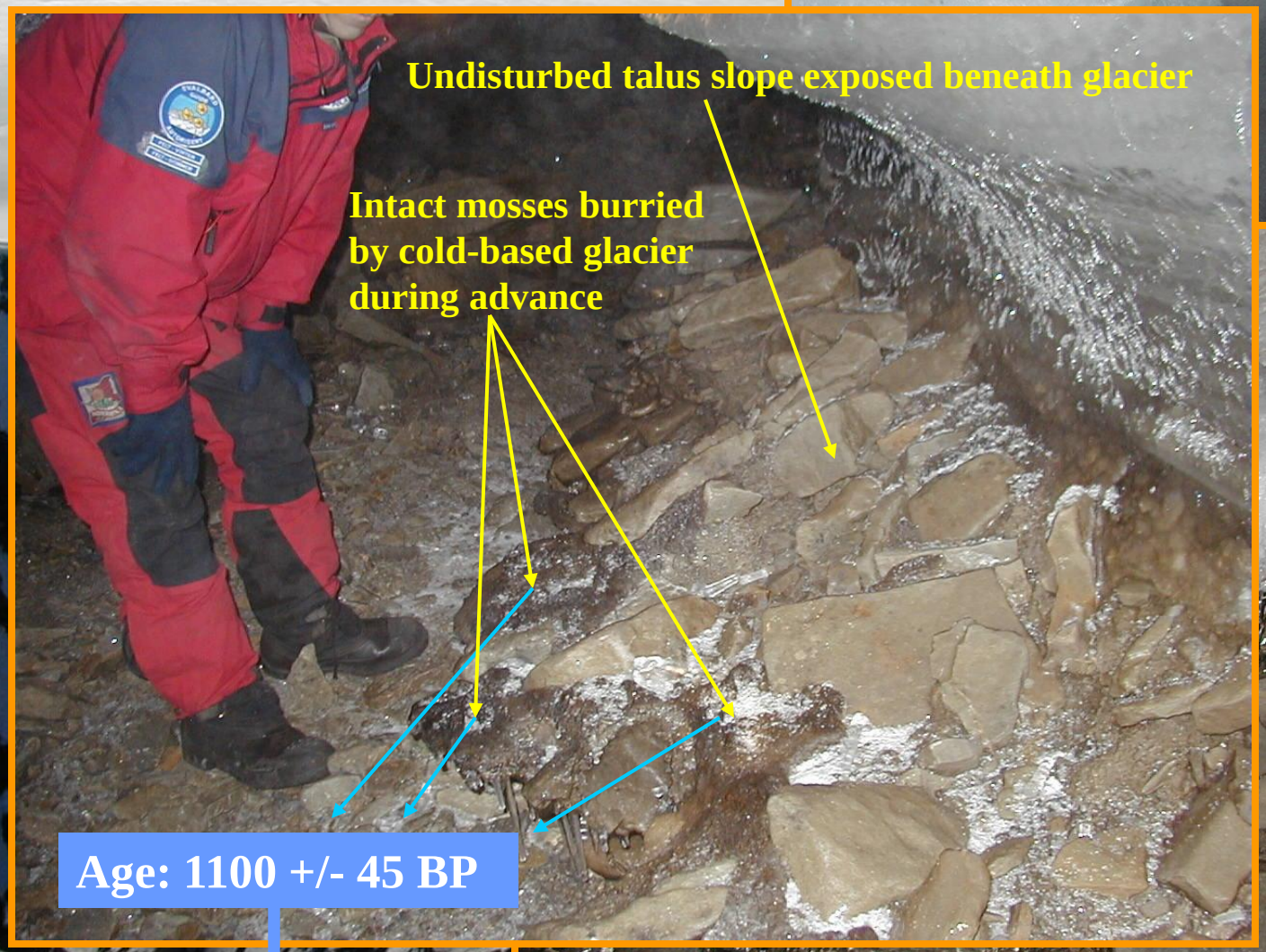
Example of Late Holocene glacier growth:

Many small and medium-sized glaciers in the Arctic presumably only came into existence following the Late Holocene climatic decline after about 4000 BP.

The Late Holocene establishment of these glaciers is demonstrated by the absence of raised delta features where the modern meltwater stream meets the ocean.



Example of Late Holocene glacier growth:



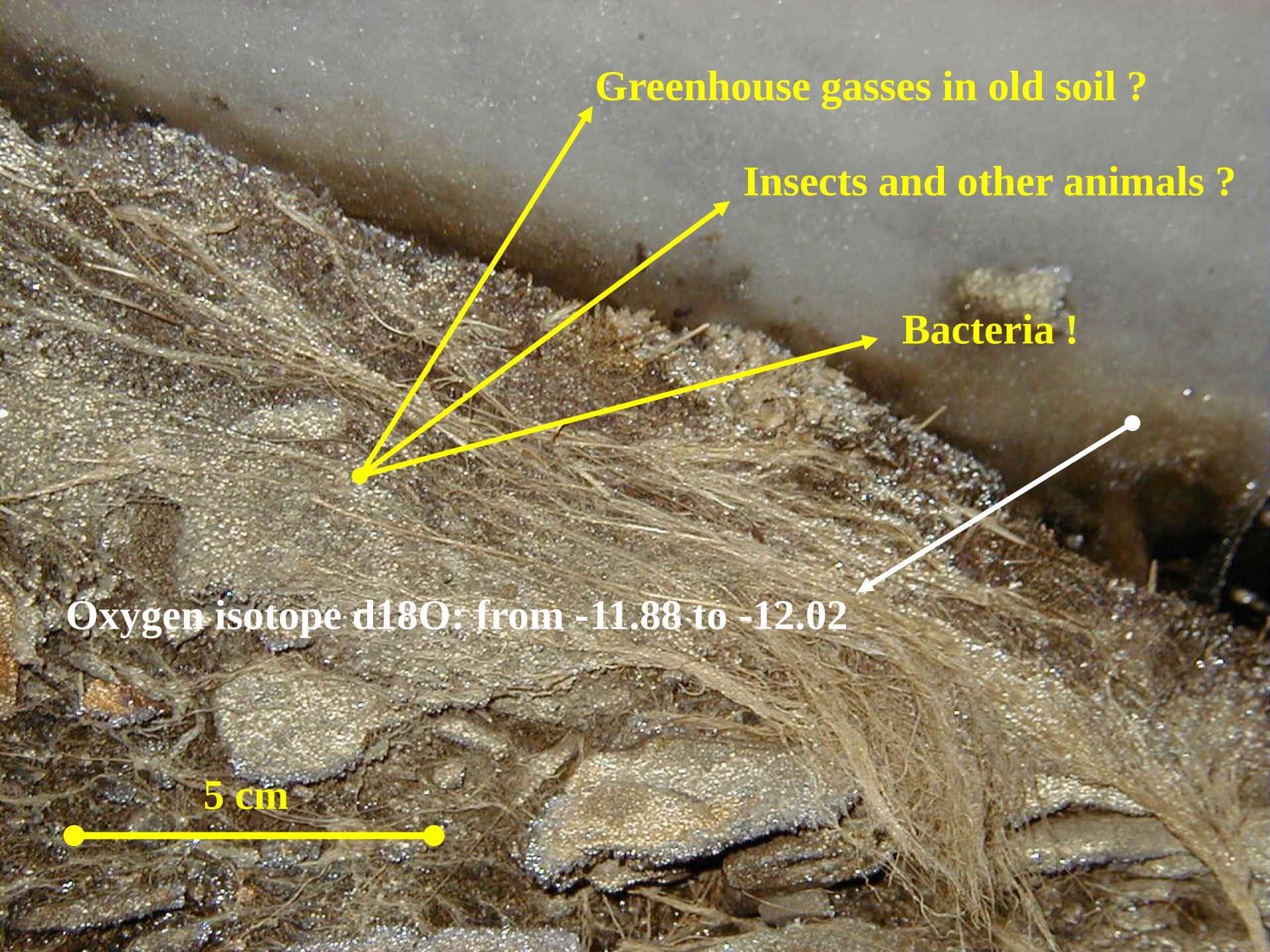
Ice cave created by supraglacial channel leads to the glacier bed

