Recent glaciological activities in Zackenberg

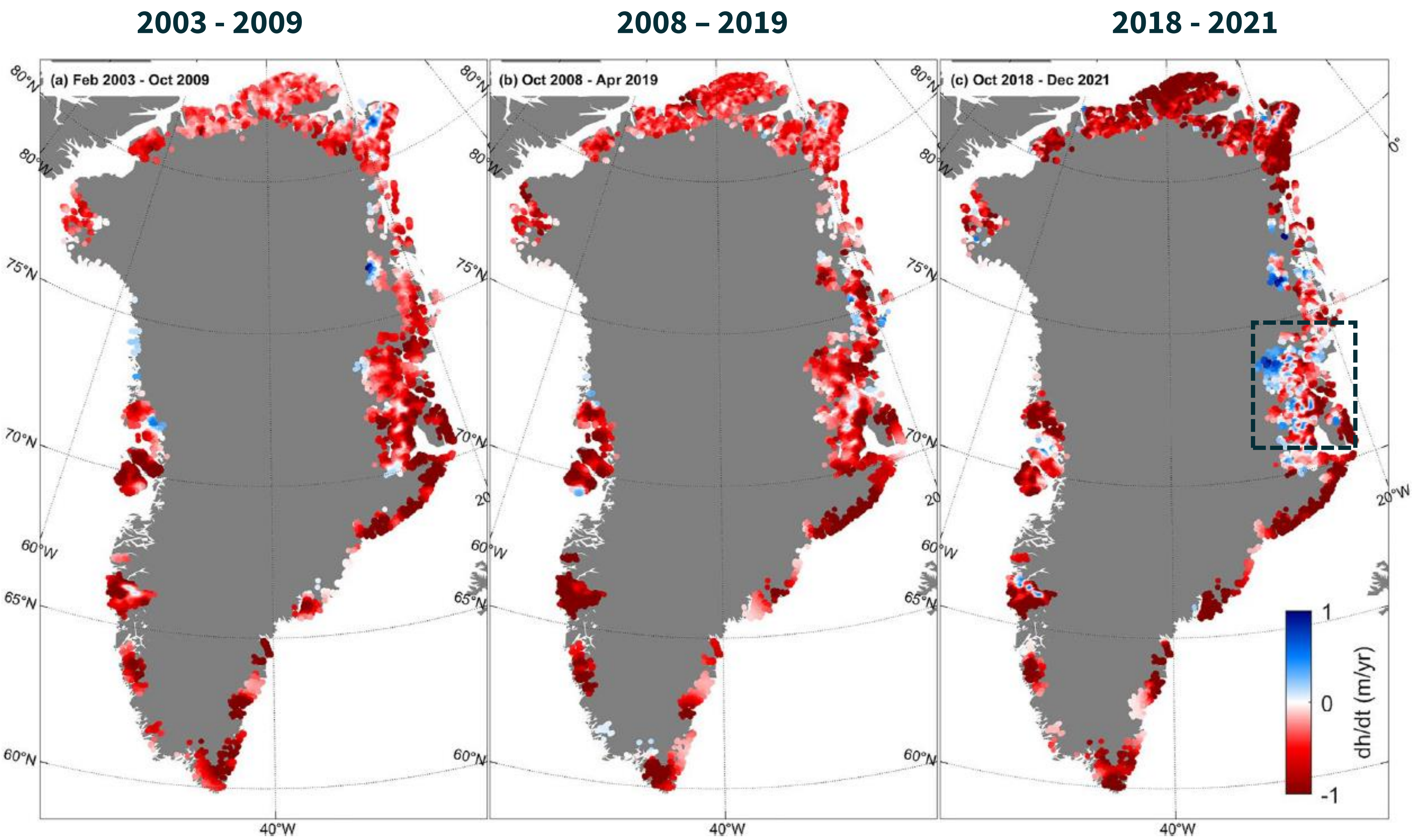
Freya Glacier, A.P. Olsen Icecap,
Zackenberg River discharge & Jökulhaups

Bernhard Hynek, Daniel Binder
and many more…

APRI Working Group Greilinger

9. Nov 2023

Greenland´s Peripheral Glaciers: 4 % of Ice Cover 11% of Total Ice Loss (SLR)



Khan et al., 2021, GRL

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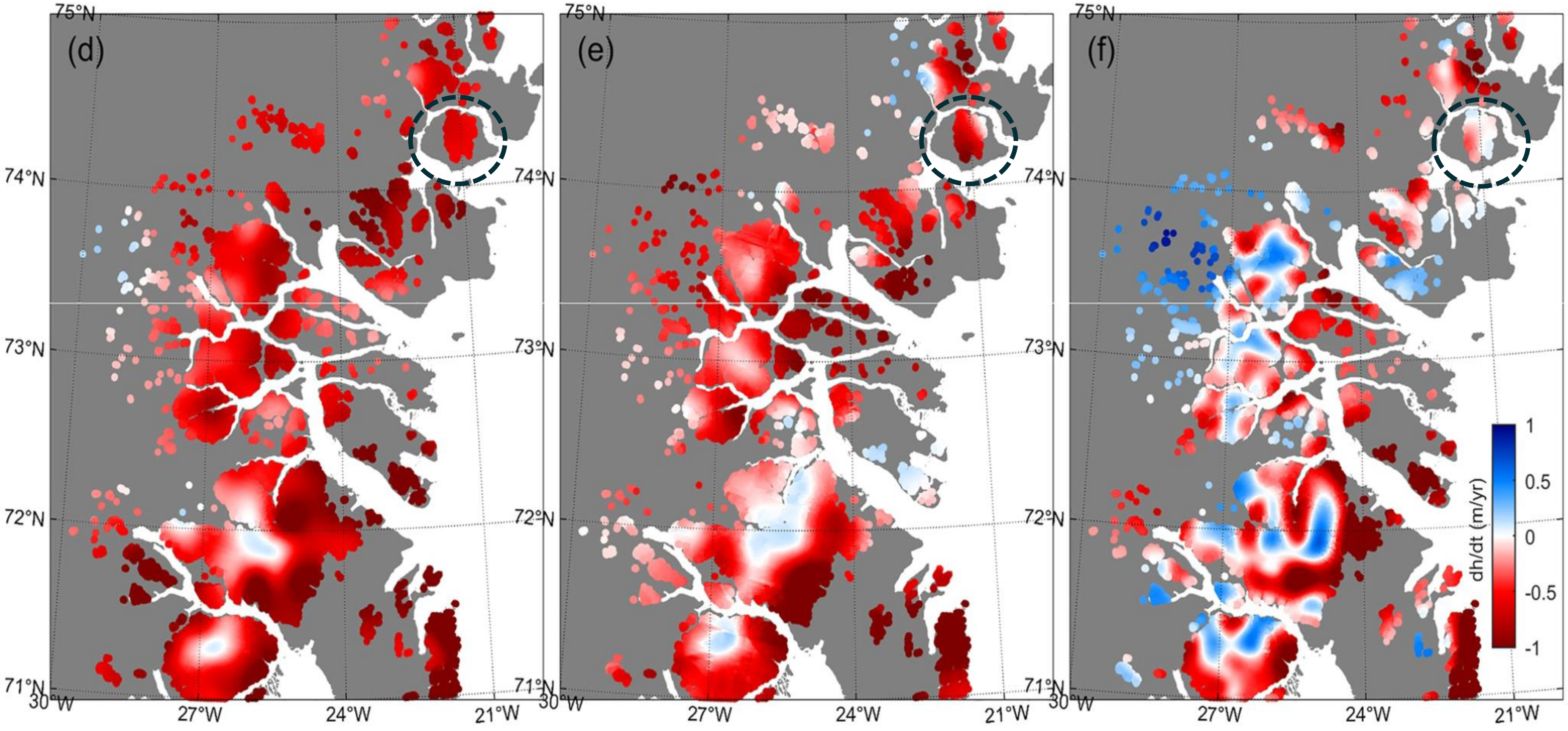
Greenland´s Peripheral Glaciers: 4 % of Ice Cover 11% of Total Ice Loss (SLR)

