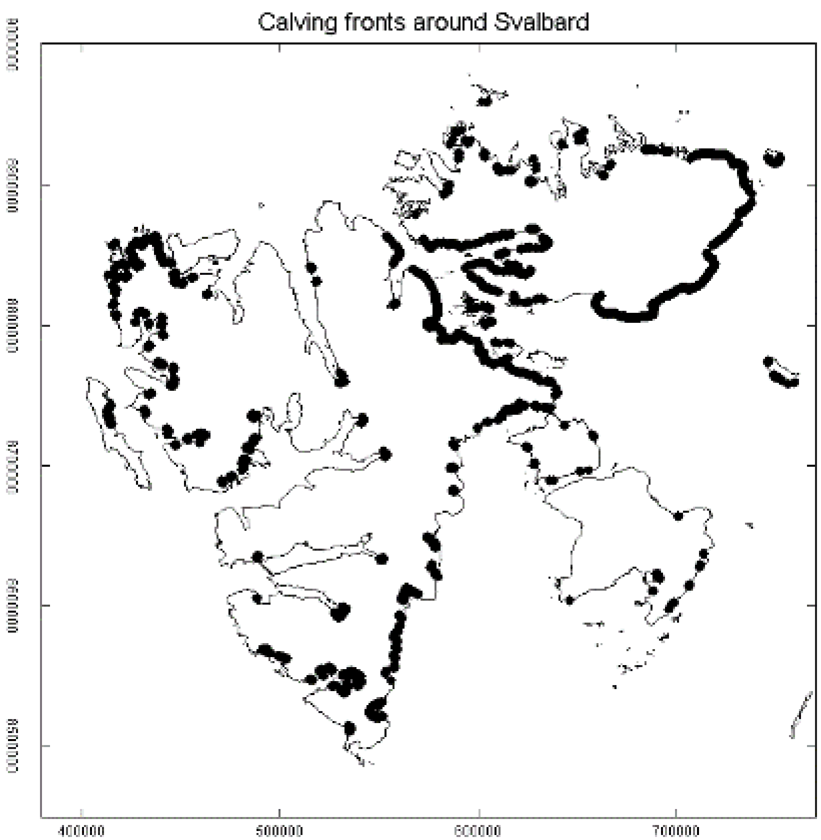
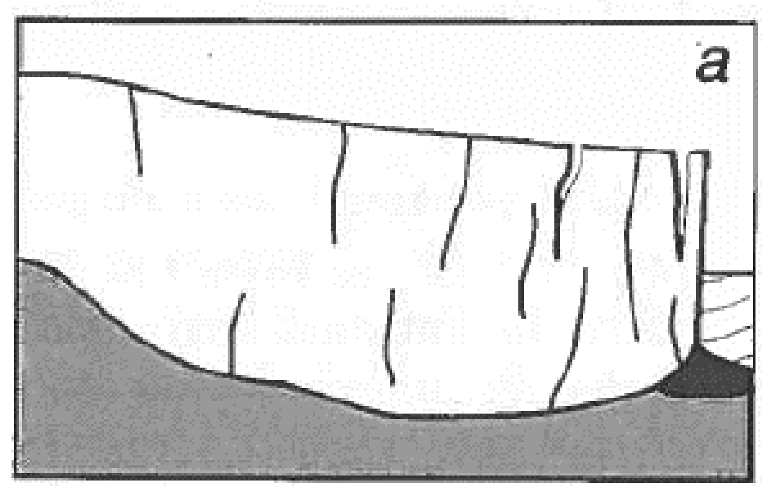

glacier
tidewater
(e.g. sea)
Tidewater glaciers

Svalbard tidewater glaciers



163 tidewater glaciers in Svalbard



More than 60% of Svalbard ice drains via tidewater glacier

Total length of calving **ice-cliffs is 860** km

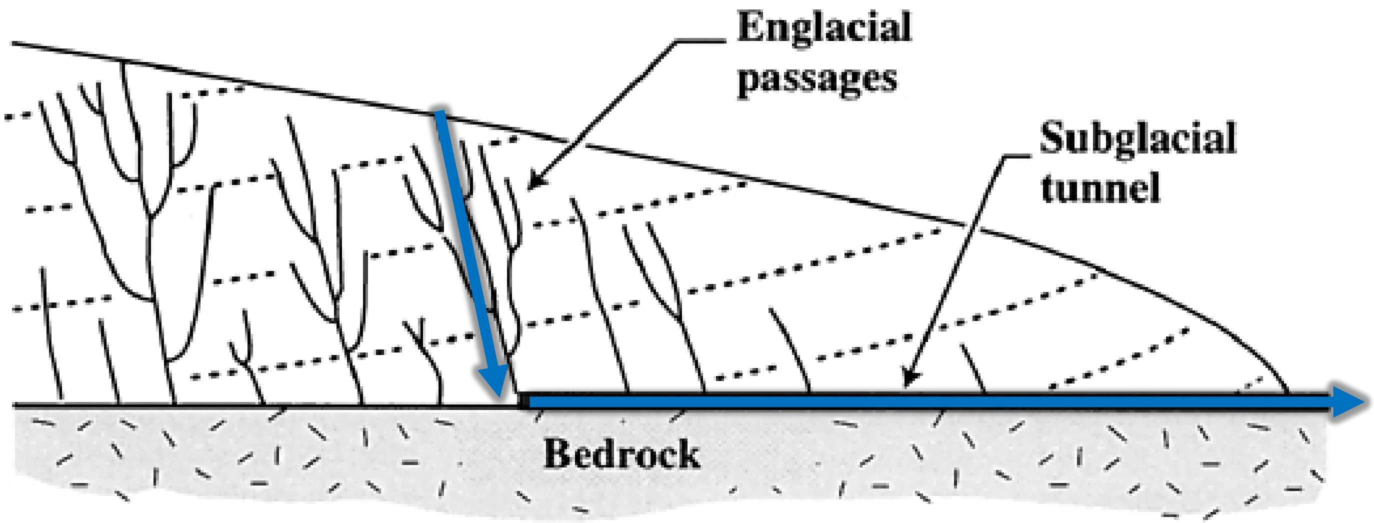
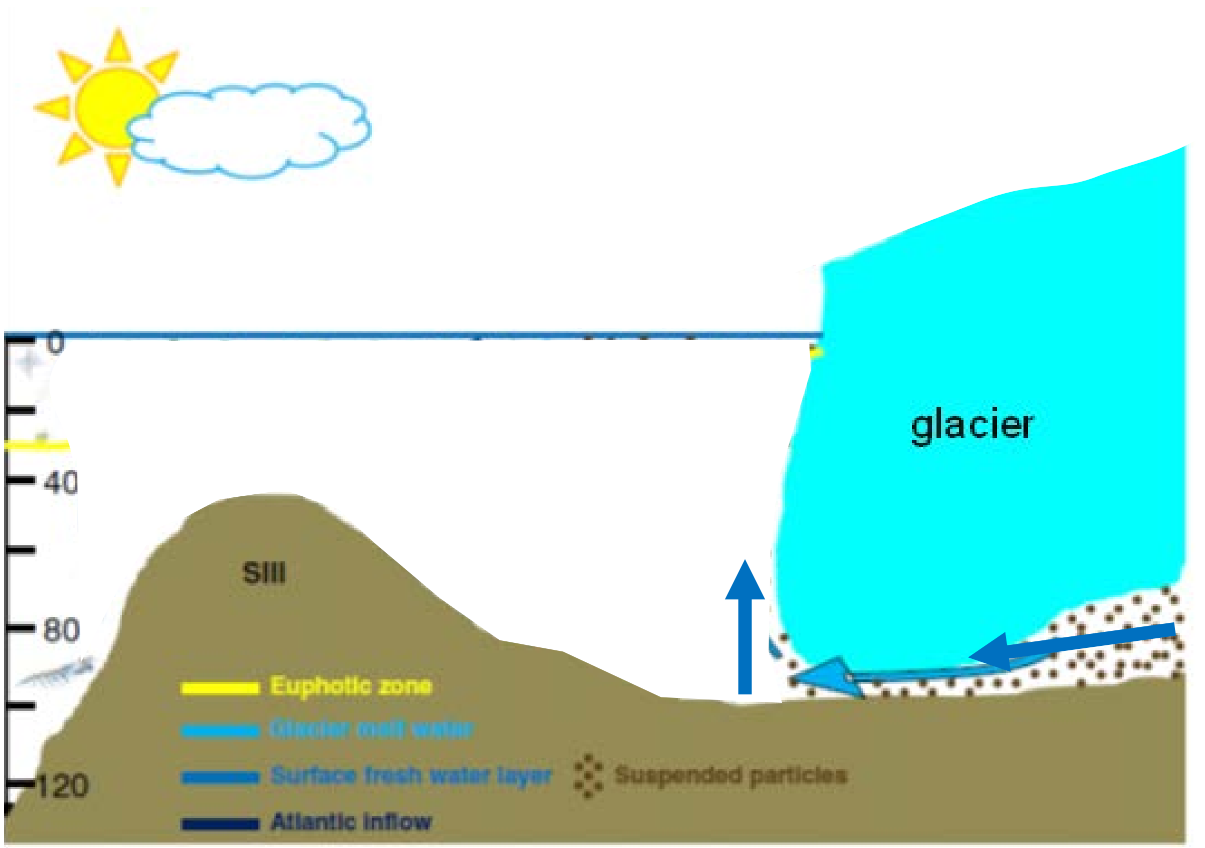


Figure 4. Fluid equipotentials (dotted curves) and a hypothetical network of arborescent englacial channels [after *Shreve*, 1985]. Reproduced with permission of the publisher, the Geological Society of America, Boulder, Colorado USA. Copyright @ 1985 Geological Society of America.

Tidewater glacier



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The importance of tidewater glaciers for marine mammals and seabirds in Svalbard, Norway

Christian Lydersen, Philipp Assmy, Stig Falk-Petersen, Jack Kohler, Kit M. Kovacs, Marit Reigstad, Harald Steen, Hallvard Strøm, Arild Sundfjord, Øystein Varpe, Waldek Walczowski, Jan Marcin Weslawski, Marek Zajaczkowski

