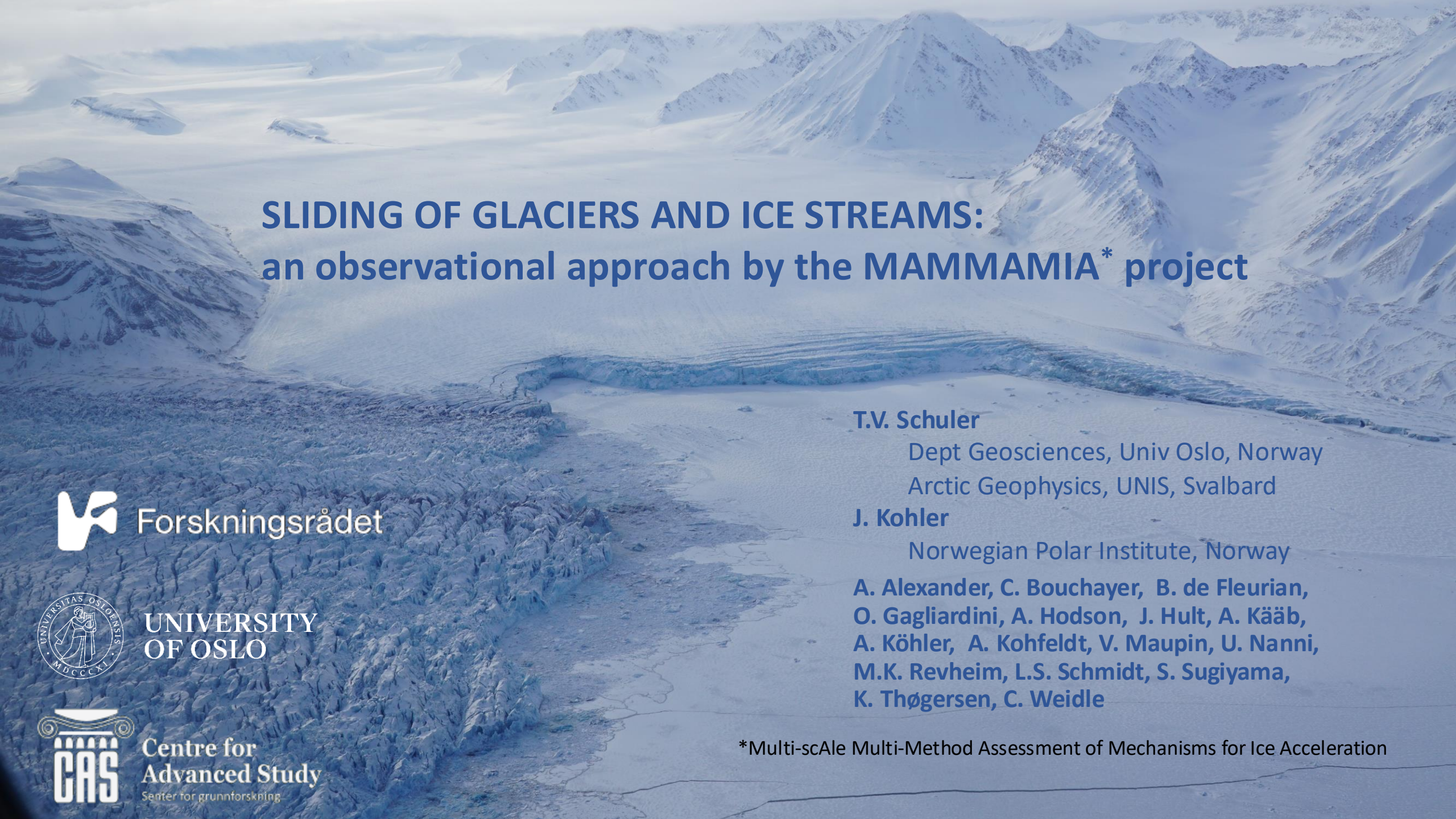
Hvor glatt er isen?
…og hva betyr dette for havsnivå?

Thomas V Schuler

Institutt for geofag, Universitetet i Oslo

United Nations | World Day for Glaciers 21 March



SLIDING OF GLACIERS AND ICE STREAMS: an observational approach by the MAMMAMIA* project

T.V. Schuler

Dept Geosciences, Univ Oslo, Norway

Arctic Geophysics, UNIS, Svalbard

J. Kohler

Norwegian Polar Institute, Norway

A. Alexander, C. Bouchayer, B. de Fleurian, O. Gagliardini, A. Hodson, J. Hult, A. Kääb, A. Köhler, A. Kohfeldt, V. Maupin, U. Nanni, M.K. Revheim, L.S. Schmidt, S. Sugiyama, K. Thøgersen, C. Weidle

