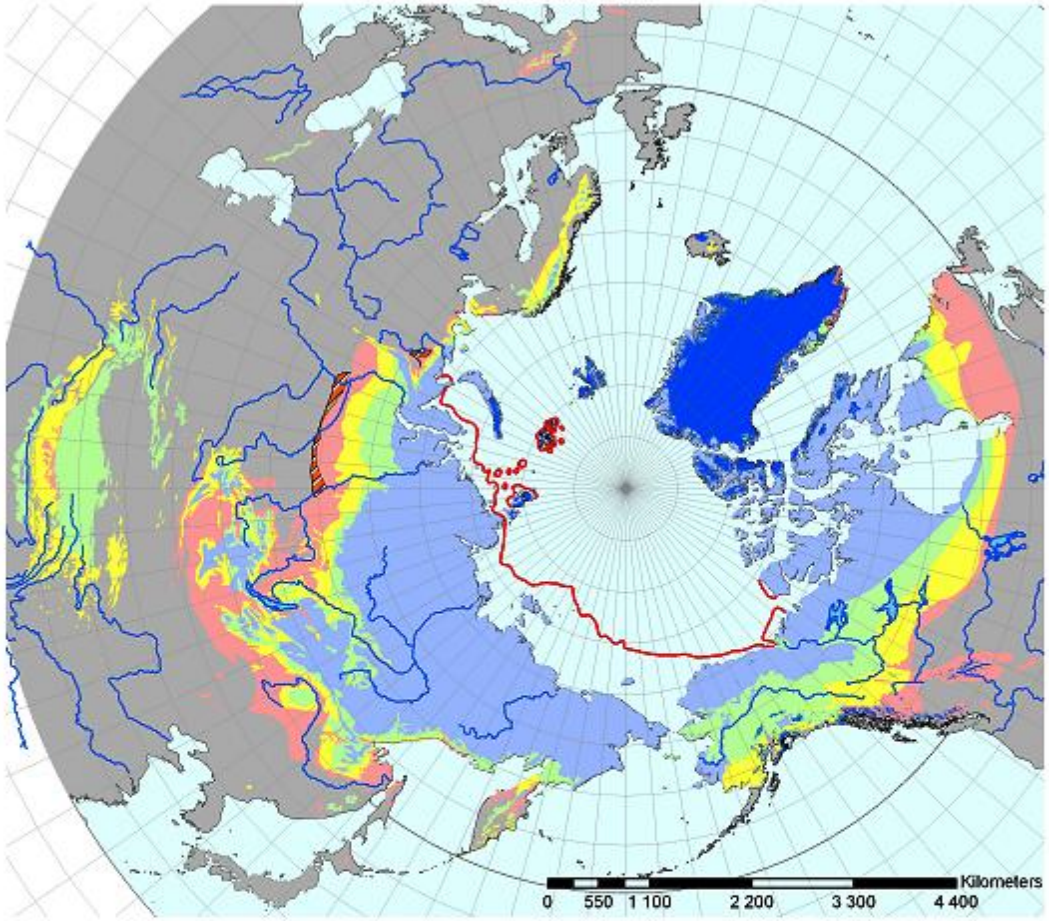
Arctic and Antarctic warming and permafrost thaw (observed and projected changes)

Vladimir Romanovsky

University of Alaska Fairbanks

Circumpolar permafrost extent

Permafrost Lab., GI UAF, 2003



Legend

Permafrost extent

- Continious (90-100% of area)
- Discontinious (50-90% of area)
- Sporadic (10-50% of area)
- Isolated (0-10% of area)

Subsea cryosphere

- Subsea permafrost limit
- Relict permafrost

Geograpic objects

- Glaciers
- Lakes
- Ocean and Seas
- Land
- Rivers
- 10 x 10 Degree Graticule

This map was prepared by using an electronic version of the "Circum-Arctic Map of Permafrost and Ground-Ice Condition", J.Brown, O.J. Ferrians, Jr., J.A. Heginbottom, & E.S.Melnikov, 1997, U.S.Geological Survey, ISBN 0-607-88745-1.

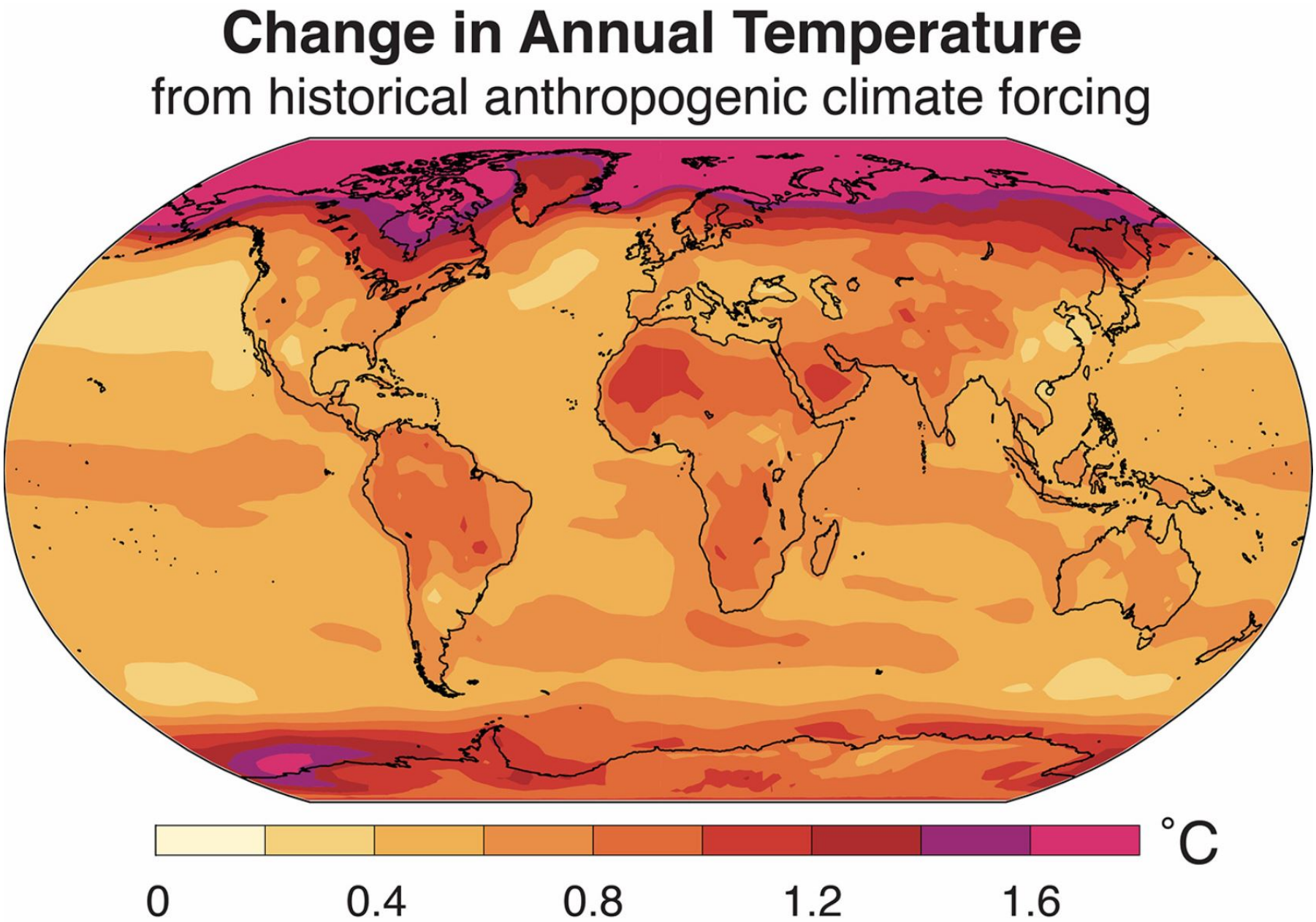
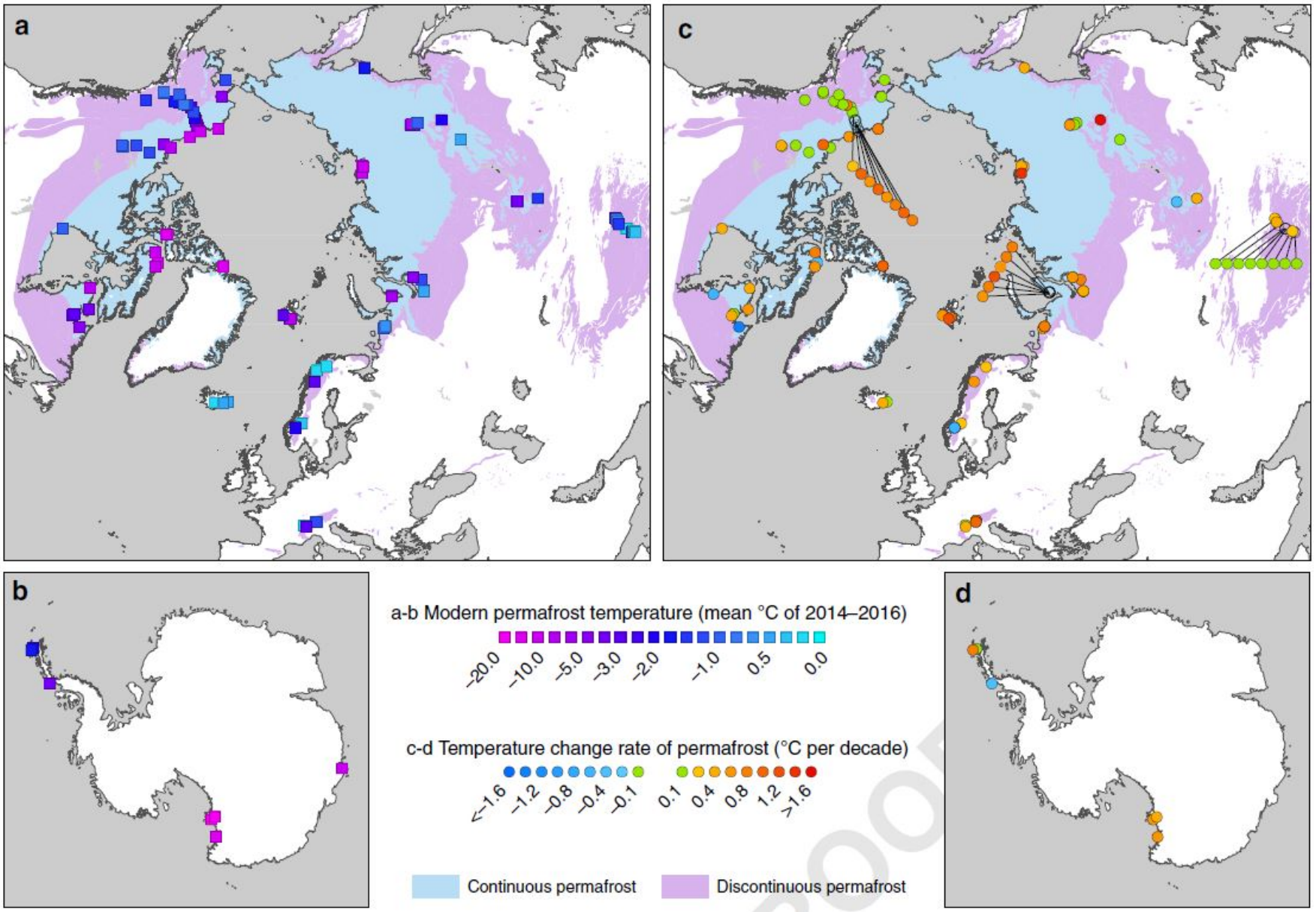
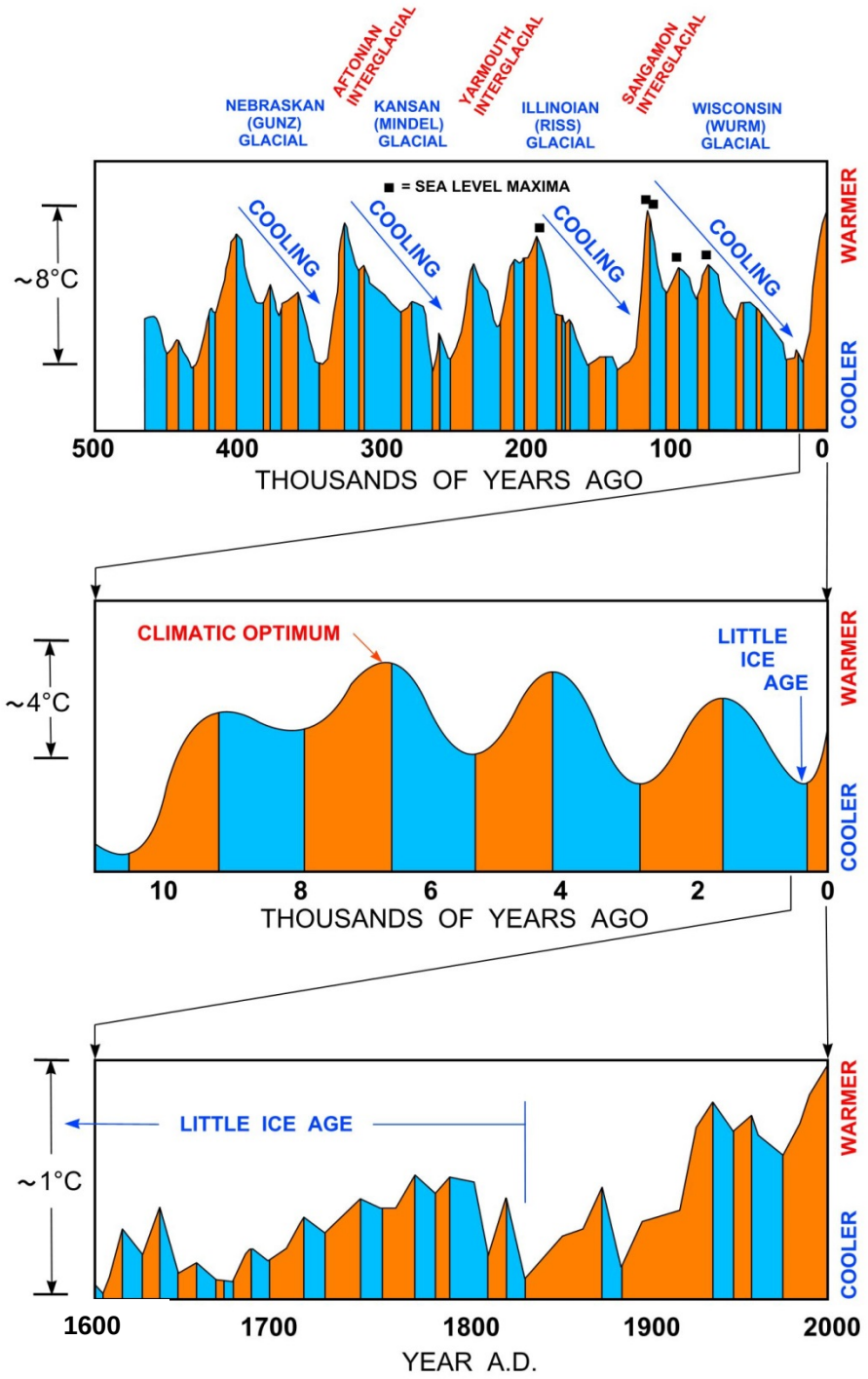
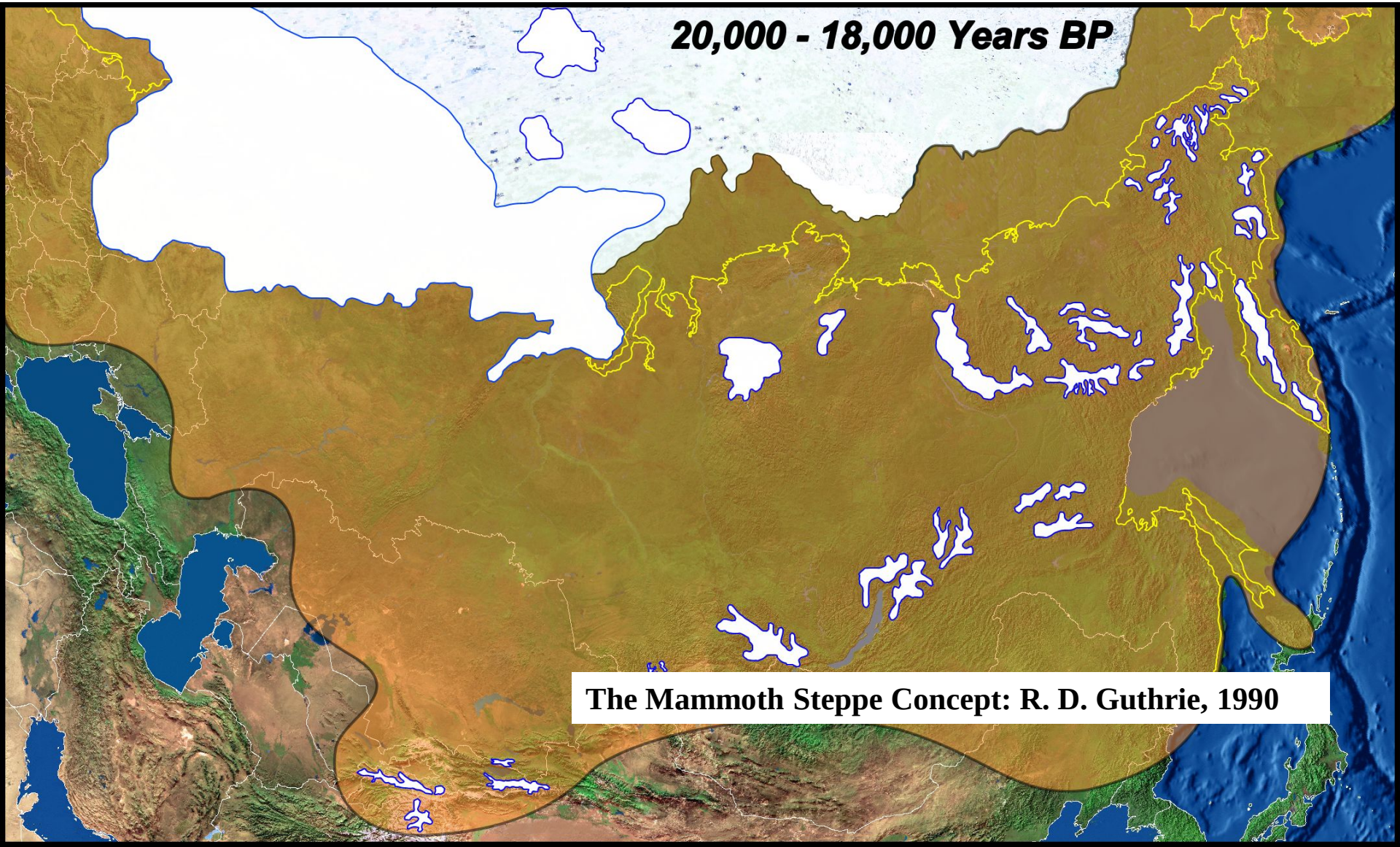