2003 - 2009 **2008 – 2019** **2018 - 2021**



Khan et al., 2021, GRL

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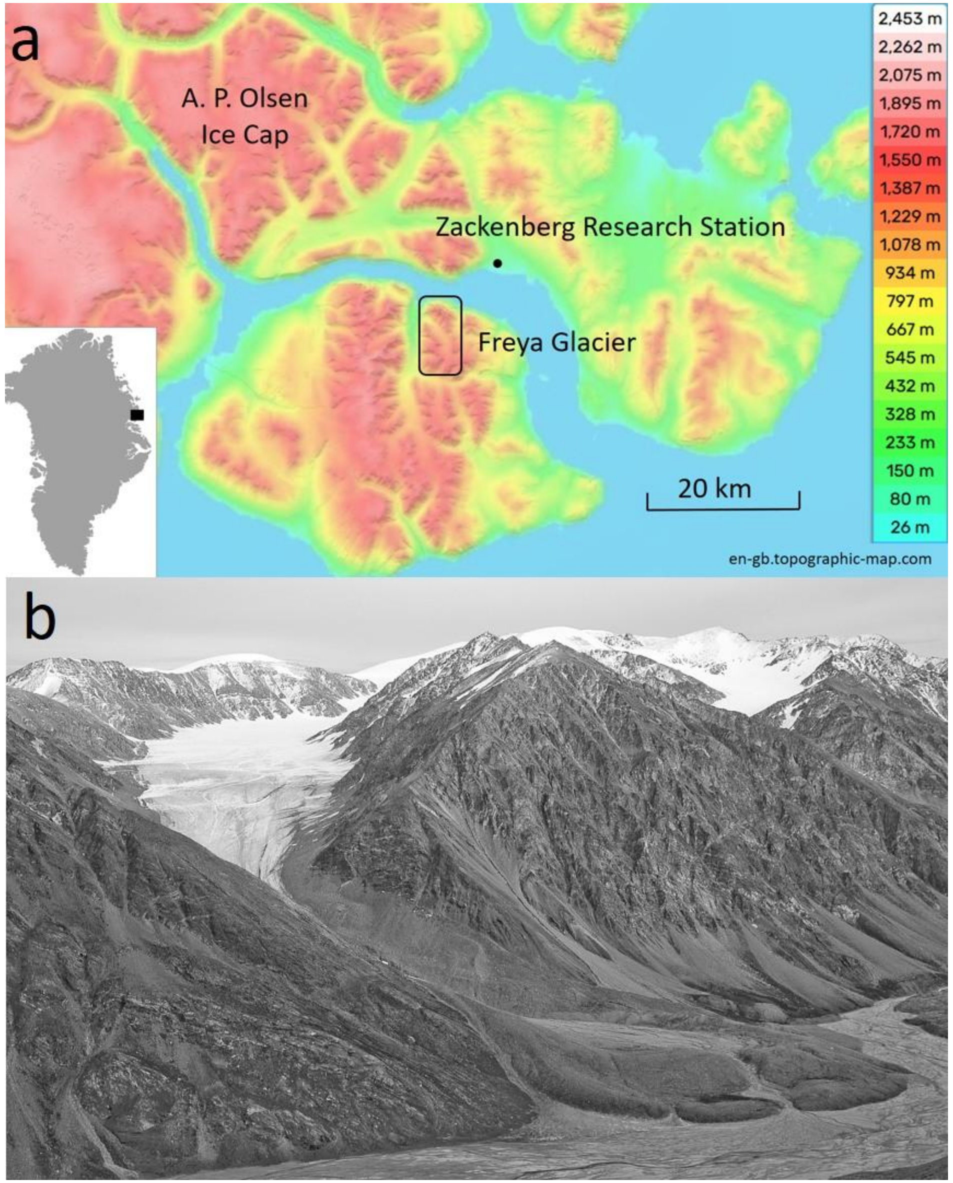
Freya Glacier



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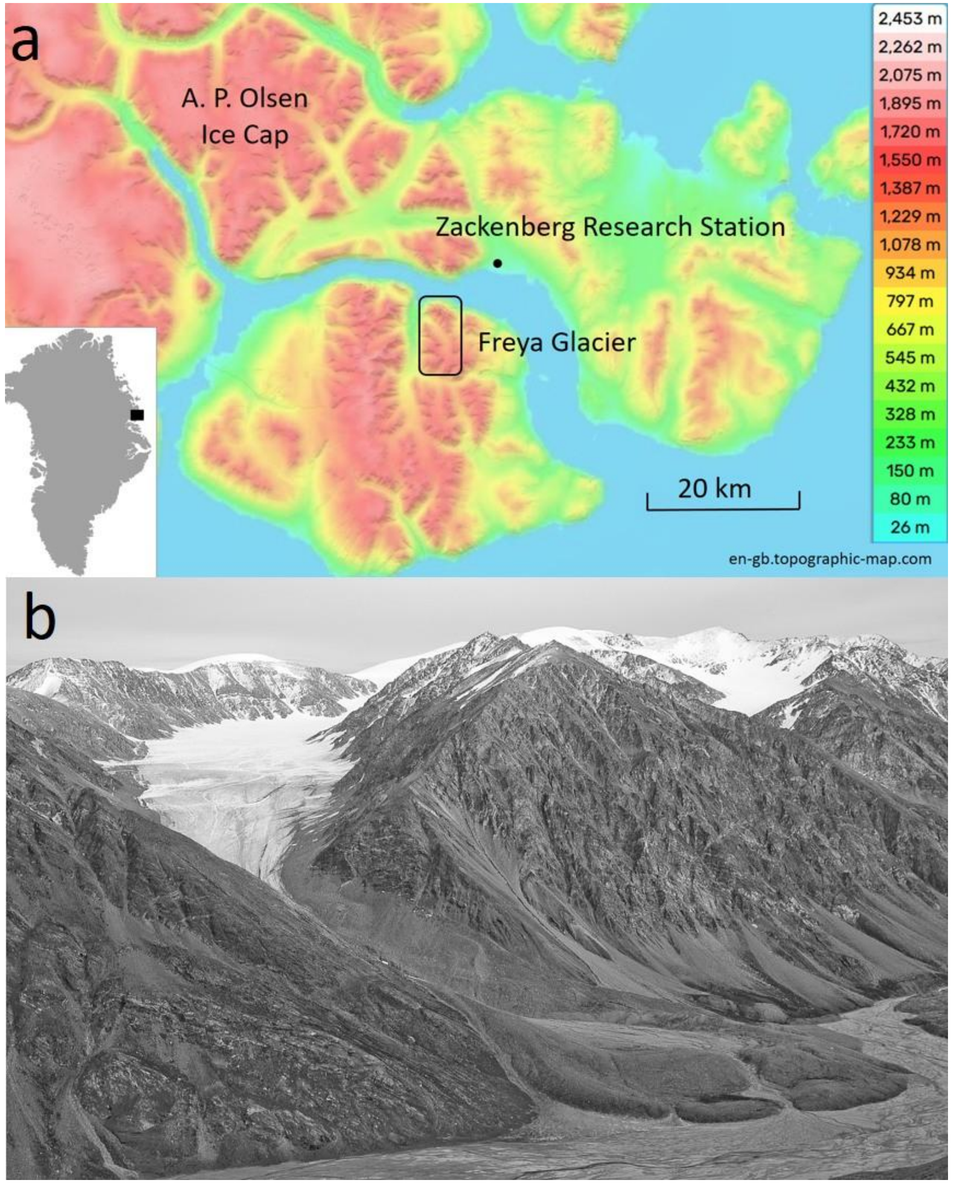
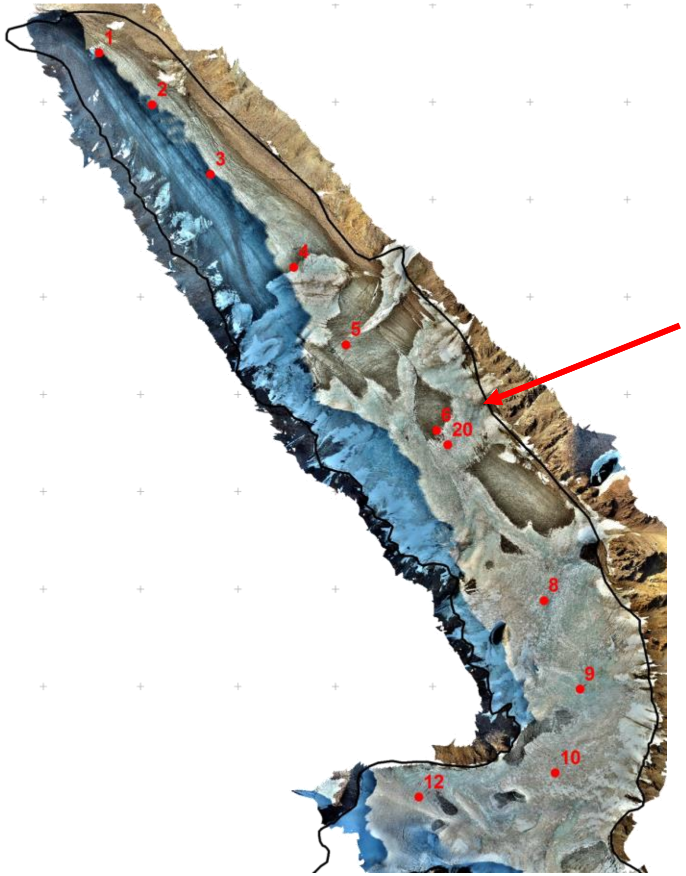
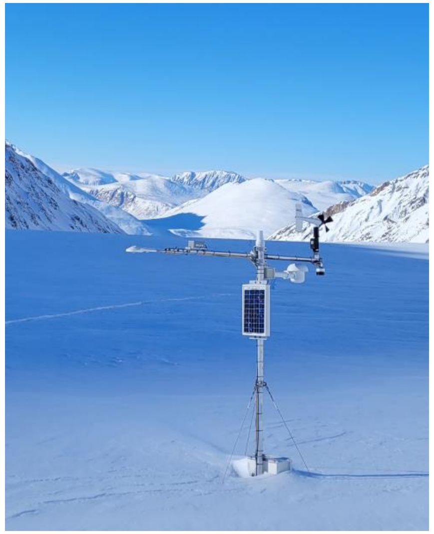
Freya Glacier