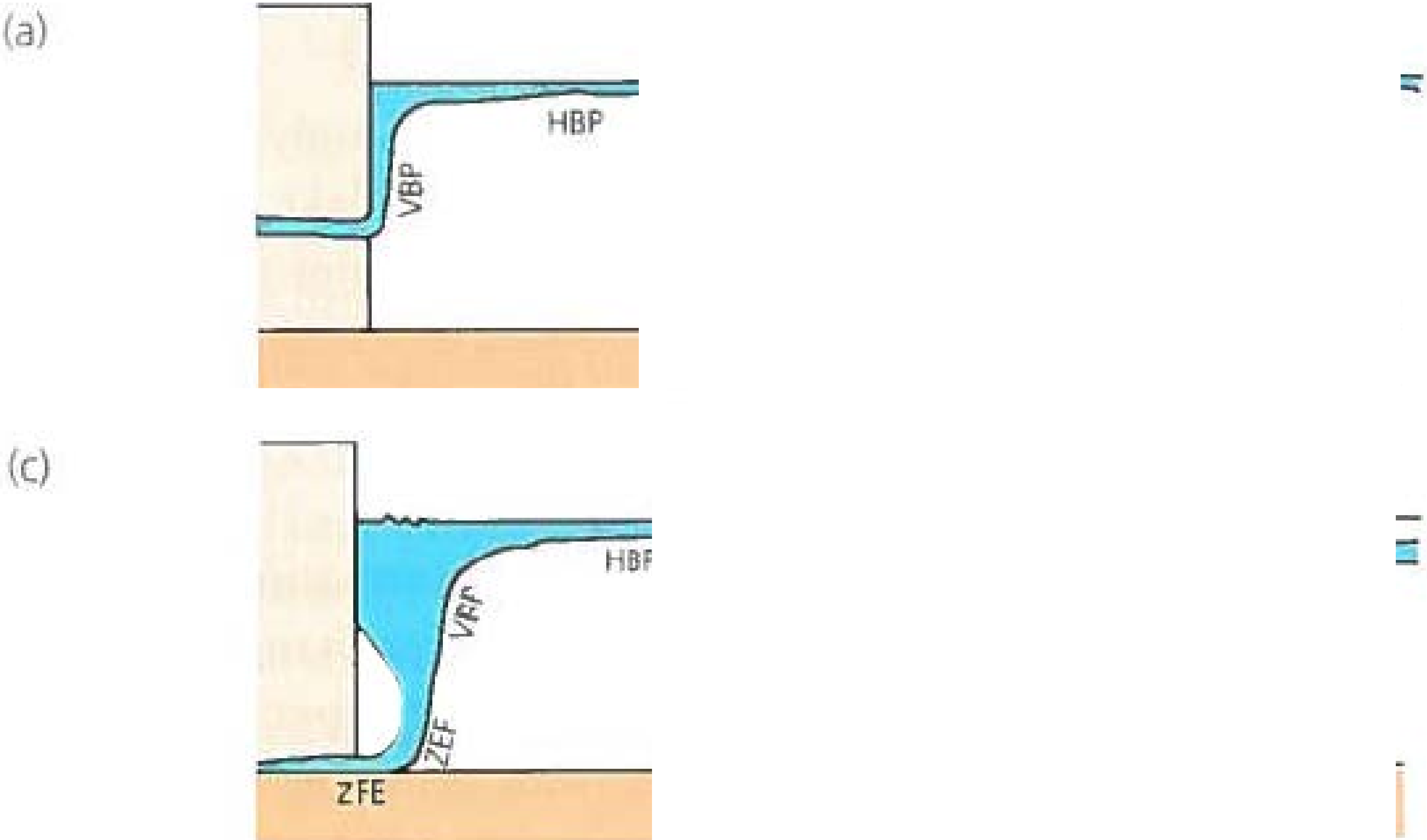
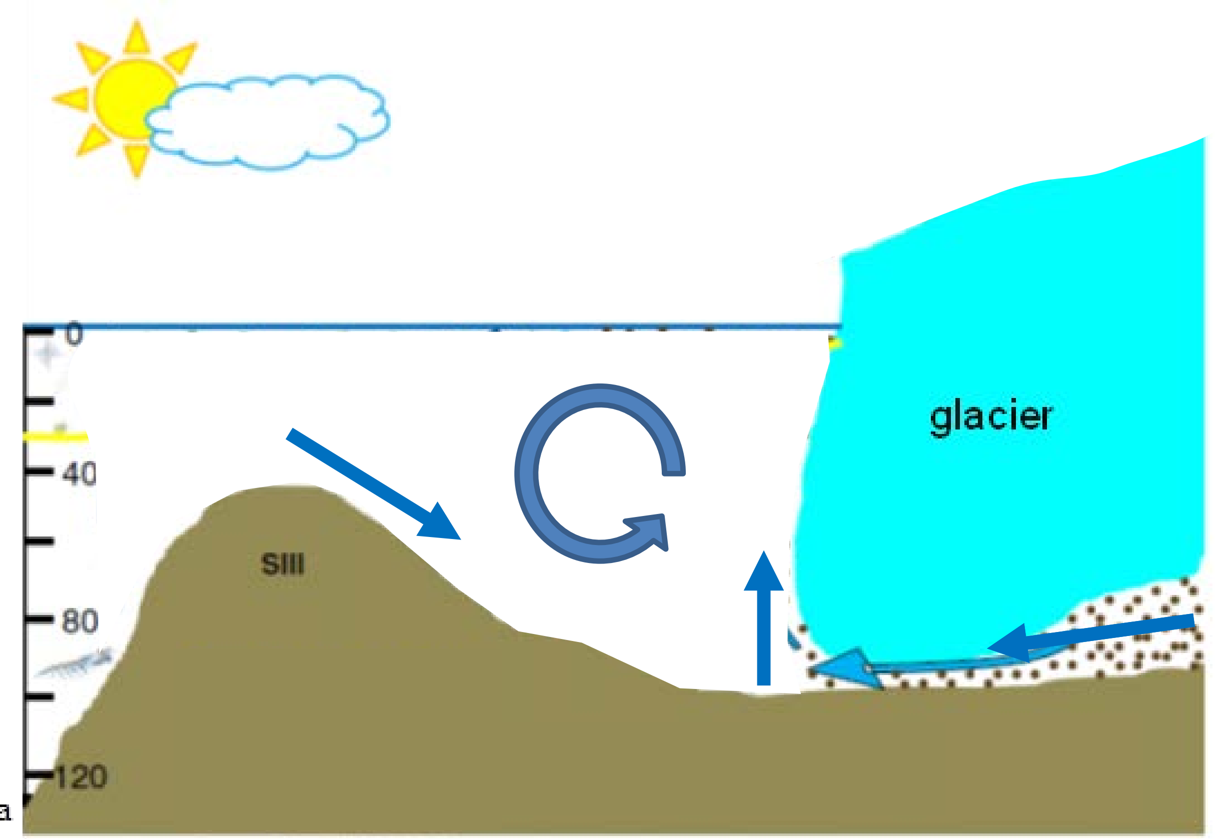


Figure 10.61 Patterns of meltwater discharges from tidewater glaciers. (a) Forced plume dominated by buoyant forces. (b) Axisymmetric jets developing into axisymmetric plumes as momentum forces give way to buoyant forces. (c) Plane jets developing into axisymmetric jets and plumes. ZFE = zone of jet flow establishment; ZEF = zone of established jet flow; VBP = vertical buoyant plume; HBP = horizontal buoyant plume (Powell, 1990, reproduced with permission of the Geological Society of London)

Plumes

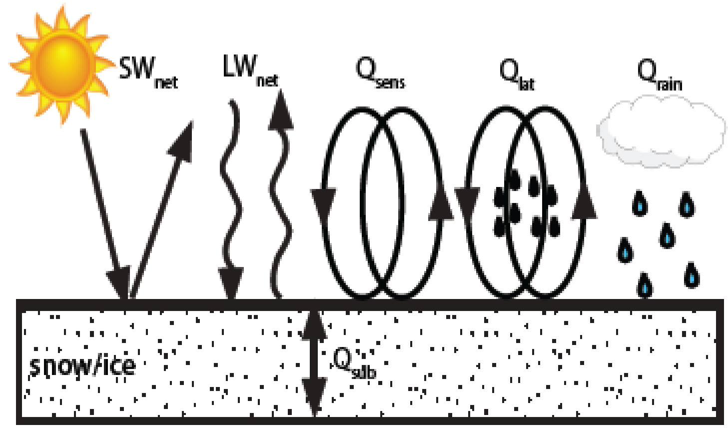
Tidewater glacier




Blomstrandbreen
Conwaybreen
Kongsbreen N
Kongsfjord
Kongsbreen S
Kronebreen
Kongsvegen
0
10 km

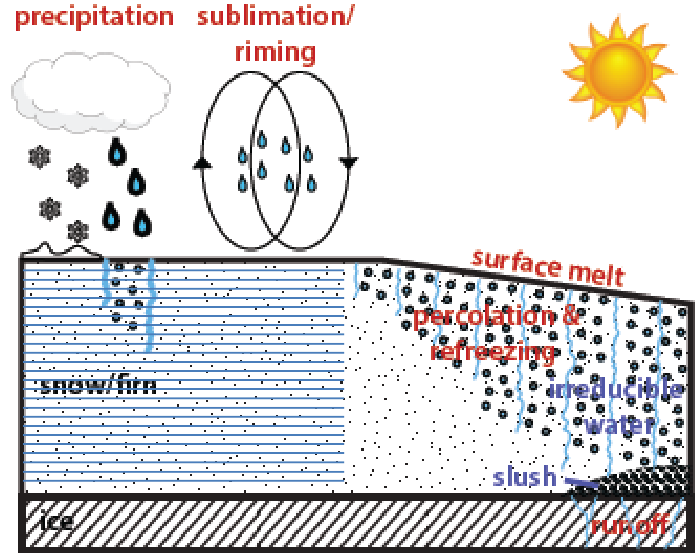
Runoff modelling

Surface energy balance model used to compute surface temperature and melt production.