Glacier-bed interface at cold-based Longyearbreen

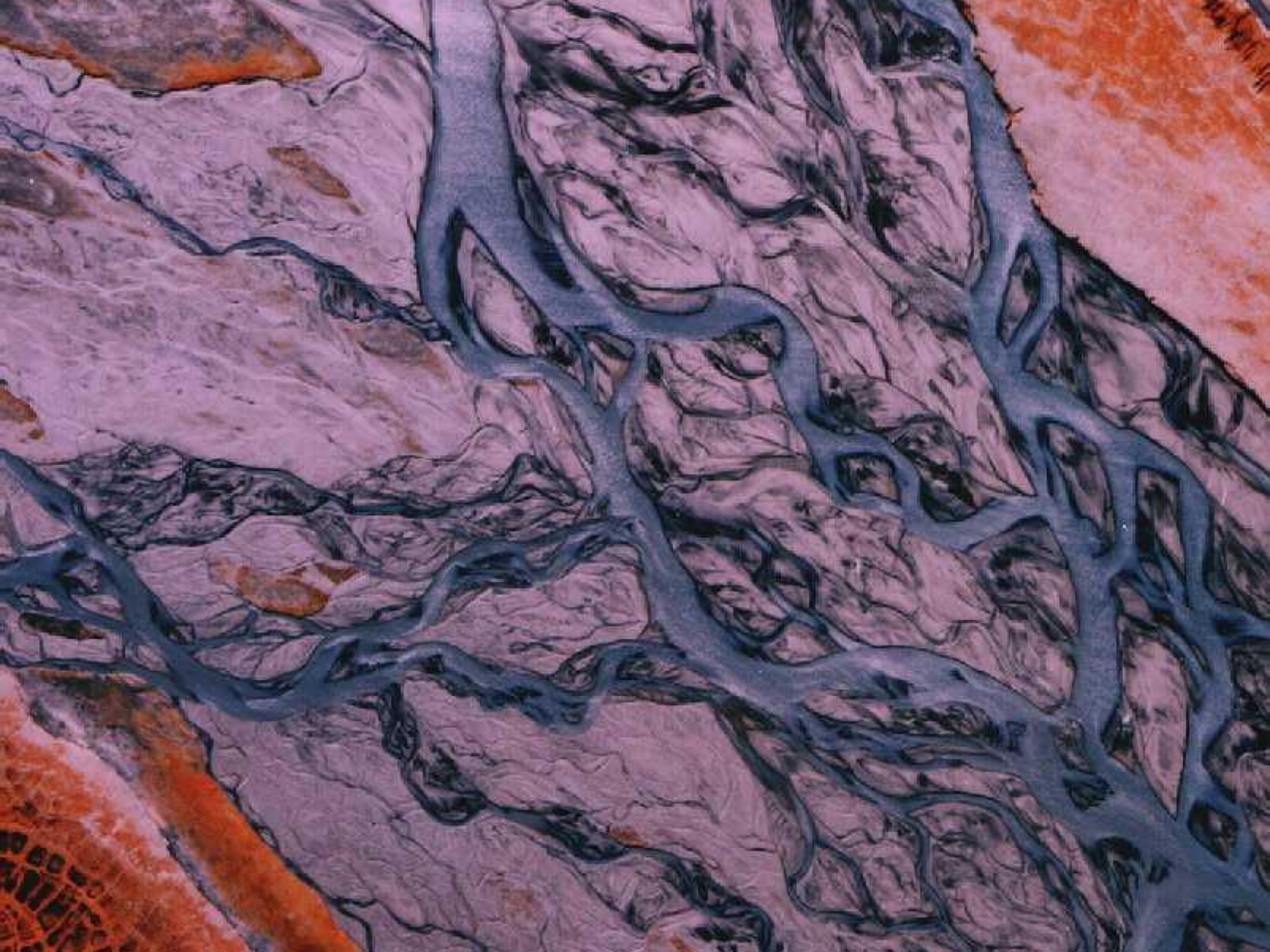
Age: 1100 +/- 45 BP

Glacier length has increased about 2 km during the last 1100 years

Longyearbreen, central Spitsbergen (78N), Svalbard

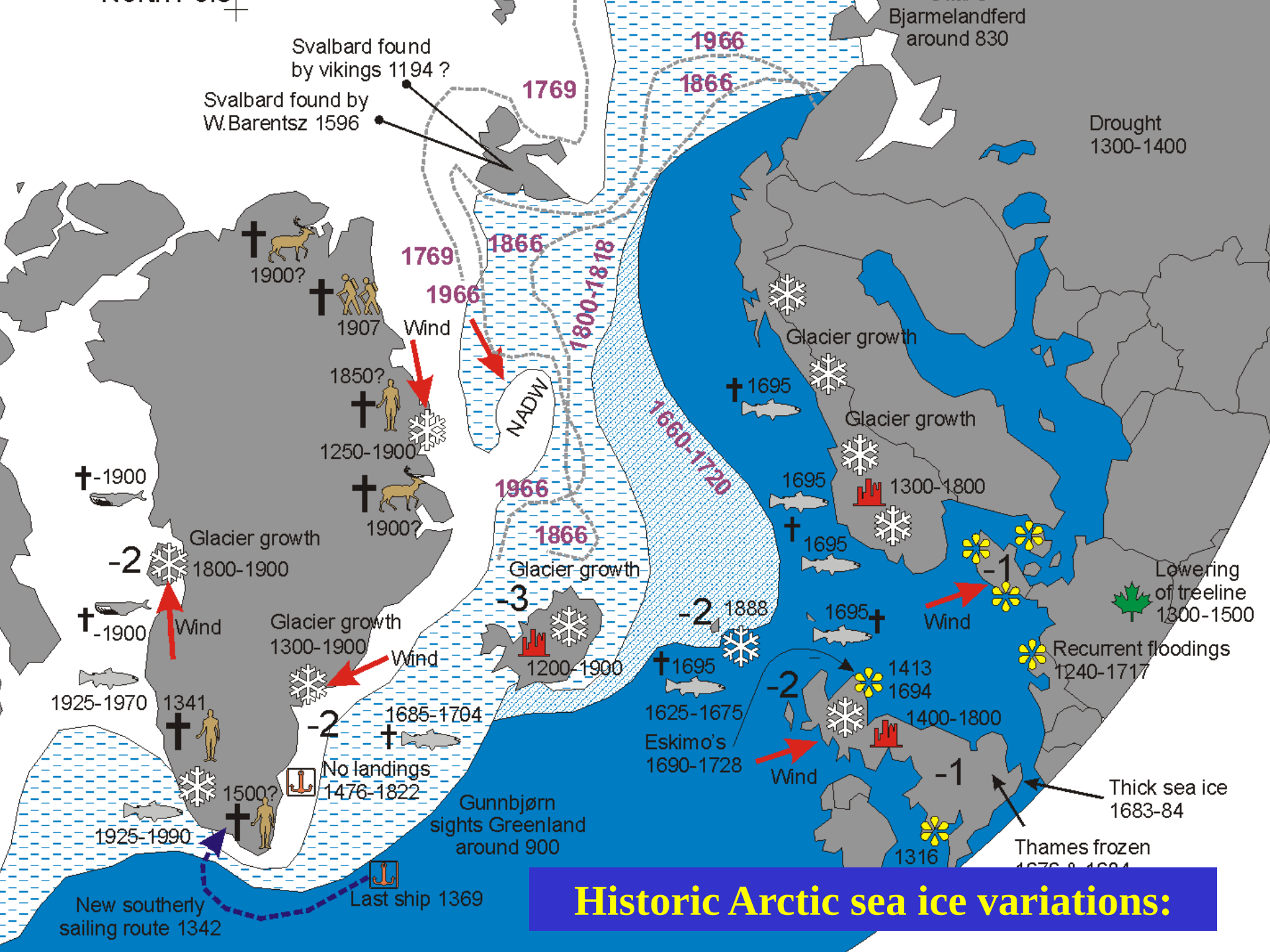

Greenhouse gasses in old soil ?
Insects and other animals ?
Bacteria !
Oxygen isotope d18O: from -11.88 to -12.02
5 cm


October 1999

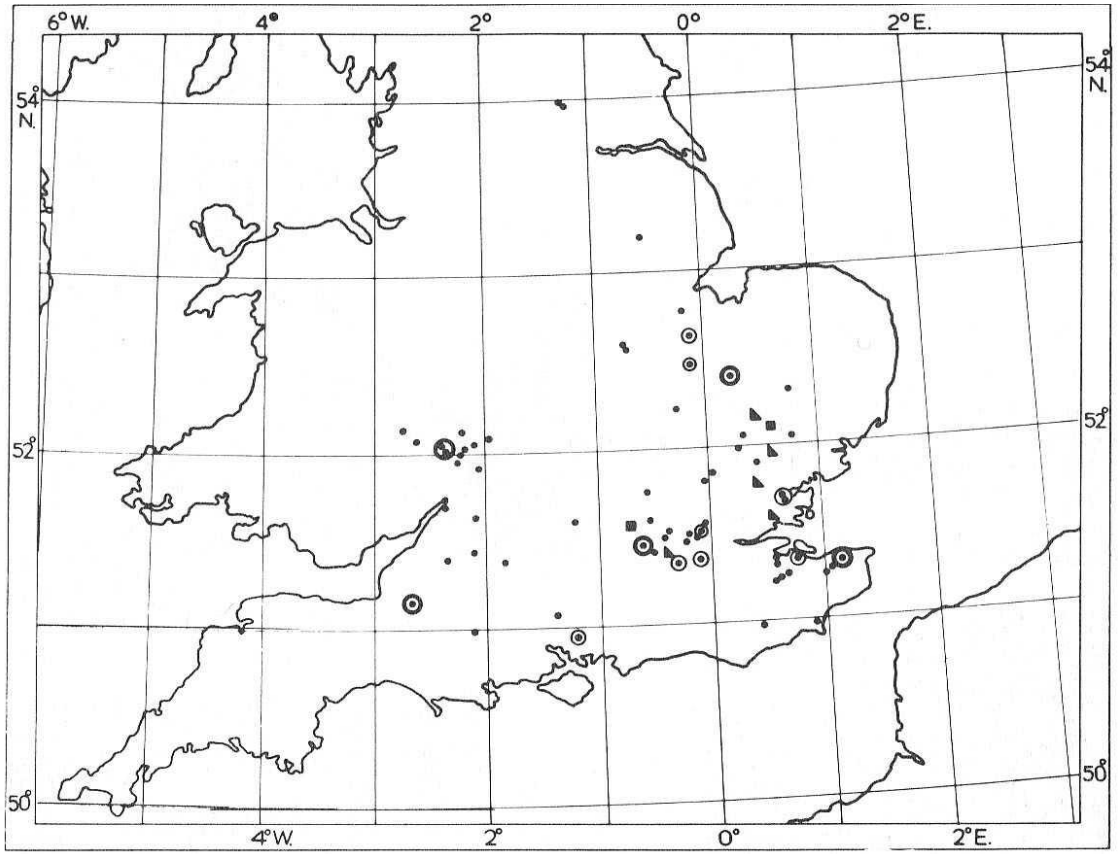


Loess accumulation since 3000 BP

Historical evidence as indicator for climate change


Svalbard found by vikings 1194 ?
Svalbard found by W.Barentsz 1596
1769
1966
1866
1800-1818
1660-1720
NADW
Bjarmelandferd around 830
Drought 1300-1400
1900?
1907
Wind
1850?
1250-1900
1900?
-1900
-1900
Glacier growth
-2
1800-1900
Wind
Glacier growth
1300-1900
Wind
1925-1970
1341
-2
1685-1704
1500?
1925-1990
No landings 1476-1822
Gunnbjørn sights Greenland around 900
New southerly sailing route 1342
Last ship 1369
Glacier growth
-3
1200-1900
1695
Glacier growth
1300-1800
1695
1695
-2
1888
1695
1695
1625-1675
Eskimo's 1690-1728
Wind
-2
1413
1694
1400-1800
-1
Wind
-1
Lowering of treeline 1300-1500
Recurrent floodings 1240-1717
Thick sea ice 1683-84
Thames frozen
1316
Historic Arctic sea ice variations:


