

Spatial patterns of summer speedup on south-central Alaska Glaciers revealed from repeat satellite imagery

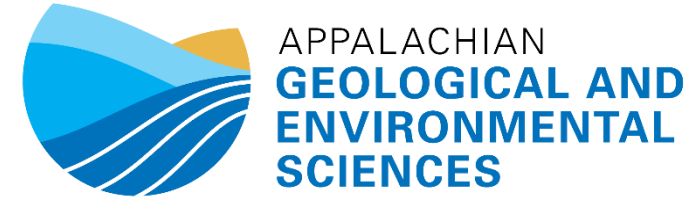
William Armstrong^{1,2,3}, Robert Anderson^{2,3}, Mark Fahnestock⁴

¹Department of Geological and Environmental Sciences, Appalachian State University, Boone, NC, USA

² Institute of Arctic and Alpine Research, University of Colorado at Boulder, CO USA

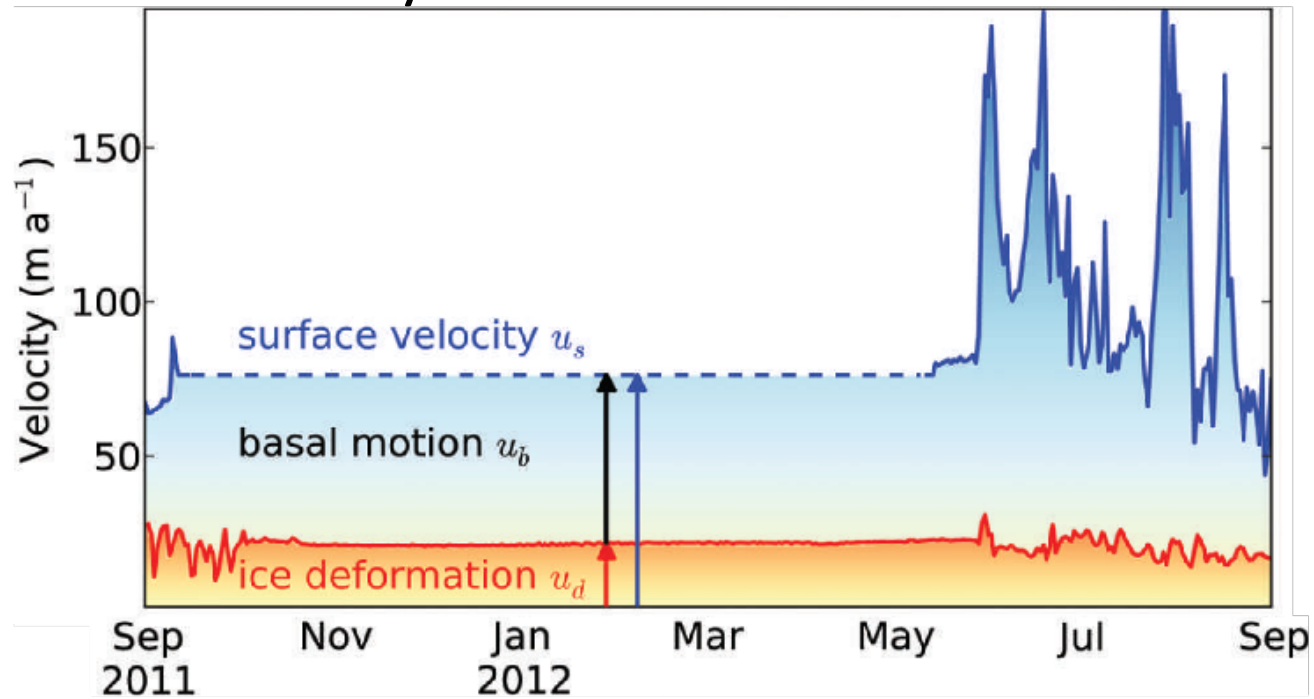
³ Department of Geological Sciences, University of Colorado at Boulder, CO USA