Image credit: Noah Diffenbaugh and Marshall Burke, 2018



Biskaborn et al., 2017


NEBRASKAN (GUNZ) GLACIAL
AFTONIAN INTERGLACIAL
KANSAN (MINDEL) GLACIAL
YARMOUTH INTERGLACIAL
ILLINOIAN (RISS) GLACIAL
SANGAMON INTERGLACIAL
WISCONSIN (WURM) GLACIAL
■ = SEA LEVEL MAXIMA
COOLING
COOLING
COOLING
COOLING
~8°C
WARMER
COOLER
500
400
300
200
100
0
THOUSANDS OF YEARS AGO
CLIMATIC OPTIMUM
LITTLE ICE AGE
~4°C
WARMER
COOLER
10
8
6
4
2
0
THOUSANDS OF YEARS AGO
LITTLE ICE AGE
~1°C
WARMER
COOLER
1600
1700
1800
1900
2000
YEAR A.D.


20,000 - 18,000 Years BP
The Mammoth Steppe Concept: R. D. Guthrie, 1990


The Mammoth Steppe Concept: R. D. Guthrie, 1990

Dan Mann holds the skull of a steppe bison that died on Alaska's North Slope more than 40,000 years ago.

Photo by Pam Groves

Bison Bob a big discovery on the North Slope

By Ned Rozell

Ice Wedges

Photo by M. Grigoriev

Photo by M. Grigoriev

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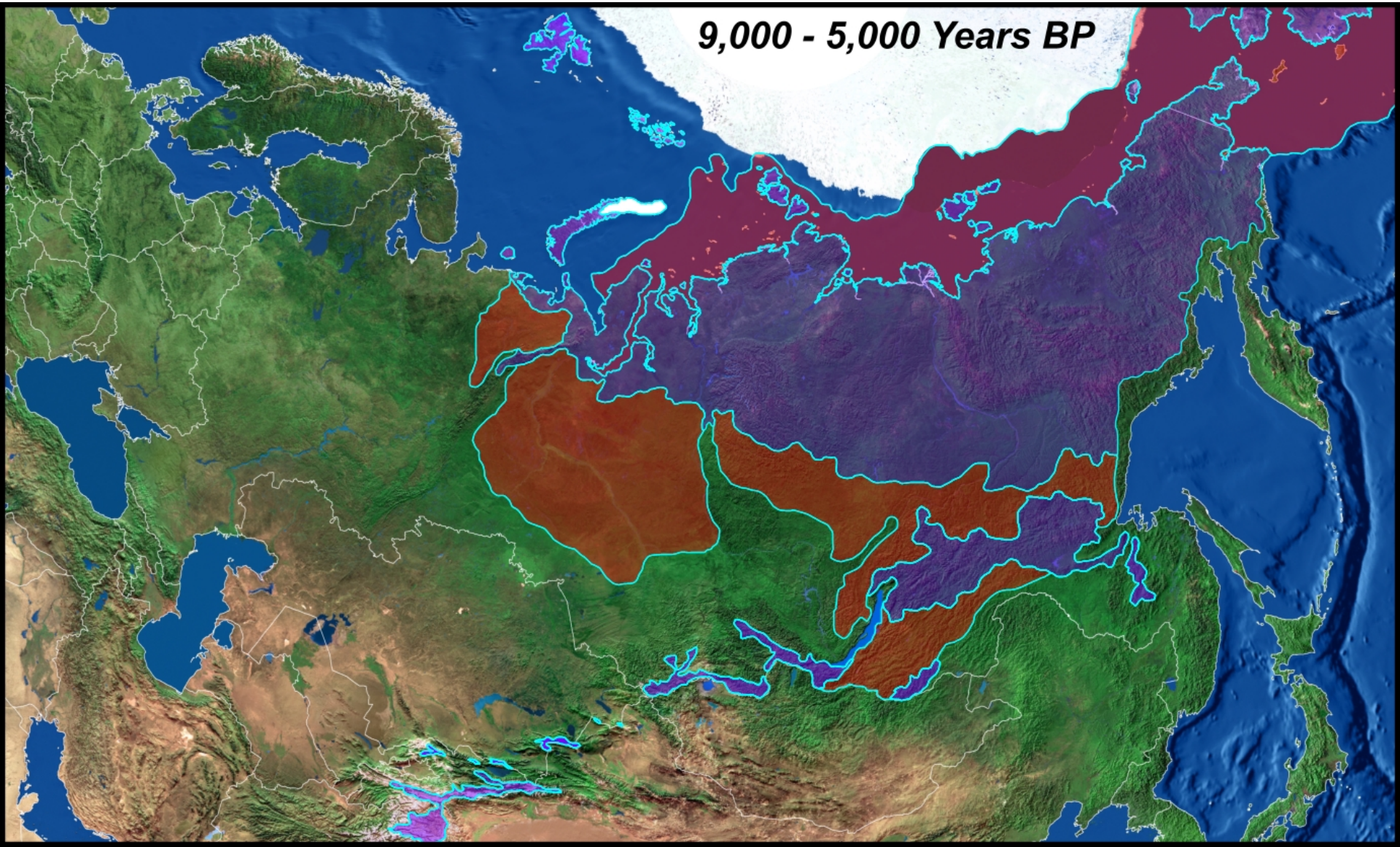
Permafrost Laboratory
Geophysical Institute - University of Alaska Fairbanks



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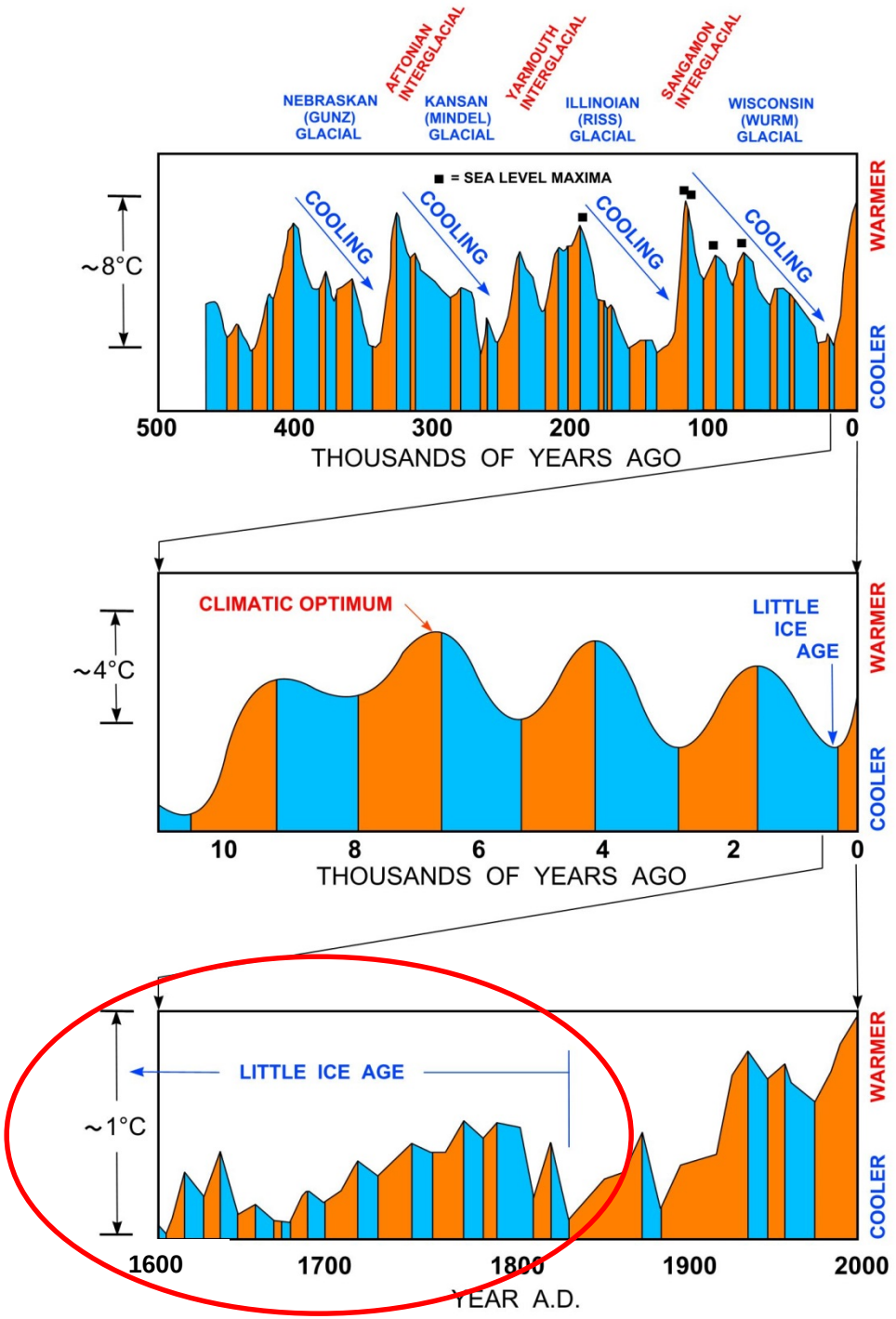
NEBRASKAN (GUNZ) GLACIAL
AFTONIAN INTERGLACIAL
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YARMOUTH INTERGLACIAL
ILLINOIAN (RISS) GLACIAL
SANGAMON INTERGLACIAL
WISCONSIN (WURM) GLACIAL
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COOLING
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COOLING
COOLING
~8°C
WARMER
COOLER
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THOUSANDS OF YEARS AGO
CLIMATIC OPTIMUM
LITTLE ICE AGE
~4°C
WARMER
COOLER
10
8
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4
2
0
THOUSANDS OF YEARS AGO
LITTLE ICE AGE
~1°C
WARMER
COOLER
1600
1700
1800
1900
2000
YEAR A.D.