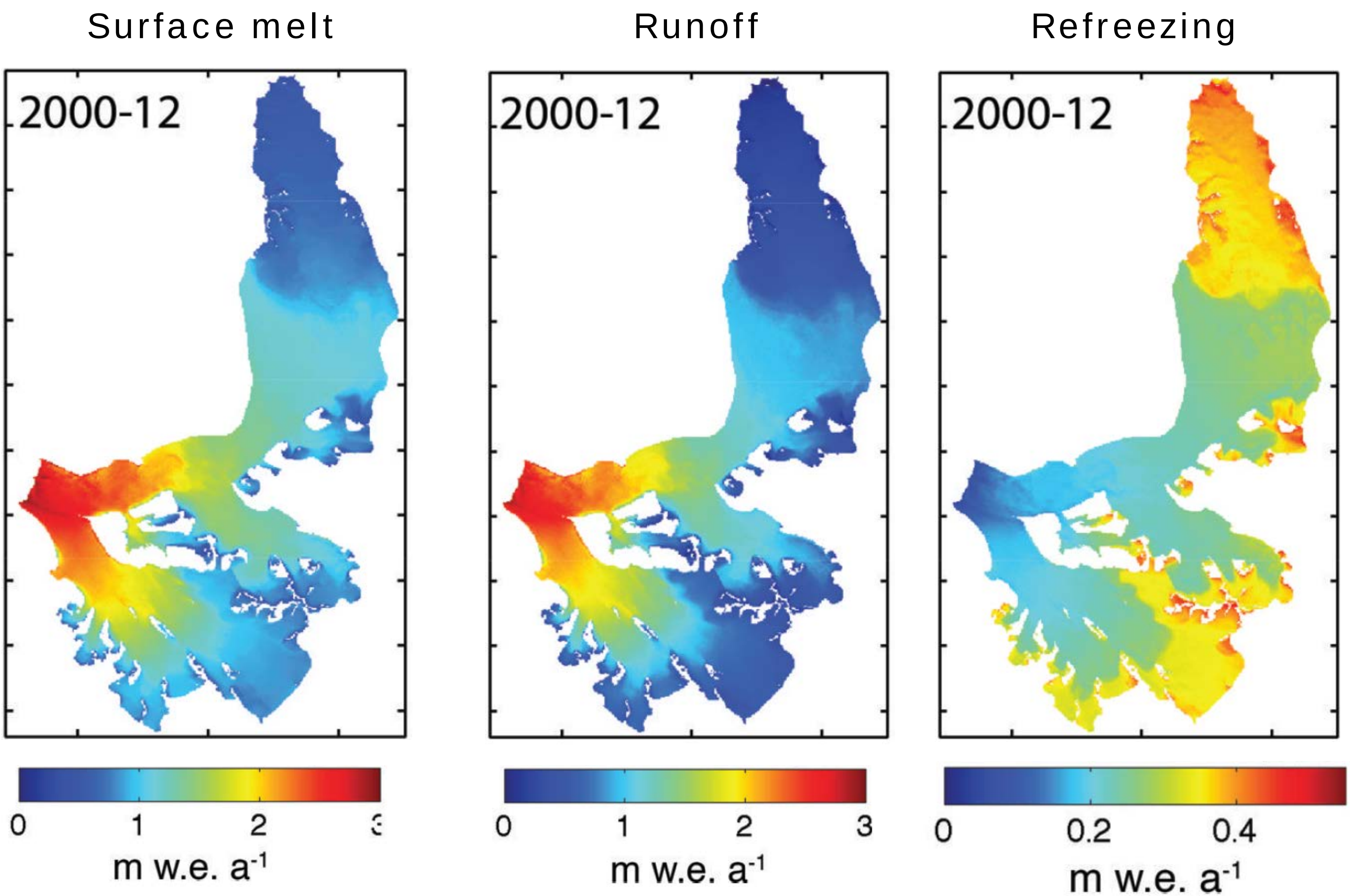


+

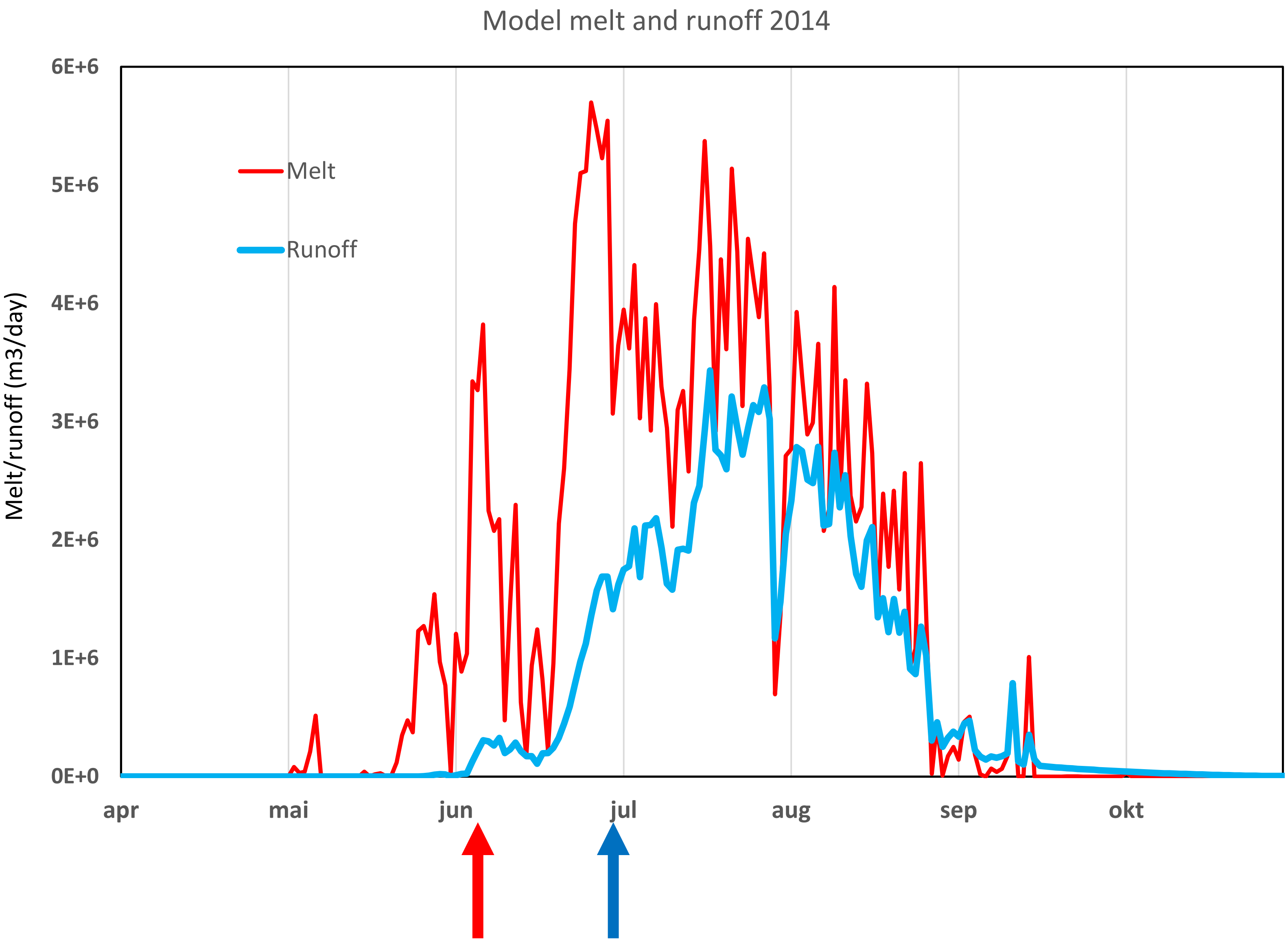
Surface model coupled to <u>multilayer</u> snow model simulating vertical evolution of density, temperature and water content, accounting for percolation, refreezing, storage and water runoff.

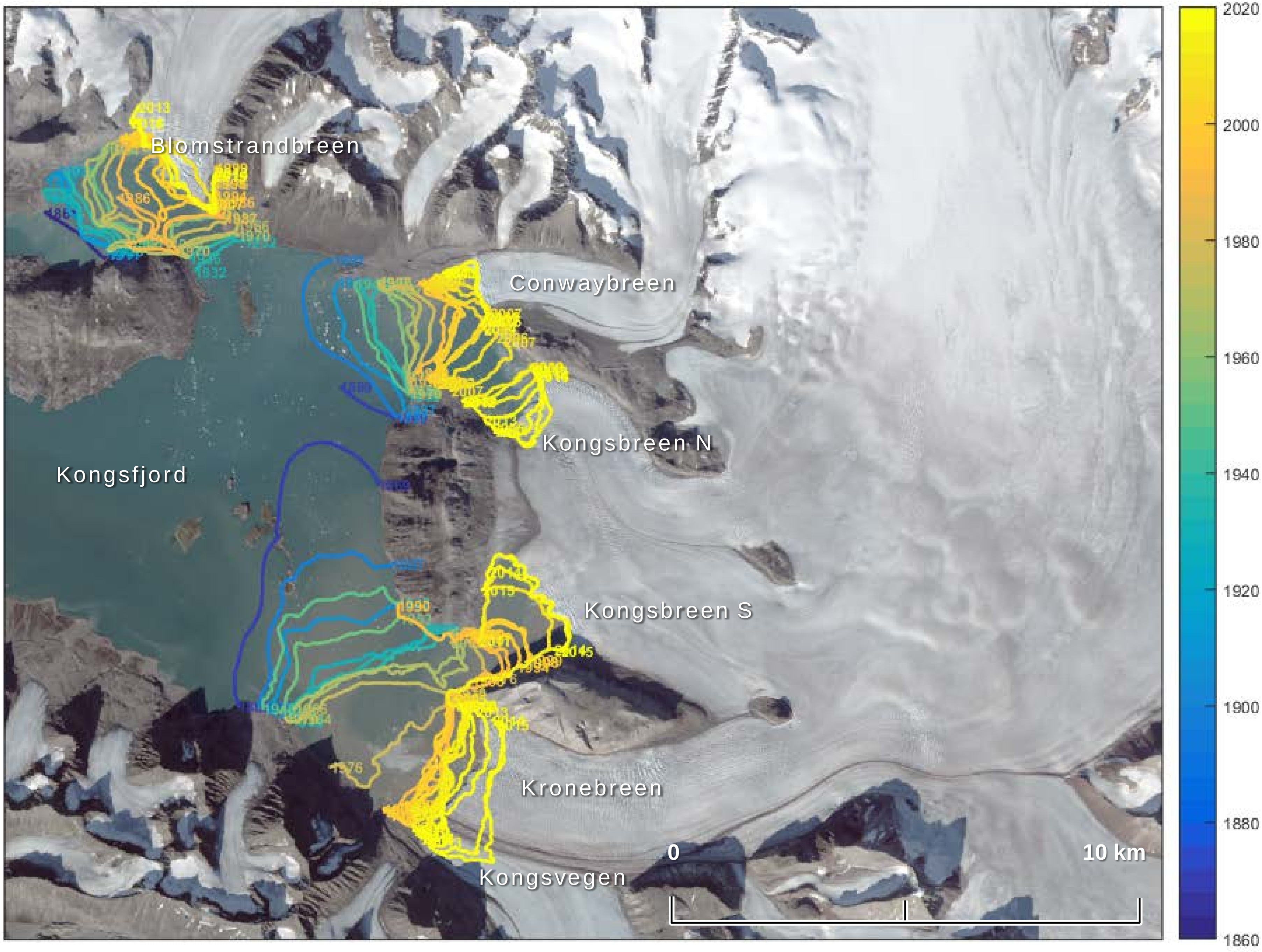


Runoff modelling



Runoff modelling

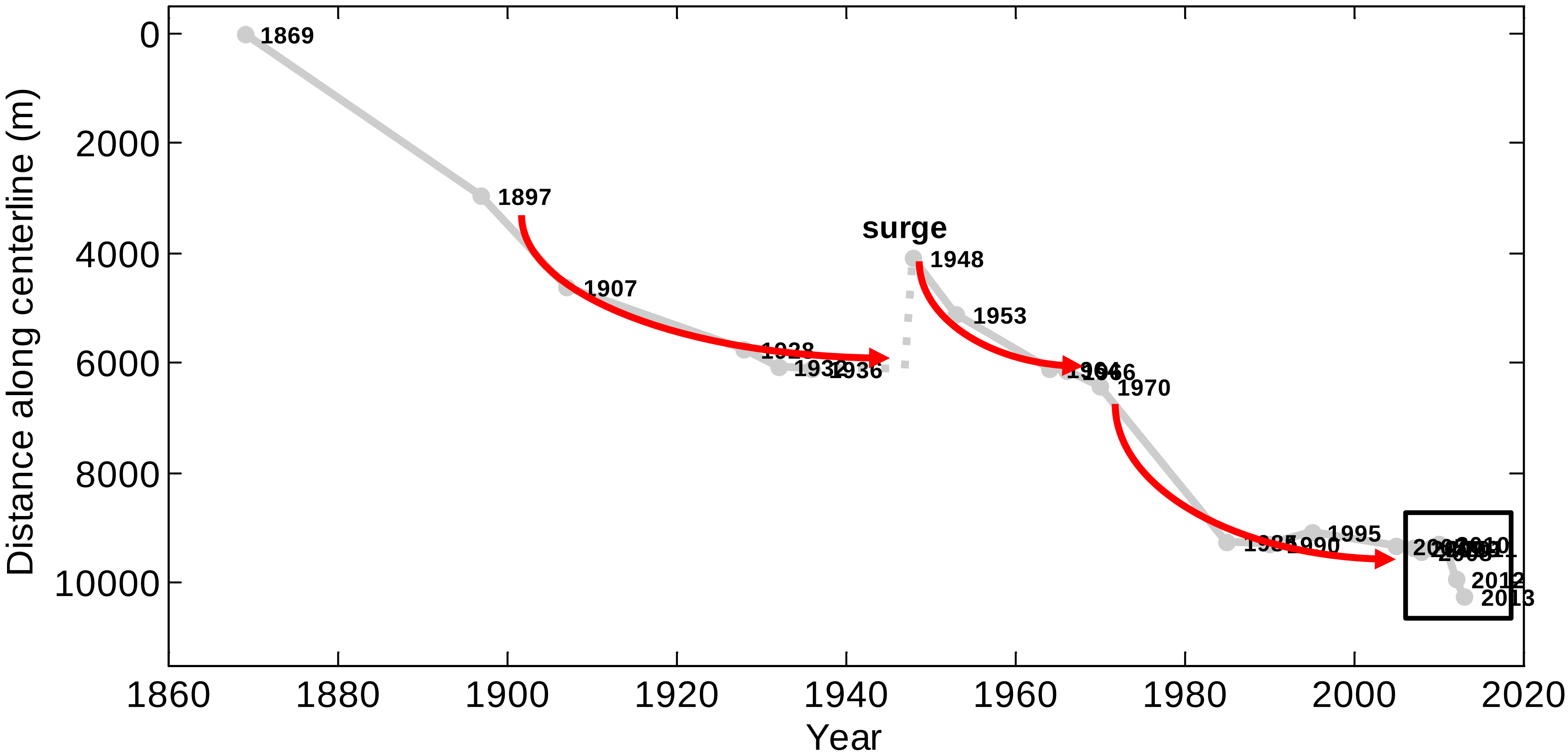




Blomstrandbreen
Conwaybreen
Kongsbreen N
Kongsfjord
Kongsbreen S
Kronebreen
Kongsvegen
0
10 km
2020
2000
1980
1960
1940
1920
1900
1880
1860