*Multi-scAle Multi-Method Assessment of Mechanisms for Ice Acceleration

Forskningsrådet

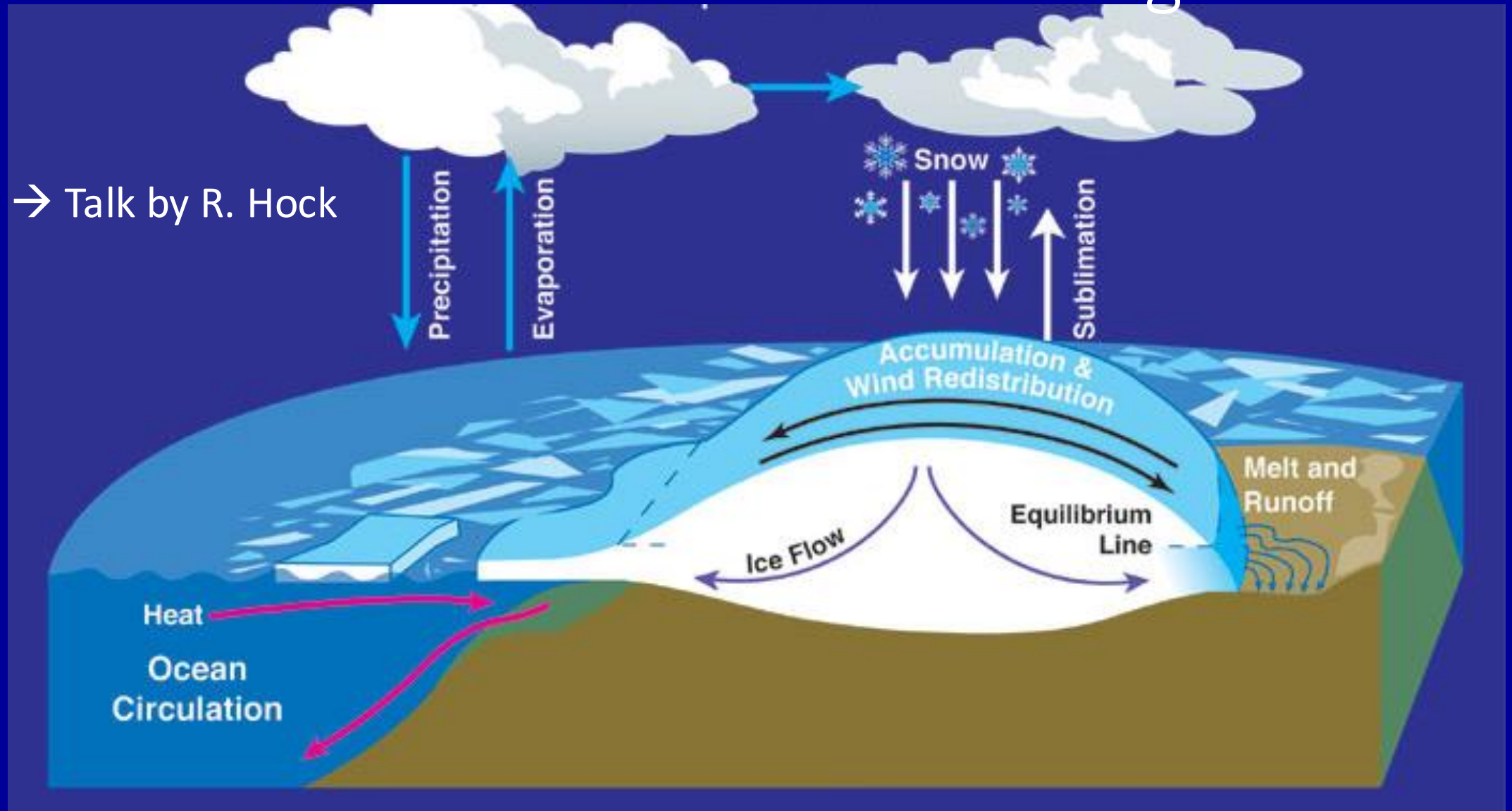
UNIVERSITY OF OSLO

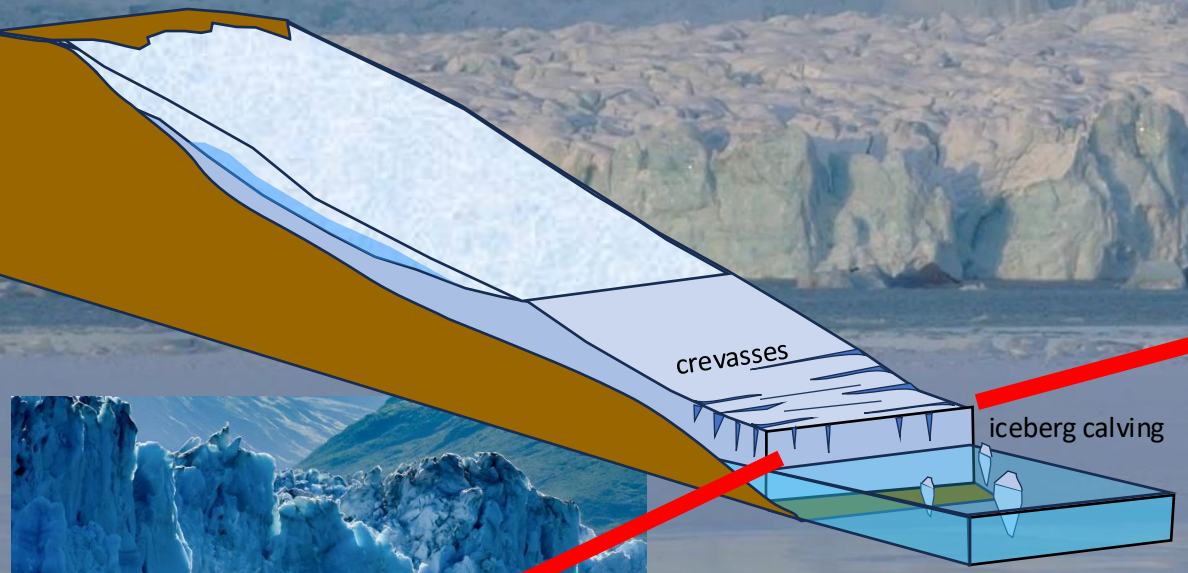
Centre for Advanced Study

Senter for grunnforskning

How do glaciers respond to climate change and contribute to sea level change?

→ Talk by R. Hock



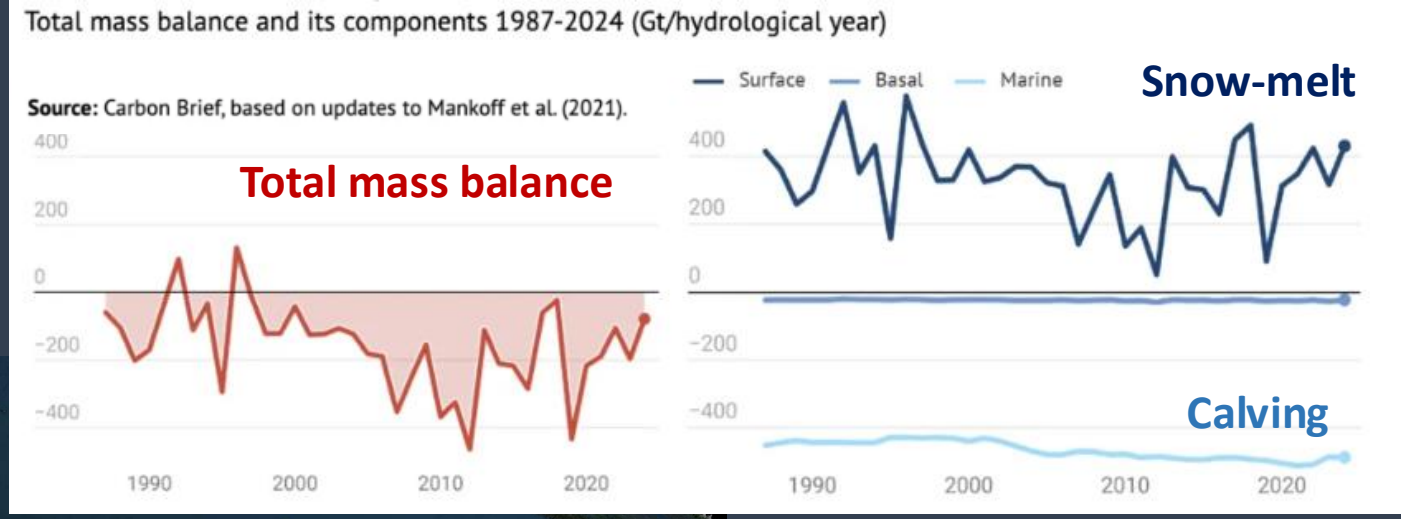


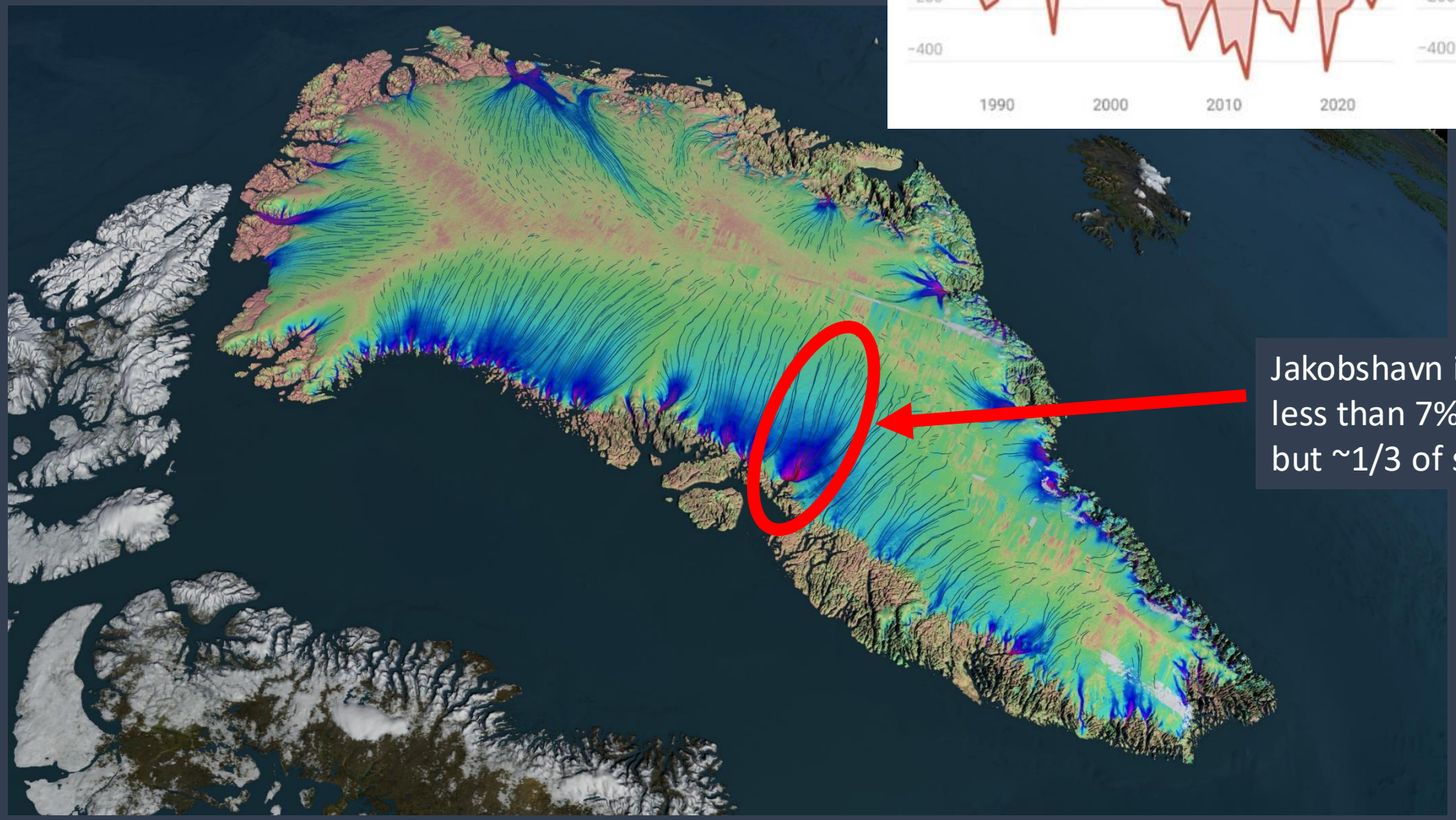
All glaciers (outside Greenland & Antarctica):
Ice discharge accounts for **~11% of mass loss change**
(King&Gourmelen 2020)