⁴ Geophysical Institute, University of Alaska Fairbanks, AK USA



Motivation

Glacier dynamics

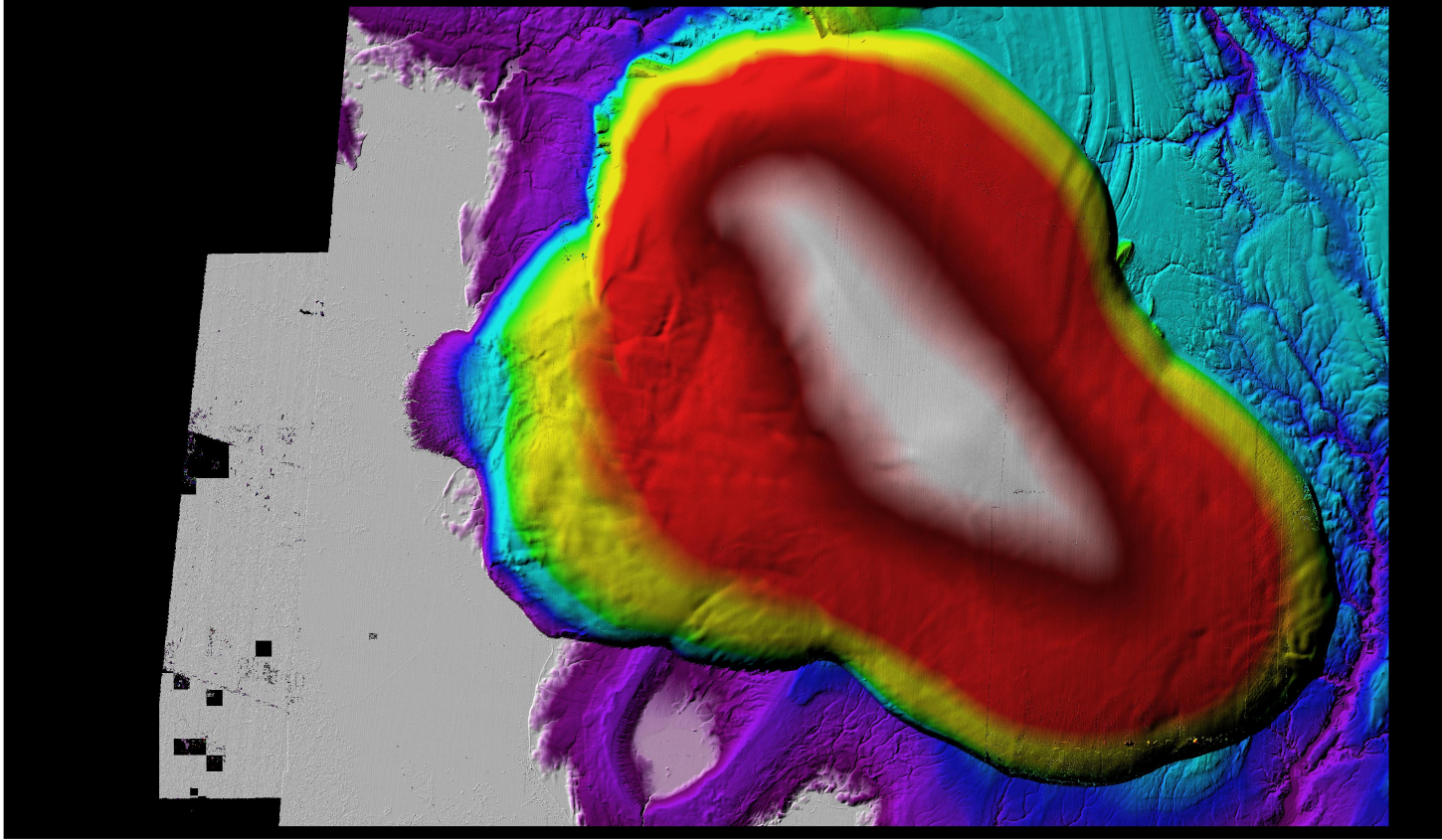