Kronebreen front position

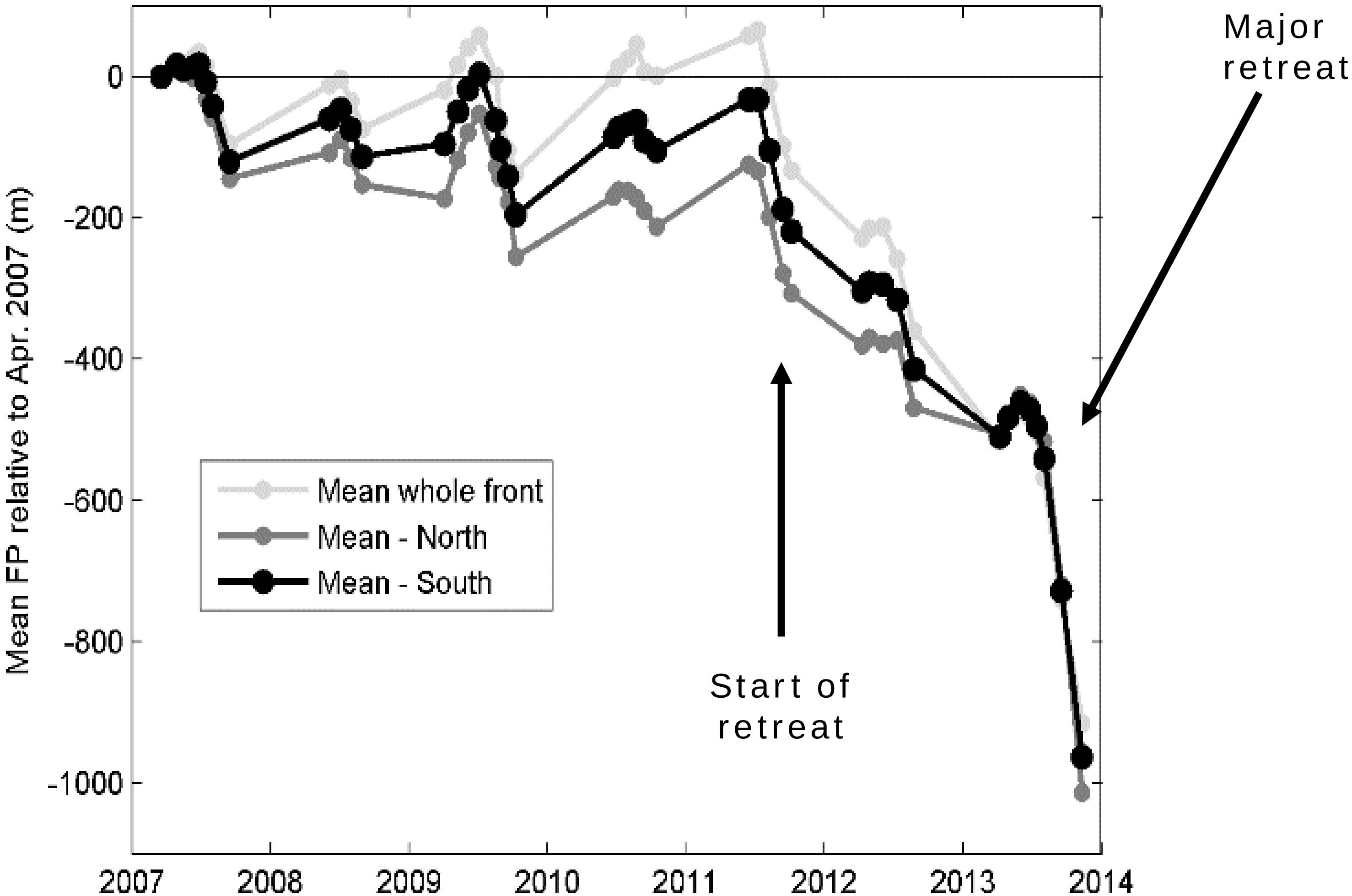
Episodic retreat history

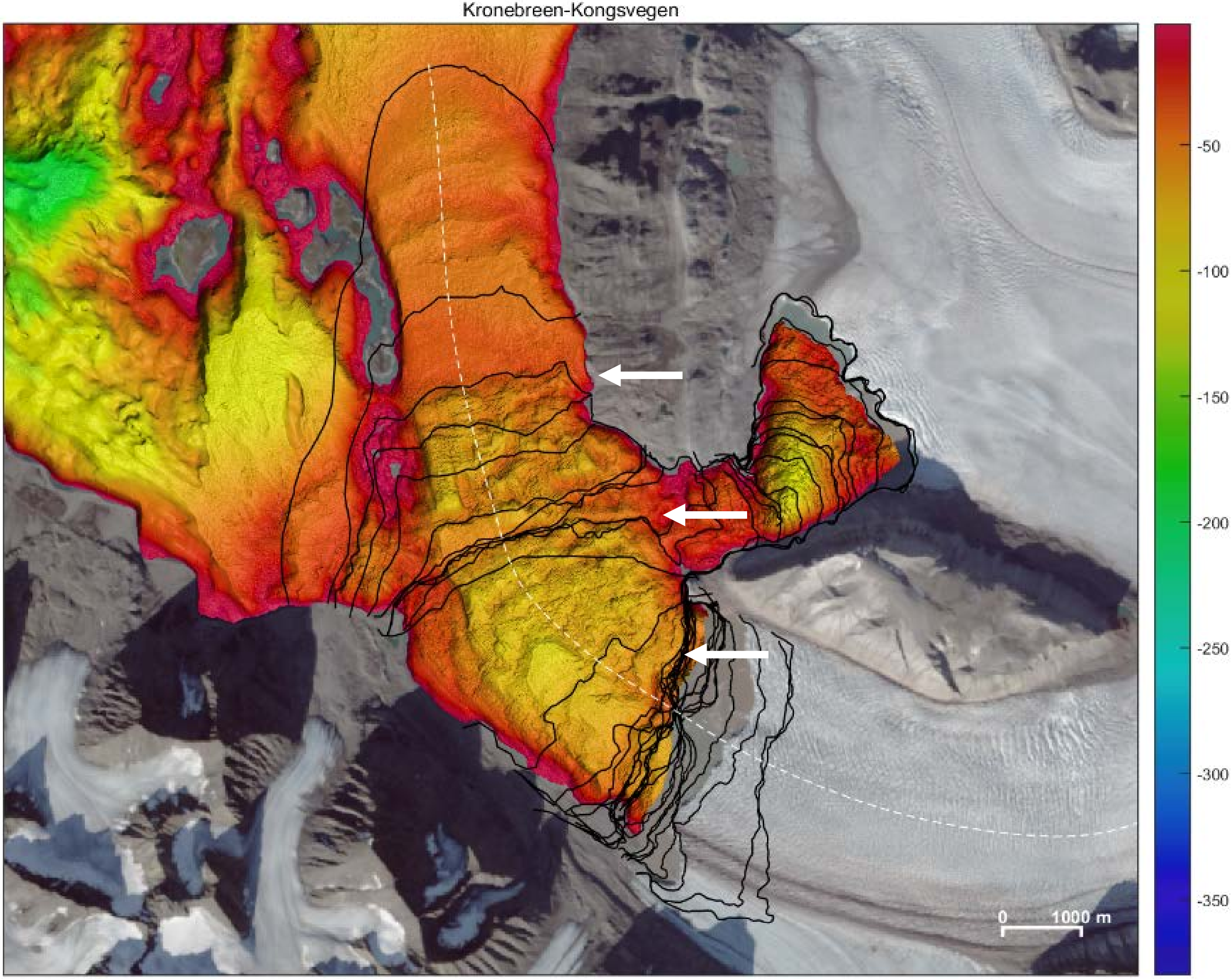


Kronebreen front position

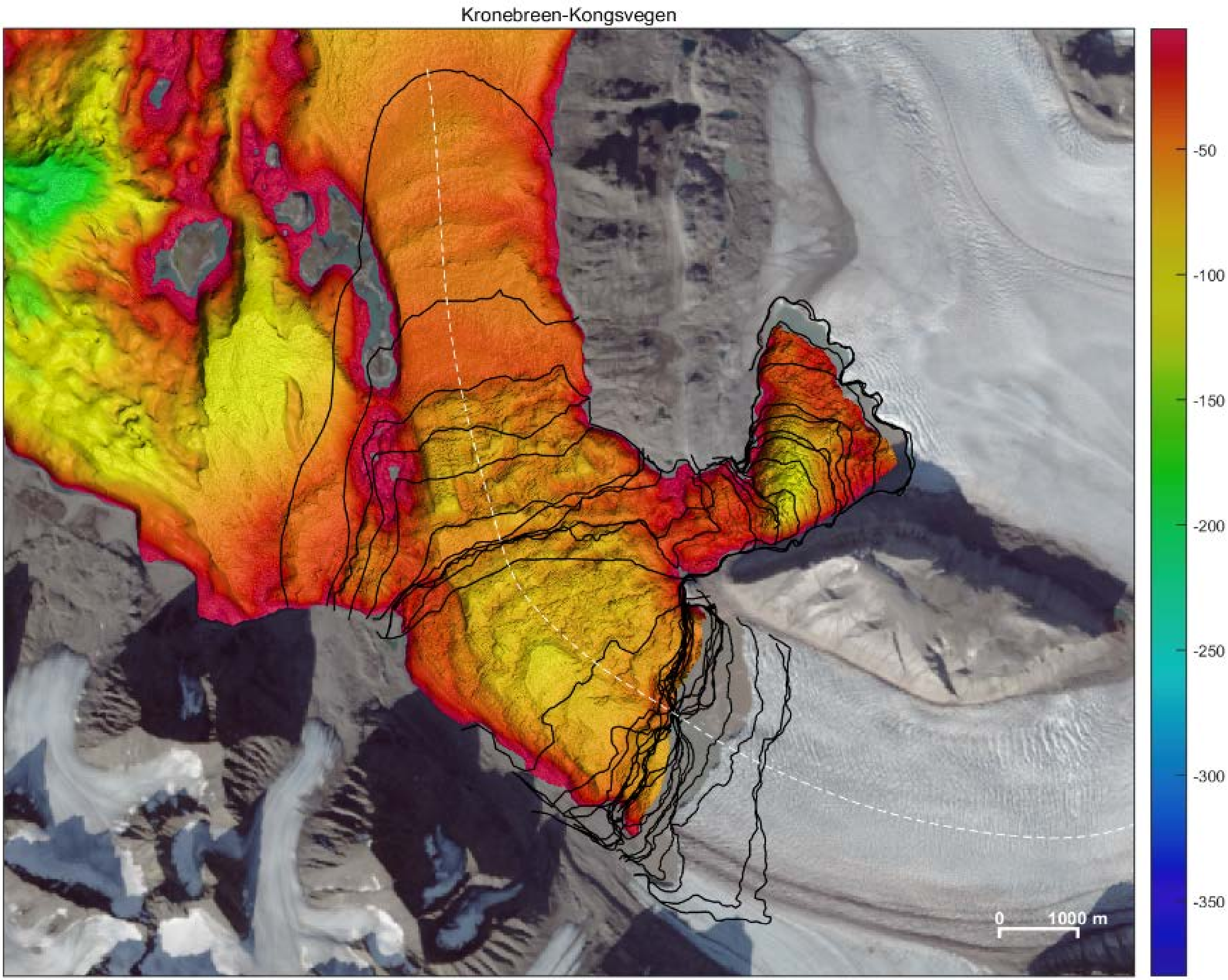
Latest retreat starts 2011

Major retreat (> 500 m) in late summer 2013

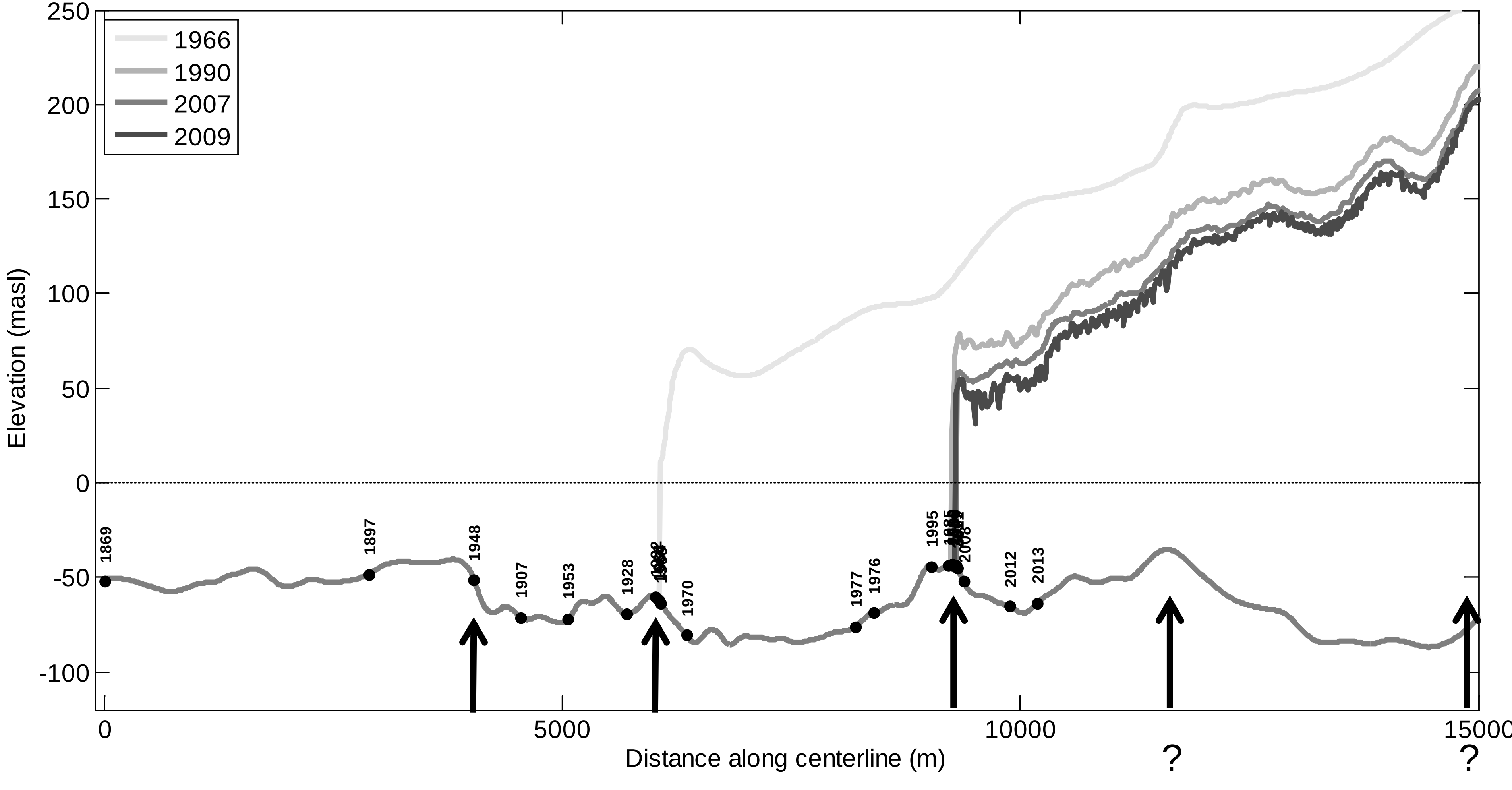




Kronebreen-Kongsvegen
-50
-100
-150
-200
-250
-300
-350
0
1000 m



Kronebreen-Kongsvegen
-50
-100
-150
-200
-250
-300
-350
0
1000 m



1966
1990
2007
2009
Elevation (masl)
Distance along centerline (m)
250
200
150
100
50
0
-50
-100
0
5000
10000
15000
1869
1897
1948
1907
1953
1928
1970
1977
1976
1995
2008
2012
2013
?
?

Given that Svalbard tidewater glaciers are retreating…

- What will be the impact on fjord circulation when they retreat so much that they terminate on dry land?

- What are the implications of circulation changes for fjord ecosystems?

TIGRIF: TIdewater Glacier Retreat Impact on Fjord circulation and ecosystems

NFR-funded project, 2015-2018

Norwegian Polar Institute:

J. Kohler, ***P. Duarte***, *A. Sundfjord , K. Kovacs, C. Lydersen*

Institute of Marine Research:

J. Albretsen, *P. Budgell, L. Asplin*

U. Oslo Dept. of Geoscience:

T.V. Schuler *, J.O. Hagen*

TIGRIF: TIdewater Glacier Retreat Impact on Fjord circulation and ecosystems

A) Model fjord circulation under present conditions

B) Model fjord circulation for glacier retreat onto land.

C) Use ocean model output to drive a physical-biogeochemical ecosystem model

D) Assess the impact of the resultant changes in biomass production to the higher trophic levels of the ecosystem