BUT:
Regionally important: Svalbard ~50%
Mass balance of GrIS would be positive w/o Q
Antarctica…exclusive way of mass loss

Glaciers = conveyor belt for ice to the ocean

Greenland ice sheet

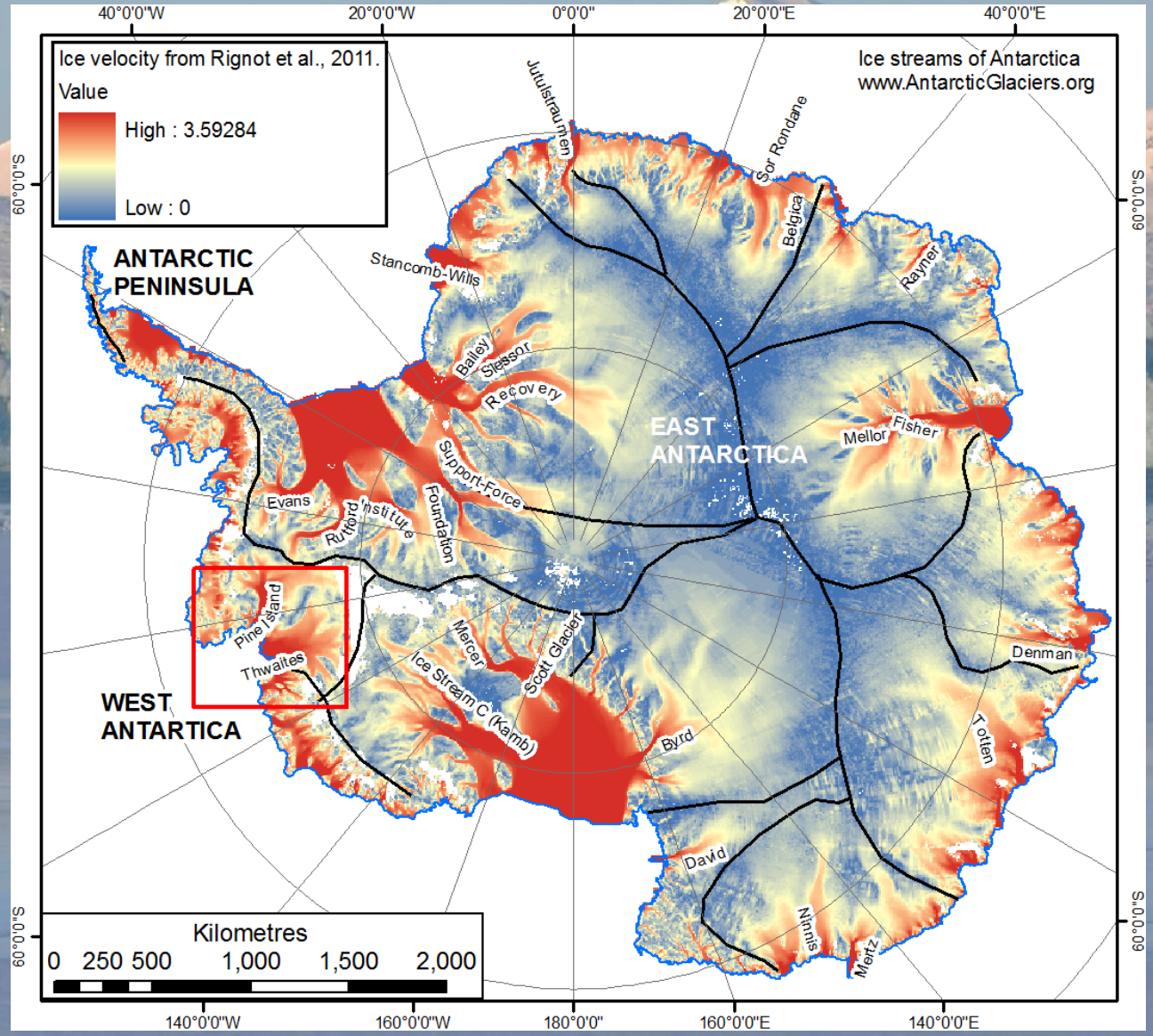




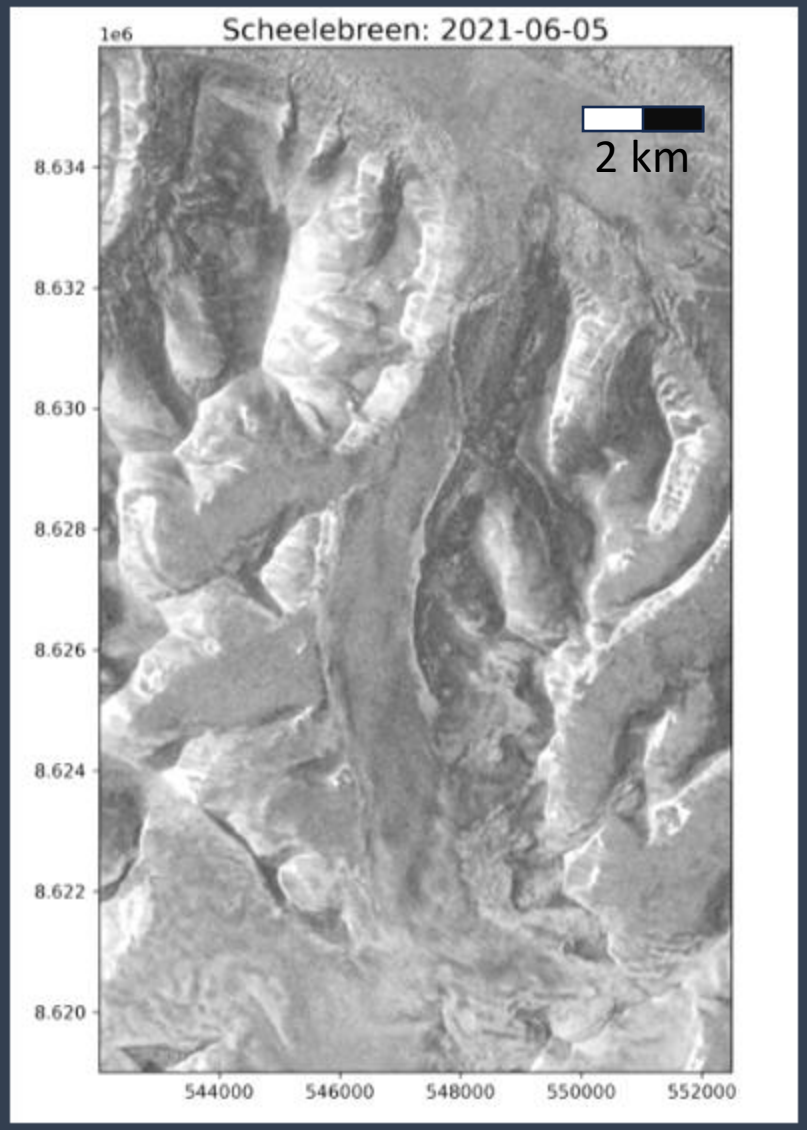
Jakobshavn isbræ/ sermeq kujalleq
less than 7% of GrIS area
but ~1/3 of solid ice Q (!!)

Antarctic ice sheet

- Transport depends on how fast the conveyor belt goes…
- Do glaciers change speed?