Brattalid SV Grønland
Photo: Hanne H. Christiansen

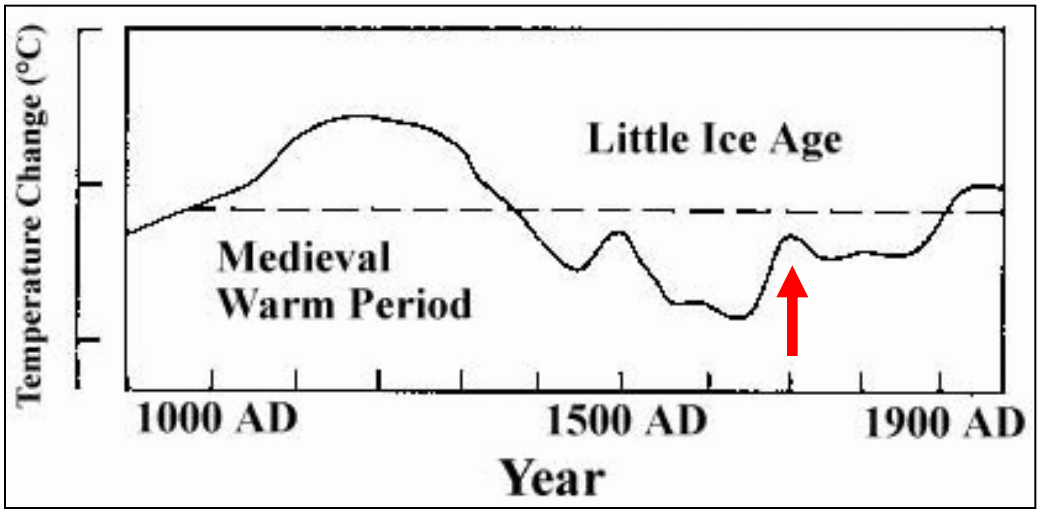


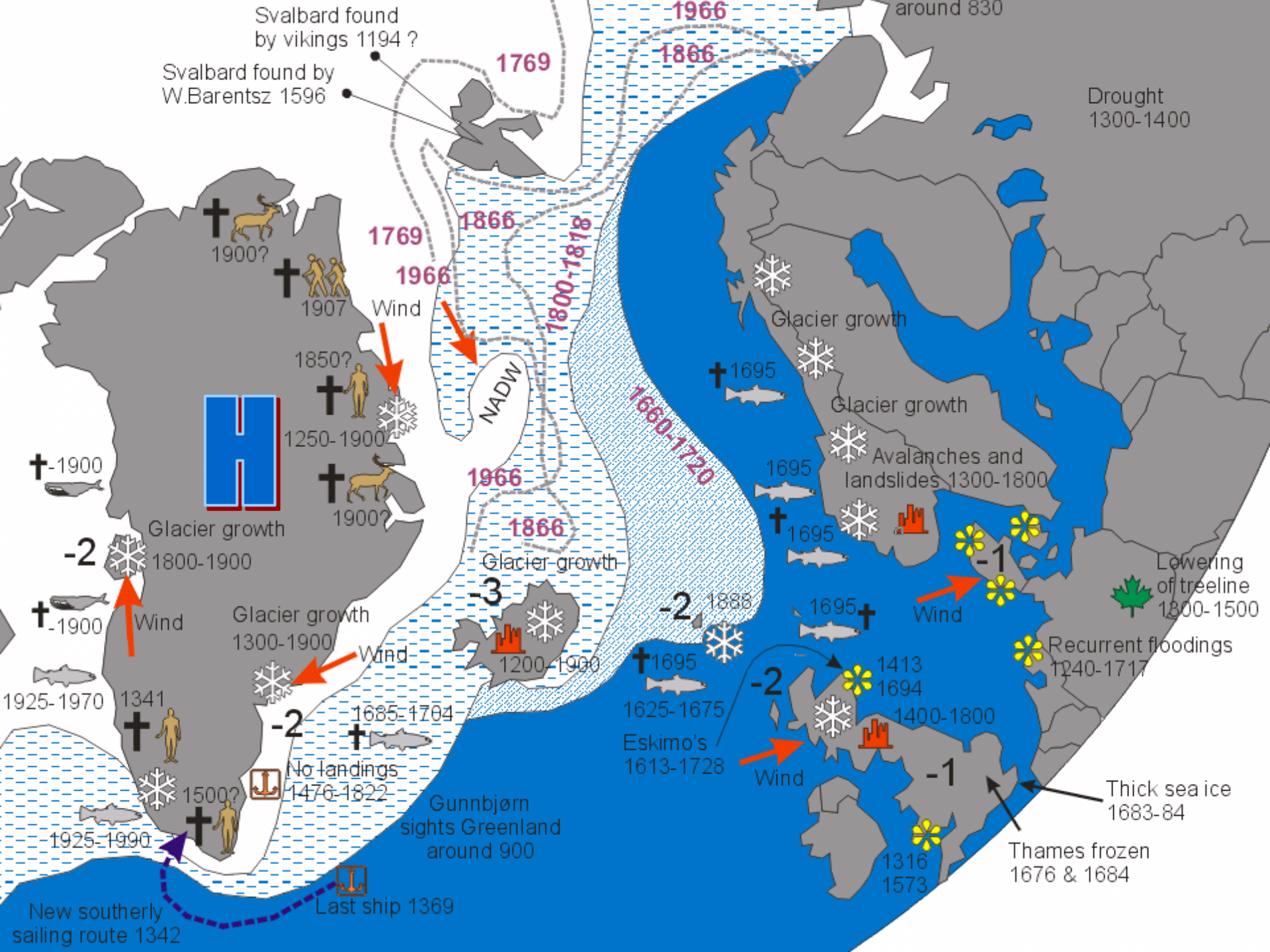
LEGEND

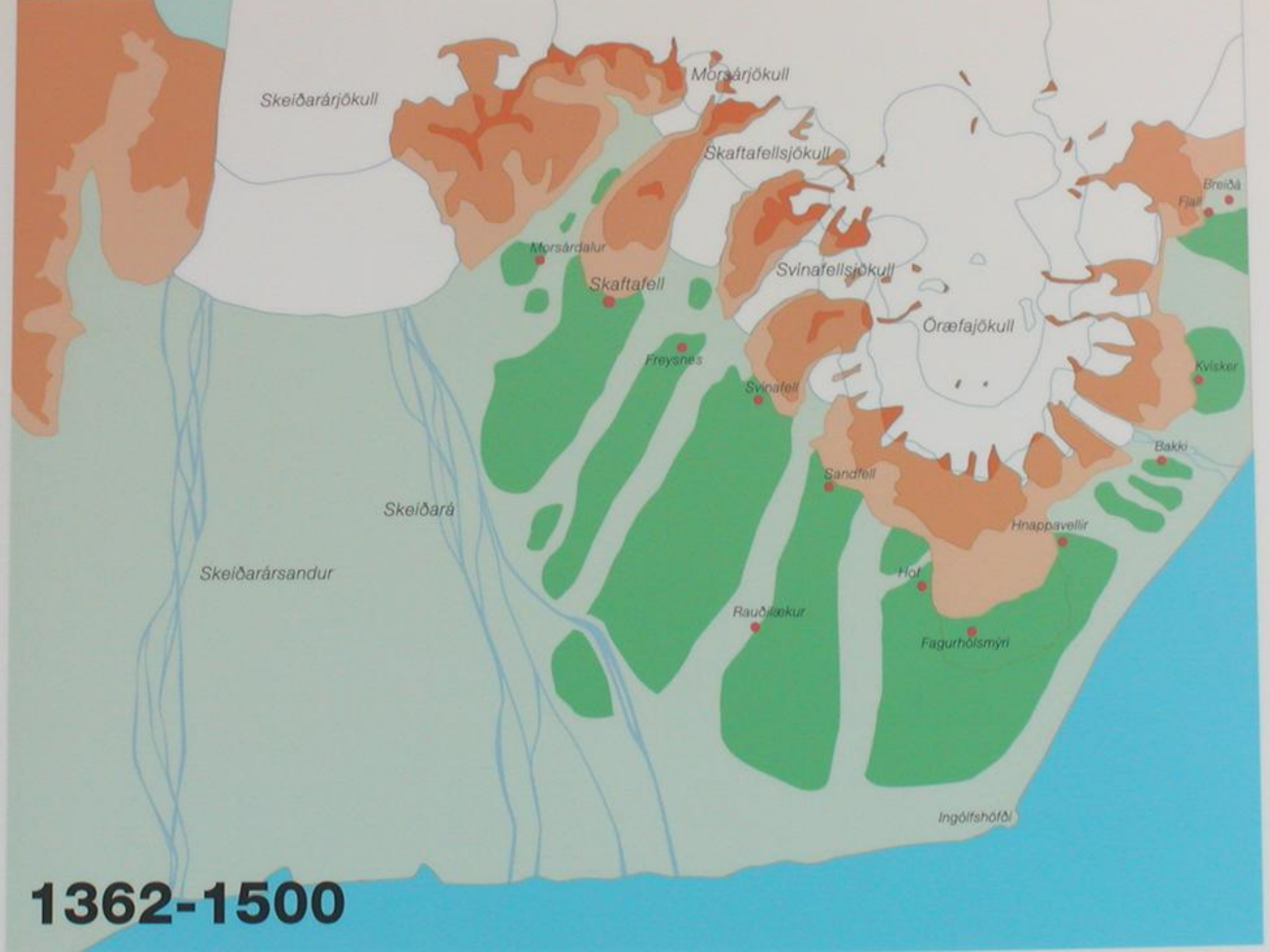
- Vineyard, usually 1–2 acres or size not known.
- Vineyard, 5–10 acres.
- Vineyard, over 10 acres.
- Denotes evidence of continuous operation for 30–100 years.
- Denotes evidence of continuous operation for over 100 years.