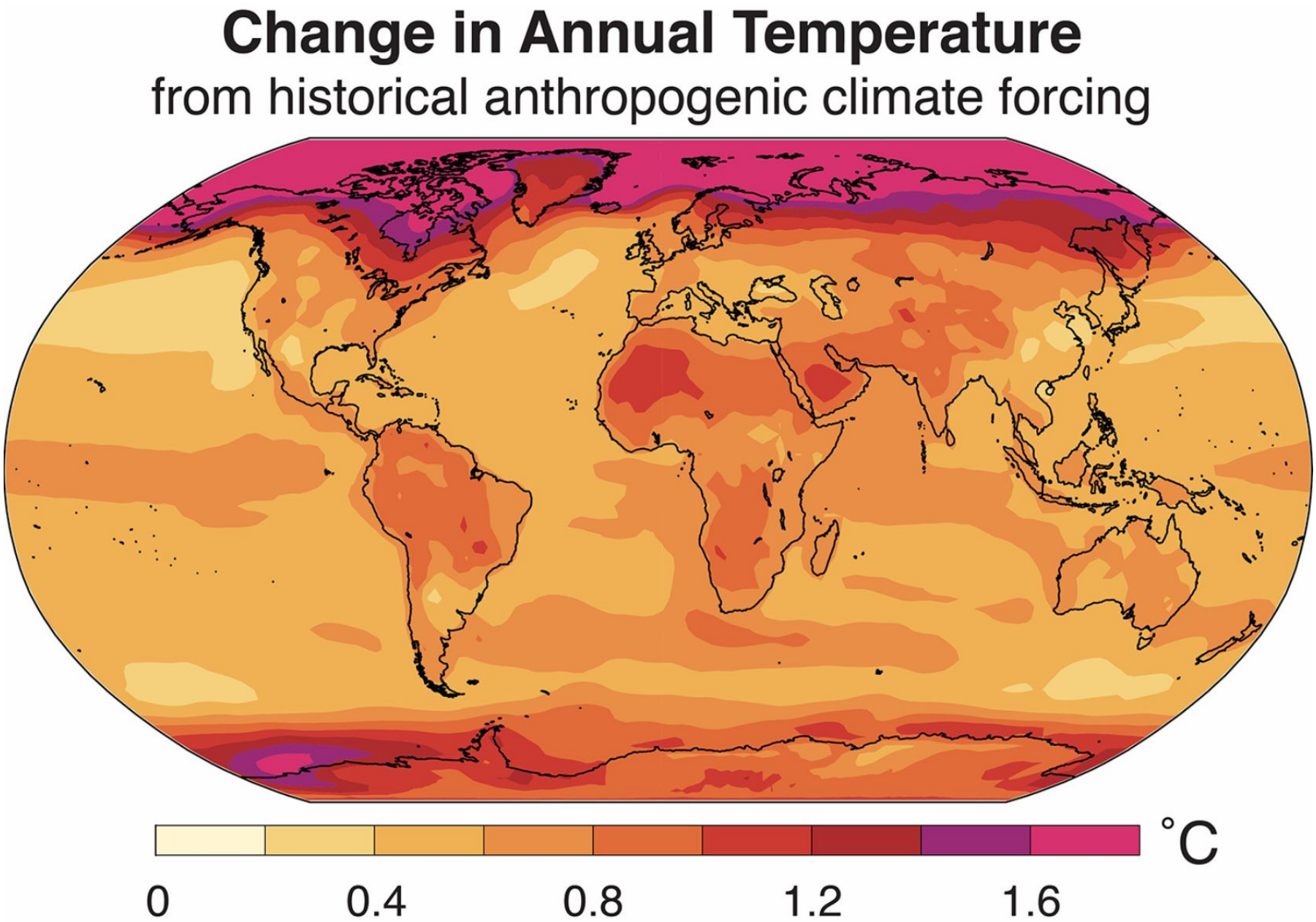
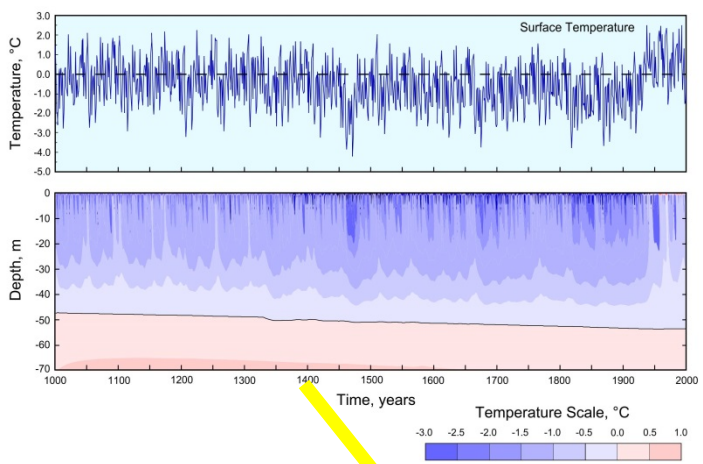
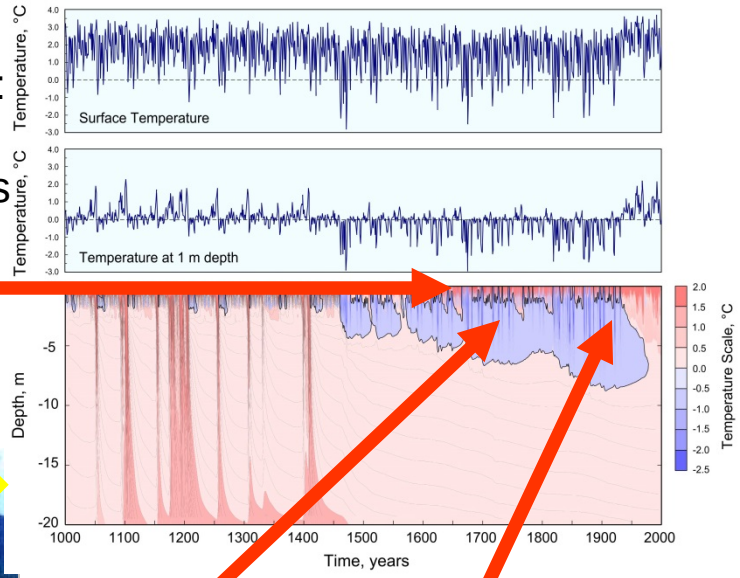


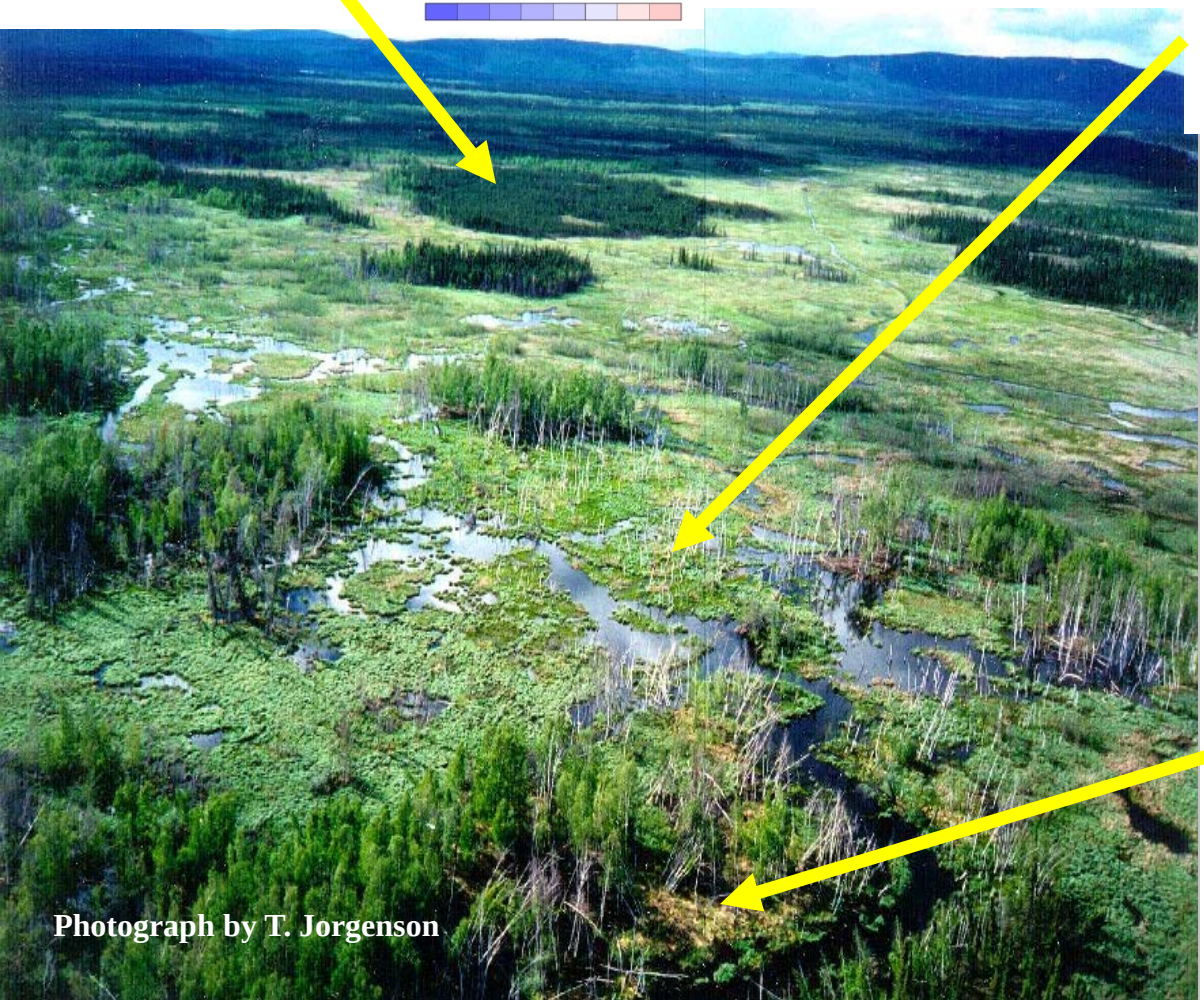
Image credit: Noah Diffenbaugh and Marshall Burke, 2018

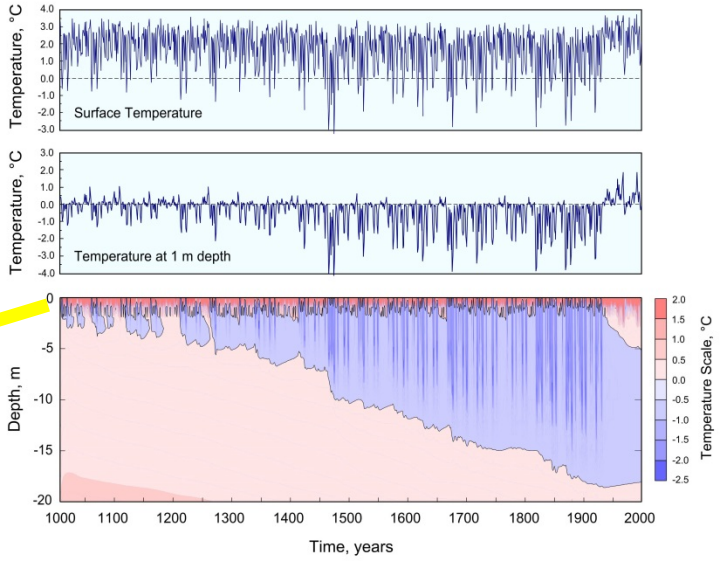


T. Jorgenson et al., 2001: "Permafrost aggradation and the change from fens to forests occurred in the late 1600s."

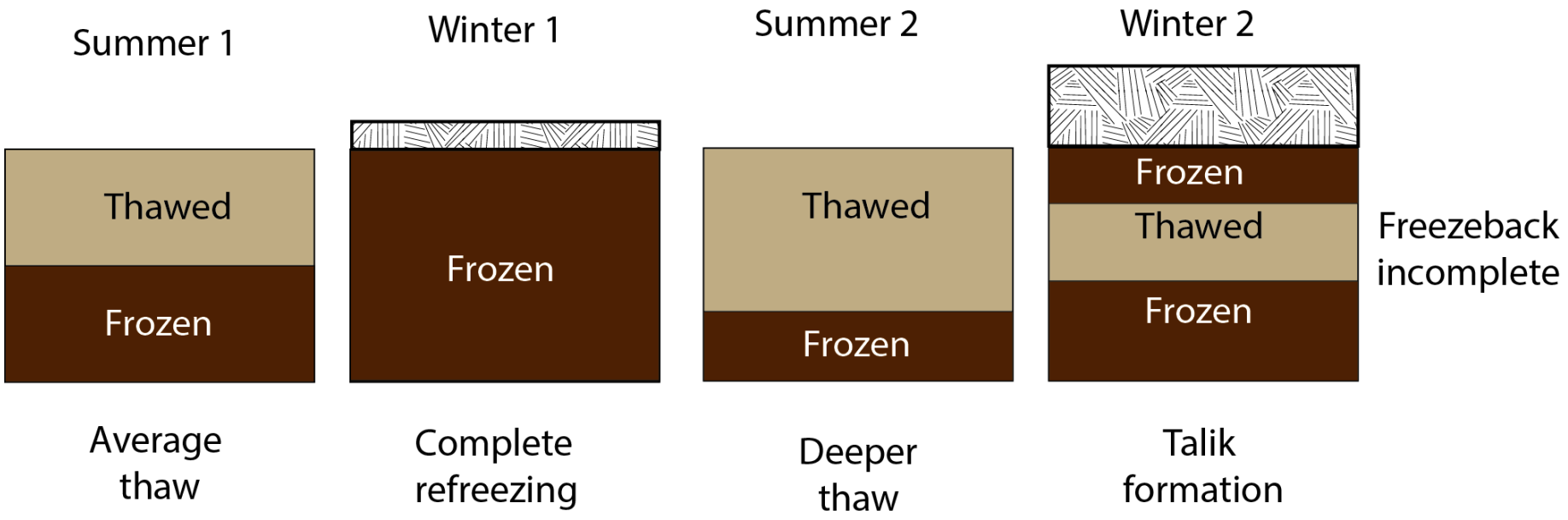


"Permafrost degradation began in the mid-1700s and is associated with periods with relatively warm climate during the mid-late 1700s and 1900s"