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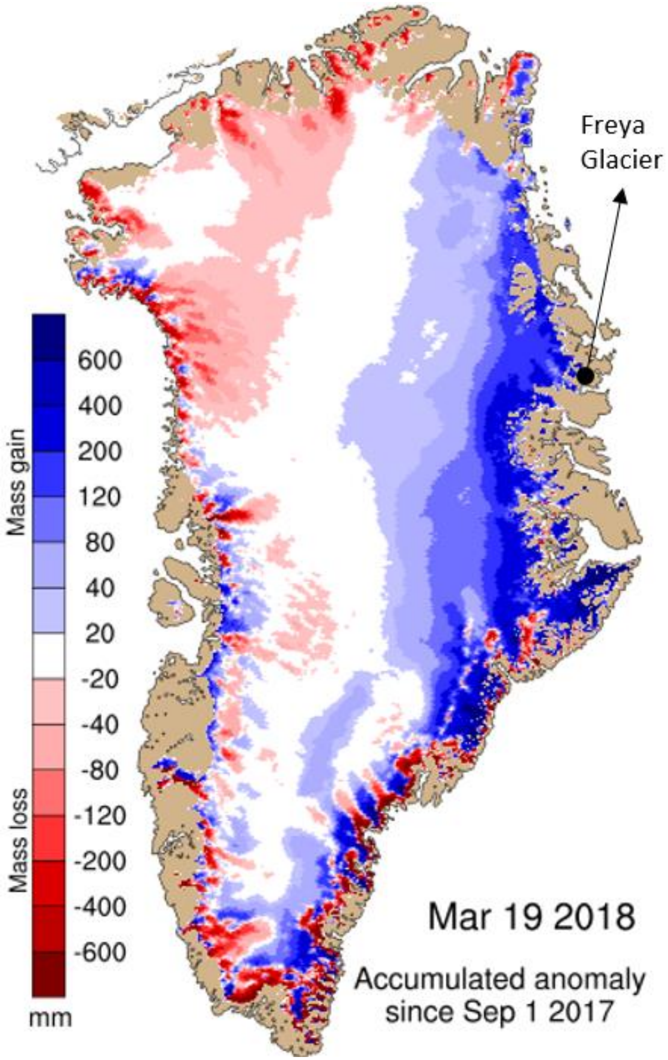
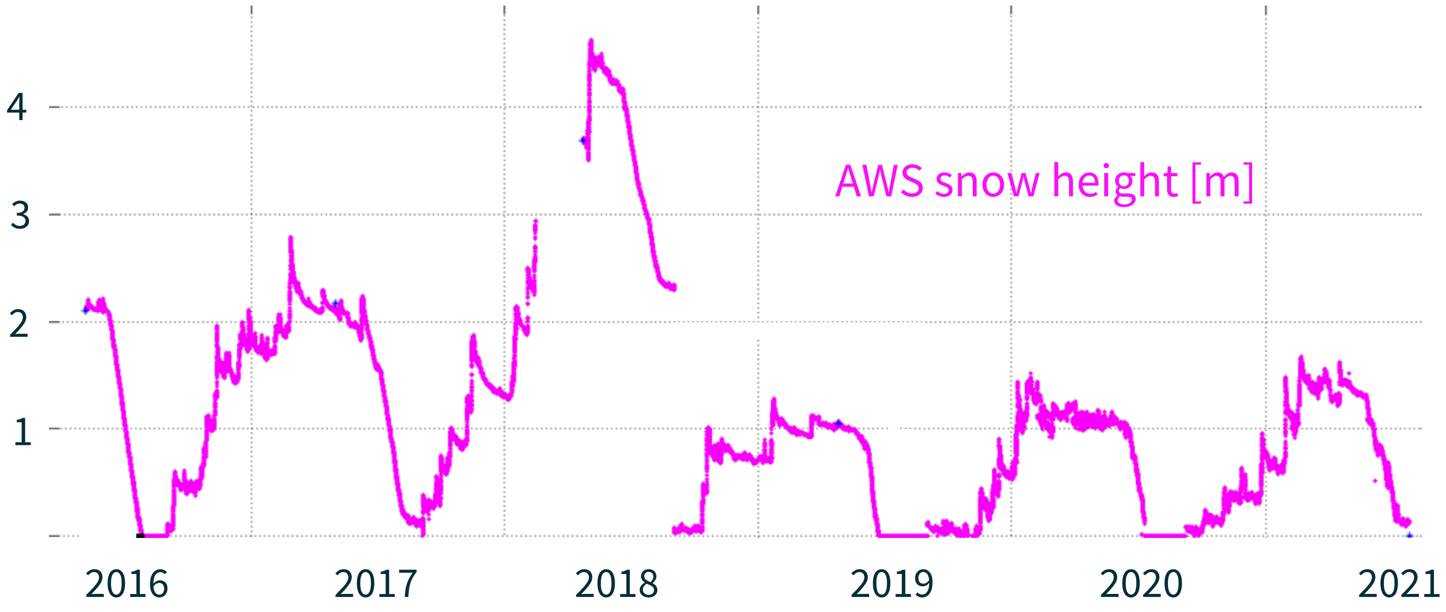
Winter 2018