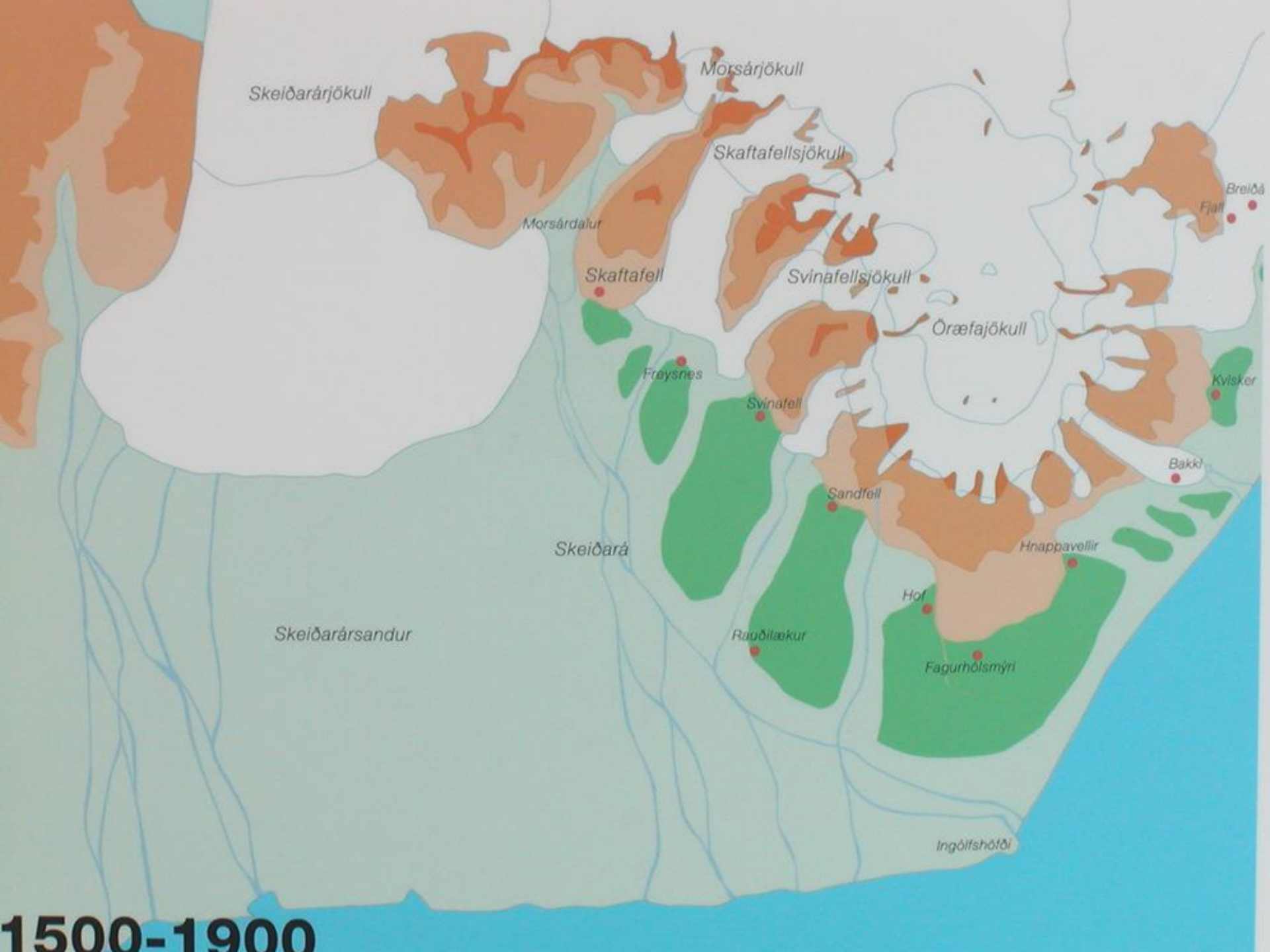
Fig. 65 The distribution of known medieval vineyard sites in England.


HANS EGEDE


Temperature Change (°C)
Little Ice Age
Medieval
Warm Period
1000 AD
1500 AD
1900 AD
Year


Svalbard found by vikings 1194 ?
Svalbard found by W.Barentsz 1596
1769
1866
1966
around 830
Drought 1300-1400
1900?
1907
Wind
1850?
1250-1900
1900?
1769
1866
1966
1800-1818
NADW
1660-1720
H
-1900
-1900
Glacier growth 1800-1900
-2
Wind
Glacier growth 1300-1900
Wind
1925-1970
1341
-2
1685-1704
No landings 1476-1822
1500?
1925-1990
Gunnbjørn sights Greenland around 900
New southerly sailing route 1342
Last ship 1369
1966
1866
Glacier growth
-3
1200-1900
-2
1888
1695
1625-1675
Eskimo's 1613-1728
Wind
Glacier growth
1695
Glacier growth
Avalanches and landslides 1300-1800
1695
1695
1695
-1
Wind
Lowering of treeline 1300-1500
Recurrent floodings 1240-1717
1413
1694
1400-1800
-2
-1
Thick sea ice 1683-84
Thames frozen 1676 & 1684
1316
1573


Skeiðarárjökull
Morsárjökull
Skaftafellsjökull
Breiðá
Fjall
Morsárdalur
Skaftafell
Svínafellsjökull
Öræfajökull
Freysnes
Svínafell
Kvísker
Bakki
Sandfell
Hnappavellir
Skeiðará
Skeiðarársandur
Hof
Rauðilækur
Fagurhólsmýri
Ingólfshöfði
1362-1500


Skeiðarárjökull
Morsárjökull
Skaftafellsjökull
Morsárdalur
Skaftafell
Svínafellsjökull
Öræfajökull
Freysnes
Svínafell
Sandfell
Hnappavellir
Hof
Rauðilækur
Fagurhólsmýri
Skeiðará
Skeiðarársandur
Ingólfshöfði
Bakki
Kvísker
Breiðá
Fjall
1500-1900


Population Iceland:
1095: 77.500
1311: 72.000
1703: 50.000
1780: 38.000

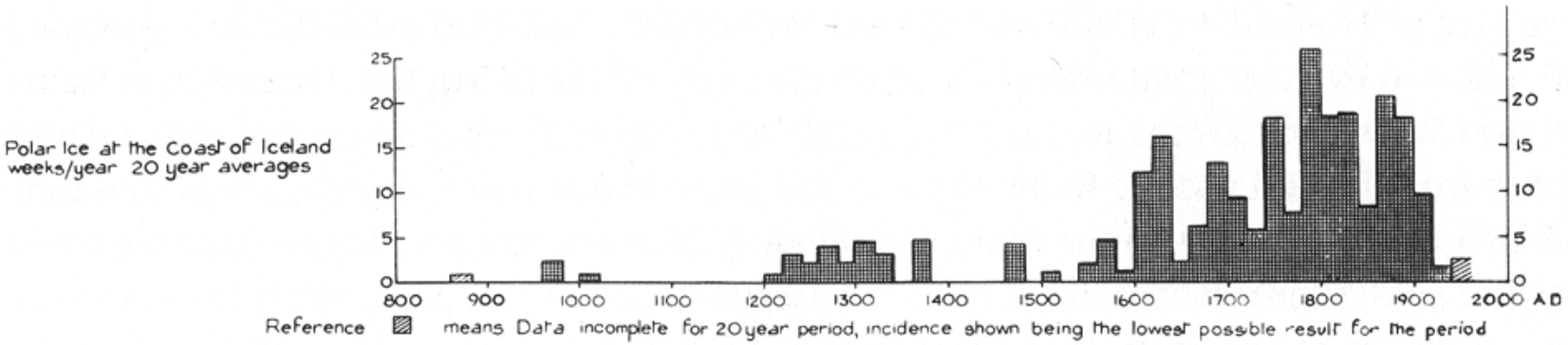
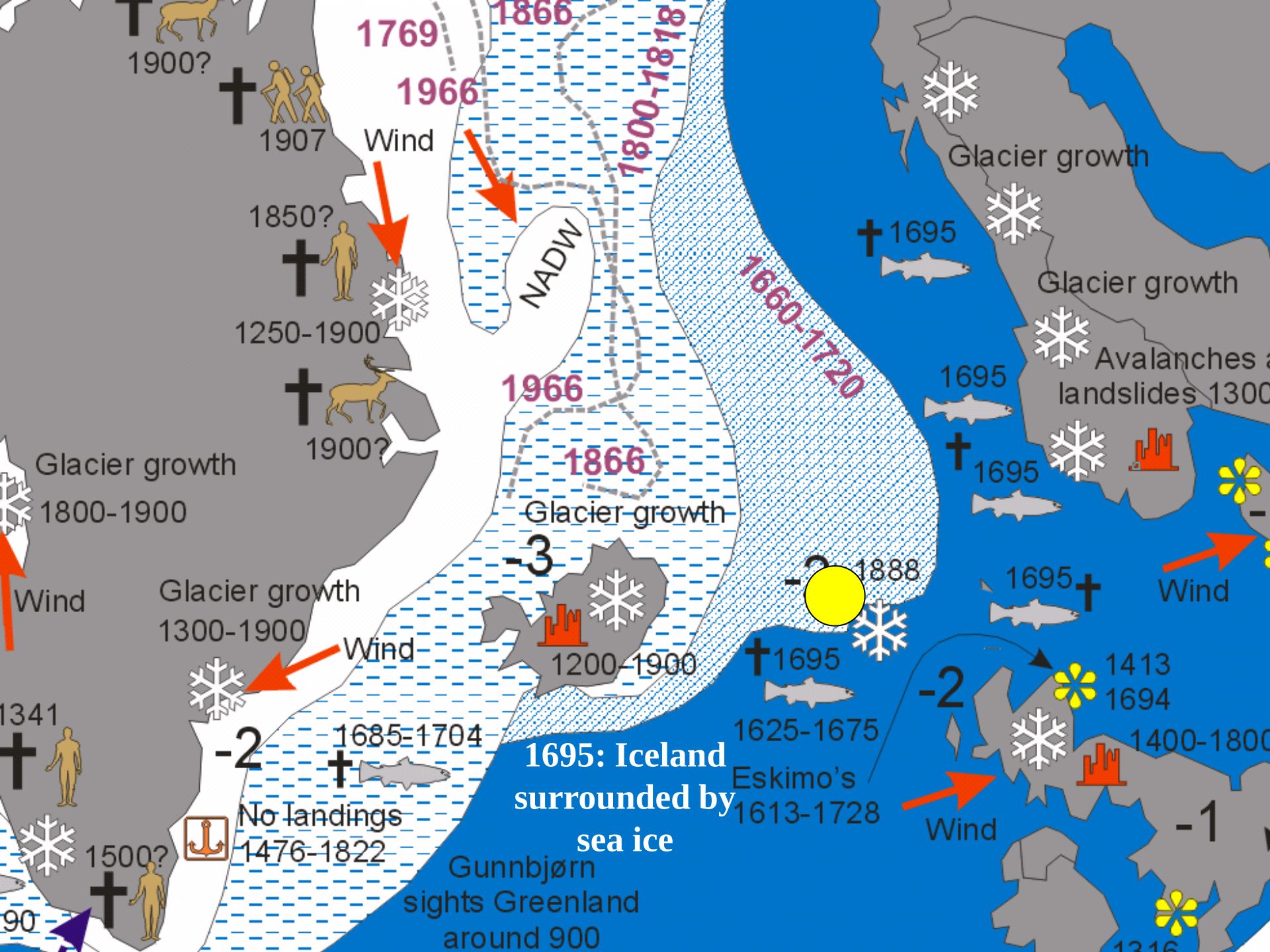


Fig. 17.13 Variations in the incidence of sea ice at the coast of Iceland since A.D. 860.
20-year averages, compiled by KOCH (1945) from Icelandic records and subsequently extended to 1960.