Example for a change of gear: Scheelebreen, Svalbard



credit: E. Schytt Mannerfelt

What determines basal sliding?

https://doi.org/10.5194/tc-2021-96
Preprint. Discussion started: 22 April 2021

The Cryosphere Discussions

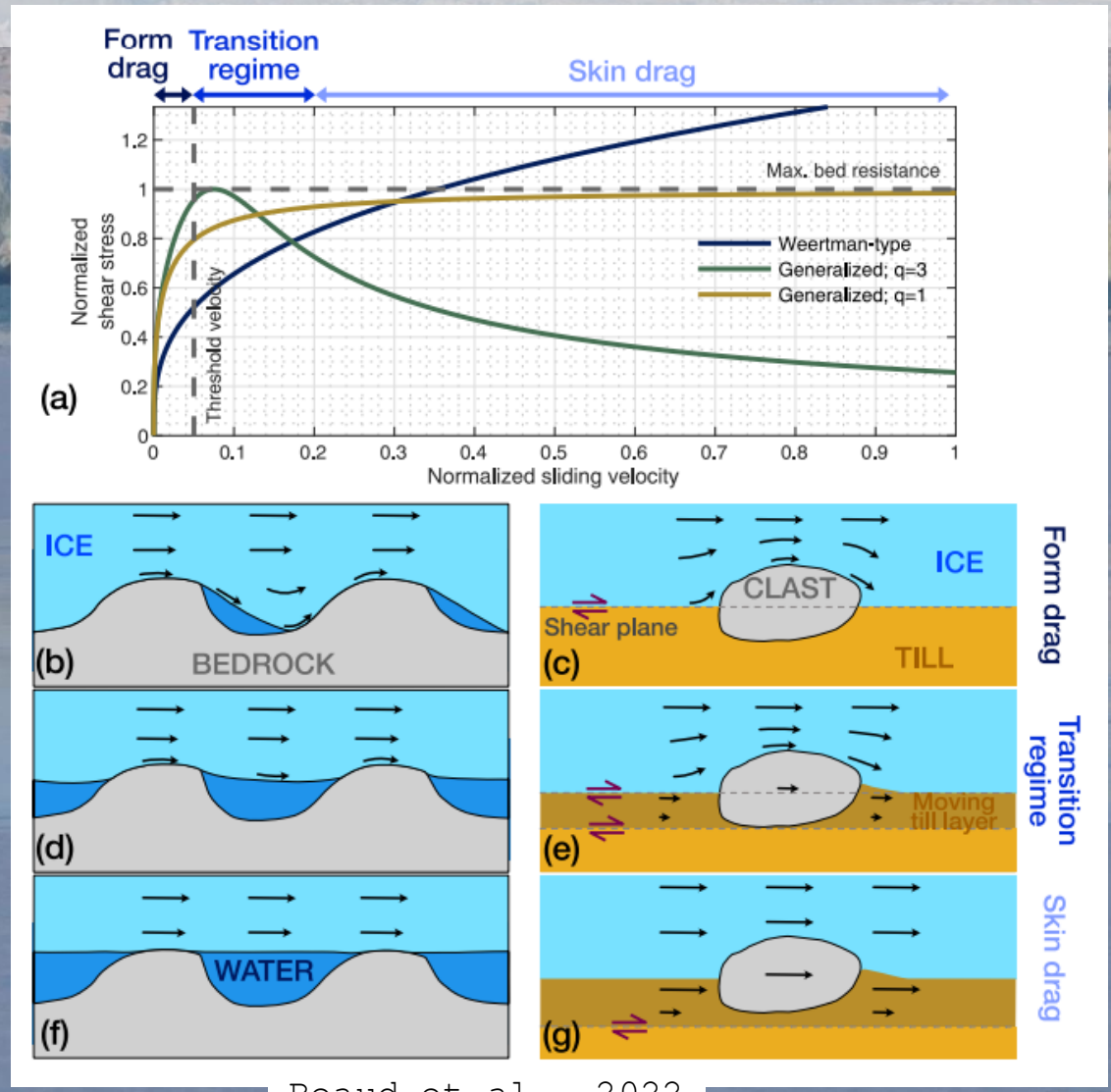
Generalized sliding law applied to the surge dynamics of Shisper Glacier and constrained by timeseries correlation of optical satellite images

Flavien Beaud[1,2], Saif Aati[1], Ian Delaney[3,4], Surendra Adhikari[3], and Jean-Philippe Avouac[1]

Finite-element modeling of subglacial cavities and related friction law

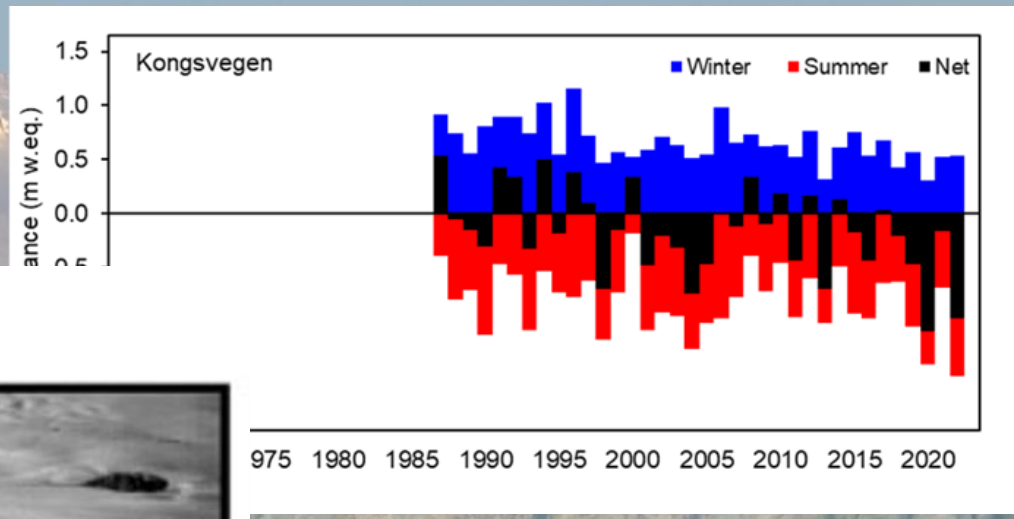
O. Gagliardini,[1] D. Cohen,[2] P. Råback,[3] and T. Zwinger[3]