Source: polarportal.org



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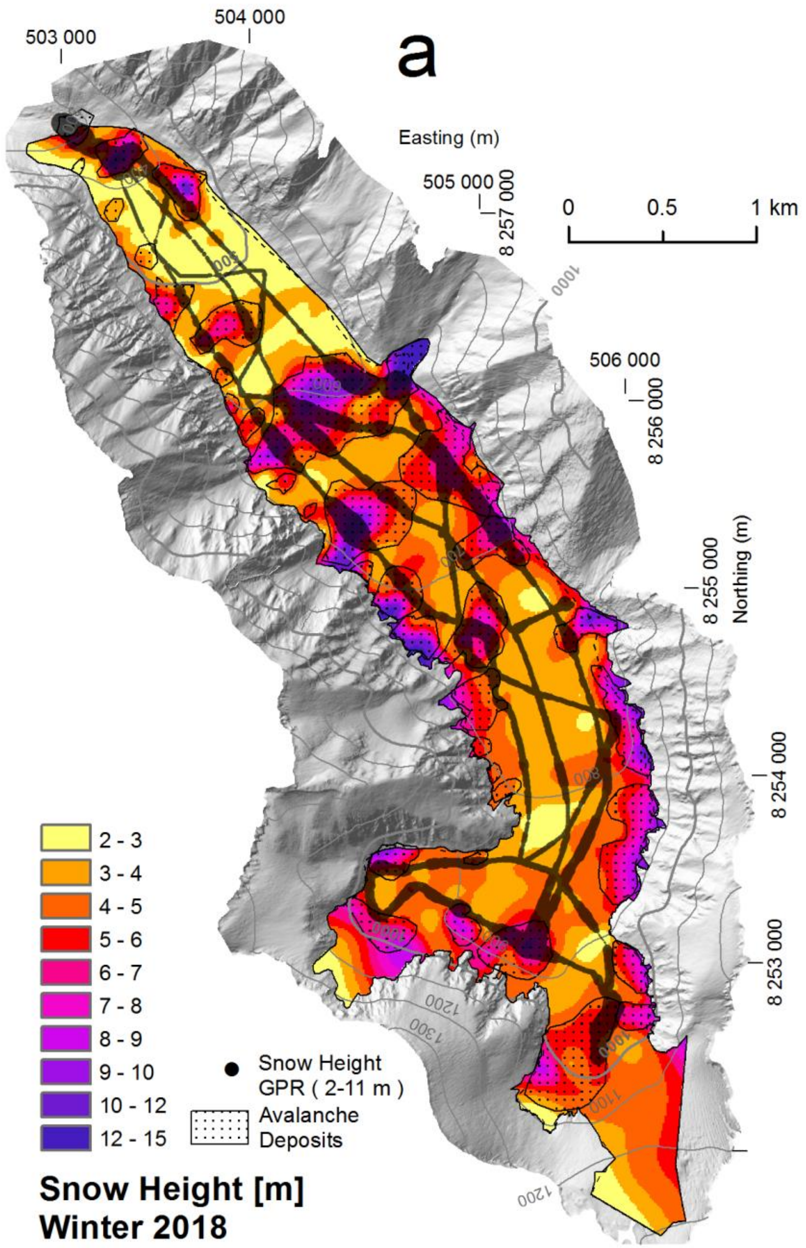
Visible avalanches





Fotos: D. Binder and Freya CAMs

Winter Mass Balance 2018



Observations:

- GPR snow height 2-11 m
- Snow density at AWS: 385 kg/m^3

Spatial interpretation:

- 36% of surface area affected by avalanches

	TOT	AVA	NOT	
• Average sh [m]	**4.8**	6.2	4.0	
• Average SWE [m]	**1.9**	2.4	1.5	*(same snow density)*

Contribution of avalanches:

0.3 m w.e *(same snow density) → lower boundary*
0.4 m w.e. *(10% density increase)*
0.5 m w.e. *(20% density increase)*

Main uncertainty: snow density of avalanche deposits

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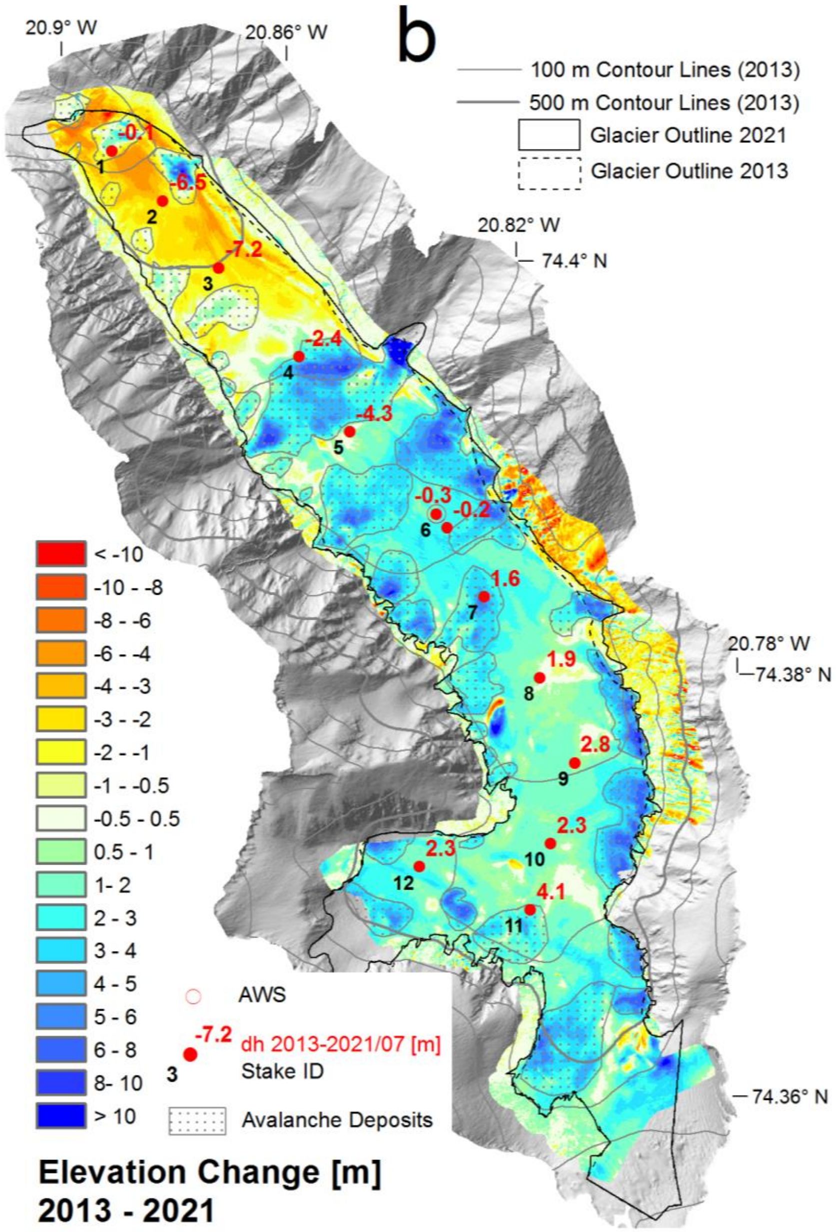
Elevation Changes 2013 - 2021



Main results:

- **Elevation Changes from -11 m to +18 m**
- Glacier wide mean values:
  - dh = 1.56 ± 0.10 m
  - mb = 0.85 ± 0.20 m w.e.
- **Full Period 2013/14 – 2020/21**
  - **mb = 0.25 ± 0.21 m w.e.**
  - Main uncertainty: firn density!

Inluence of avalanches on Mass Balance:

+ 0.55 m w.e.