The curve may be used as an index of prevailing temperatures in Iceland and southeast Greenland.


1900?
1907
1769
1966
1866
1800-1818
Wind
1850?
1250-1900
NADW
1660-1720
1695
Glacier growth
Glacier growth
Avalanches a
landslides 1300
1695
1695
1966
1900?
1866
Glacier growth
1800-1900
Glacier growth
-3
1888
Wind
Glacier growth
1300-1900
Wind
1200-1900
1695
1695
Wind
1413
1694
1400-1800
1341
-2
1685-1704
-2
1625-1675
Eskimo's
1613-1728
1695: Iceland
surrounded by
sea ice
No landings
1476-1822
Wind
-1
1500?
Gunnbjørn
sights Greenland
around 900
90


Faroe Islands

Meteorological records as evidence for climate change

Instrumental record of cold climate meteorological parameters:

Measurements of surface meteorological parameters in the Arctic only experience relatively small problems associated urban growth and shade from nearby trees.

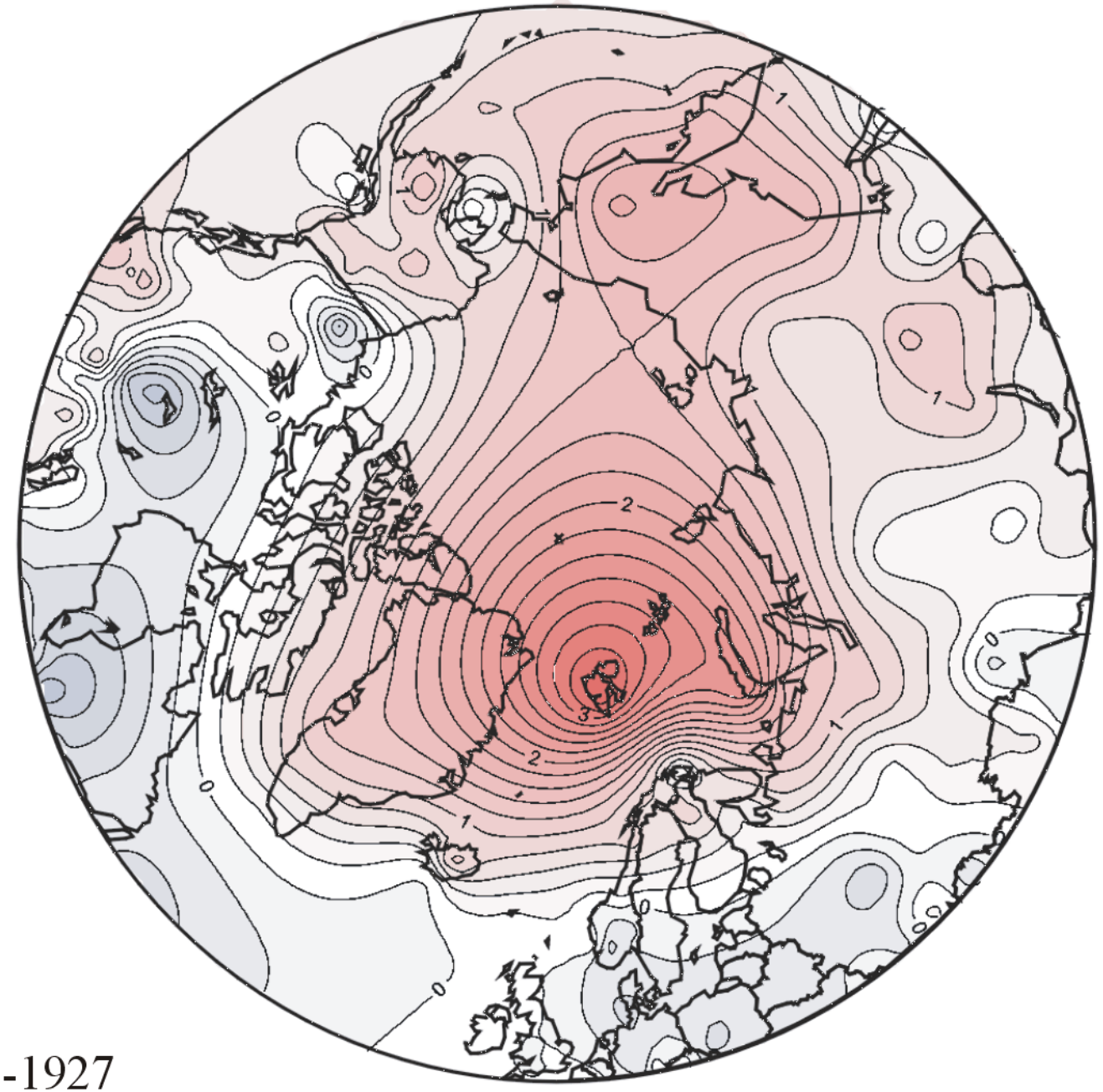
On the other hand, the arctic environment have a suite of other difficulties to offer.


Icing is one of such problems

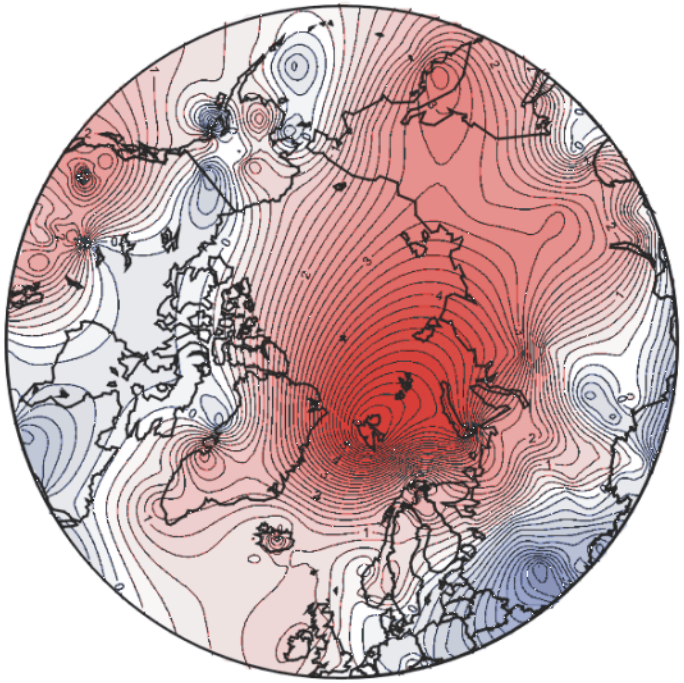
Strong wind is another problem.