CENTRE FOR ICE, CLIMATE AND ECOSYSTEMS
Forskningsrådet
INSTITUTE OF MARINE RESEARCH
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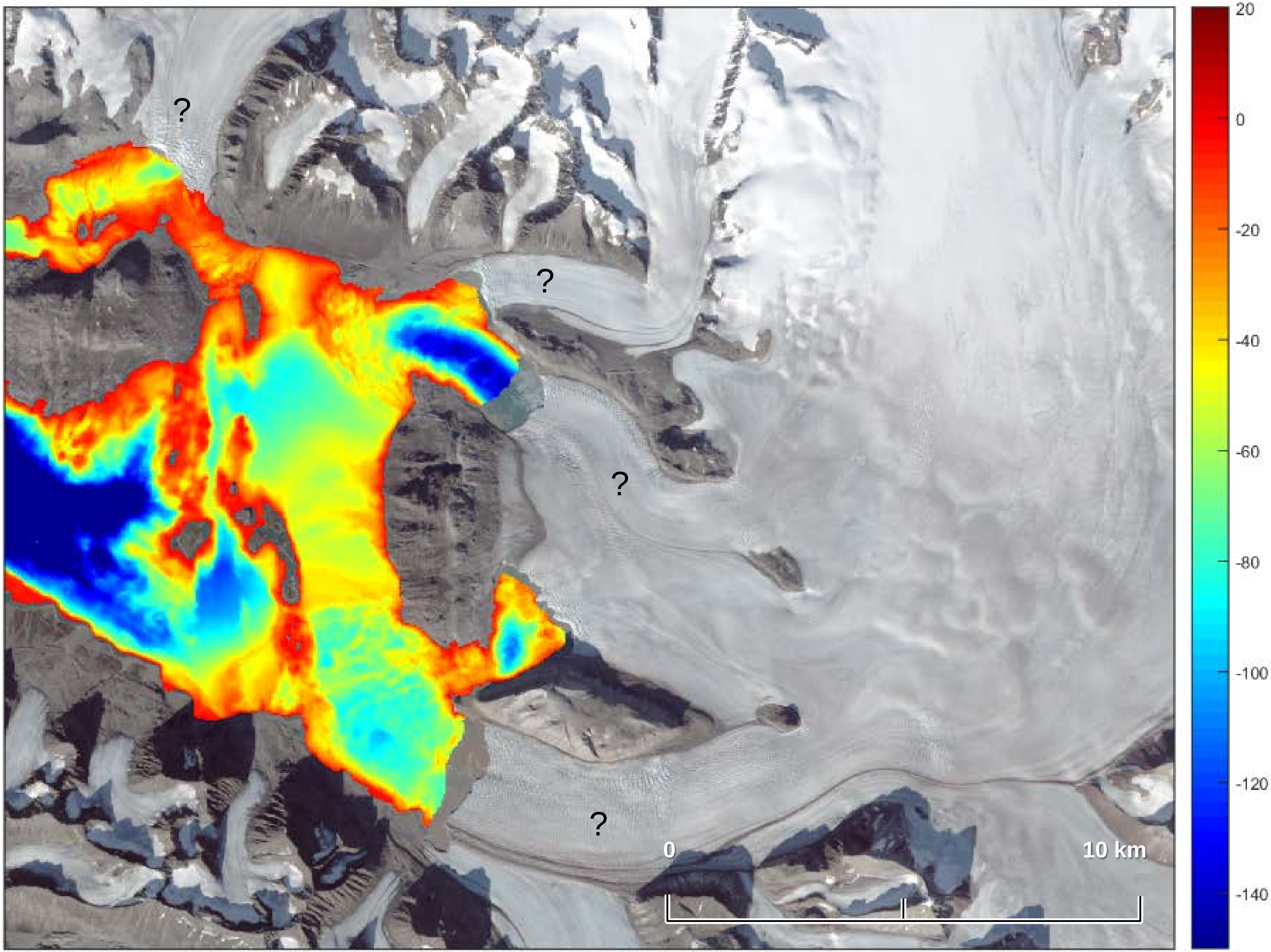
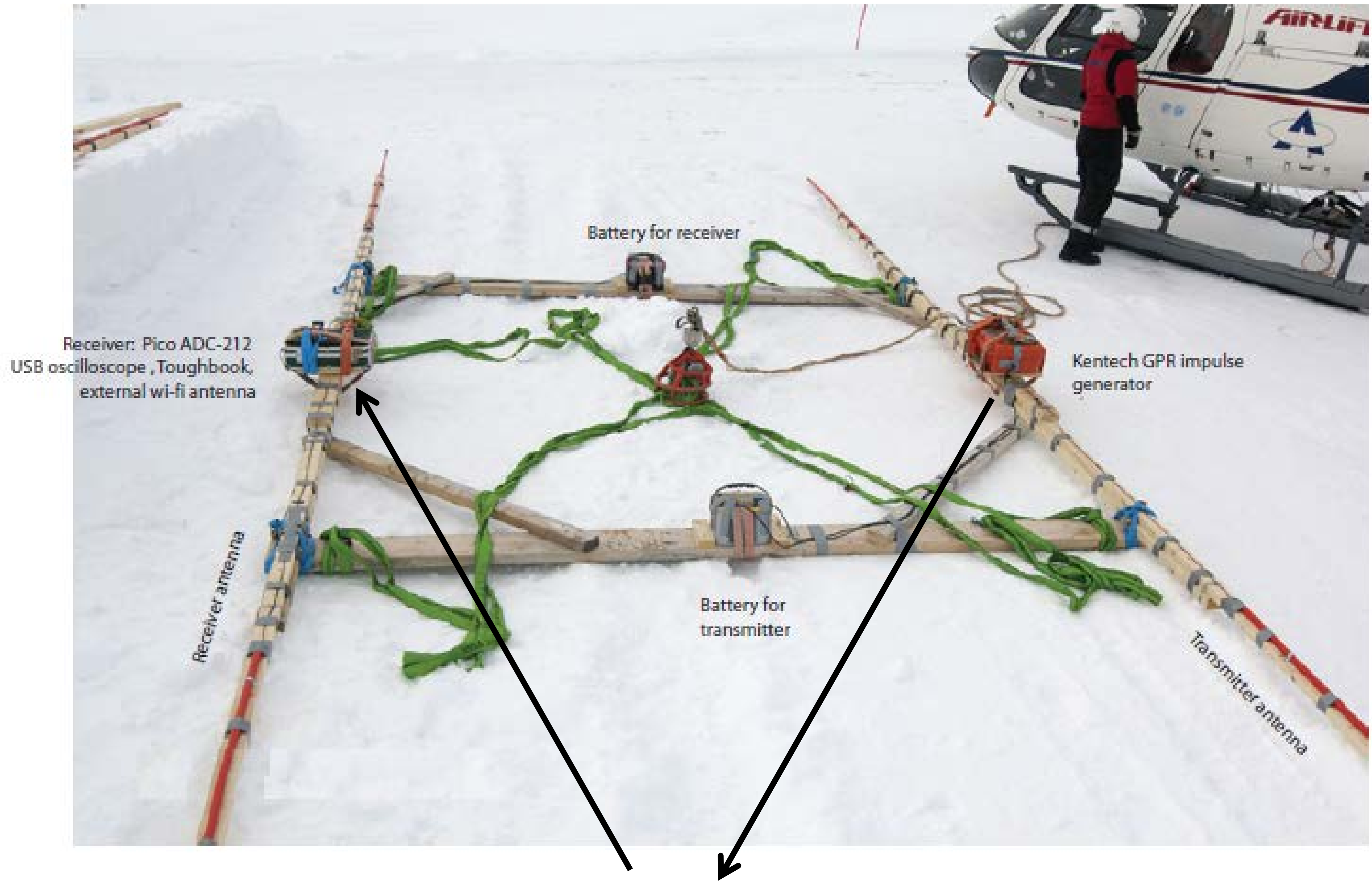
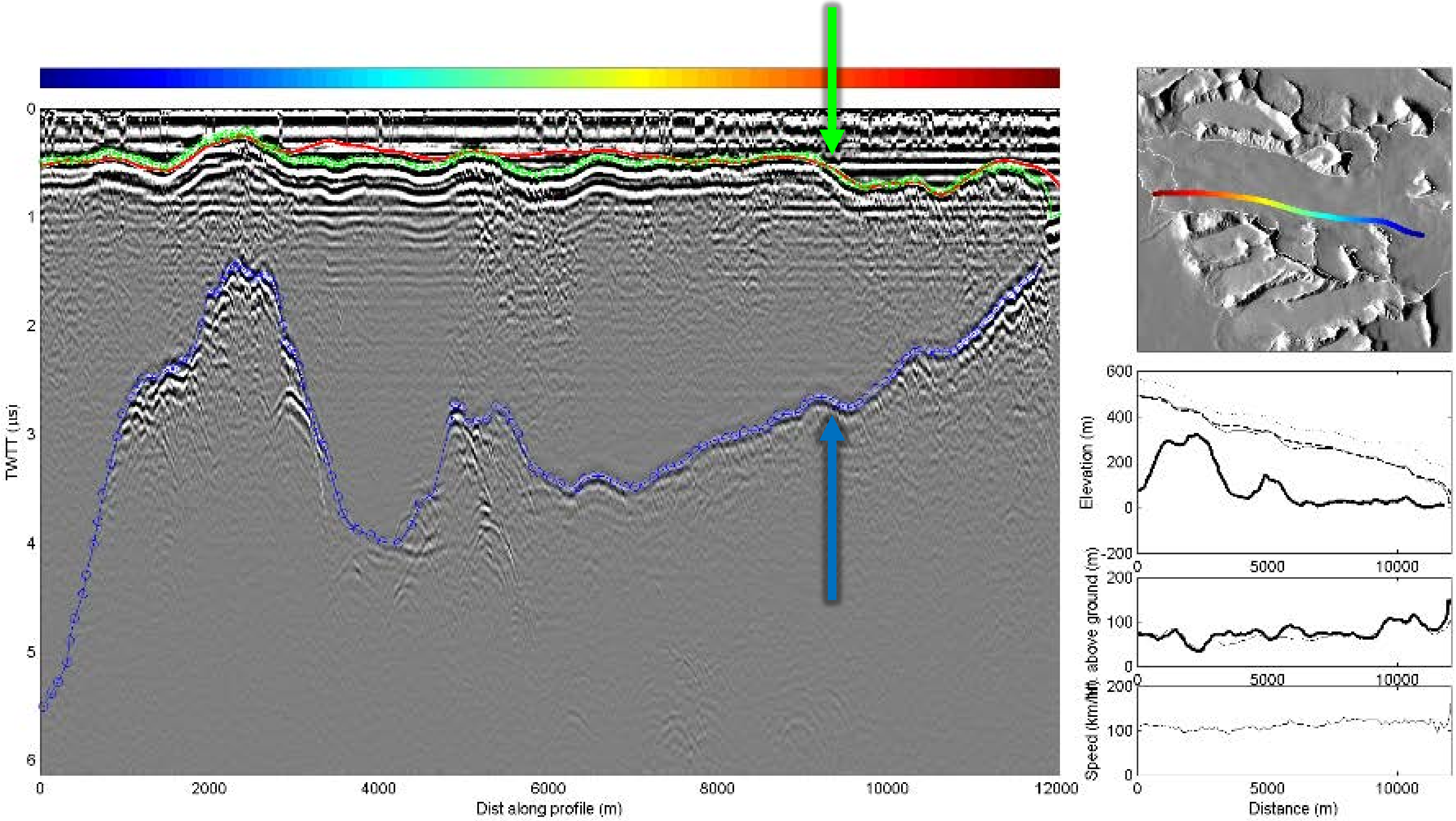
UiO