$$\frac{\tau_b}{N} = C\left(\frac{\chi}{1+\alpha\chi^q}\right)^{1/n}$$

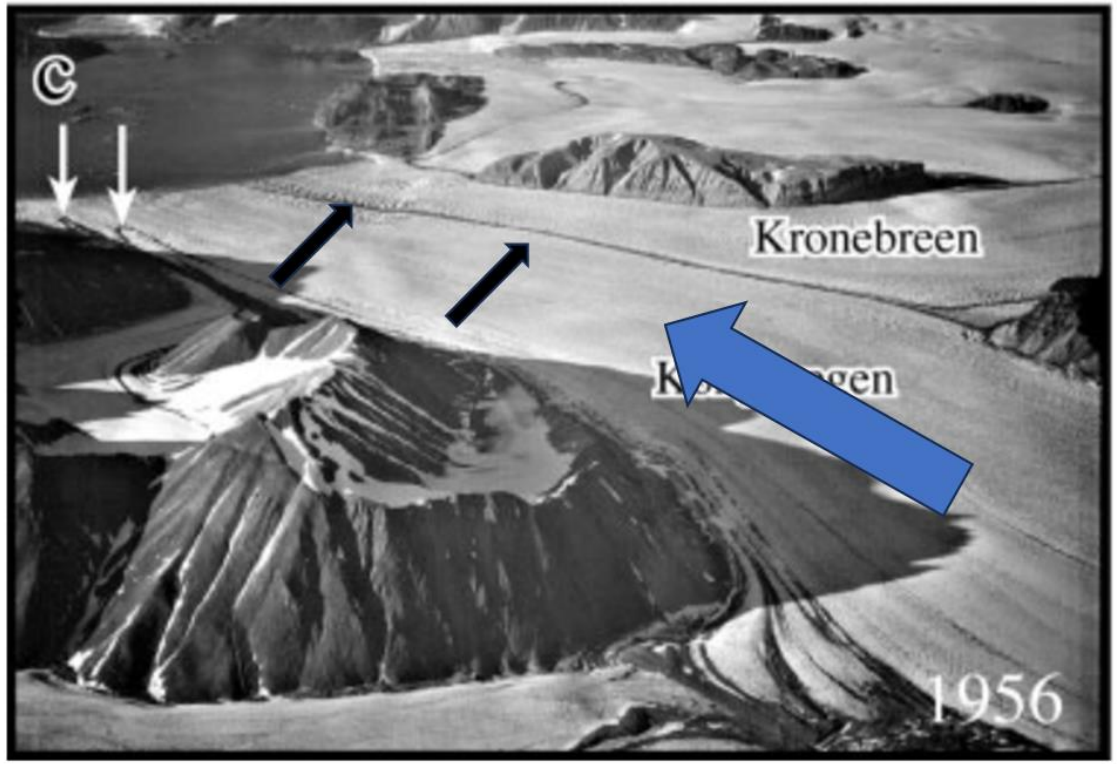


Beaud et al., 2022

toposvalbard.npolar.no

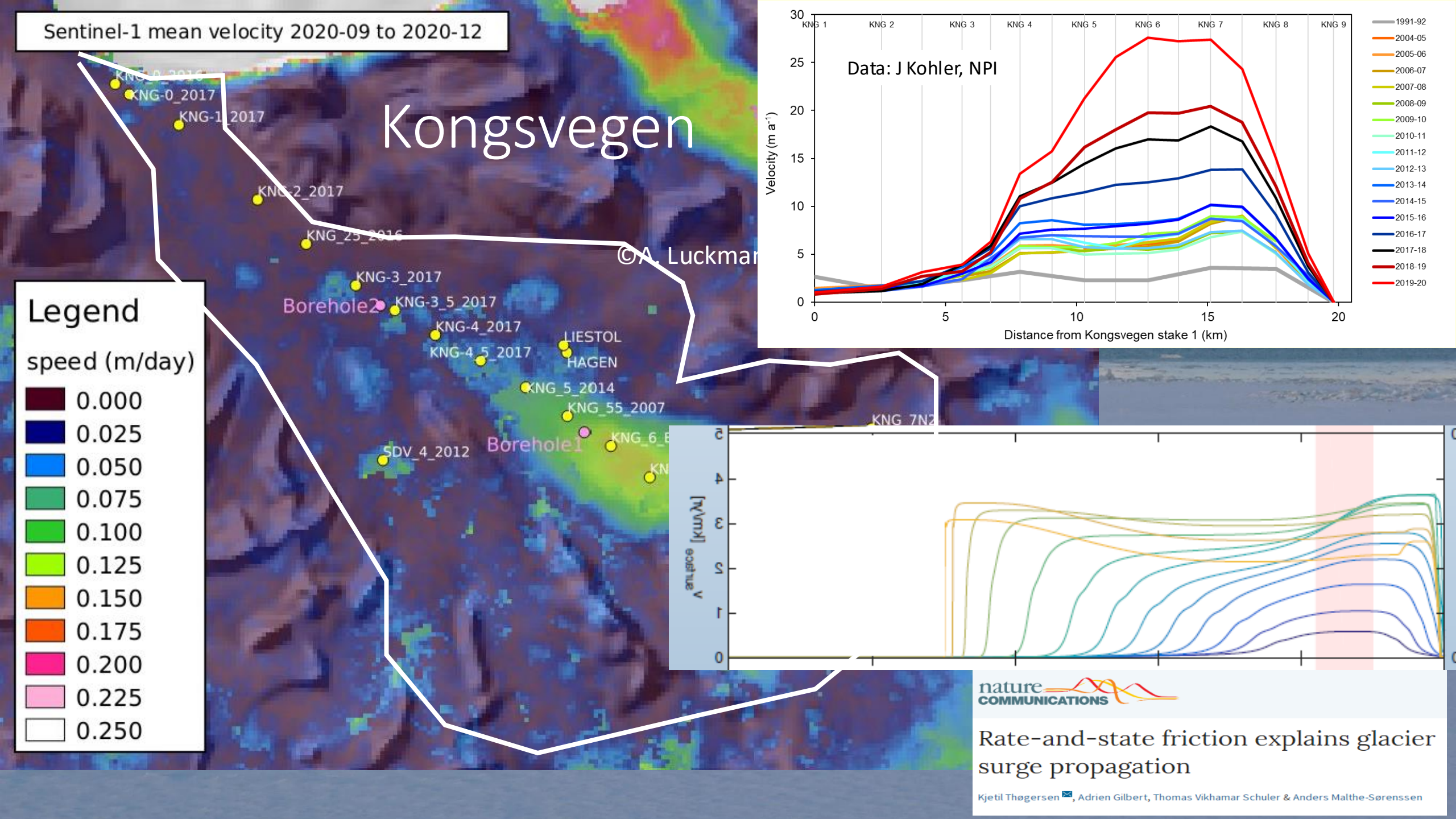


Surge in 1948



Woodward, J., Murray, T. and McCaig, A. (2002), Formation and reorientation of structure in the surge-type glacier Kongsvegen, Svalbard. J. Quaternary Sci., 17: 201-209. https://doi.org/10.1002/jqs.673

toposvalbard.npolar.no


Sentinel-1 mean velocity 2020-09 to 2020-12
Kongsvegen
©A. Luckman
KNG-0_2017
KNG-1_2017
KNG-2_2017
KNG_25_2016
KNG-3_2017
KNG-3_5_2017
Borehole2
KNG-4_2017
KNG-4_5_2017
LIESTOL
HAGEN
KNG_5_2014
KNG_55_2007
Borehole1
SDV_4_2012
Legend
speed (m/day)
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
0.225
0.250
Data: J Kohler, NPI
KNG 1
KNG 2
KNG 3
KNG 4
KNG 5
KNG 6
KNG 7
KNG 8
KNG 9
Velocity (m a-1)
Distance from Kongsvegen stake 1 (km)
1991-92
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
KNG_7N2
nature COMMUNICATIONS
Rate-and-state friction explains glacier surge propagation
Kjetil Thøgersen, Adrien Gilbert, Thomas Vikhamar Schuler & Anders Malthe-Sørenssen