In this example the road has been destroyed by wind

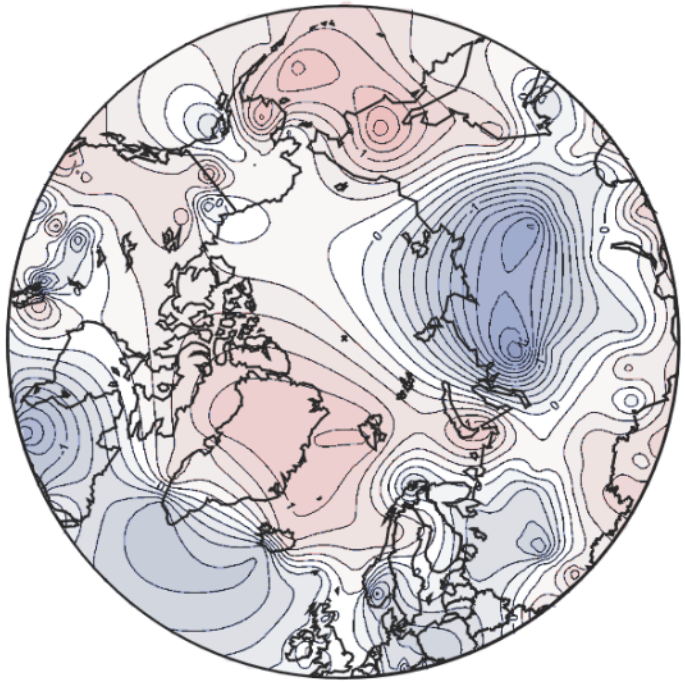
MAAT change 1915-1925



Running 5-yr means;
data 1913-1917 and 1923-1927



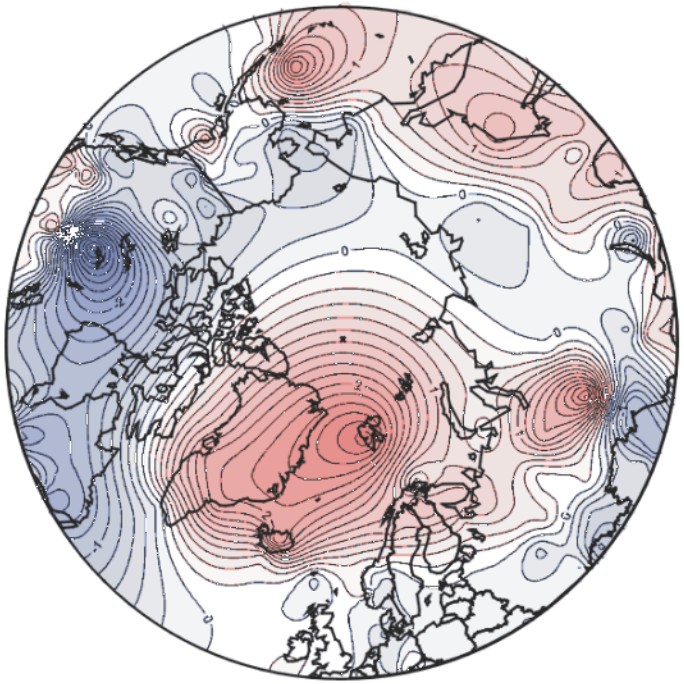
DJF



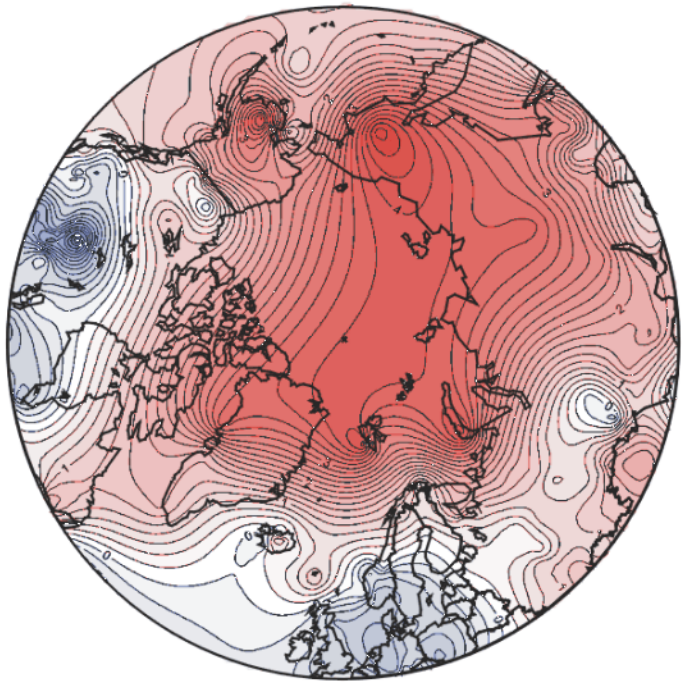
JJA

Change
1915-1925

Running 5-yr means;
data 1913-1917 and 1923-1927

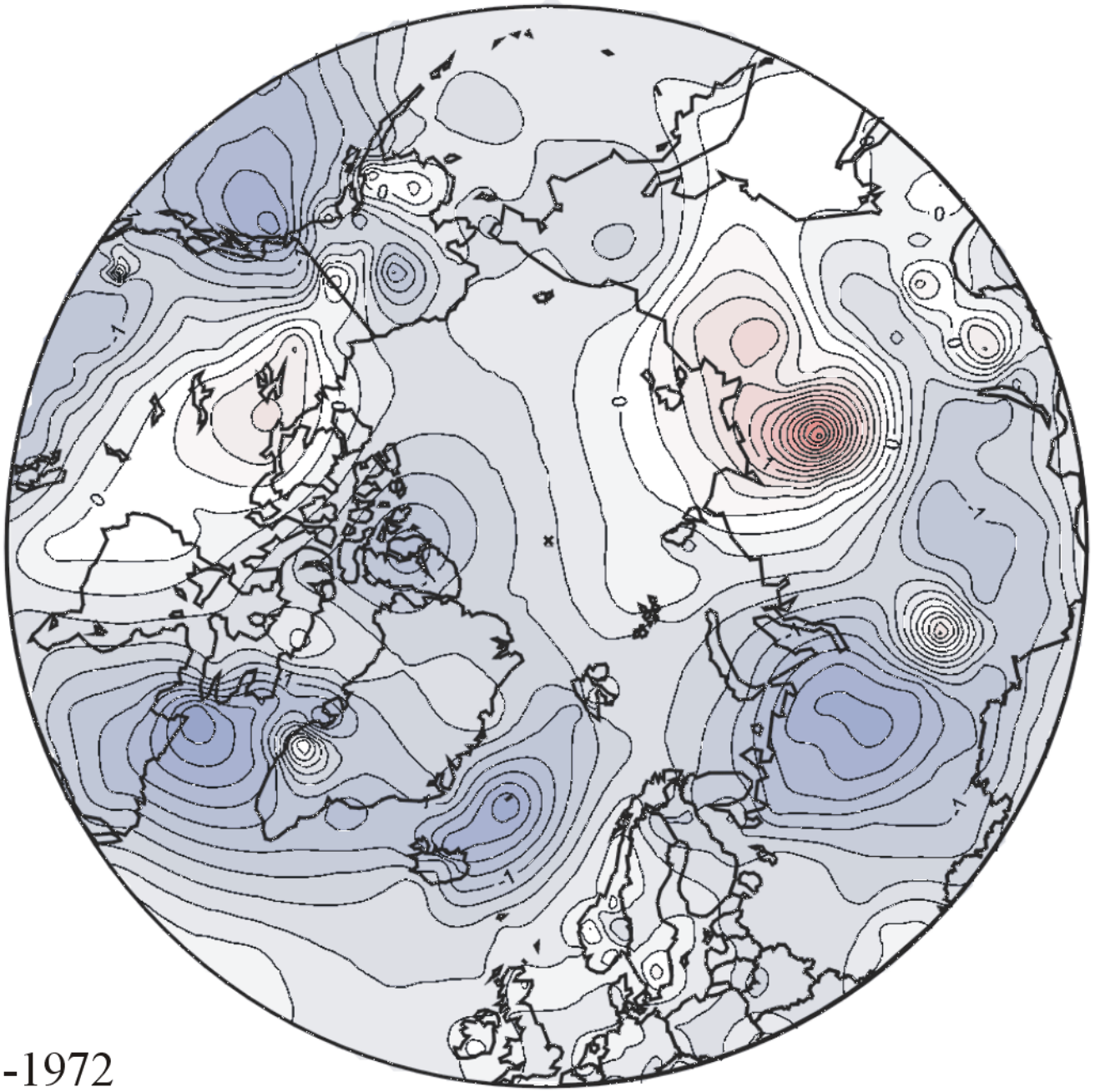


MAM

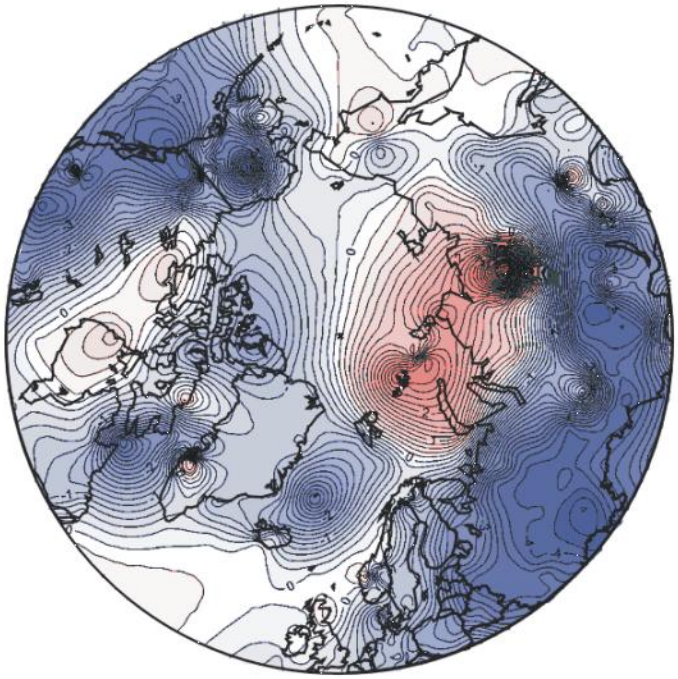


SON

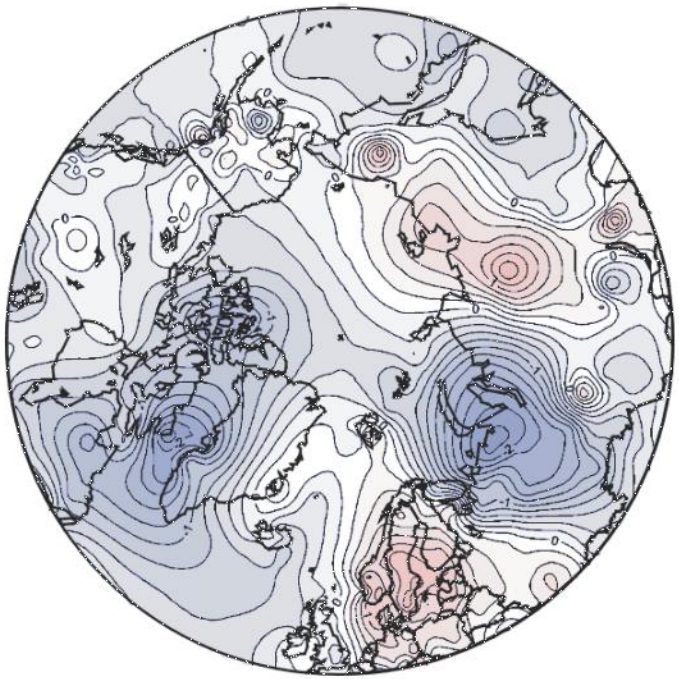
MAAT change 1960-1970



Running 5-yr means;
data 1958-1962 and 1968-1972



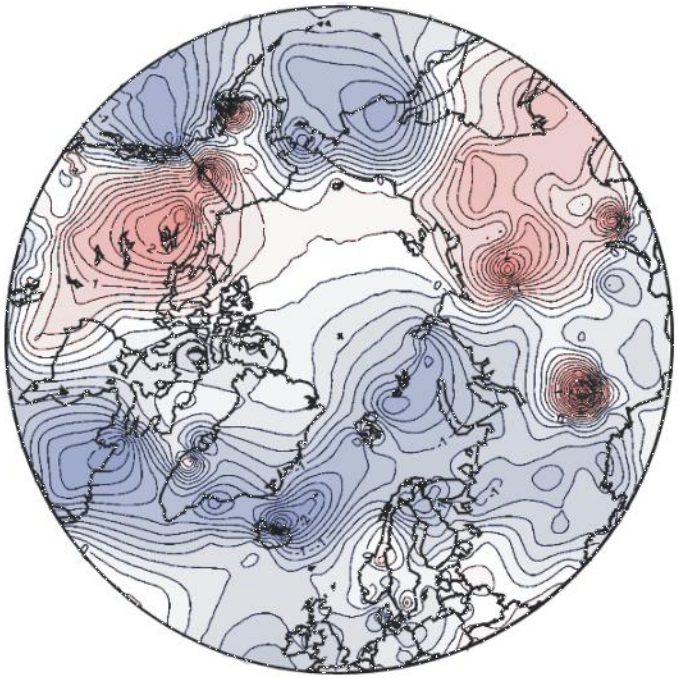