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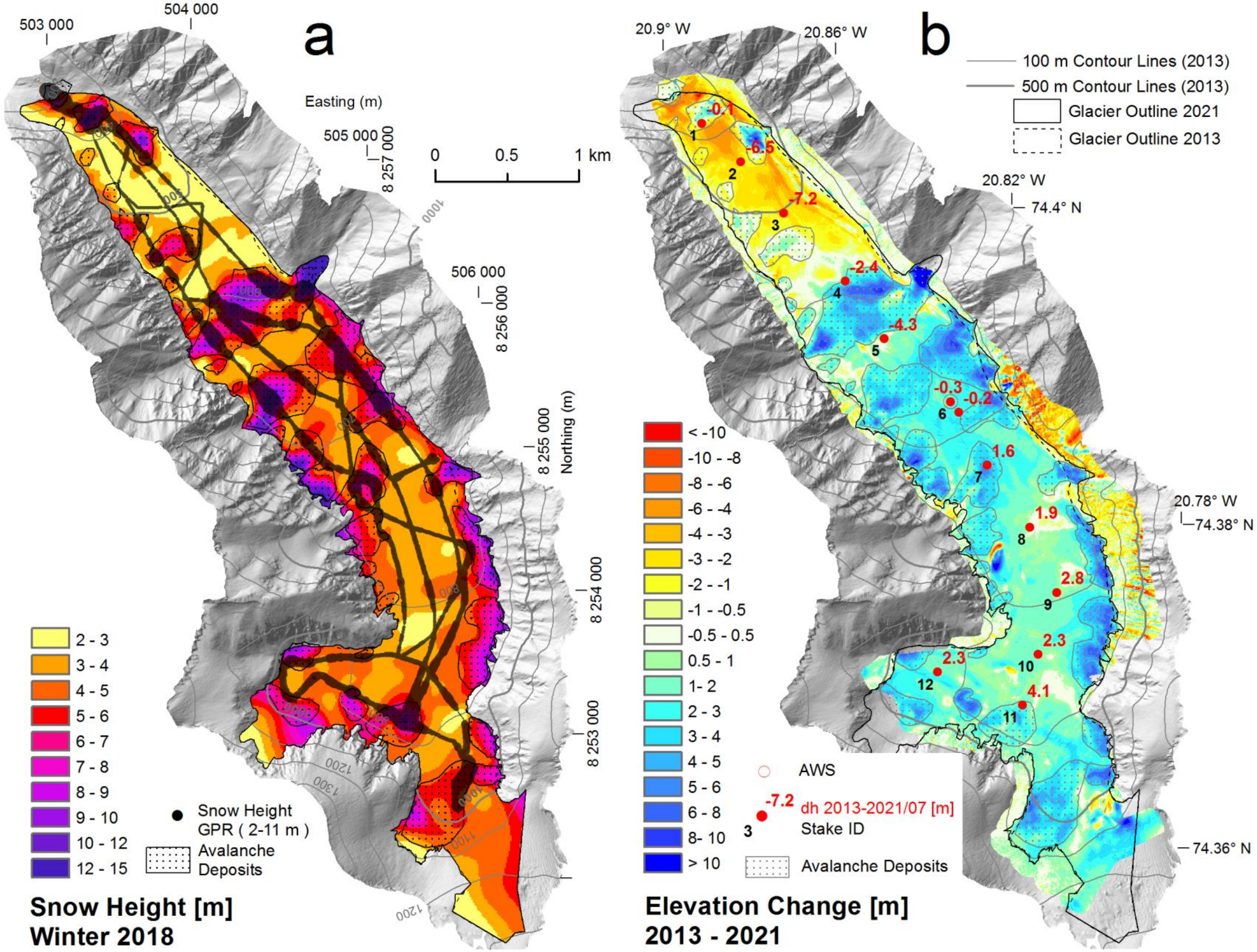
Winter Snow Height – Elevation Changes



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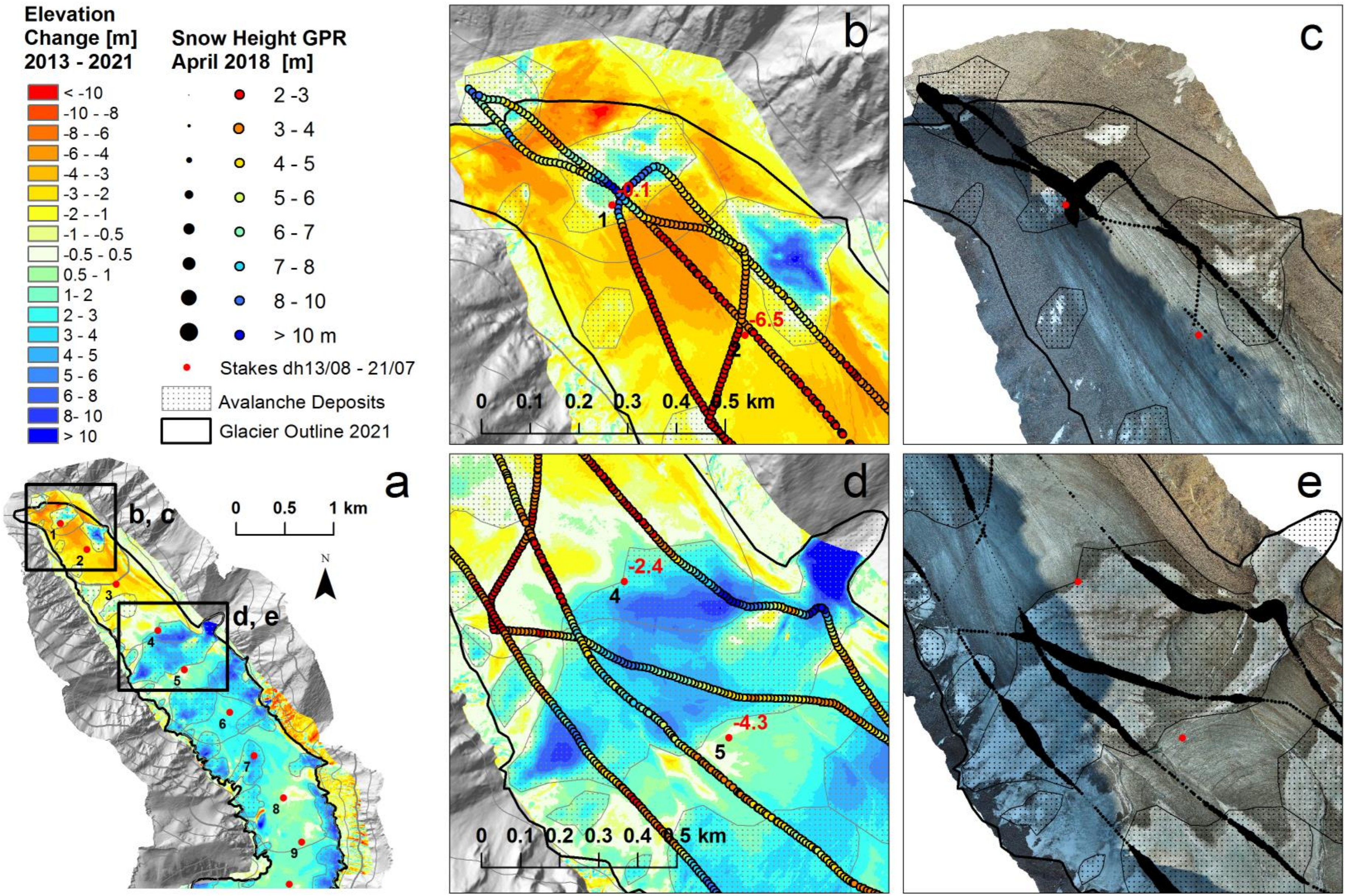
Elevation Changes 2013 - 2021



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Accumulation by avalanches as significant contributor to the mass balance of a High Arctic mountain glacier

Bernhard Hynek[1,2,3], Daniel Binder[4,3], Michele Citterio[5], Signe Hillerup Larsen[5], Jakob Abermann[2,3], Geert Verhoeven[6], Elke Ludewig[7], Wolfgang Schöner[2,3]

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[2] Institut für Geographie und Raumforschung, Universität Graz, Austria
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https://tc.copernicus.org/preprints/tc-2023-157/