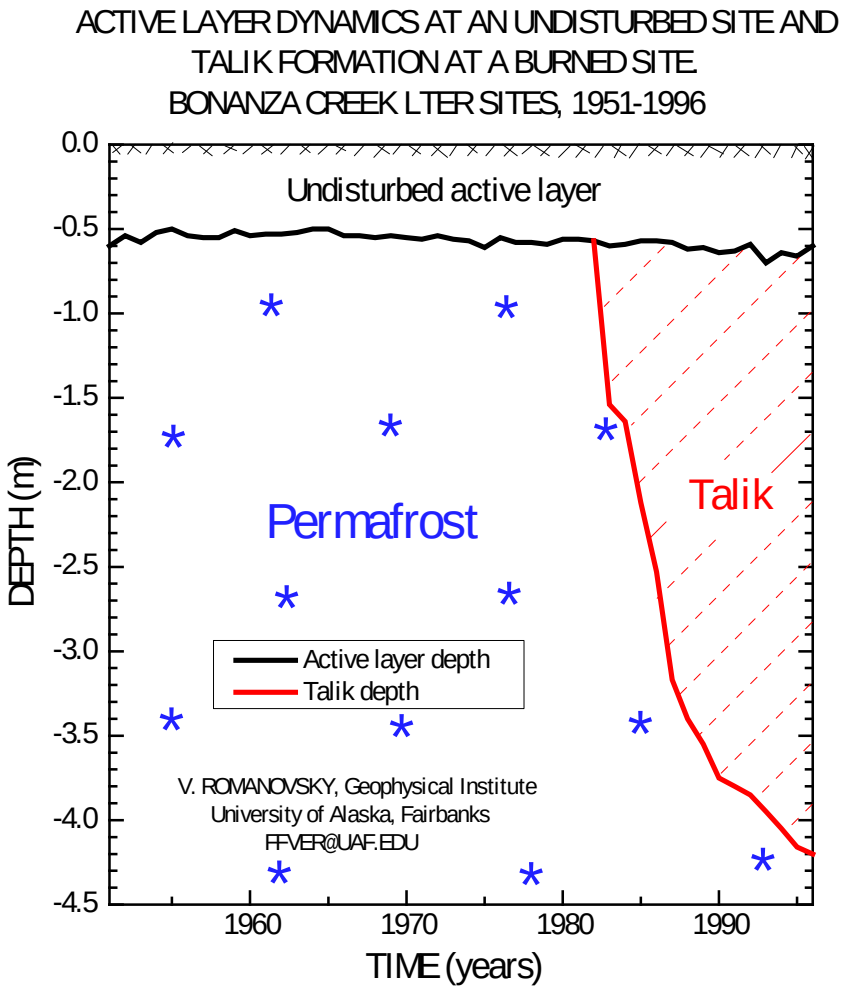


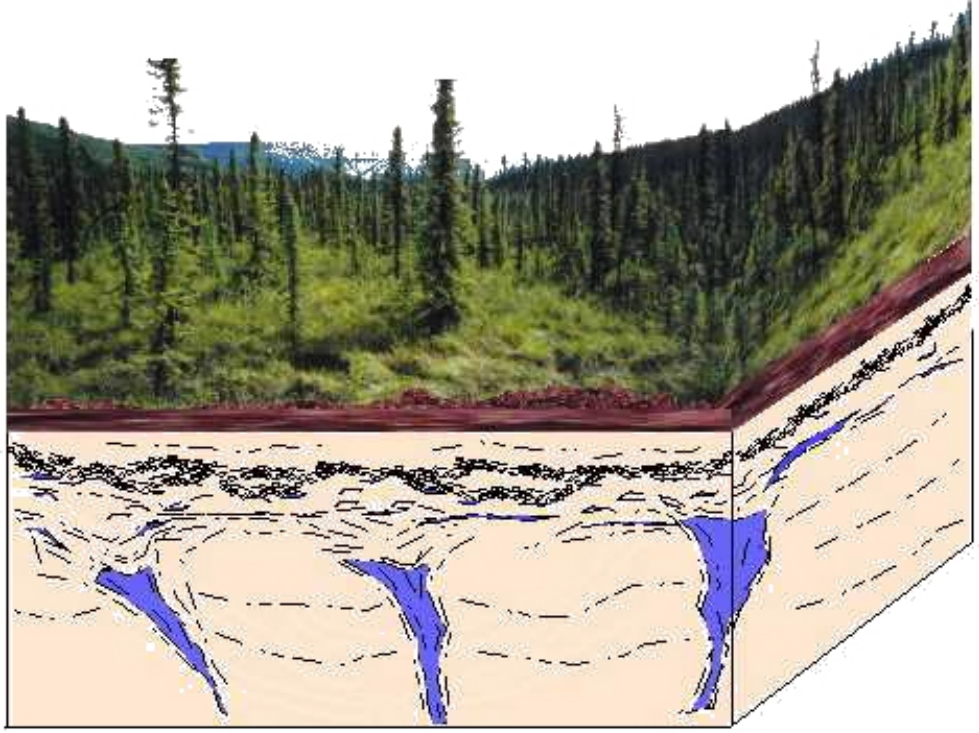
How would the formation of taliks influence Soil Carbon?

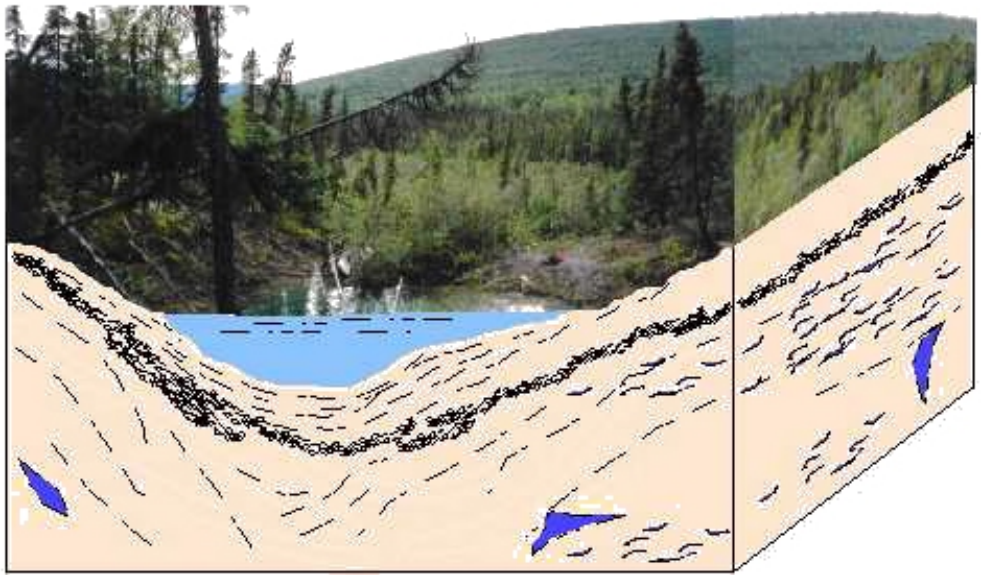


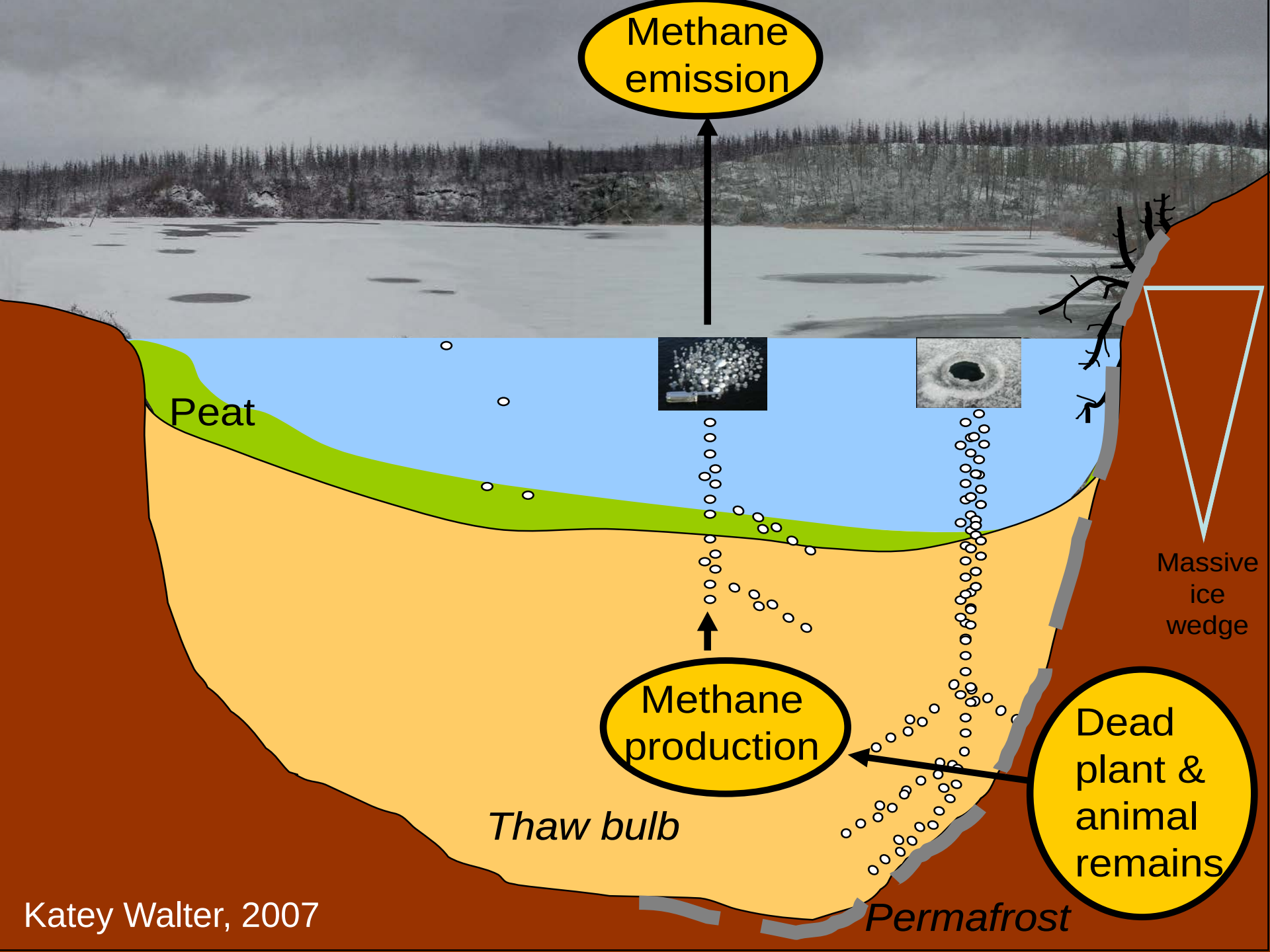
- Increase in decomposition period (entire year vs. just the summer)
- Increase in soil temperature during the summer (by several deg. C)
- Changes in soil moisture – complicated: generally drying on the slopes and increase in moisture/oversaturation in low-laying areas/depressions

Abrupt Permafrost Thaw


ACTIVE LAYER DYNAMICS AT AN UNDISTURBED SITE AND
TALIK FORMATION AT A BURNED SITE.
BONANZA CREEK LTER SITES, 1951-1996
Undisturbed active layer
Permafrost
Talik
Active layer depth
Talik depth
V. ROMANOVSKY, Geophysical Institute
University of Alaska, Fairbanks
FFVER@UAF.EDU
DEPTH (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
1960
1970
1980
1990
TIME (years)






Methane emission
Peat
Massive ice wedge
Methane production
Dead plant & animal remains
Thaw bulb
Permafrost
Katey Walter, 2007

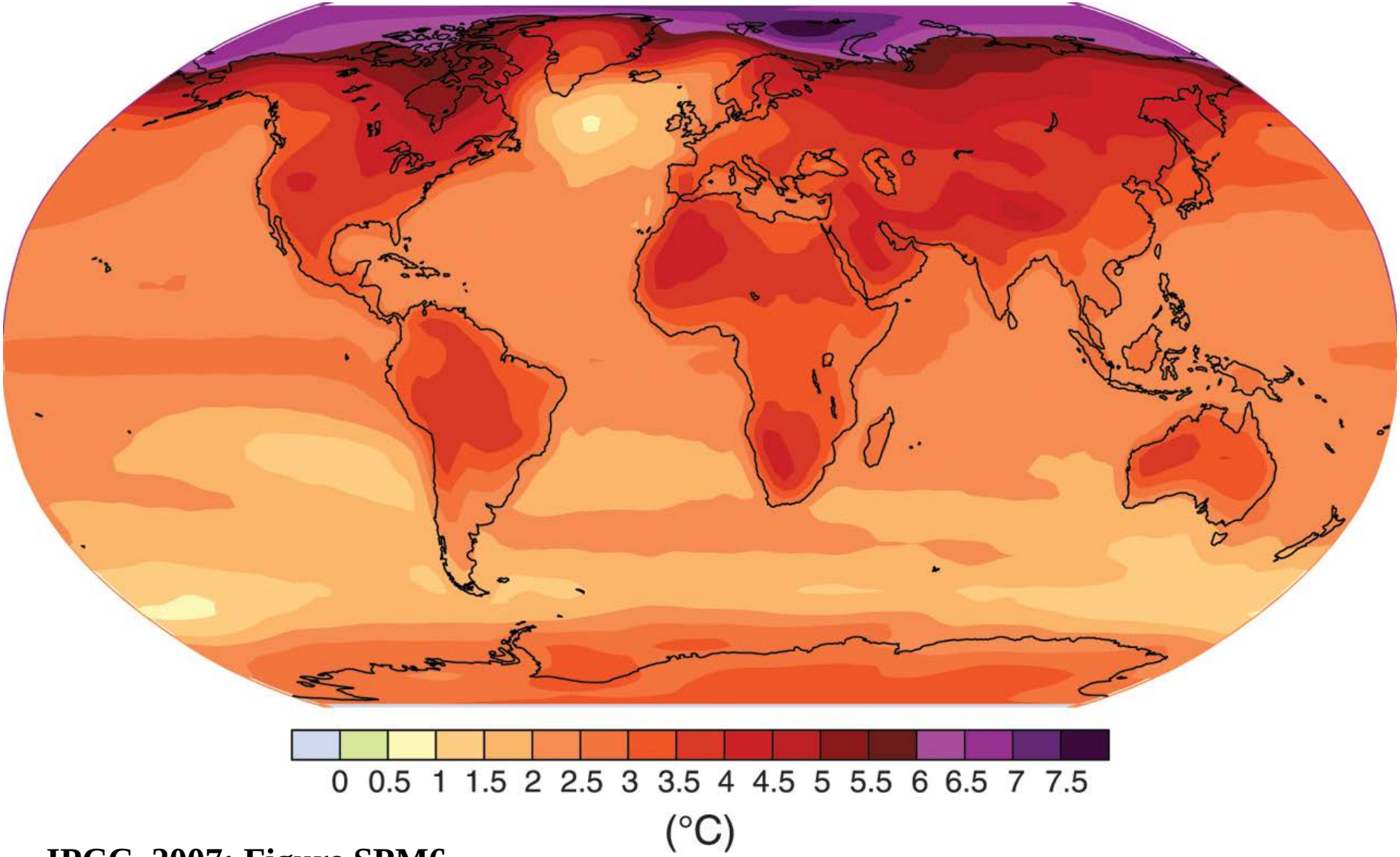
Thawing permafrost and melting ice lenses are adding turbidity to the Wulik River

Retrogressive thaw slumps, west coast of Baldwin Peninsula, Alaska, June 2010 (Photos: G. Grosse, GIPL UAF)

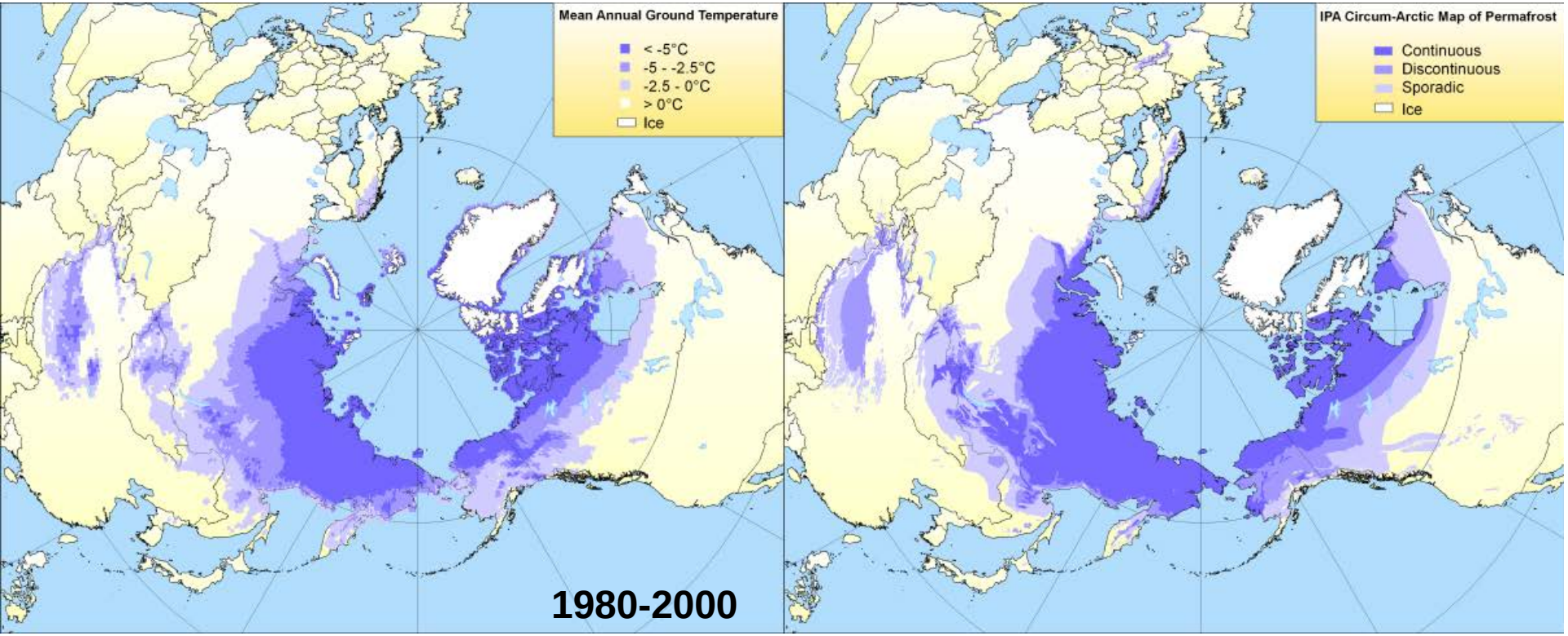
Cryostratigraphy of late Pleistocene syngenetic permafrost (yedoma) in northern Alaska, Itkillik River exposure