DJF



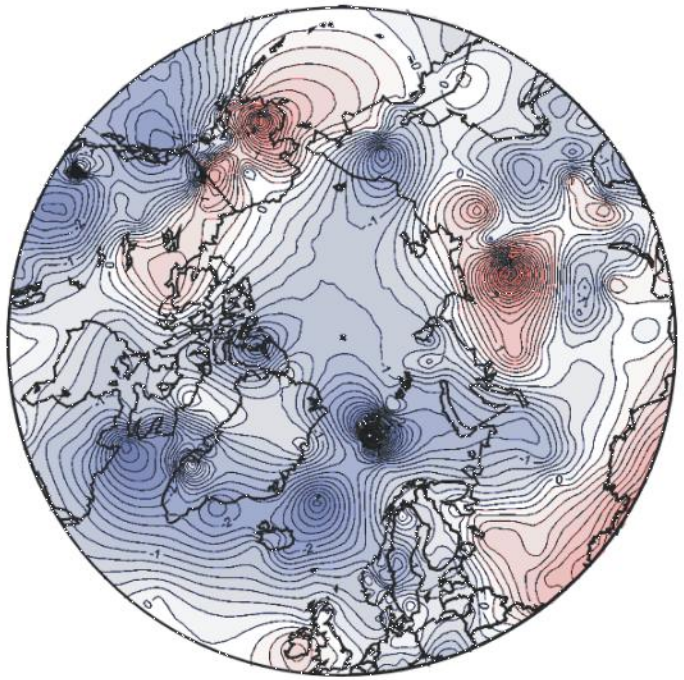
JJA

Change
1960-1970

Running 5-yr means;
data 1958-1962 and 1968-1972

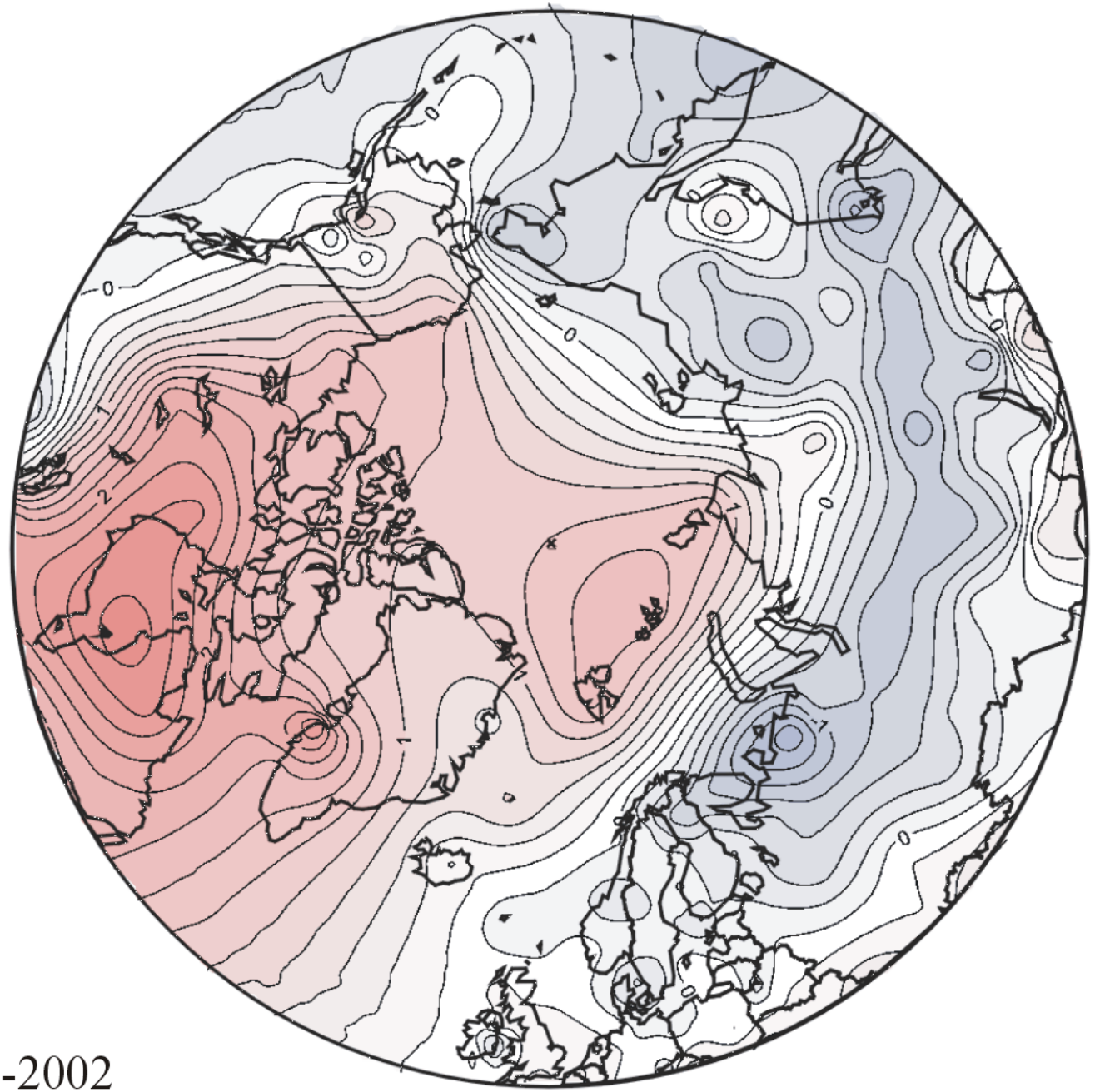


MAM

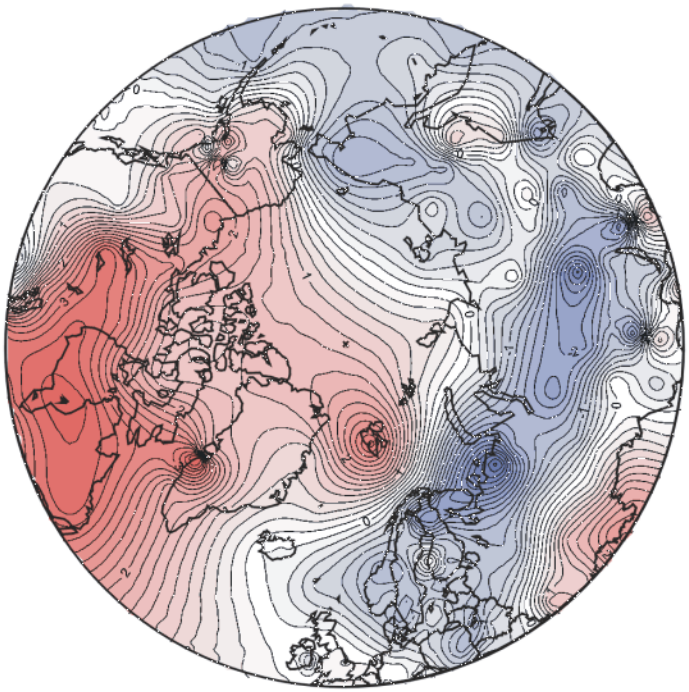


SON

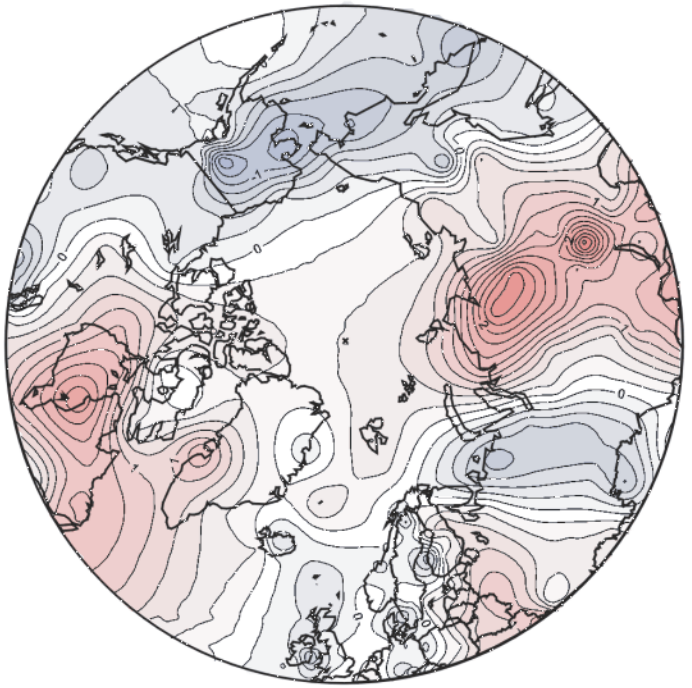
MAAT change 1990-2000



Running 5-yr means;
data 1988-1992 and 1998-2002



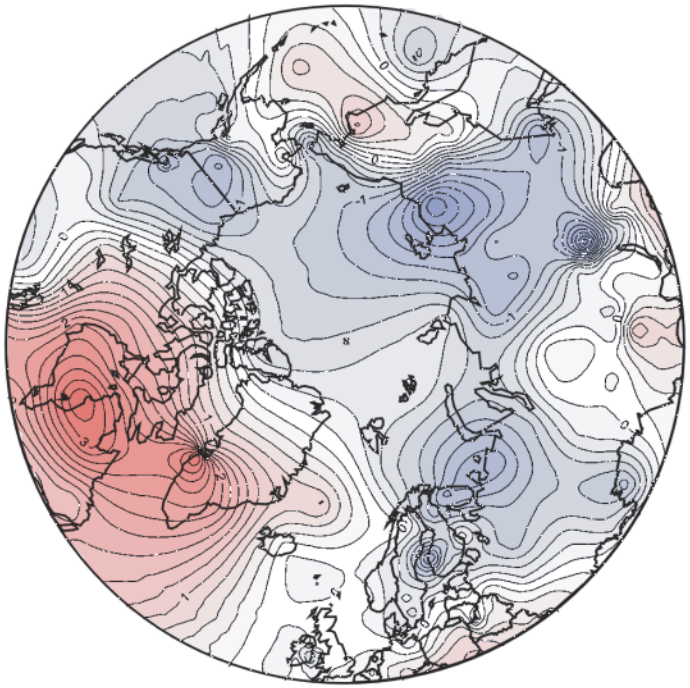
DJF



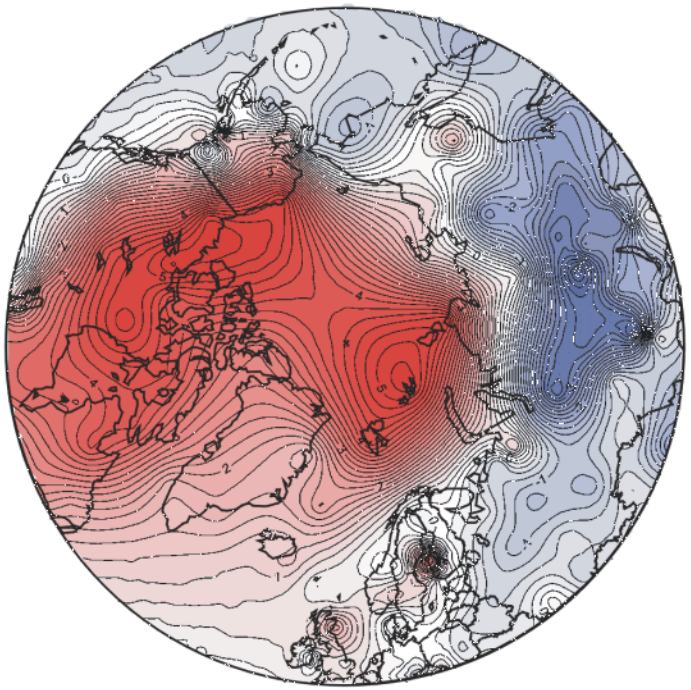
JJA

Change
1990-2000

Running 5-yr means;
data 1988-1992 and 1998-2002



MAM



SON

How will geomorphological processes respond to climatic changes ?