Water intake

Heat & pressure

Motorized hose wheel

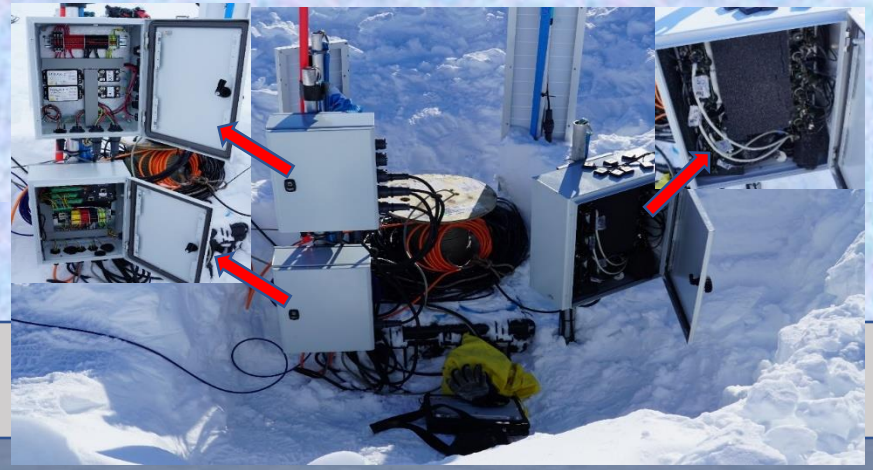
Drilling

Instrumentation

Data logging

Hot water drilling: rapid access to glacier base

Data recording and retrieval



subglacial water pressure,
seismicity,
sediment strength

meteo : T + P

Q

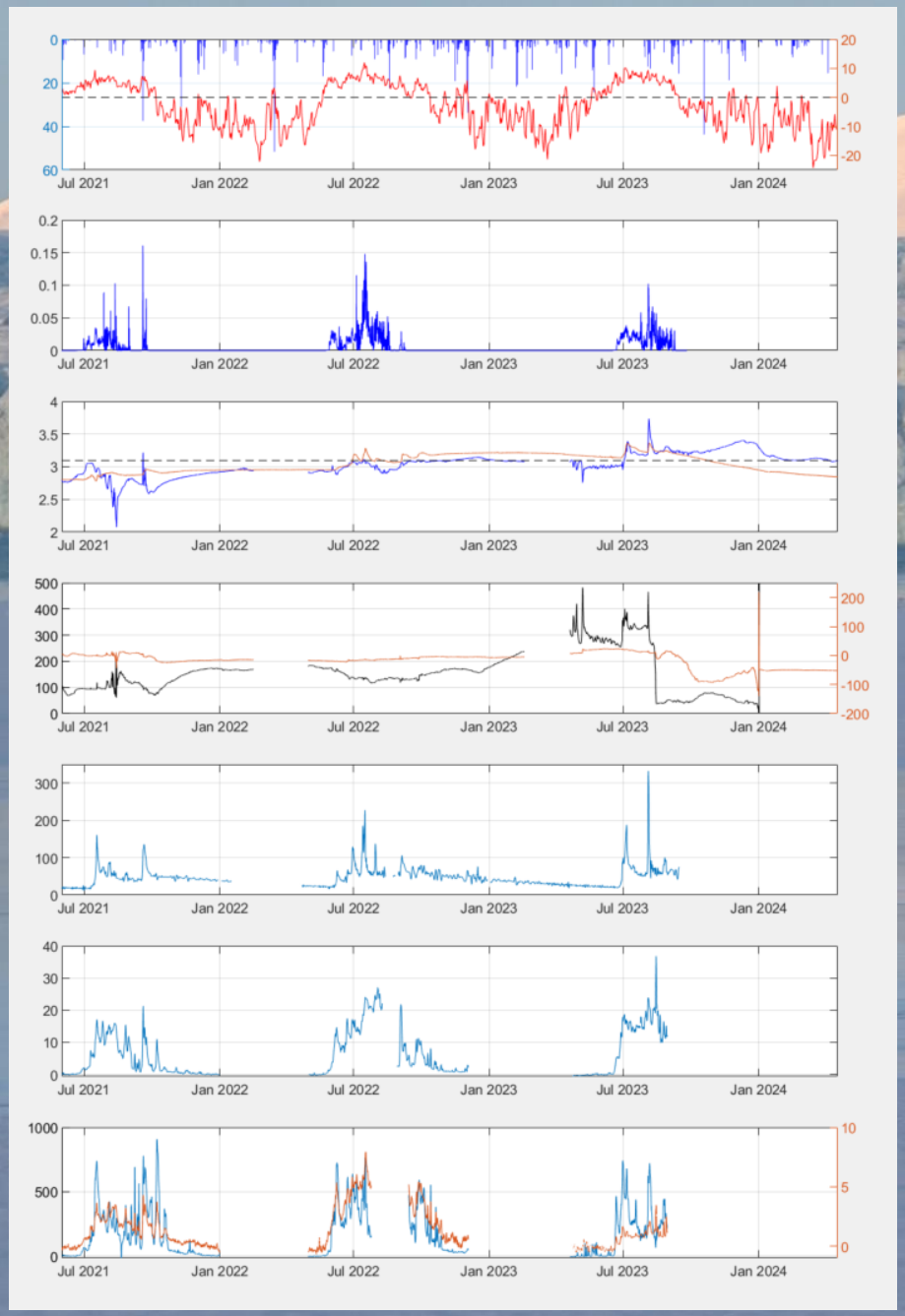
Pw: BH1 + BH2

Ploughing force& azimuth

speed

seismic power

seismic events: rate & amplitude



3 melt seasons of varying duration and intensity

3 melt seasons of varying duration and intensity

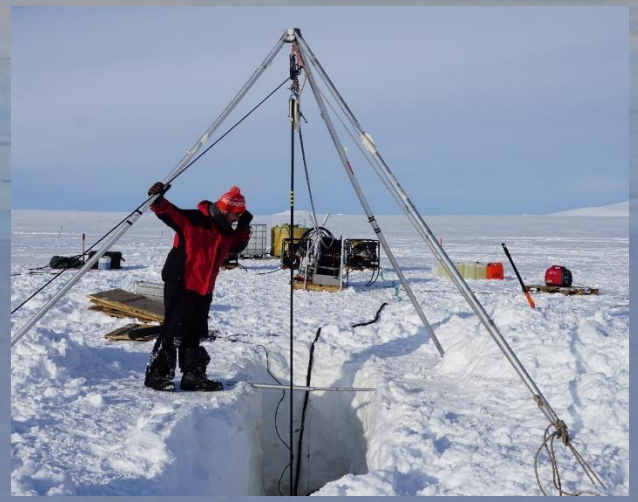
longterm increase and complex variations in summer, NOW : decline...(?)

some co-variation with Pw, but not simple

longterm increase and complex variations in summer, NOW : decline...(?)

co-variation with Q

co-variation with Q




20
10
0
-10
-20
-20
-10
0
10
20
Force+Direction
15-Sep-2021 00:59:00
70
80
60
90
50
100
40
110
30
120
20
130
10
140
0
150
Speed (m/year)
400
350
300
250
200
150
100
50
0
m H2O


20
10
0
-10
-20
-20
-10
0
10
20
Force+Direction
15-Sep-2021 00:10:00
70
80
60
90
50
100
40
110
30
120
20
130
10
140
0
150
Speed (m/year)
400
350
300
250
200
150
100
50
0
m H2O

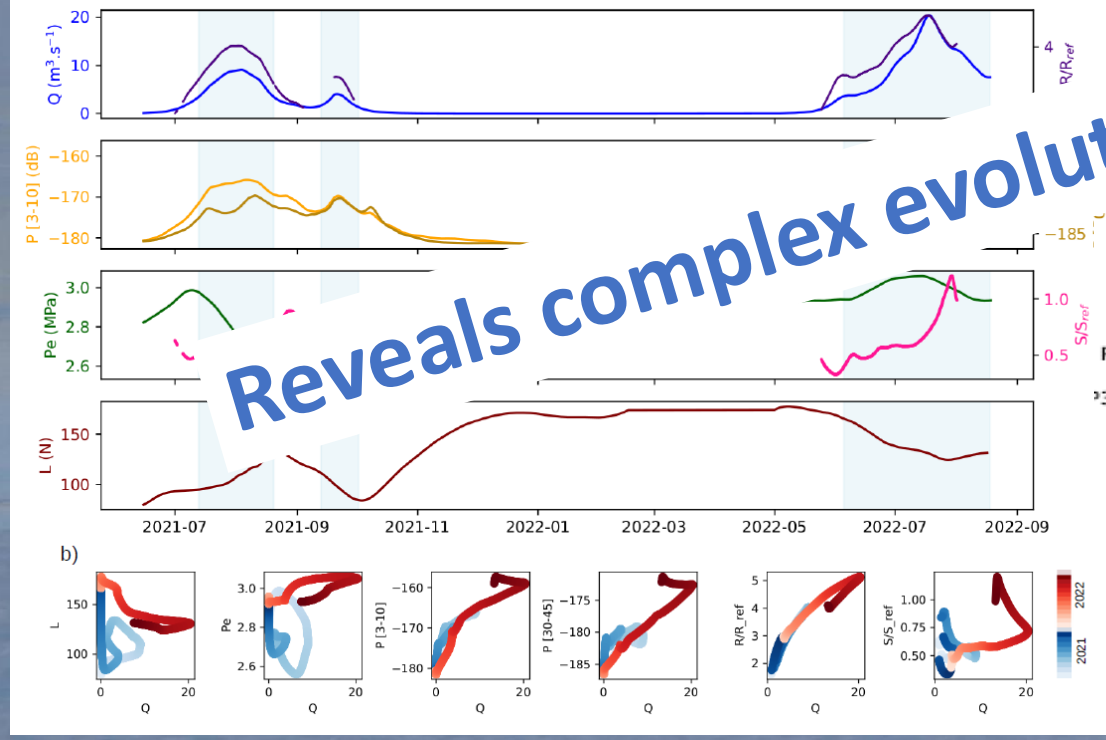
https://doi.org/10.5194/egusphere-2023-618
Preprint. Discussion started: 12 April 2023

EGUsphere Preprint repository

Multi-scale variations of hydro-mechanical conditions at the base of the surge-type glacier Kongsvegen, Svalbard

Coline Bouchayer[1,2], Ugo Nanni[2], Pierre-Marie Lefeuvre[3], John Hulth[2], Louise Steffensen Schmidt[2], Jack Kohler[3], François Renard[1,4], and Thomas V. Schuler[2]