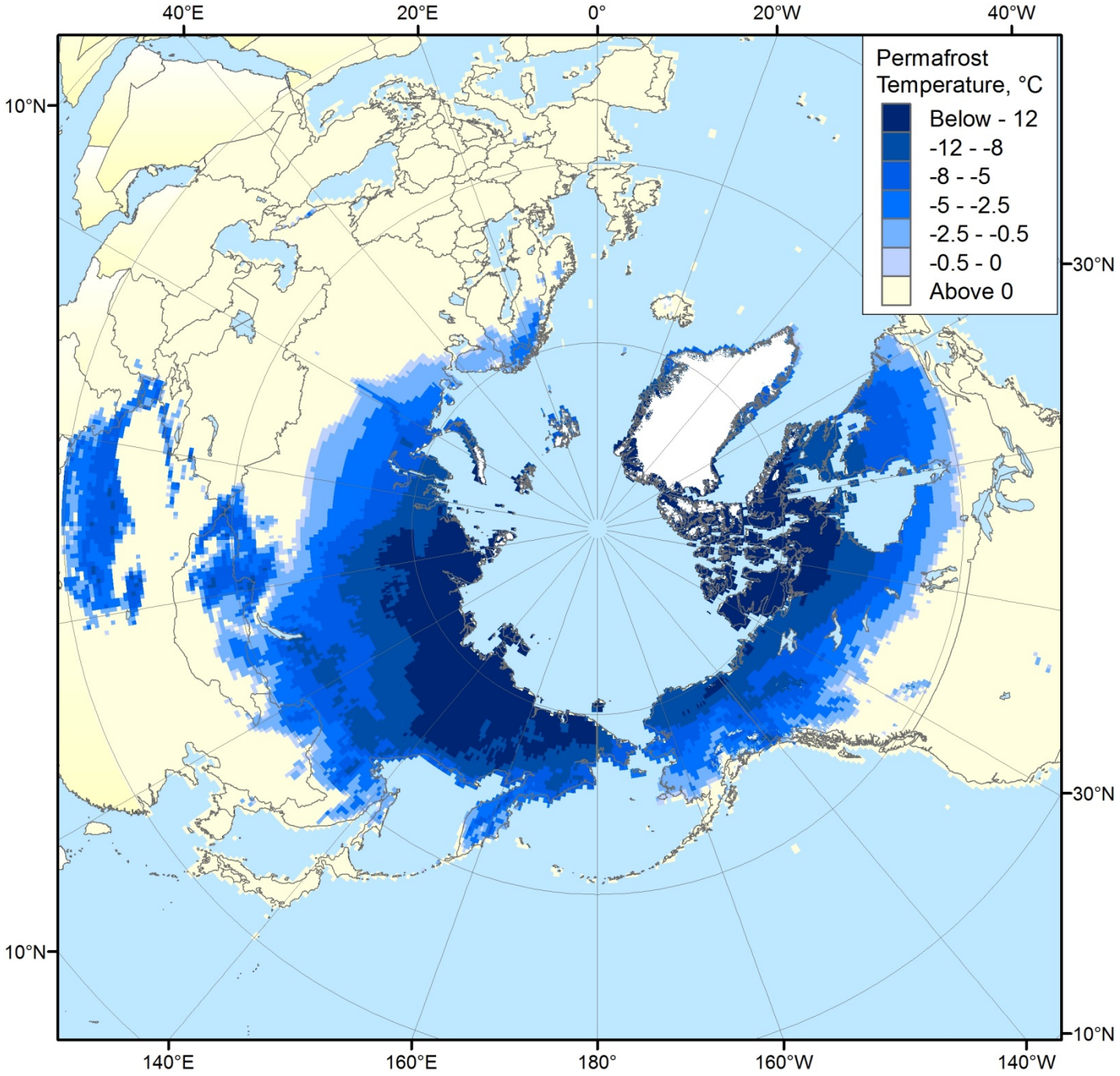
M. Kanevskiy [a,*], Y. Shur [a], D. Fortier [a,b], M.T. Jorgenson [a,c], E. Stephani [a]

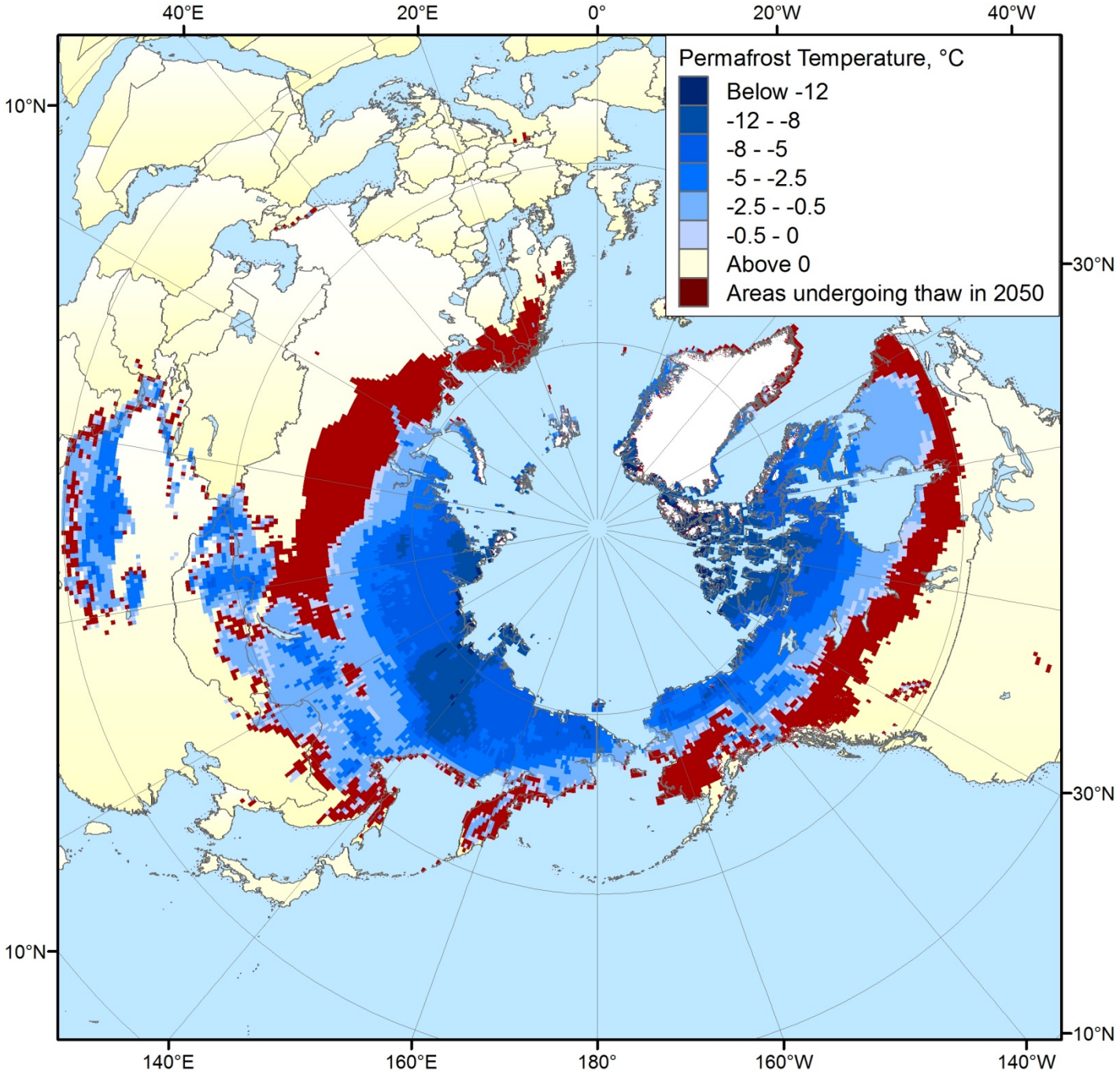
Projected surface air temperature (2090-2099 relative to 1980-1999)