Geohazards

Geohazards are geomorphological processes in action

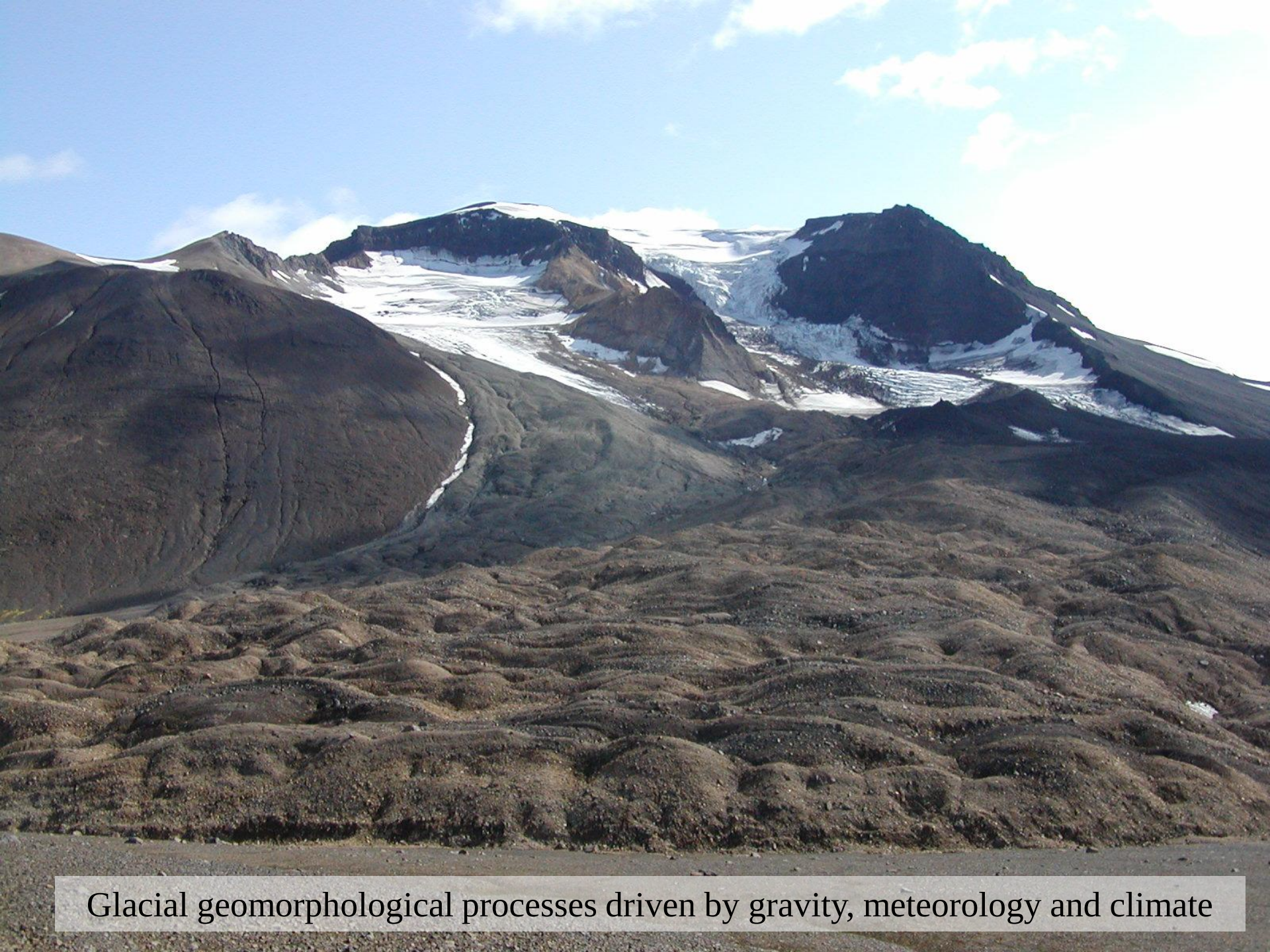

Another type of geohazard


Geomorphological processes driven by wind

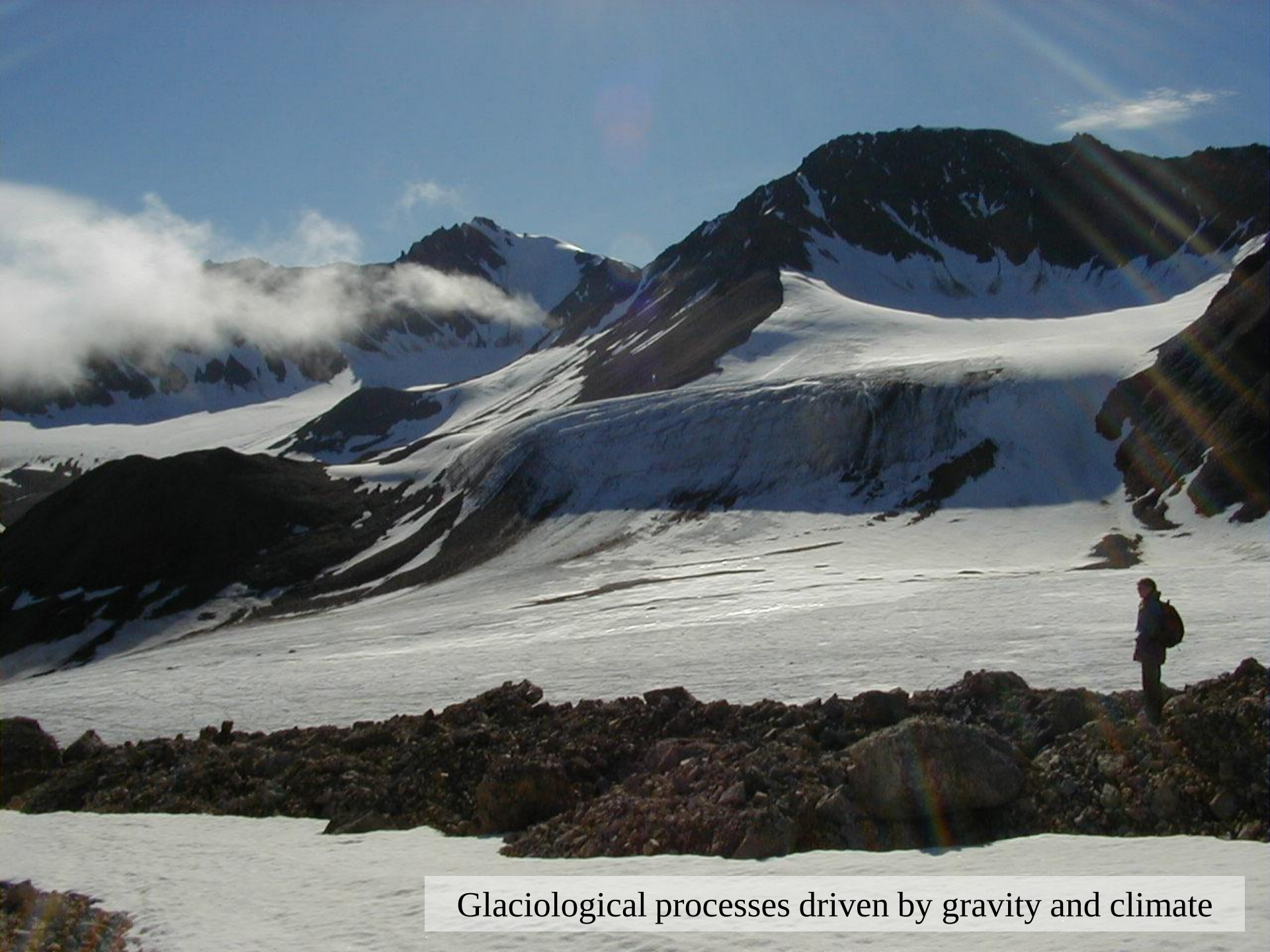
Geomorphological processes driven by gravity, thaw and freezing

Geomorphological processes driven by gravity and rain


Geomorphological processes driven by gravity and rain



Glacial geomorphological processes driven by gravity, meteorology and climate



Glaciological processes driven by gravity and climate

Next time:

Permafrost and active layer