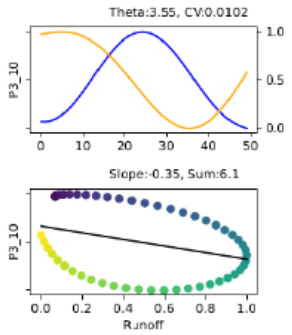
seasonal



Hysteresis classes

Class I

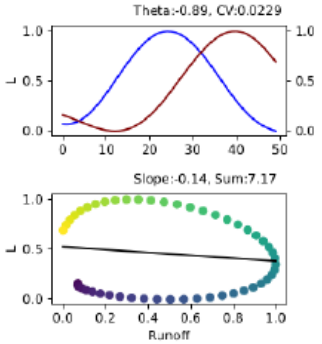
$\theta > 0$ & $S>2$



The peak of the observed variable is preceding the peak in runoff

Class II

$\theta < 0$ & $S>2$

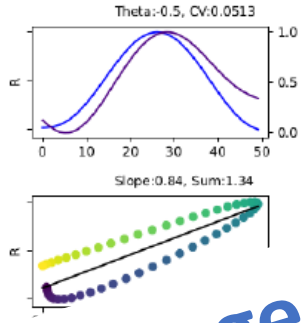


The peak of the variable is

Linear classes

Class III

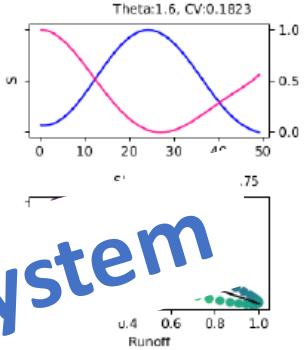
$m > 0$ & $S<2$



in

Class IV

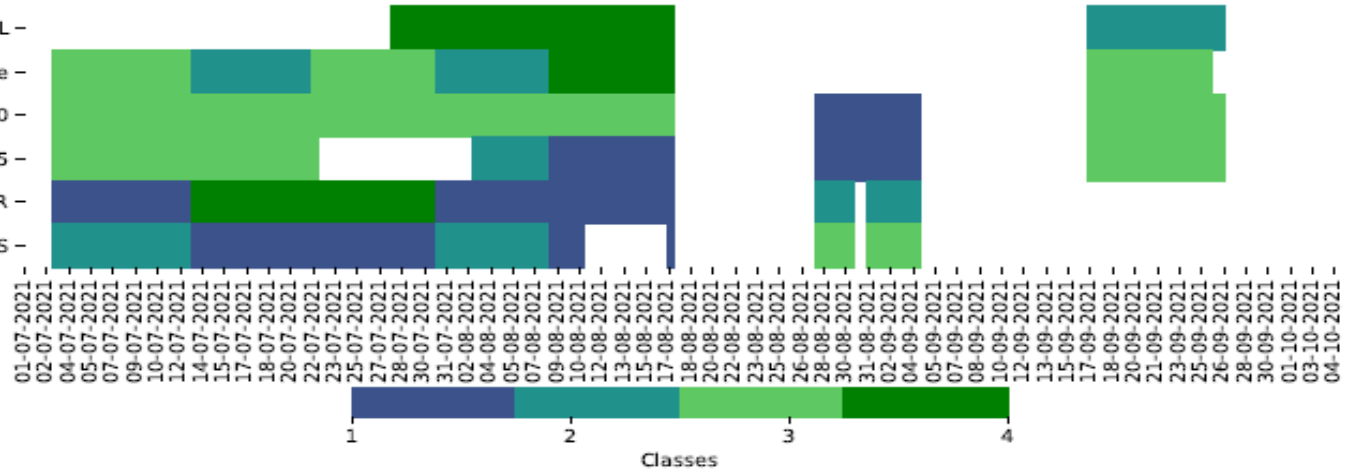
$m < 0$ & $S<2$



The two variables are out of phase

Reveals complex evolution of subglacial drainage system

Multi-day



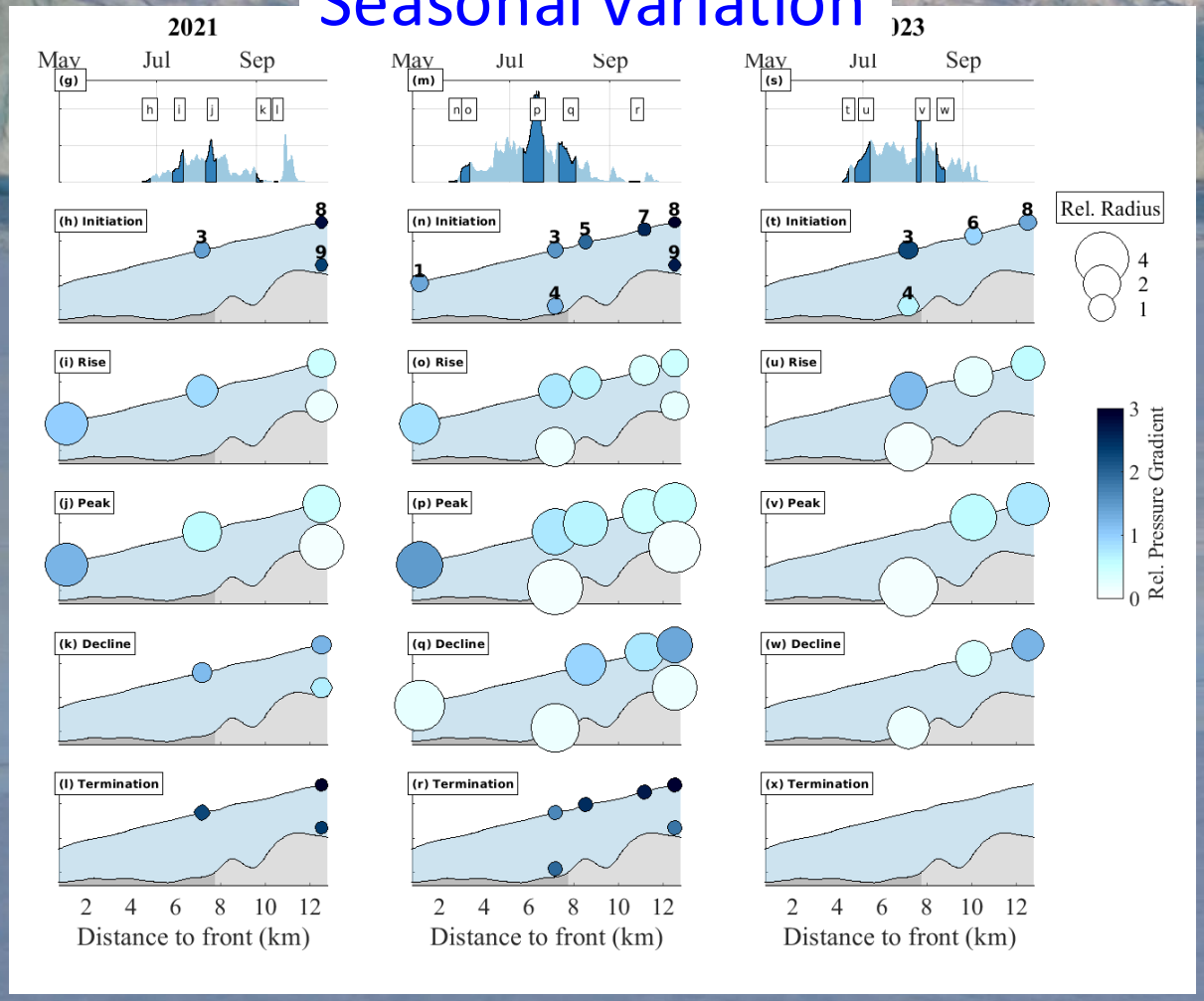
Observed weakening of glacier ice-bed interface caused by climatic and hydro-mechanical feedbacks: towards glacier-wide acceleration?

Ugo Nanni [1,*], Coline Bouchayer[1,2], Henning Åkesson[1], Pierre M. Lefeuvre [3], Erik S. Mannerfelt[1], Andreas Köhler [4], Louise S. Schmidt [1], John Hult [1], François Renard [2,5], Thomas V. Schuler [1]