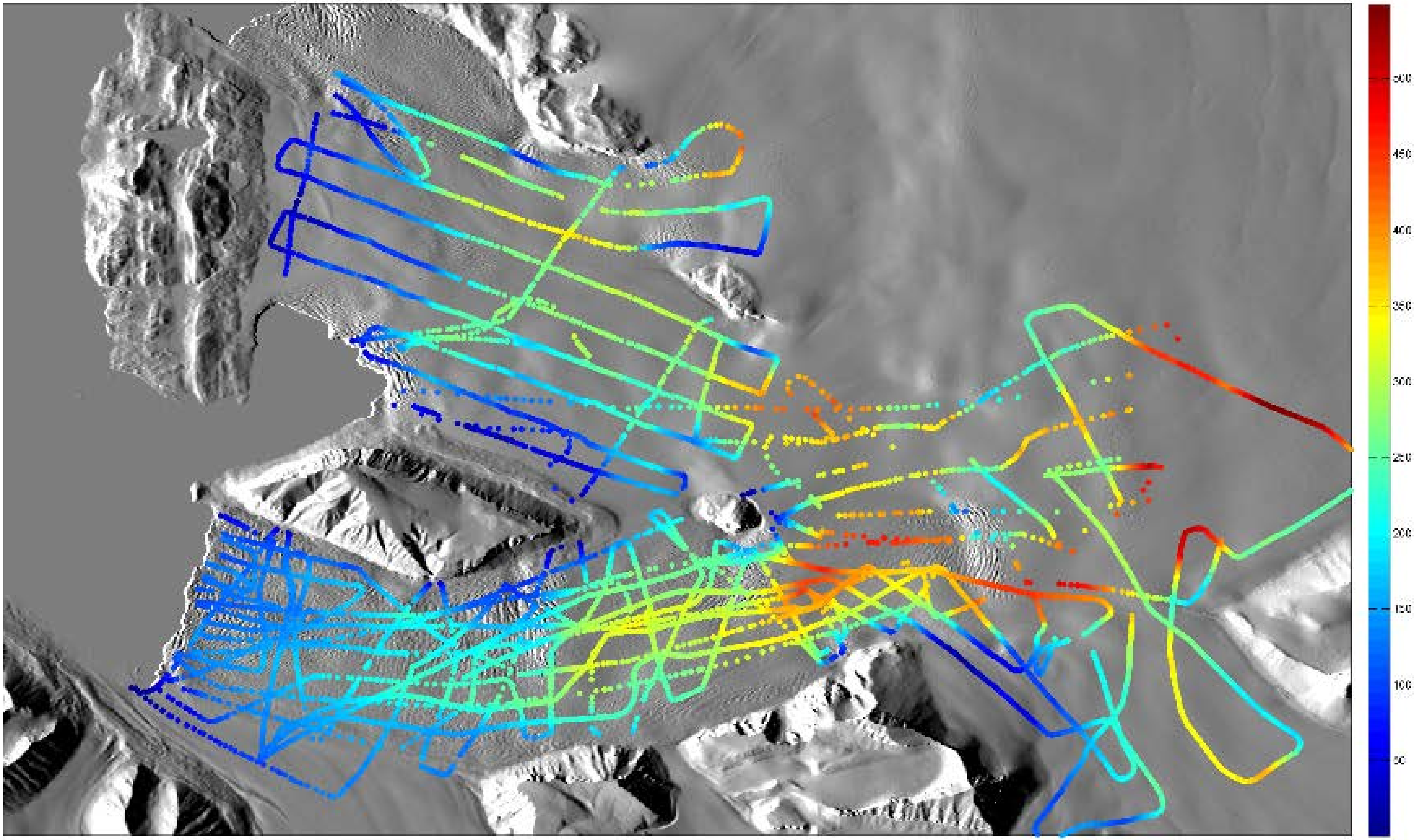

?
?
?
?
0
10 km
20
0
-20
-40
-60
-80
-100
-120
-140

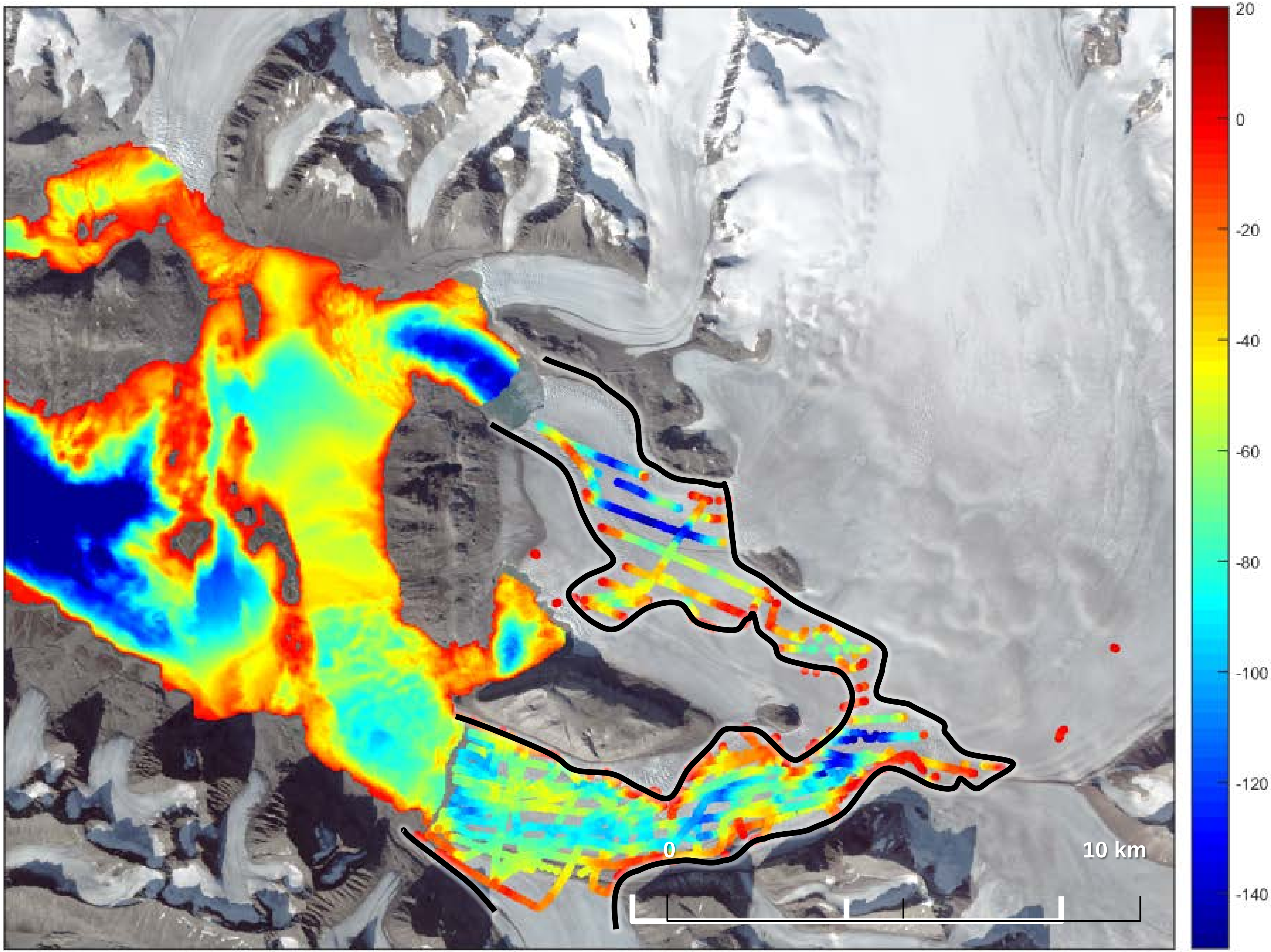
Helicopter radar


Battery for receiver
Receiver: Pico ADC-212
USB oscilloscope , Toughbook,
external wi-fi antenna
Kentech GPR impulse
generator
Battery for
transmitter
Receiver antenna
Transmitter antenna

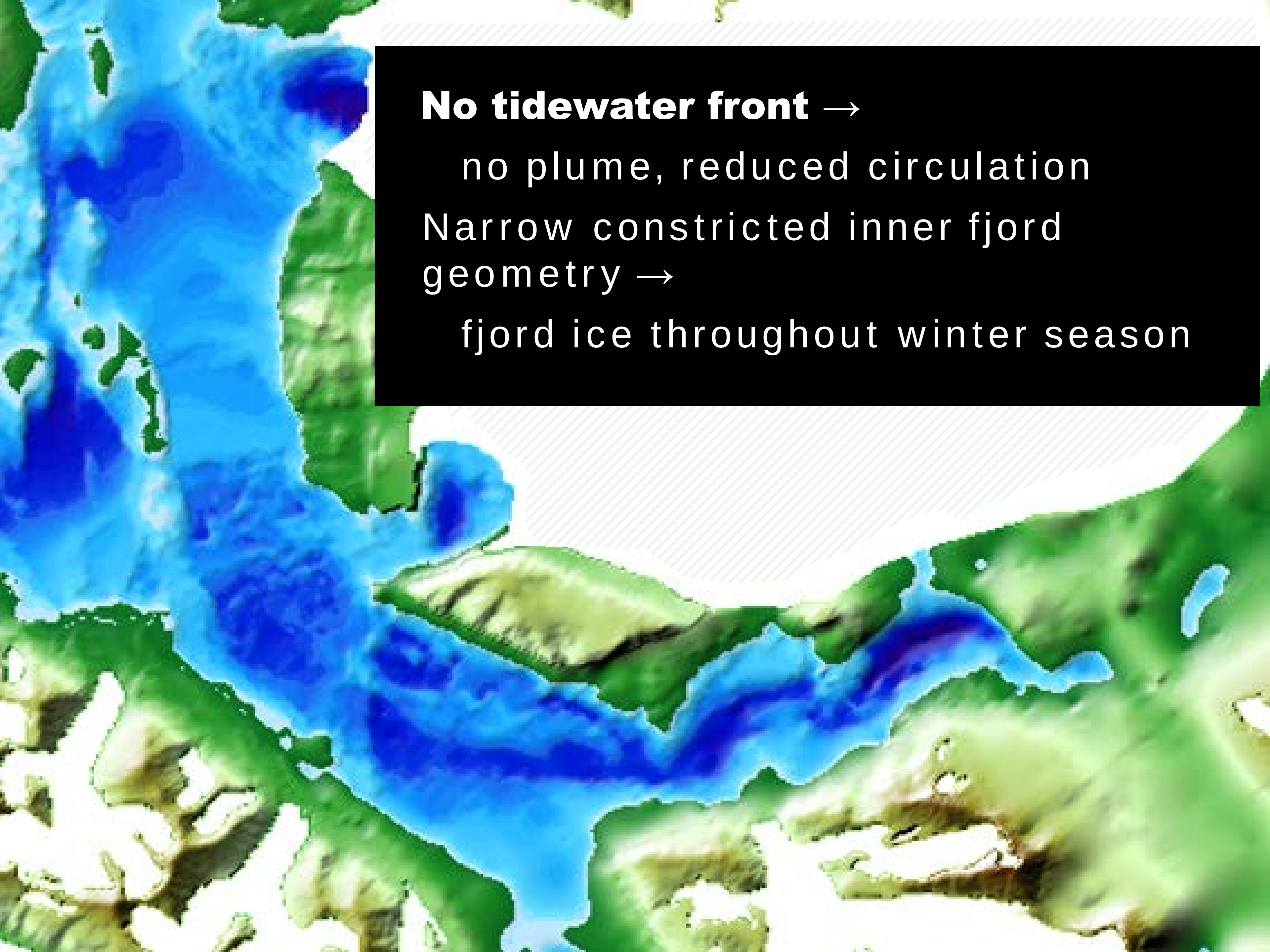


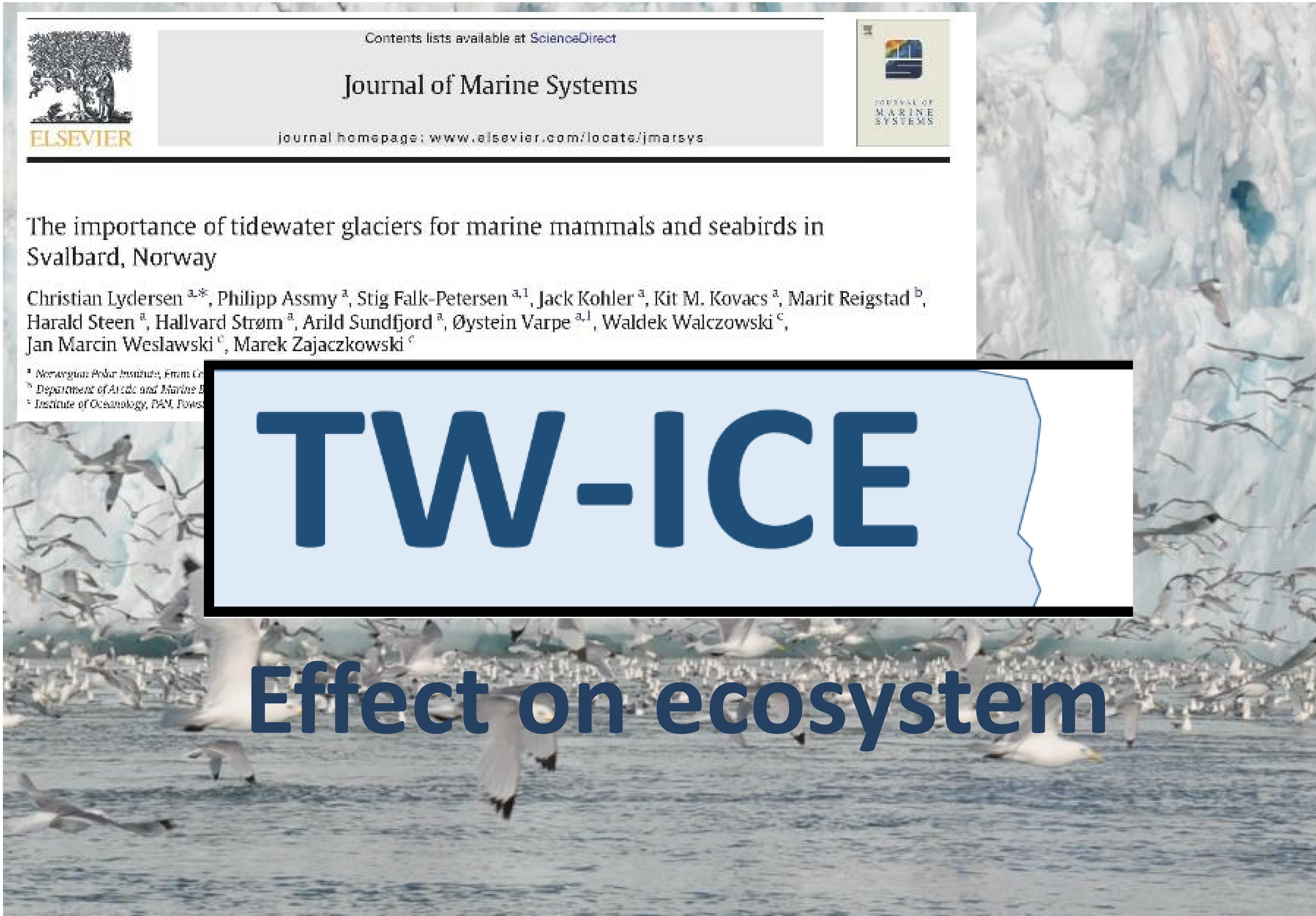
TWTT (µs)
Dist along profile (m)
Elevation (m)
Height above ground (m)
Speed (km/hr)
Distance (m)