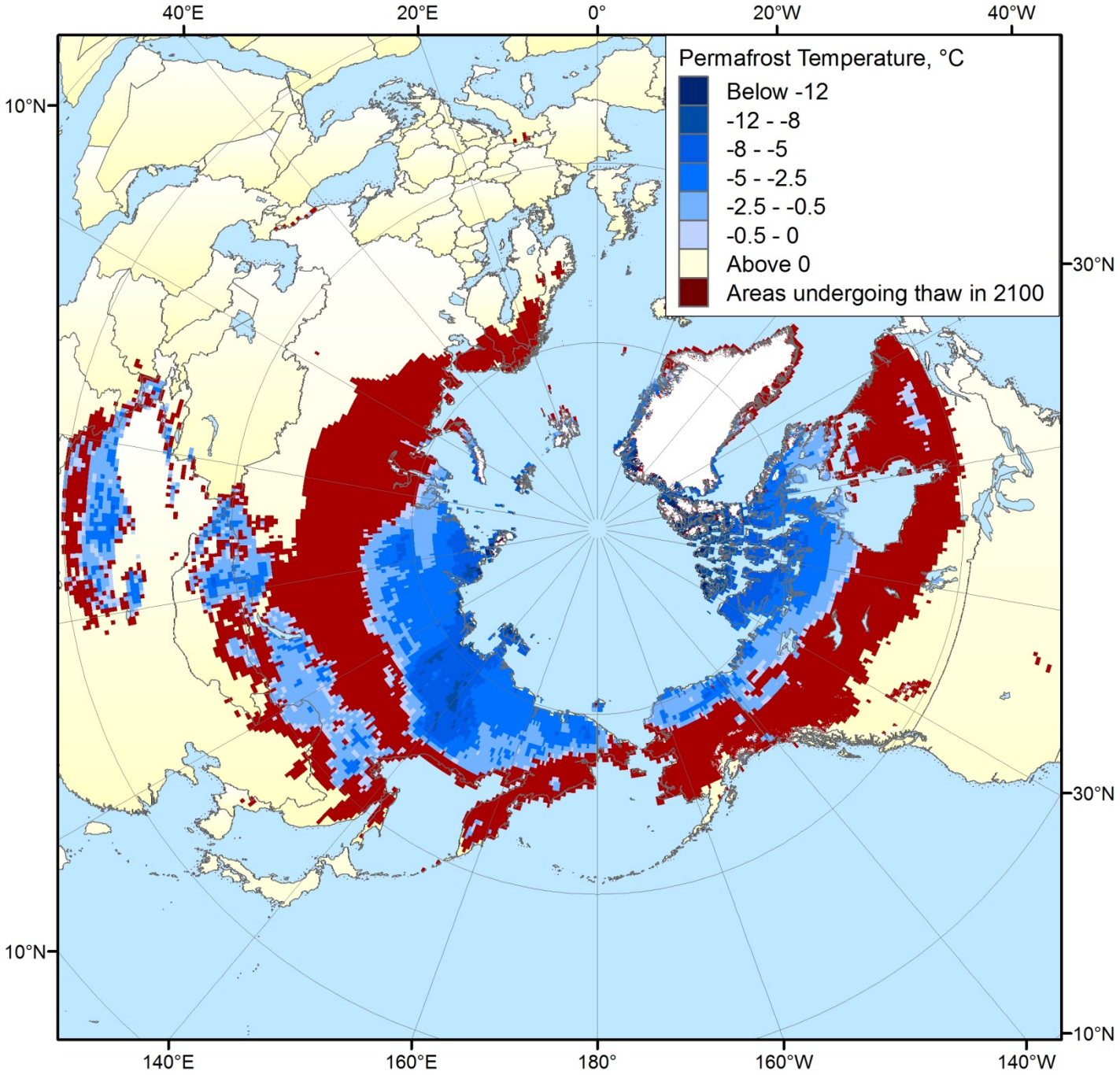


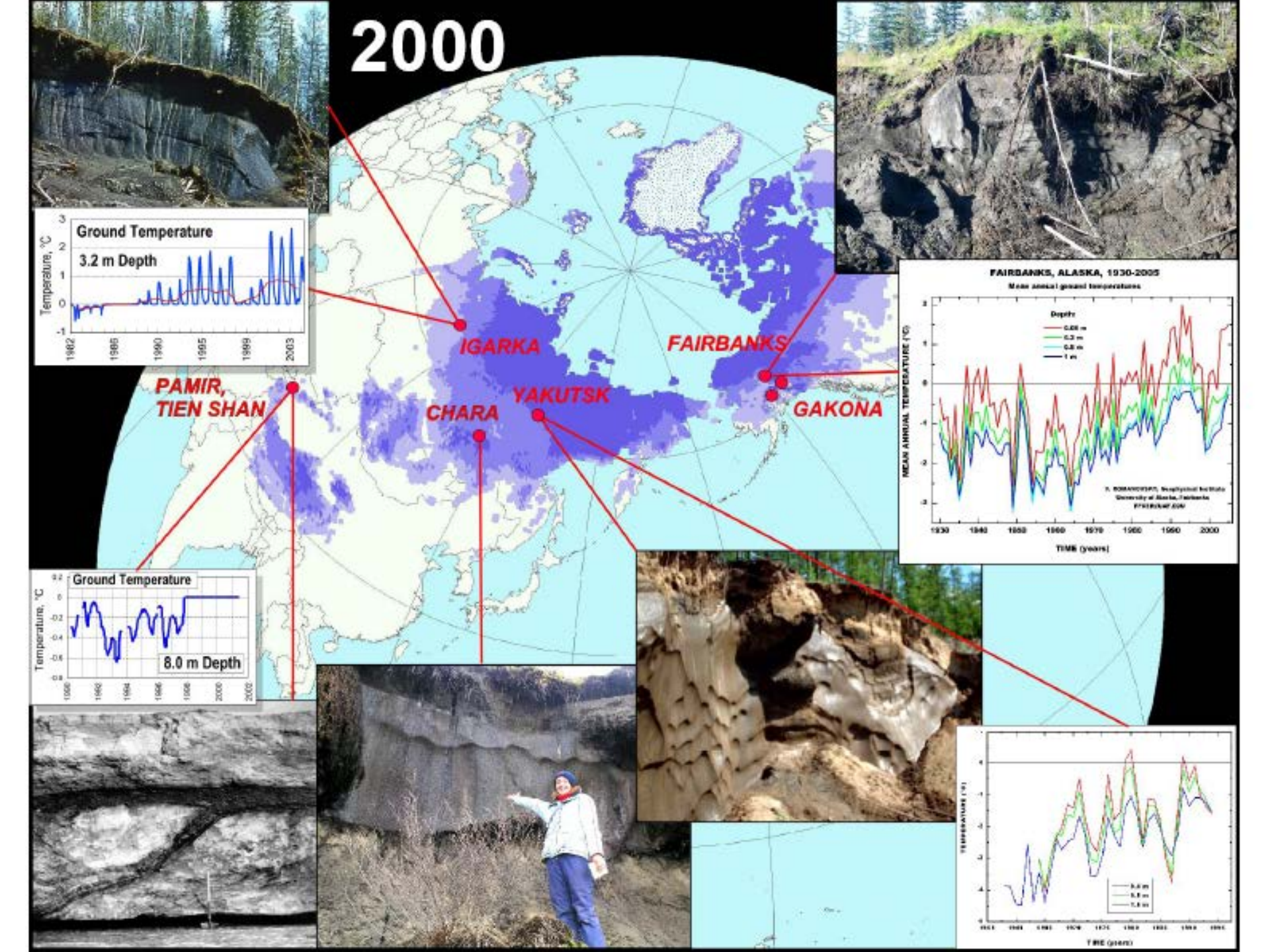
IPCC, 2007; Figure SPM6

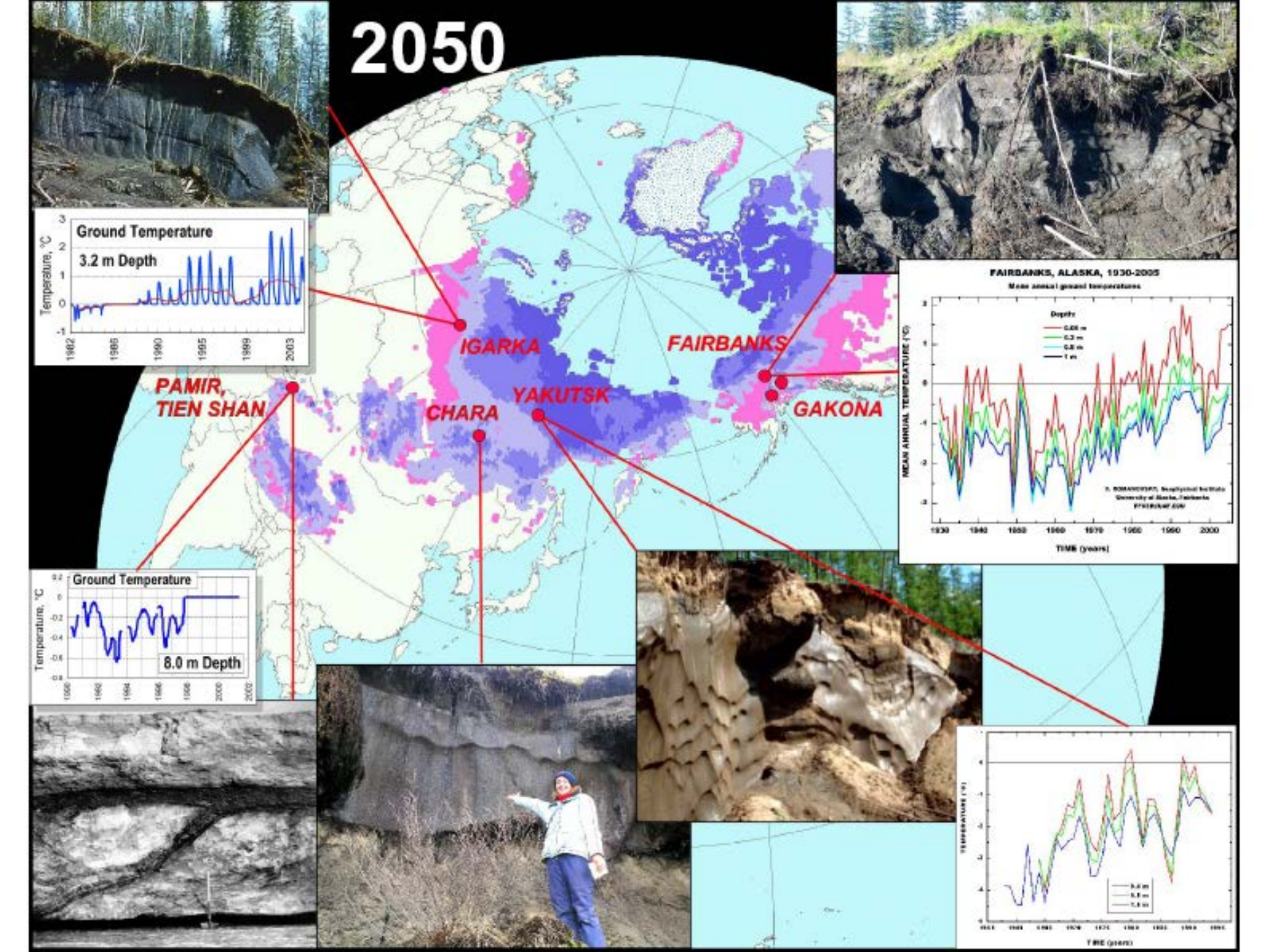

Mean Annual Ground Temperature
< -5°C
-5 - -2.5°C
-2.5 - 0°C
> 0°C
Ice
IPA Circum-Arctic Map of Permafrost
Continuous
Discontinuous
Sporadic
Ice
1980-2000

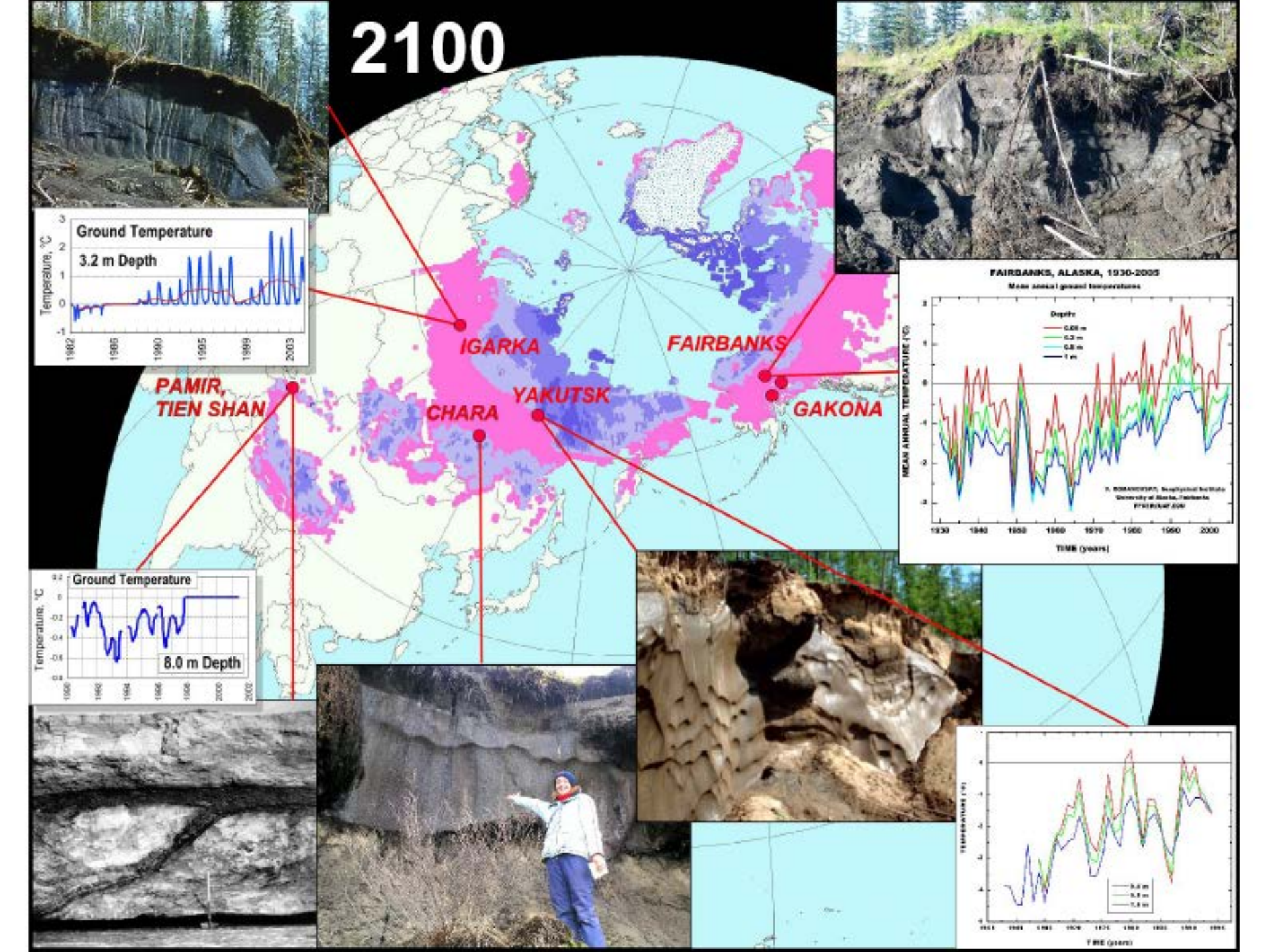

40°E
20°E
0°
20°W
40°W
10°N
30°N
30°N
10°N
140°E
160°E
180°
160°W
140°W
Permafrost
Temperature, °C
Below - 12
-12 - -8
-8 - -5
-5 - -2.5
-2.5 - -0.5
-0.5 - 0
Above 0


40°E
20°E
0°
20°W
40°W
10°N
30°N
Permafrost Temperature, °C
Below -12
-12 - -8
-8 - -5
-5 - -2.5
-2.5 - -0.5
-0.5 - 0
Above 0
Areas undergoing thaw in 2050
140°E
160°E
180°
160°W
140°W

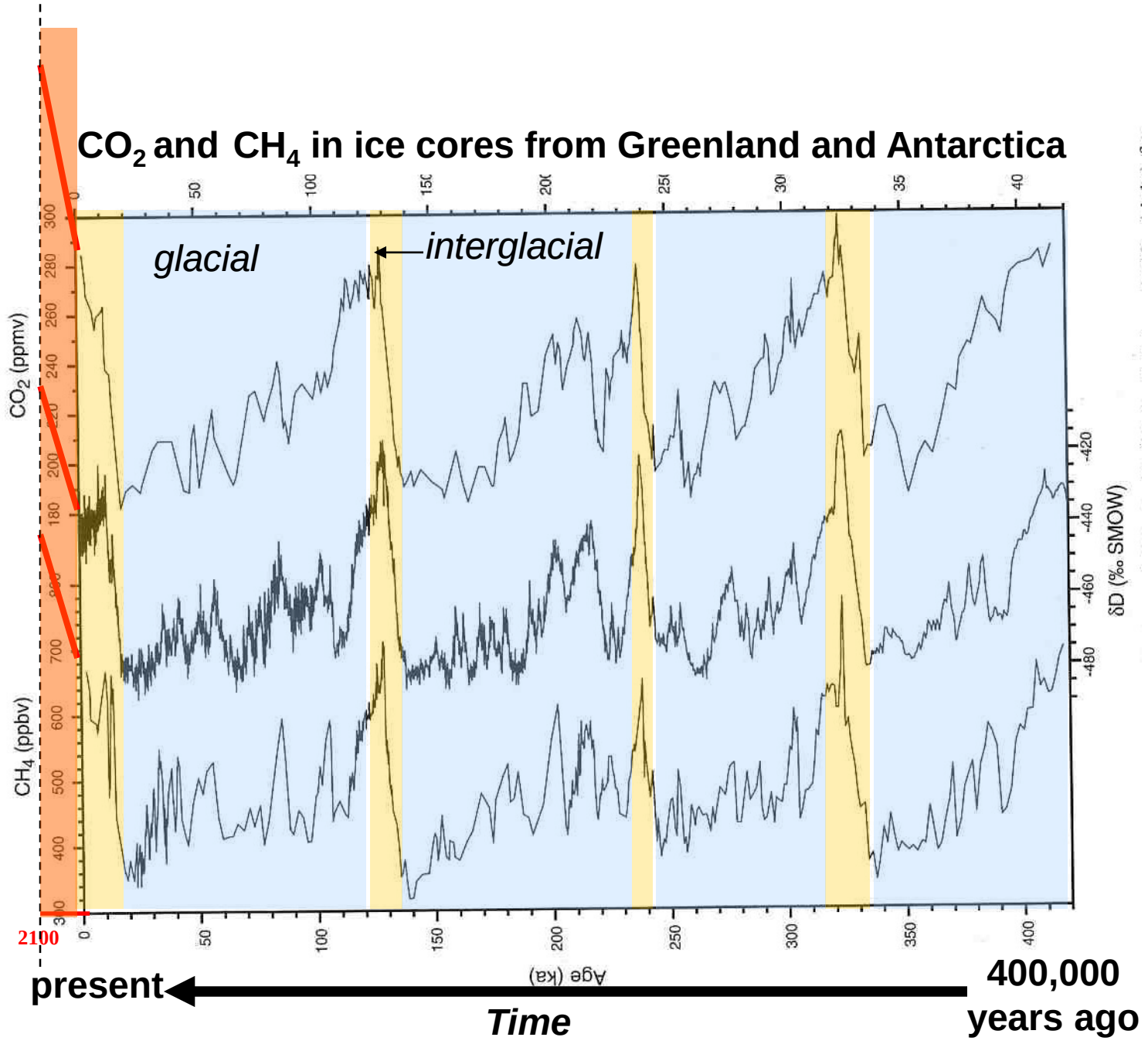

40°E
20°E
0°
20°W
40°W
10°N
30°N
30°N
10°N
140°E
160°E
180°
160°W
140°W
Permafrost Temperature, °C
Below -12
-12 - -8
-8 - -5
-5 - -2.5
-2.5 - -0.5
-0.5 - 0
Above 0
Areas undergoing thaw in 2100


2000
Ground Temperature
3.2 m Depth
Temperature, °C
IGARKA
FAIRBANKS
PAMIR,
TIEN SHAN
YAKUTSK
CHARA
GAKONA
FAIRBANKS, ALASKA, 1930-2005
Mean annual ground temperatures
MEAN ANNUAL TEMPERATURE (°C)
TIME (years)
Ground Temperature
8.0 m Depth
Temperature, °C


2050
Ground Temperature
3.2 m Depth
Temperature, °C
IGARKA
FAIRBANKS
PAMIR,
TIEN SHAN
YAKUTSK
CHARA
GAKONA
FAIRBANKS, ALASKA, 1930-2005
Mean annual ground temperatures
MEAN ANNUAL TEMPERATURE (°C)
TIME (years)
Ground Temperature
8.0 m Depth
Temperature, °C