The Cryosphere Discussions

Open Access EGU

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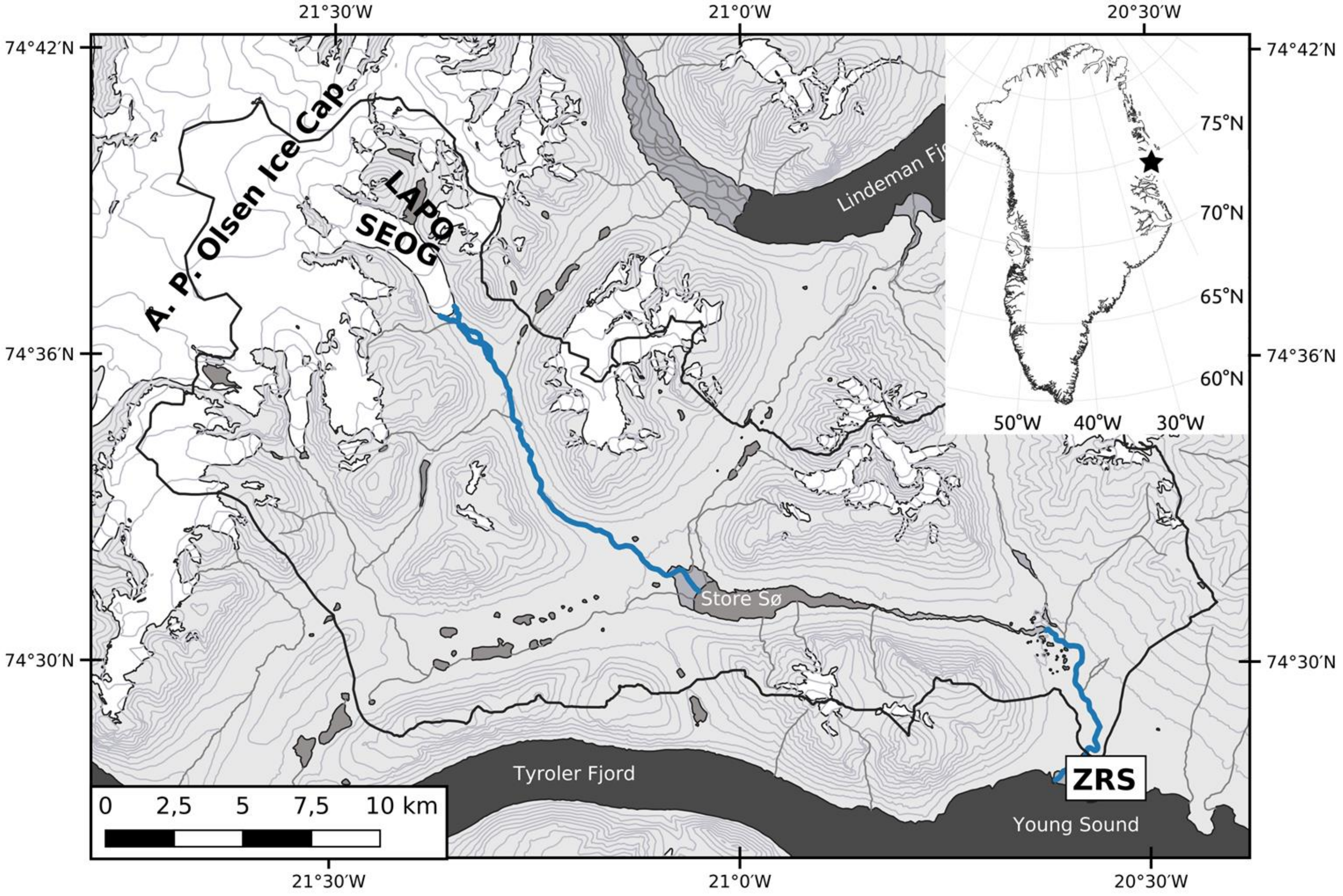
25 years of High-Arctic River Dynamics: Insights from Environmental and Jökulhlaup Monitoring in Zackenberg, NE-Greenland’

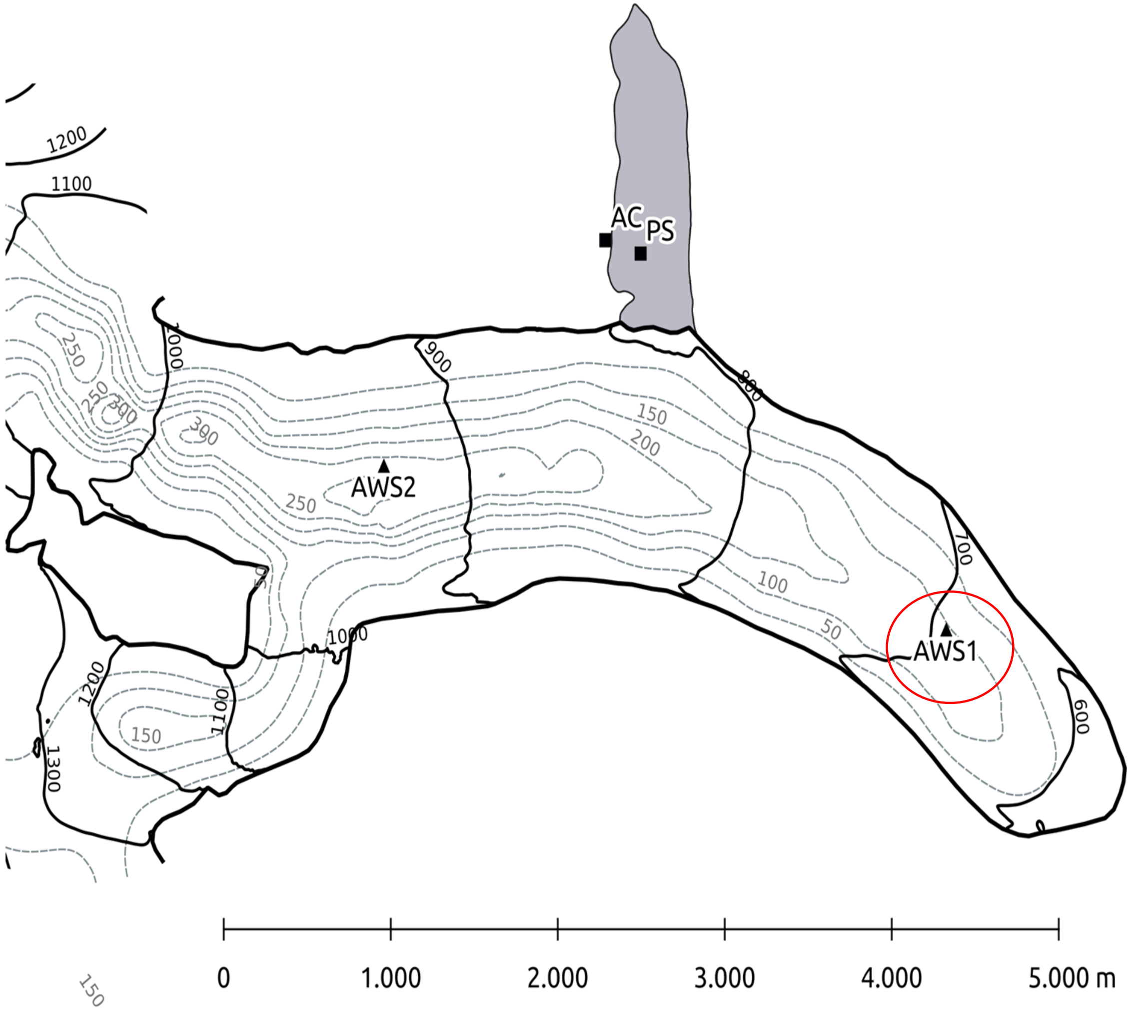
D. Binder, S. H. Larsen, M. Mastepanov, D. A. Rudd, J. Abermann, M. Citterio, K. K. Kjeldsen, K. Skov, E. P .S. Eibl, M. Tamsdorf, and K. Langley

Zackenberg River Catchment (493 km², ~18 % glacierized)

Zackenberg River discharge
is driven by
- Snow & ice melt
- Rainfall
- no meltwater contribution from
the Greenland ice sheet.

There are regular jökulhlaups,
or glacial lake outburst floods,
originating at the LAPO, dammed
by the Southeast outlet glacier
(SEOG) of the A.P. Olsen ice cap.