500
450
400
350
300
250
200
150
100
50



20
0
-20
-40
-60
-80
-100
-120
-140
0
10 km


No tidewater front →
no plume, reduced circulation
Narrow constricted inner fjord geometry →
fjord ice throughout winter season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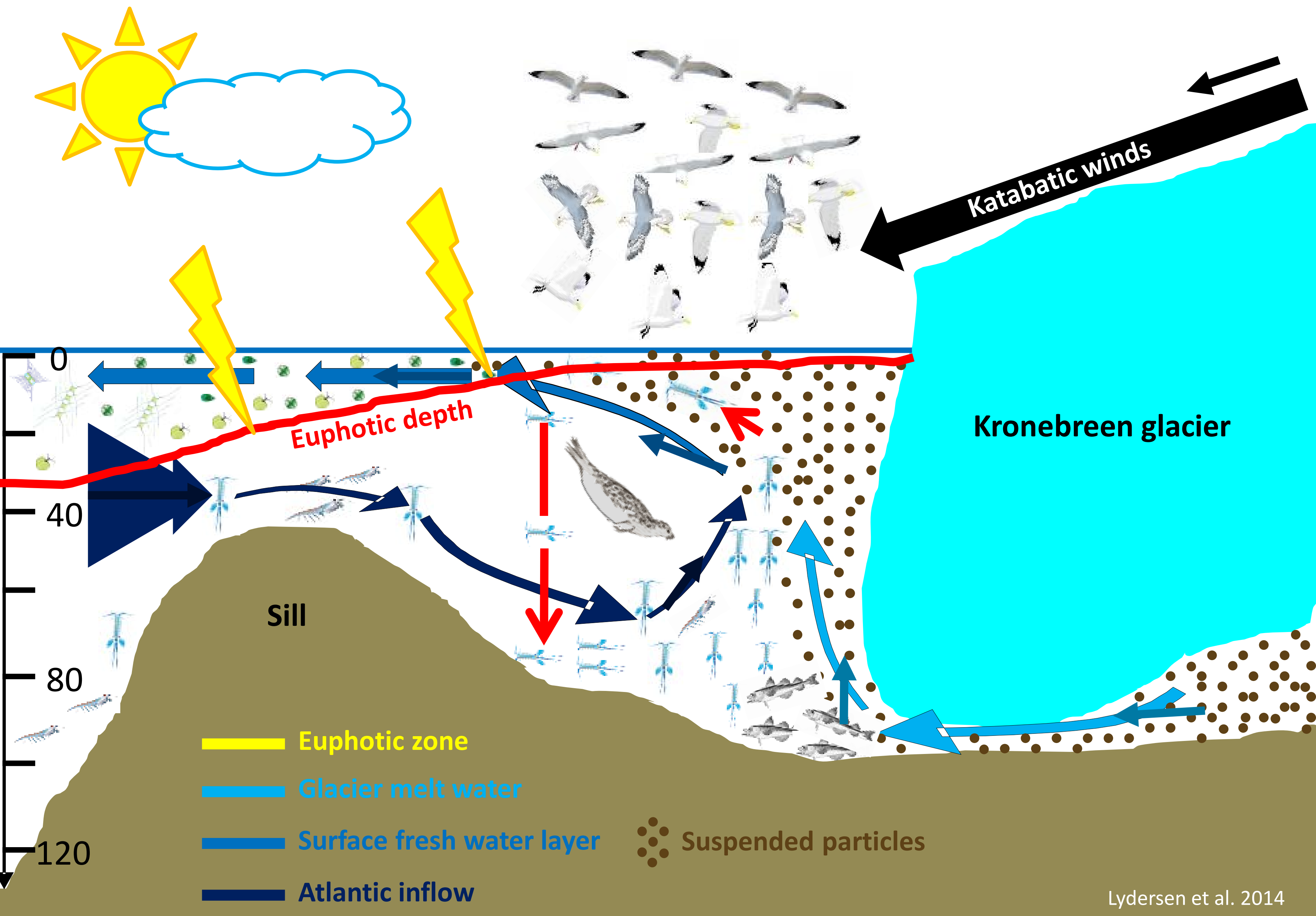
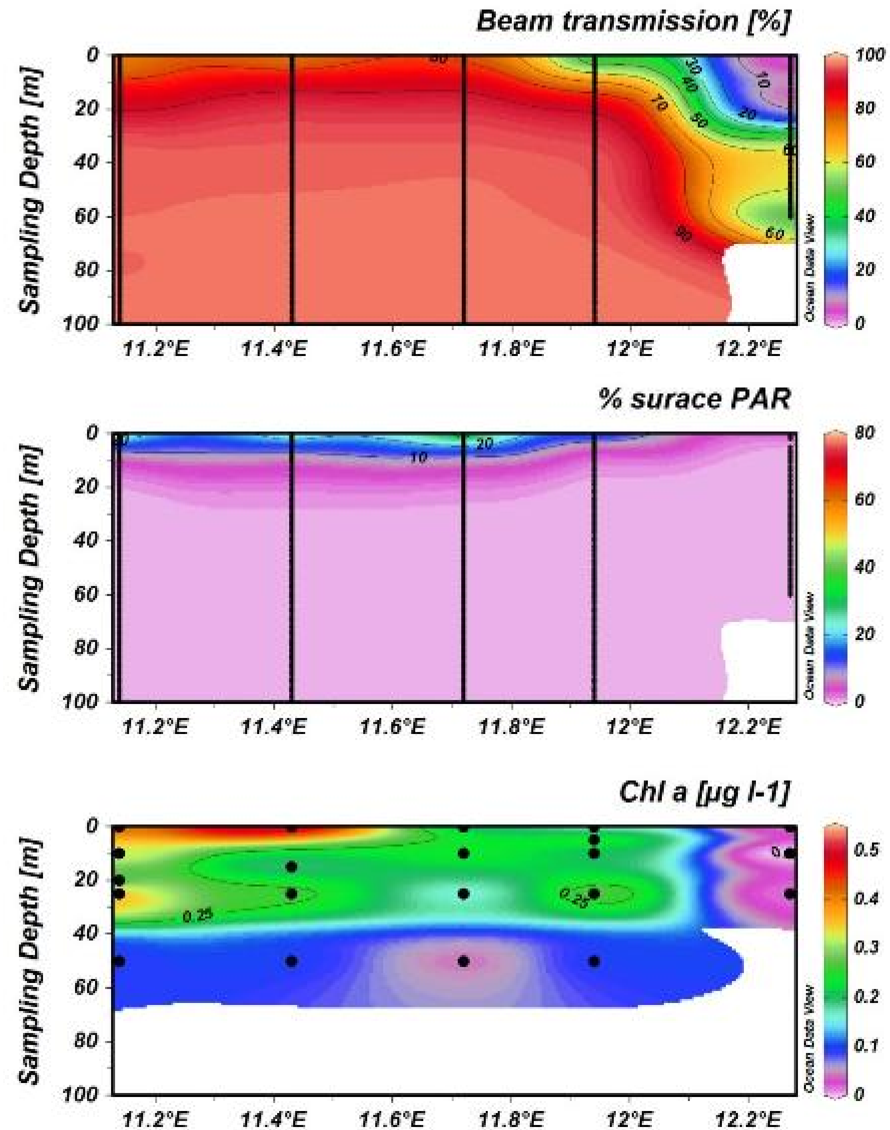
The importance of tidewater glaciers for marine mammals and seabirds in Svalbard, Norway
Christian Lydersen [a,*], Philipp Assmy [a], Stig Falk-Petersen [a,1], Jack Kohler [a], Kit M. Kovacs [a], Marit Reigstad [b], Harald Steen [a], Hallvard Strøm [a], Arild Sundfjord [a], Øystein Varpe [a,1], Waldek Walczowski [c], Jan Marcin Weslawski [c], Marek Zajaczkowski [c]
TW-ICE
Effect on ecosystem



Katabatic winds
Kronebreen glacier
Euphotic depth
Sill
0
40
80
120
Euphotic zone
Glacier melt water
Surface fresh water layer
Atlantic inflow
Suspended particles
Lydersen et al. 2014

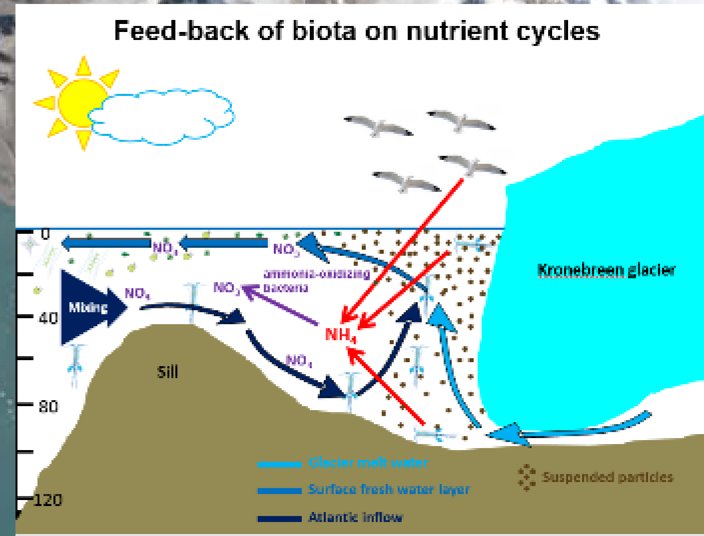
High sediment load limits PP close to the glacier during summer

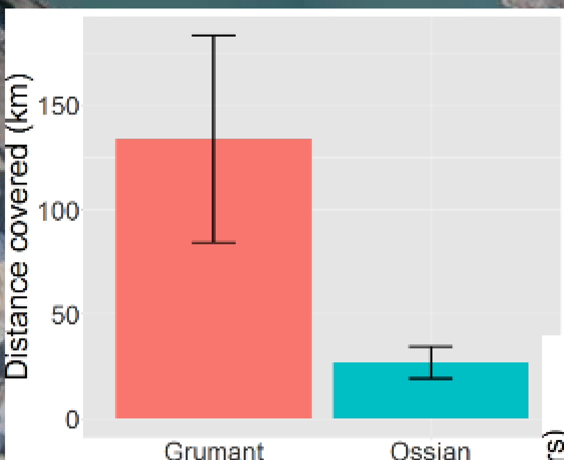
KongHau transect 2011

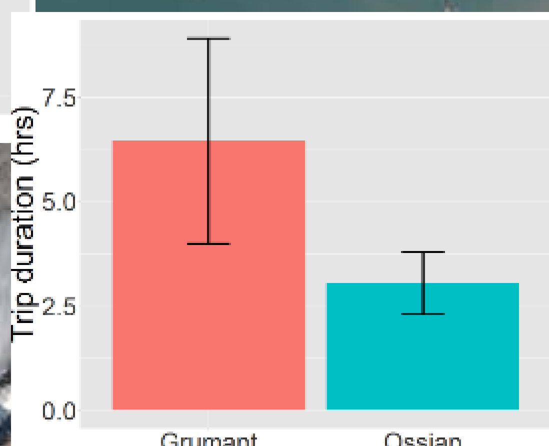


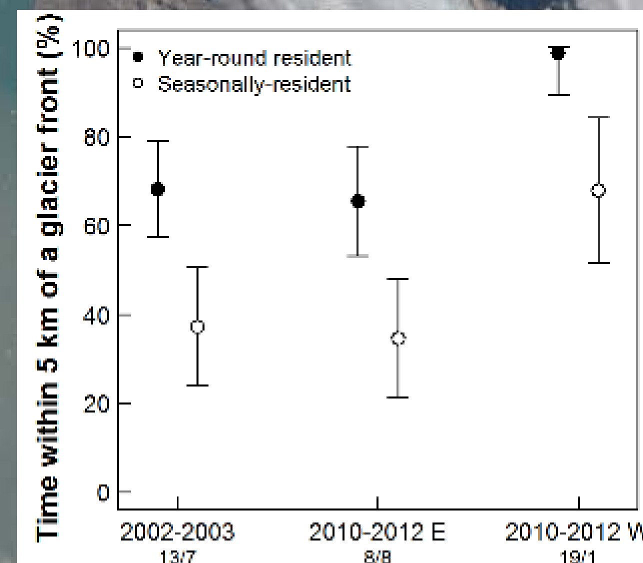
TW-ICE

Birds and animals









What happens in Kongsfjorden 2016