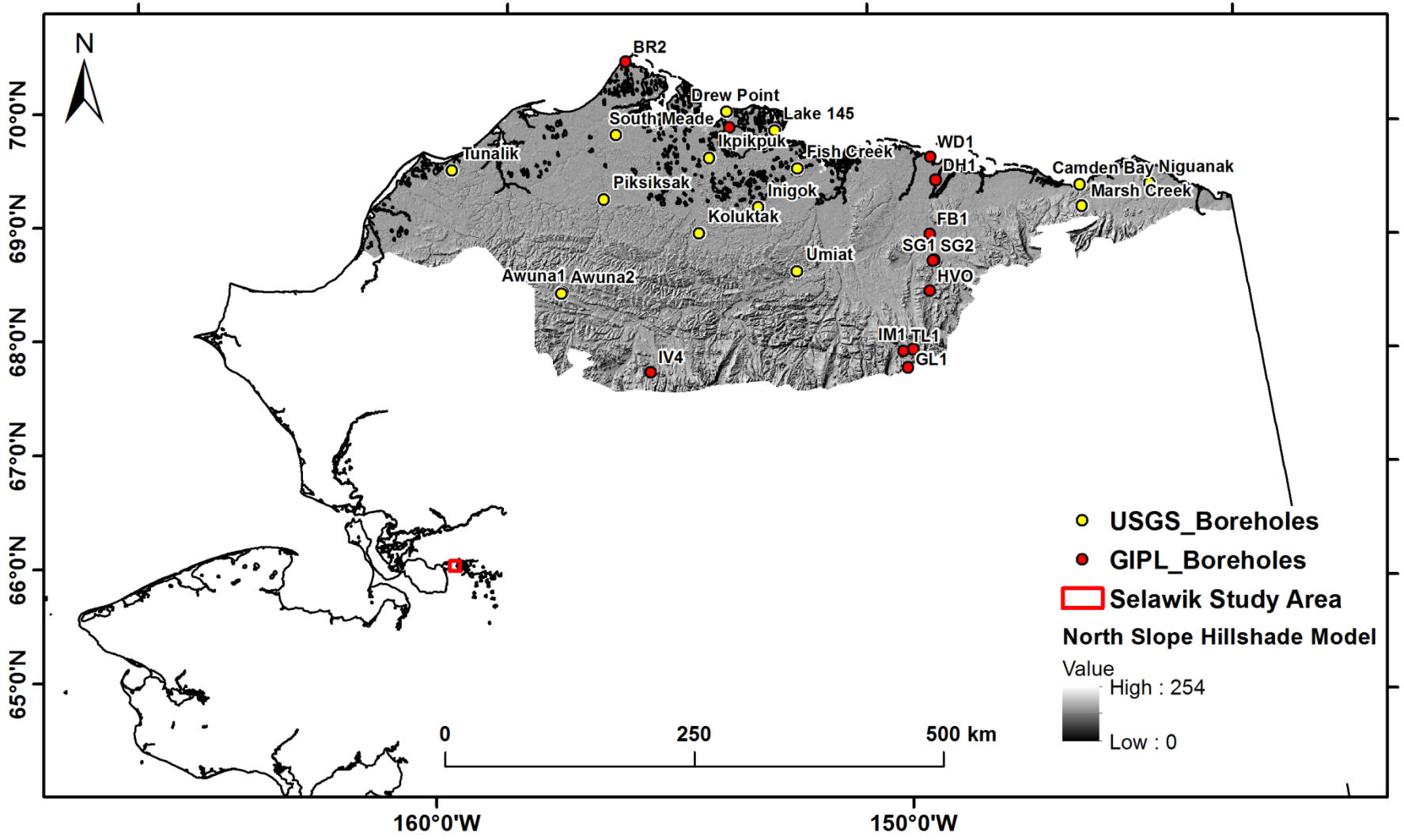

2100
Ground Temperature
3.2 m Depth
Temperature, °C
IGARKA
FAIRBANKS
PAMIR,
TIEN SHAN
YAKUTSK
CHARA
GAKONA
FAIRBANKS, ALASKA, 1930-2005
Mean annual ground temperatures
MEAN ANNUAL TEMPERATURE (°C)
TIME (years)
Ground Temperature
8.0 m Depth
Temperature, °C

?

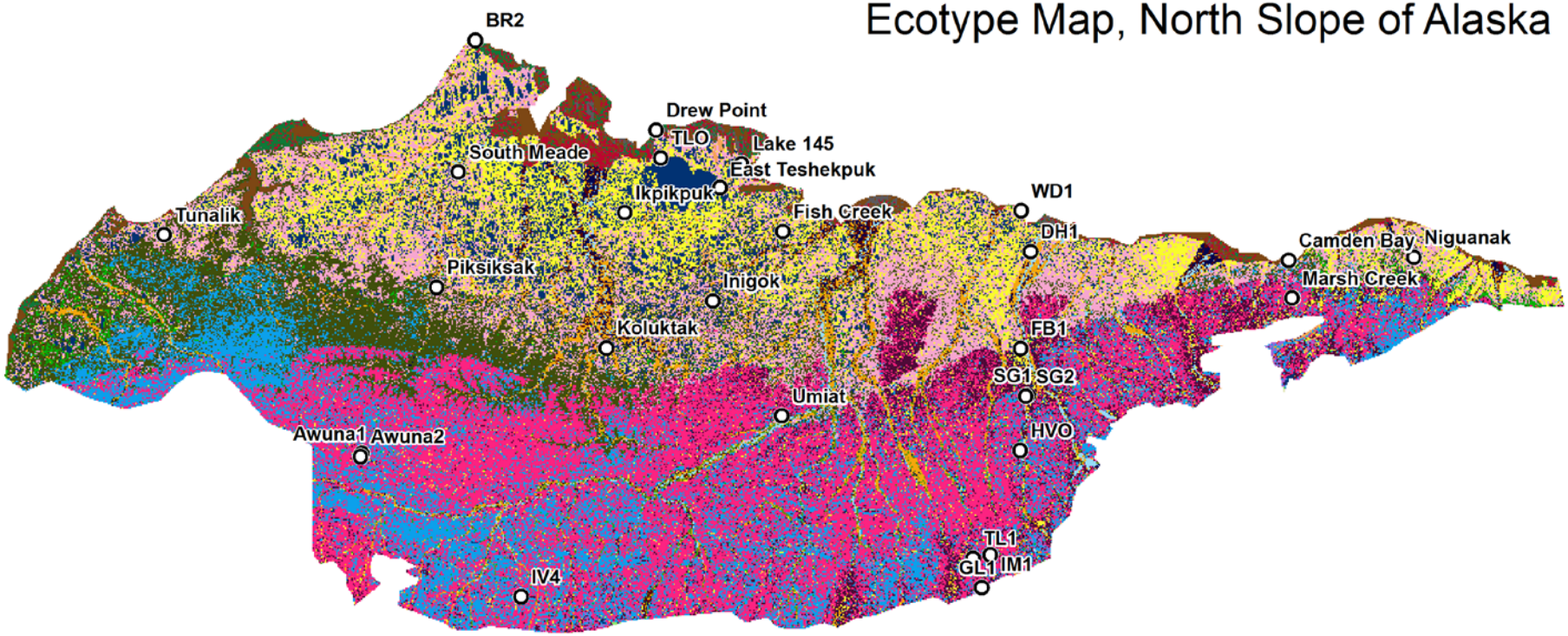

CO2 and CH4 in ice cores from Greenland and Antarctica
glacial
interglacial
CO2 (ppmv)
CH4 (ppbv)
δD (‰ SMOW)
Age (ka)
2100
present
400,000
years ago
Time


Thank you very much !
www.permafrostwatch.org

Study Area


N
BR2
Drew Point
Lake 145
South Meade
Ikpikpuk
Tunalik
Fish Creek
WD1
DH1
Camden Bay
Niguanak
Marsh Creek
Piksiksak
Inigok
Koluktak
FB1
SG1
SG2
Umiat
Awuna1
Awuna2
HVO
IM1
TL1
GL1
IV4
70°0'N
69°0'N
68°0'N
67°0'N
66°0'N
65°0'N
160°0'W
150°0'W
0
250
500 km
USGS_Boreholes
GIPL_Boreholes
Selawik Study Area
North Slope Hillshade Model
Value
High : 254
Low : 0

Ecotype Map, North Slope of Alaska

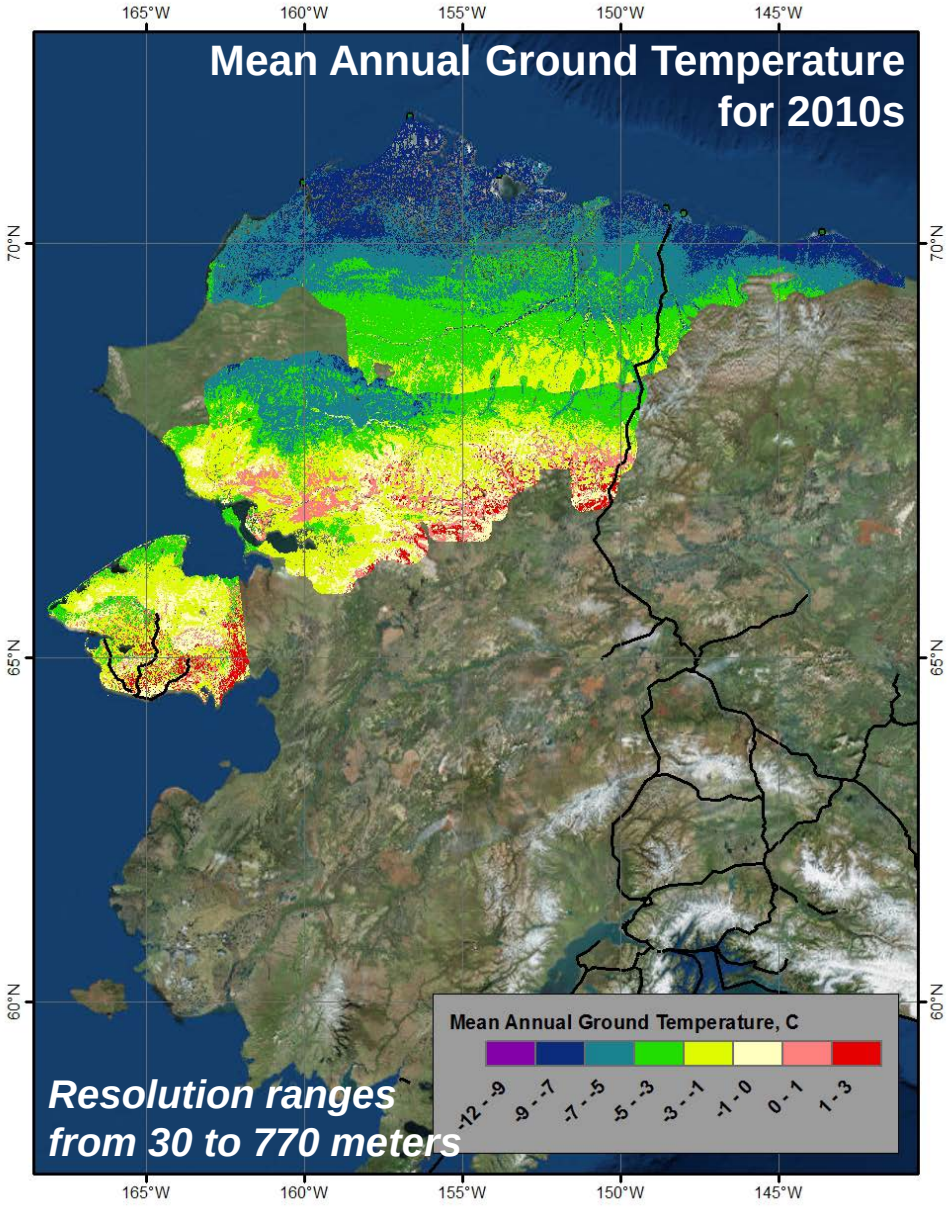


Class

- 1-Cloud, Ice (Indeterminate)
- 10-Riverine water
- 11-Riverine dwarf scrub
- 12-Lowland wet meadow (sedge tundra)
- 13-Lowland lake
- 14-Lowland moist meadow (sedge-shrub tundra)
- 15-Lowland mixed scrub (shrub-birch scrub)
- 16-Upland tussock tundra
- 17-Upland dwarf scrub tundra (Dryas tundra)
- 18-Upland shrubby tussock tundra (foothills)
- 19-Upland low scrub (shrub birch-willow tundra)
- 2-Coatal Barrens
- 20-Upland moist meadow (sedge-shrub tundra)
- 21-Upland tall scrub (alder scrub)
- 22-Alpine noncarbonate barrens
- 23-Alpine carbonate barrens
- 24-Alpine noncarbonate Dryas DST
- 25-Alpine carbonate Dryas DST
- 3-Coastal wet meadow (sedge tundra)
- 4-Coatal water
- 5-Coastal grass & DST (dwarf scrub tundra)
- 6-Riverine Barrens
- 7-Riverine low & tall scrub (scrub tundra)
- 8-Riverine moist meadow (sedge-shrub tundra)
- 9-Riverine wet meadow (sedge tundra)