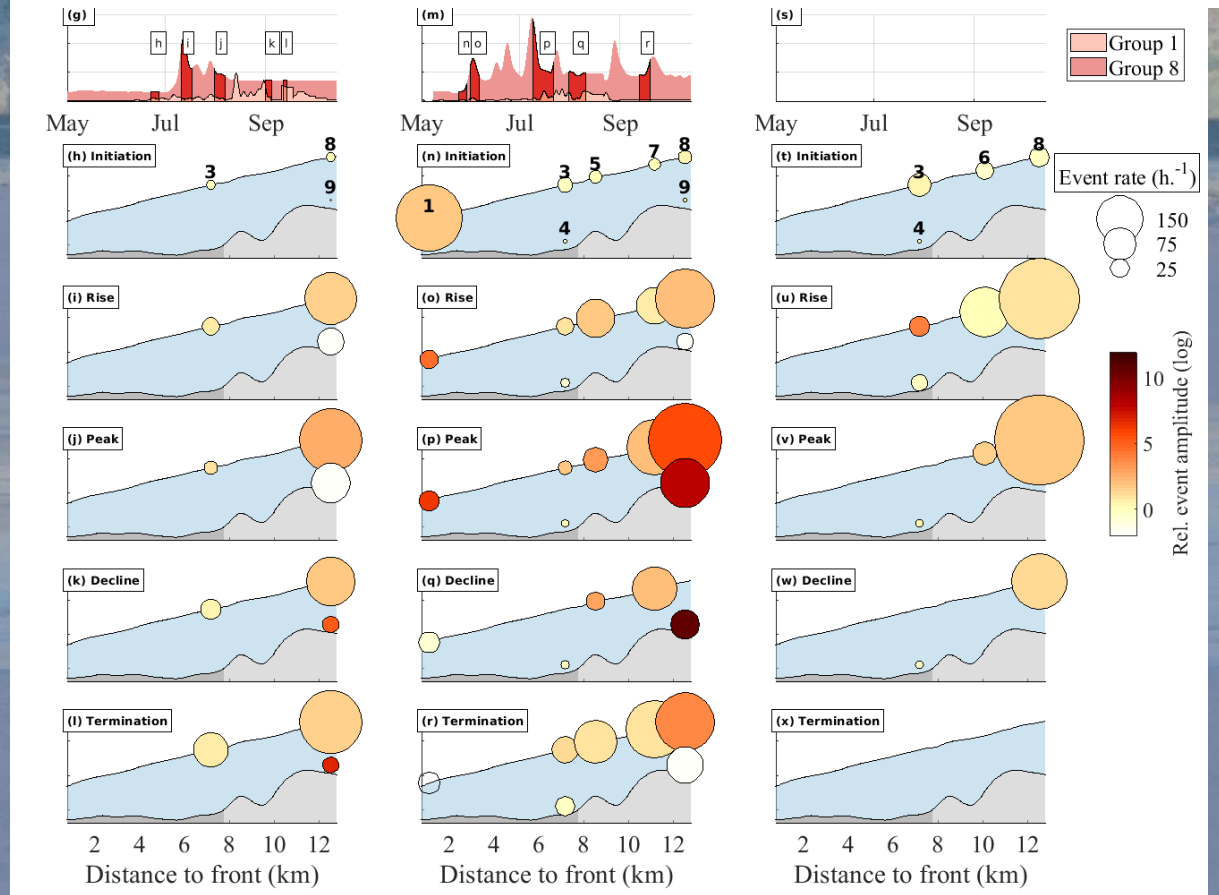
Seasonal evolution

Drainage + dynamics

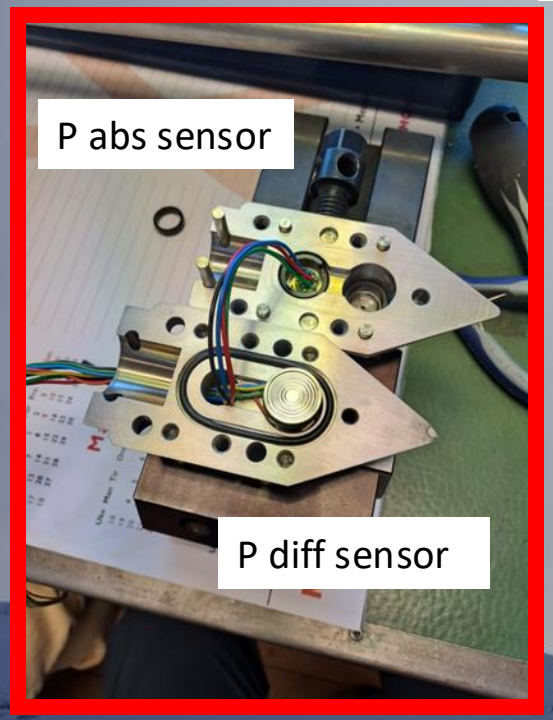
Seasonal variation



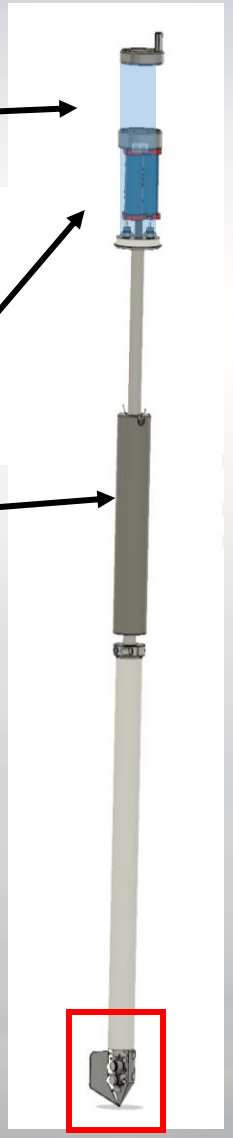
Seasonal variation + longterm increase

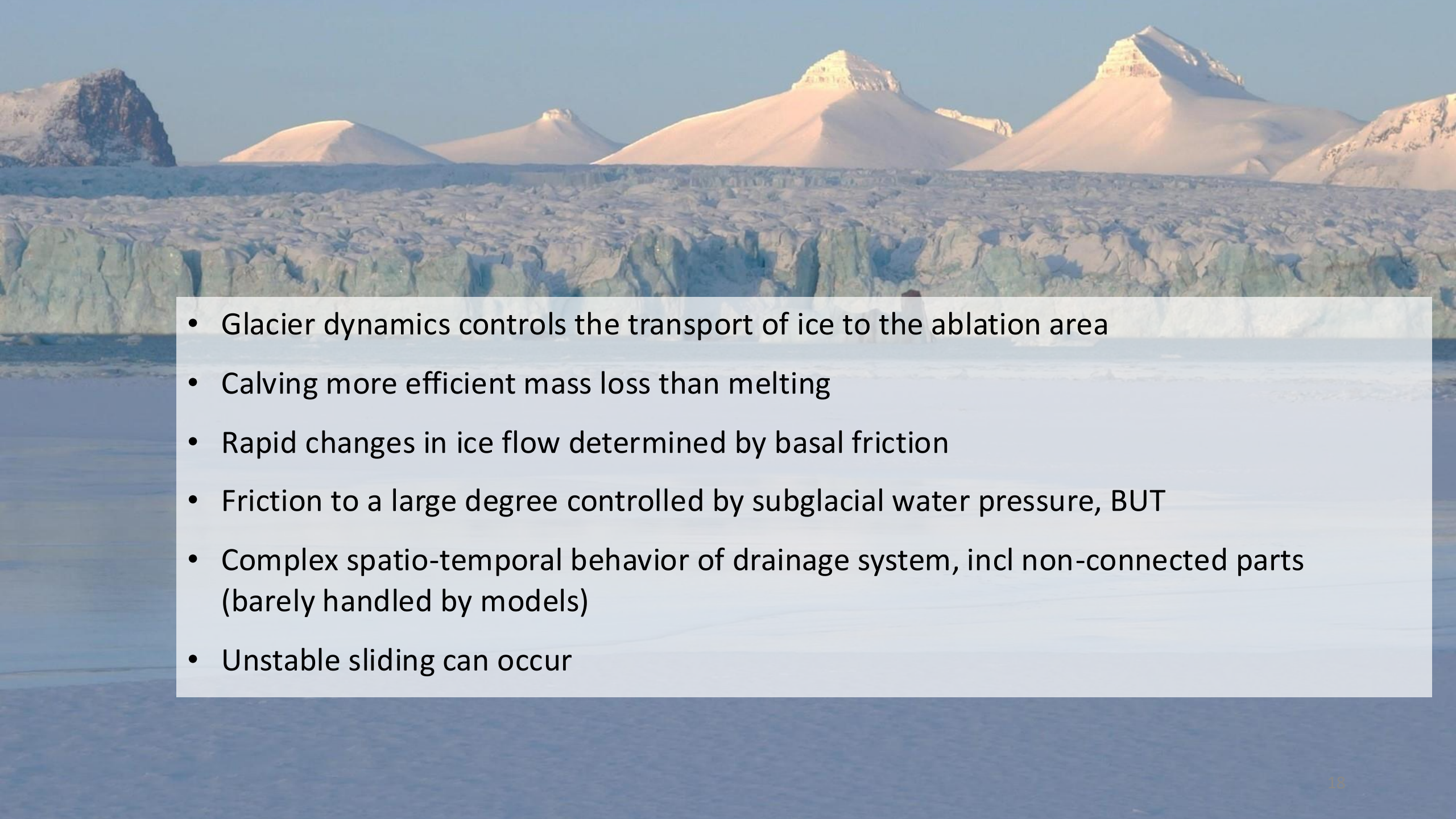


Outlook


P abs sensor
P diff sensor


Strain gauge
EC sensor
T sensor


Brain
Power supply
P abs
Tilt
Orientation
Hammer



- Glacier dynamics controls the transport of ice to the ablation area
- Calving more efficient mass loss than melting
- Rapid changes in ice flow determined by basal friction
- Friction to a large degree controlled by subglacial water pressure, BUT
- Complex spatio-temporal behavior of drainage system, incl non-connected parts (barely handled by models)
- Unstable sliding can occur