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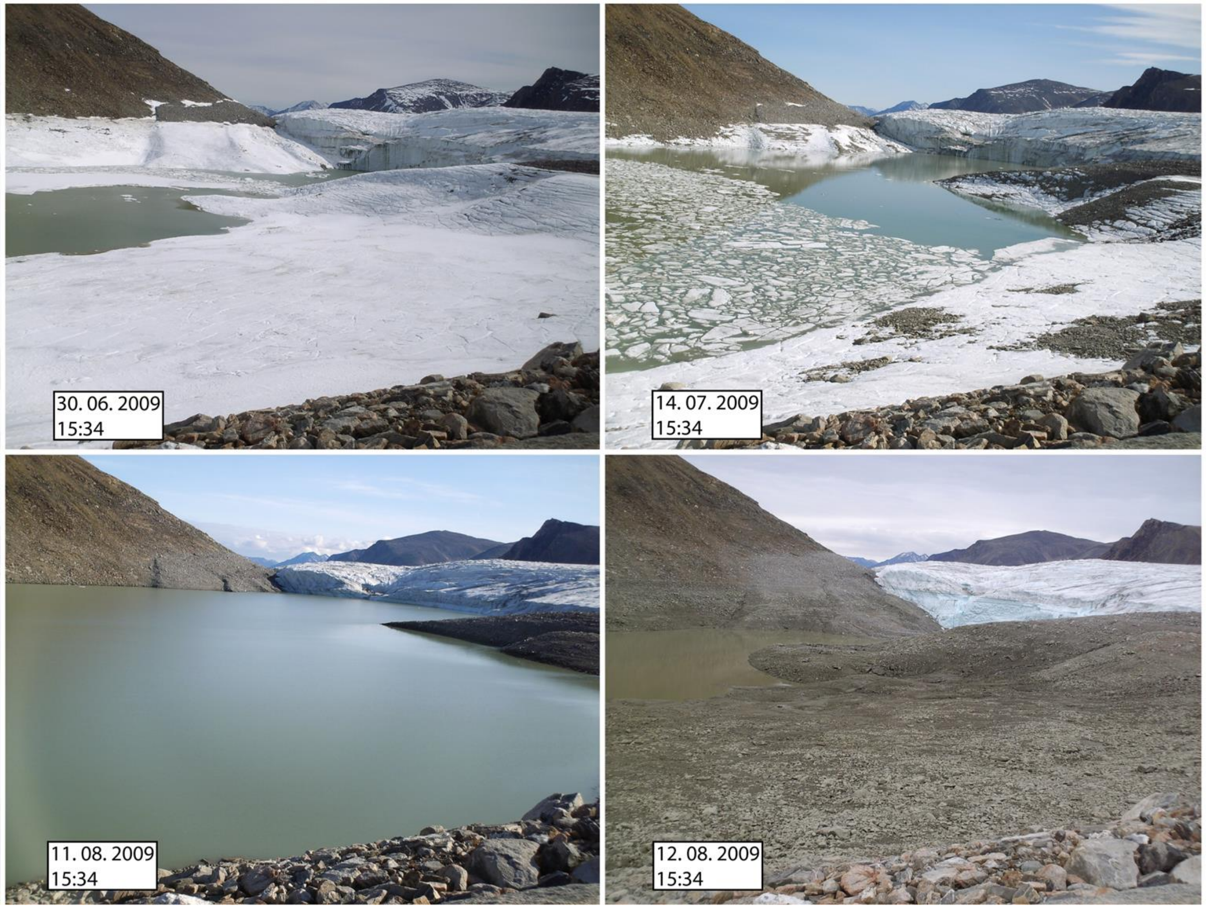

30. 06. 2009
15:34
14. 07. 2009
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11. 08. 2009
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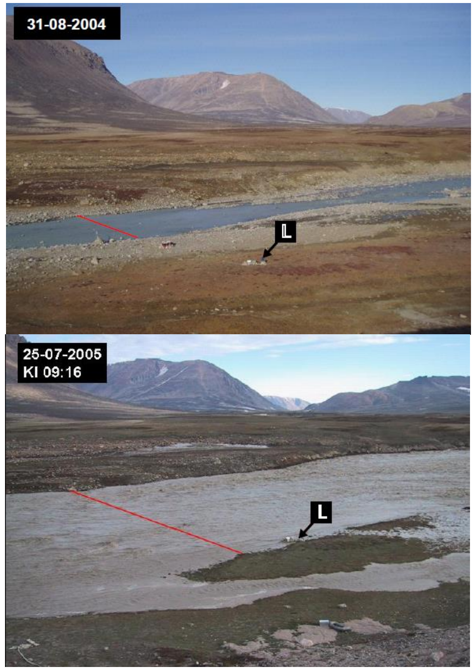
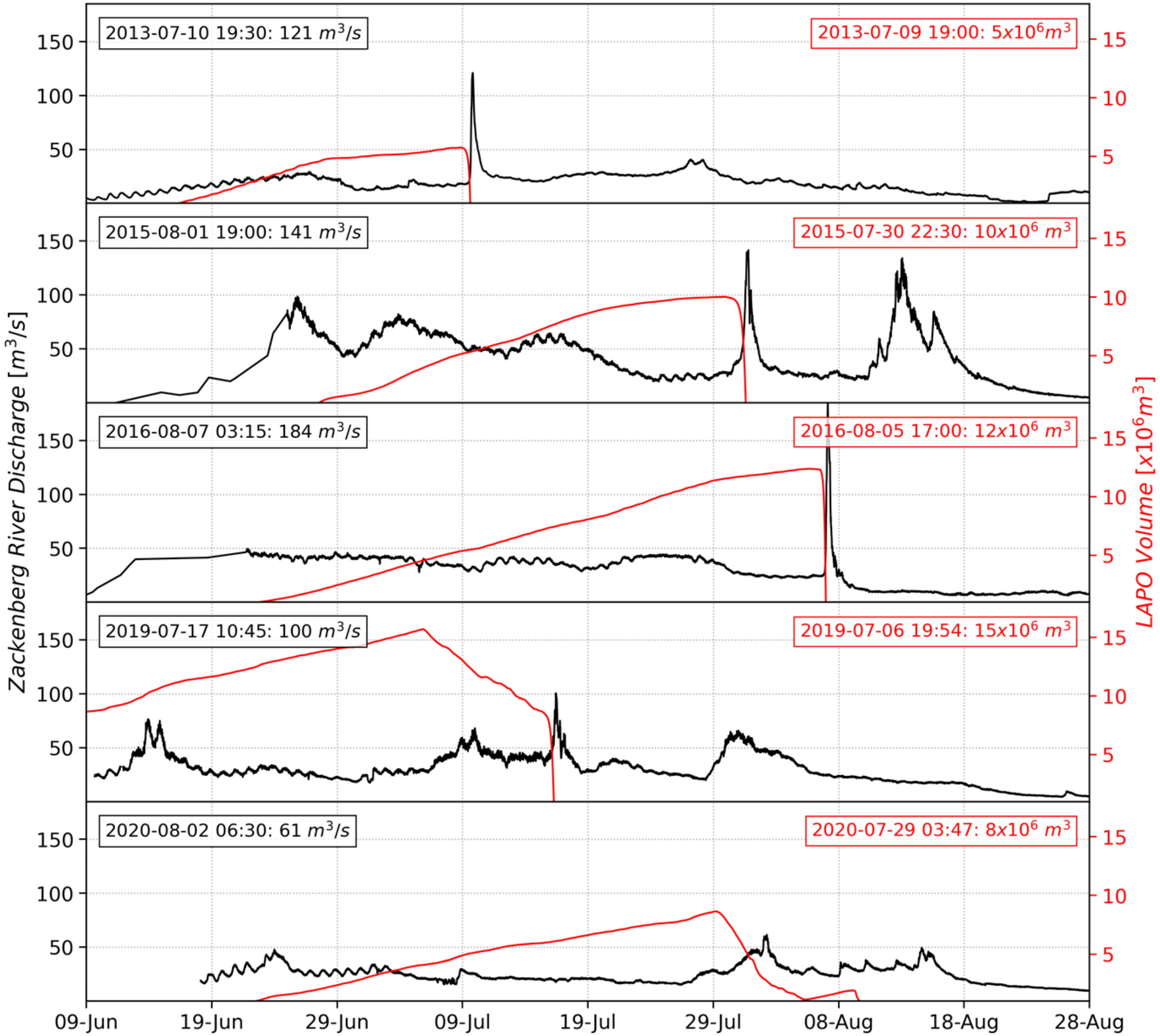
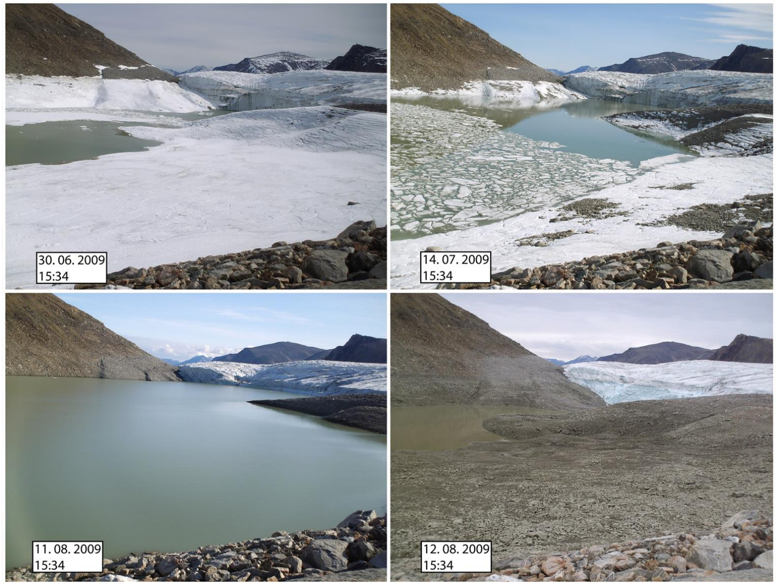
12. 08. 2009
15:34