Jorgenson and Heiner, 2004

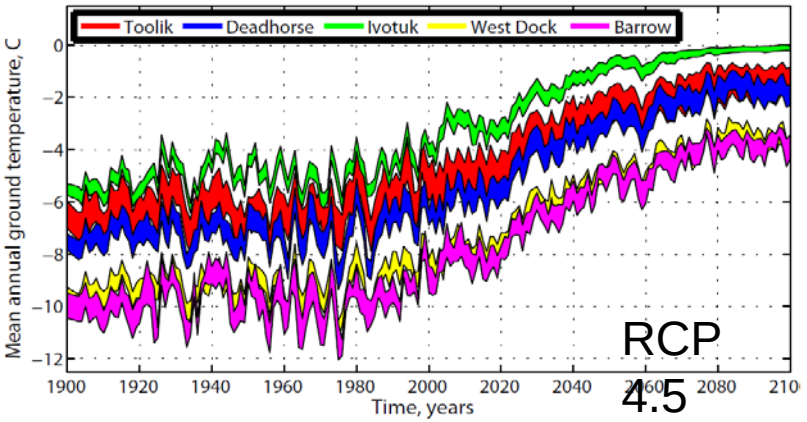
High-resolution temperature modeling



Results are available on-line at

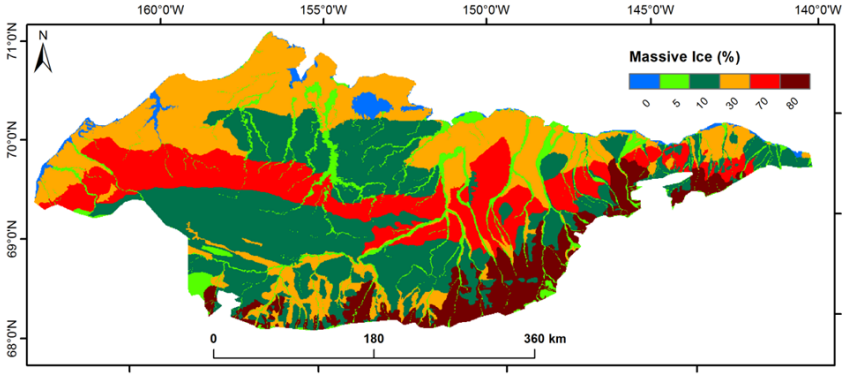
http://permamap.gi.alaska.edu

Projections of the ground temperature

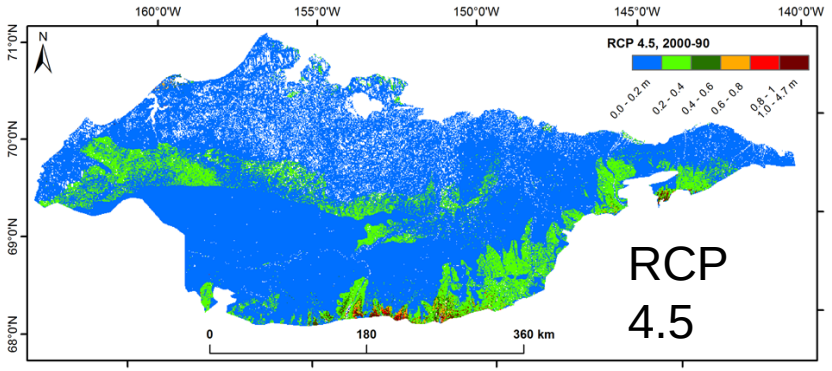


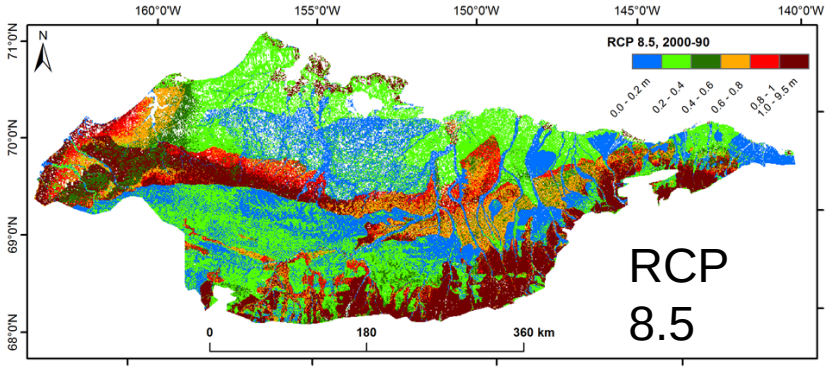
Potential ground surface subsidence

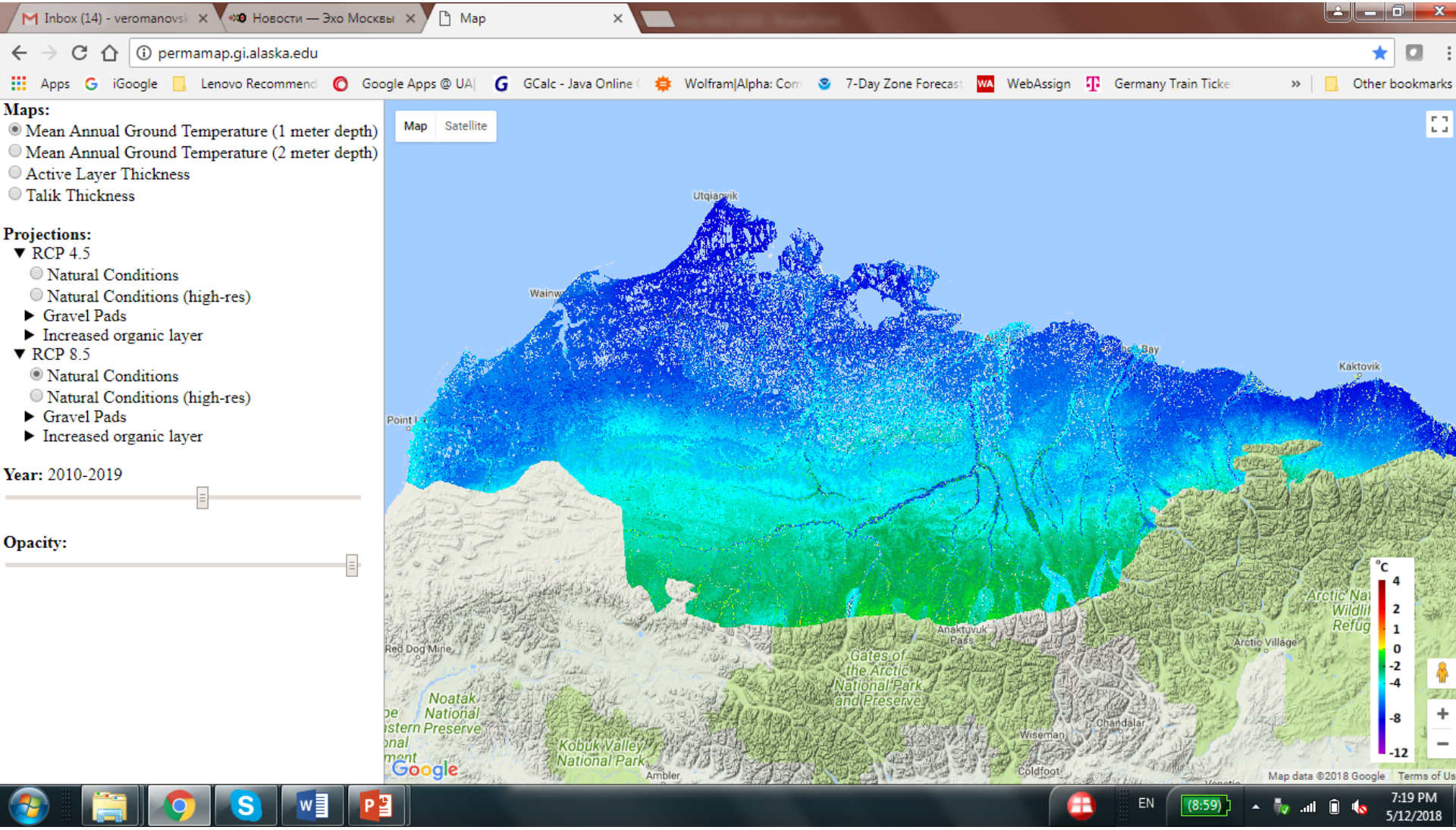
Ice content along the North Slope of Alaska

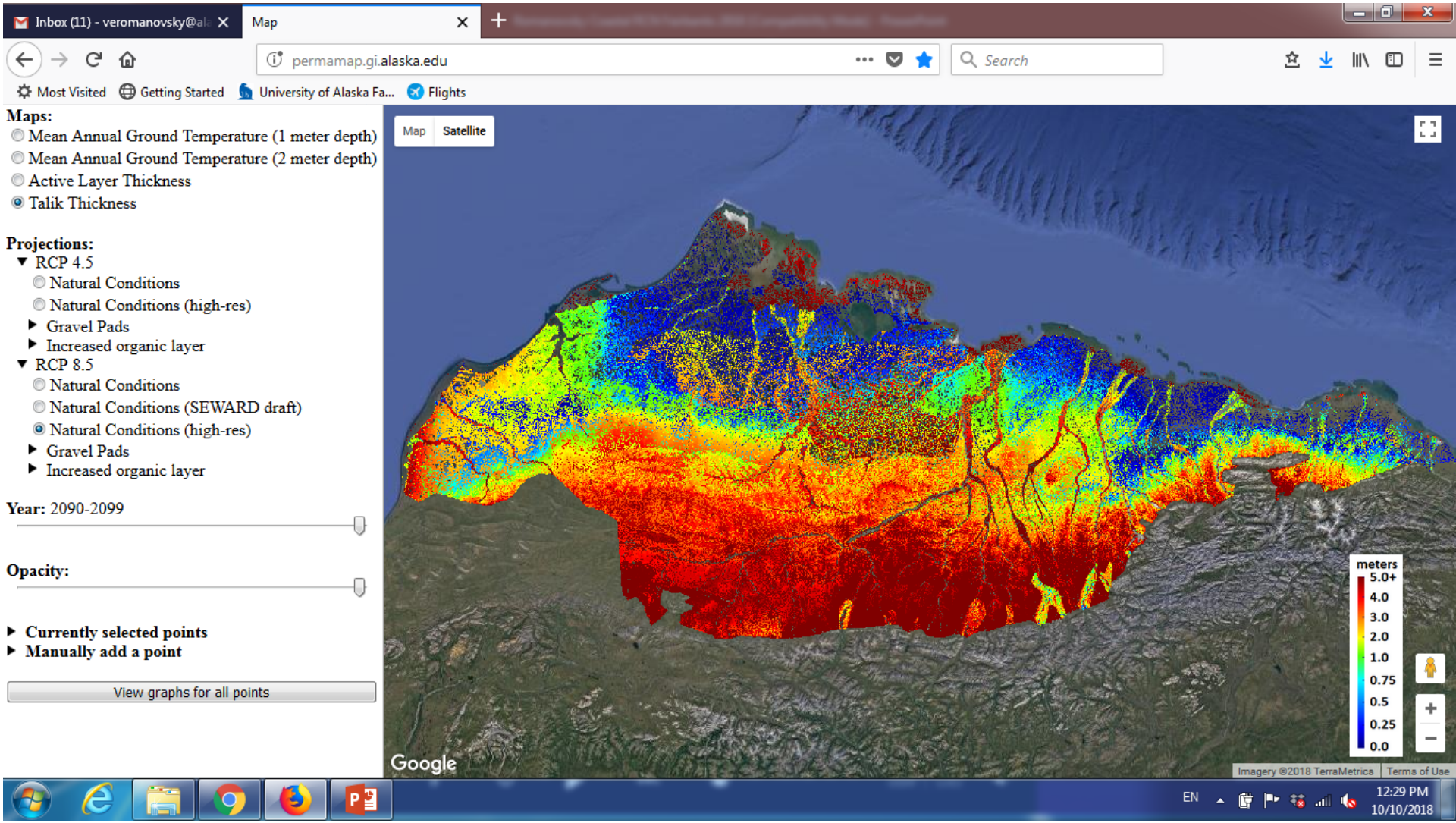


Modeled potential thaw settlement between 2000 and 2090 years from






Inbox (14) - veromanovsk
Новости — Эхо Москвы
Map
permamap.gi.alaska.edu
Apps
iGoogle
Lenovo Recommend
Google Apps @ UA
GCalc - Java Online
Wolfram|Alpha: Com
7-Day Zone Forecast
WebAssign
Germany Train Ticke
Other bookmarks
Maps:
Mean Annual Ground Temperature (1 meter depth)
Mean Annual Ground Temperature (2 meter depth)
Active Layer Thickness
Talik Thickness
Projections:
RCP 4.5
Natural Conditions
Natural Conditions (high-res)
Gravel Pads
Increased organic layer
RCP 8.5
Natural Conditions
Natural Conditions (high-res)
Gravel Pads
Increased organic layer
Year: 2010-2019
Opacity:
Map
Satellite
Utqiaġvik
Wainwright
Point Lay
Kaktovik
Red Dog Mine
Anaktuvuk Pass
Gates of the Arctic National Park and Preserve
Arctic Village
Noatak National Preserve
Kobuk Valley National Park
Ambler
Wiseman
Chandalar
Coldfoot
°C
4
2
1
0
-2
-4
-8
-12
Google
Map data ©2018 Google
Terms of Use
EN
(8:59)
7:19 PM
5/12/2018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Increased organic layer
RCP 8.5
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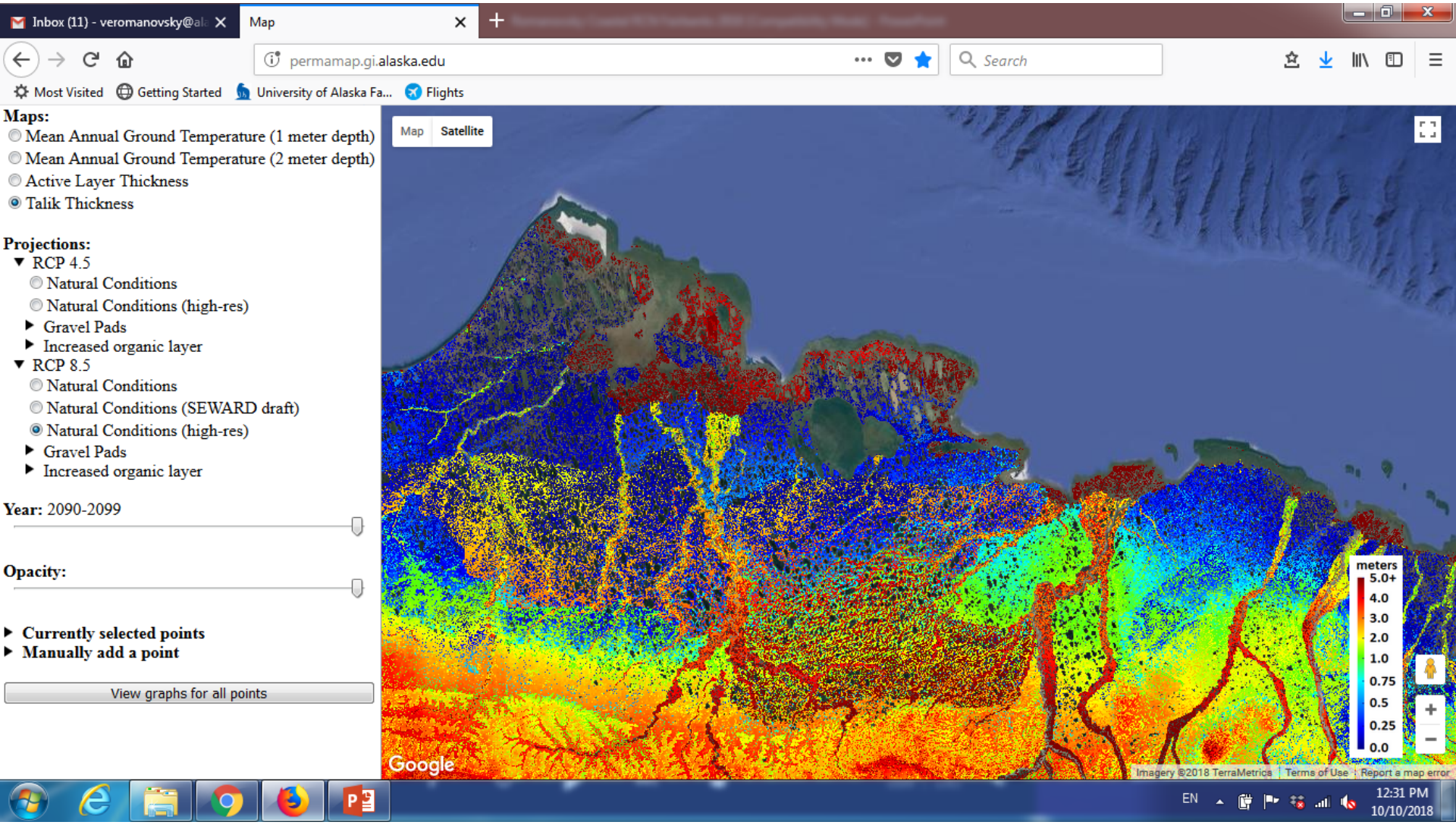
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