Jökulhlaup timing vs. LAPO volumes

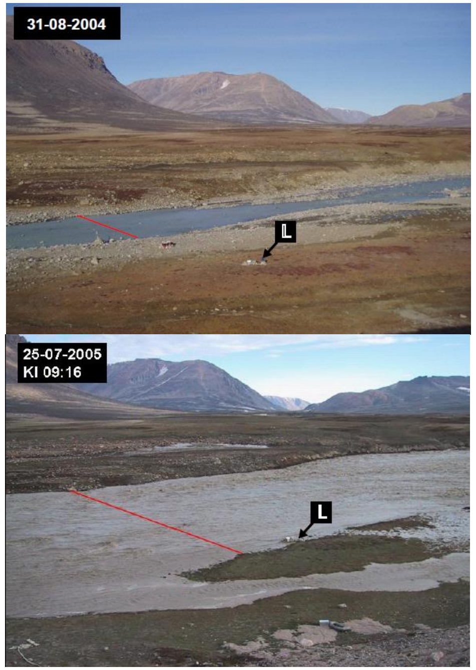


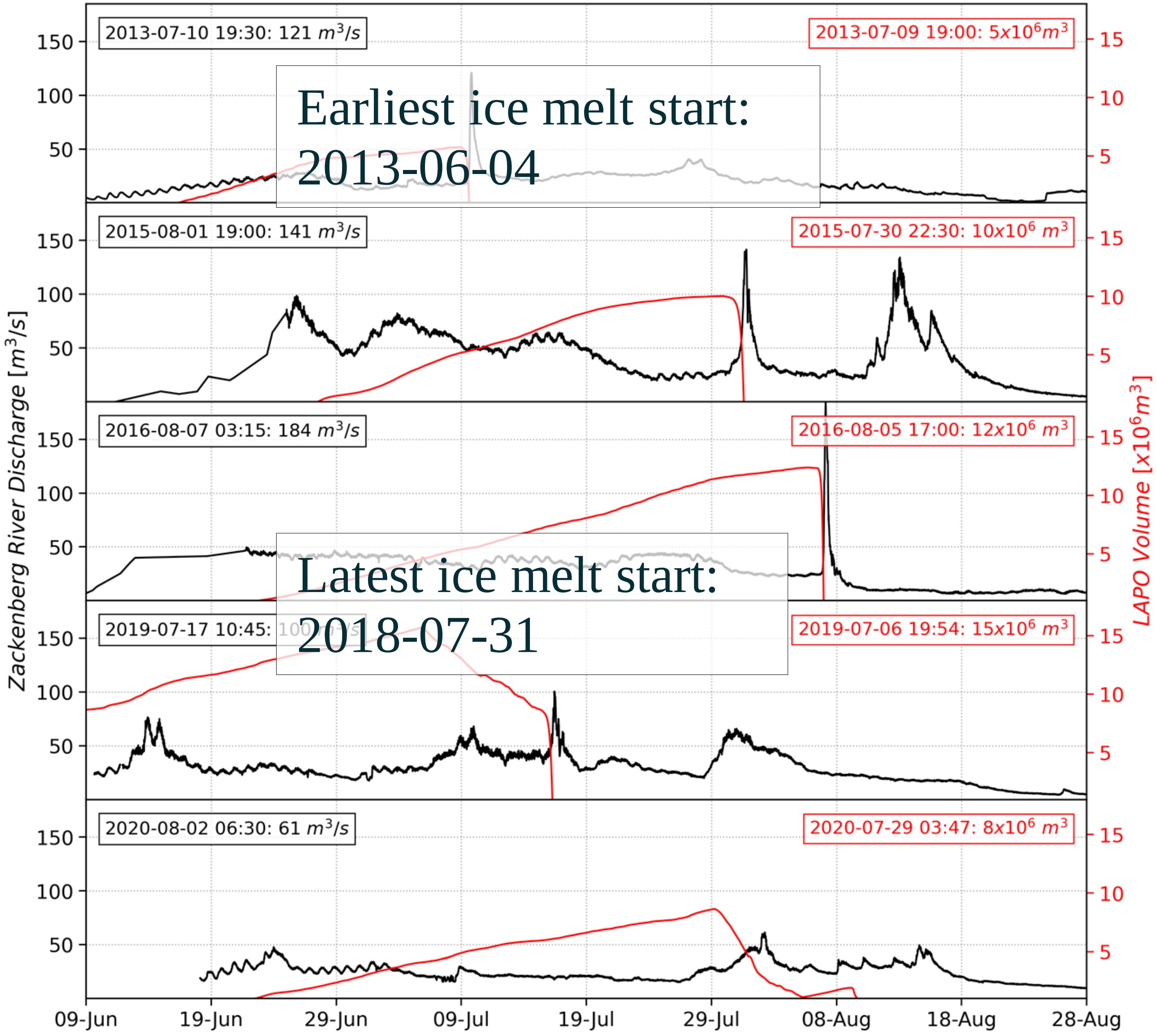




Conclusion 1:
There is no distinct LAPO threshold volume triggering the jökuhlaups.
However, it does have a ‚second order' triggering effect. (2019).

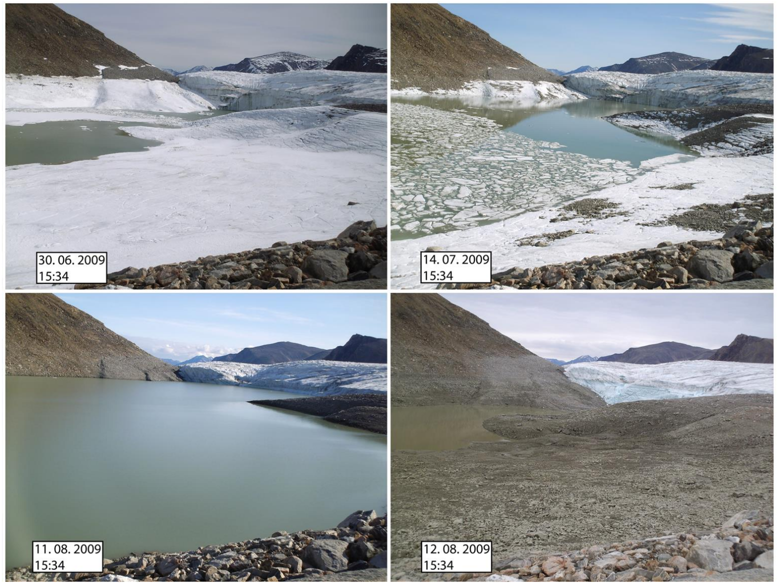
Jökulhlaup timing vs. SEOG ice melt start





Earliest ice melt start:
2013-06-04

Latest ice melt start:
2018-07-31



Conclusion 2:

There is a significant correlation between SEOG ice melt start (~snow free conditions), and the jökulhlaup timing.

Hypothesis:

The LAPO jökulhlaups depend on a developed subglacial drainage system of the SEOG (→ 'first order' - trigger).

Process-based rationale:

The snow pack retains melt water. It hinders melt water to access the glacier's base and develop an efficient subglacial drainage system.

→ We propose that the jökulhlaup-free year 2018 was due to the lack of a developed subglacial drainage system.

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Thank You!

Klimamonitoring und Kryosphäre
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