Glacier erosion



Motivation

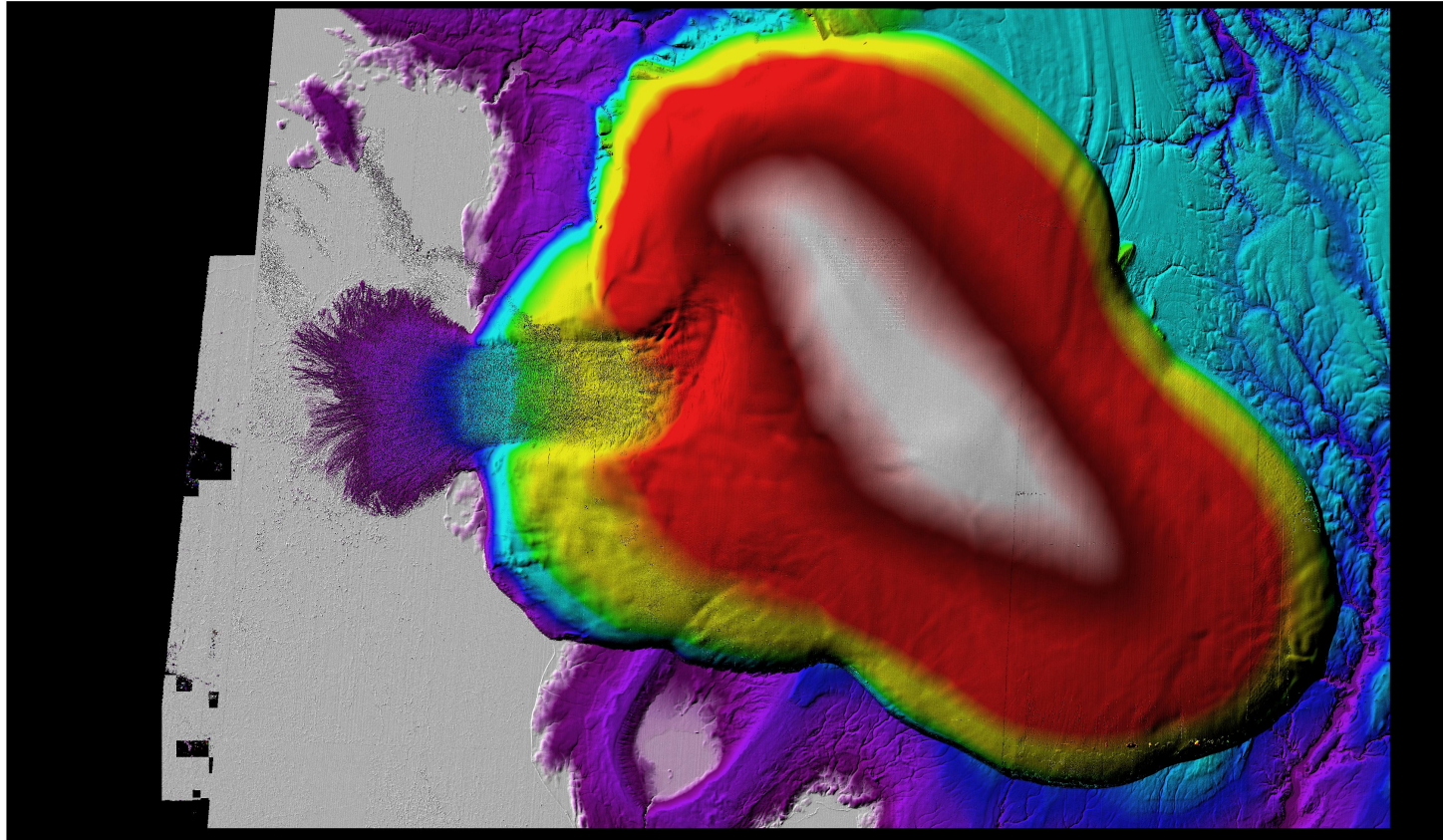
Glacier dynamics



Glacier erosion

Motivation

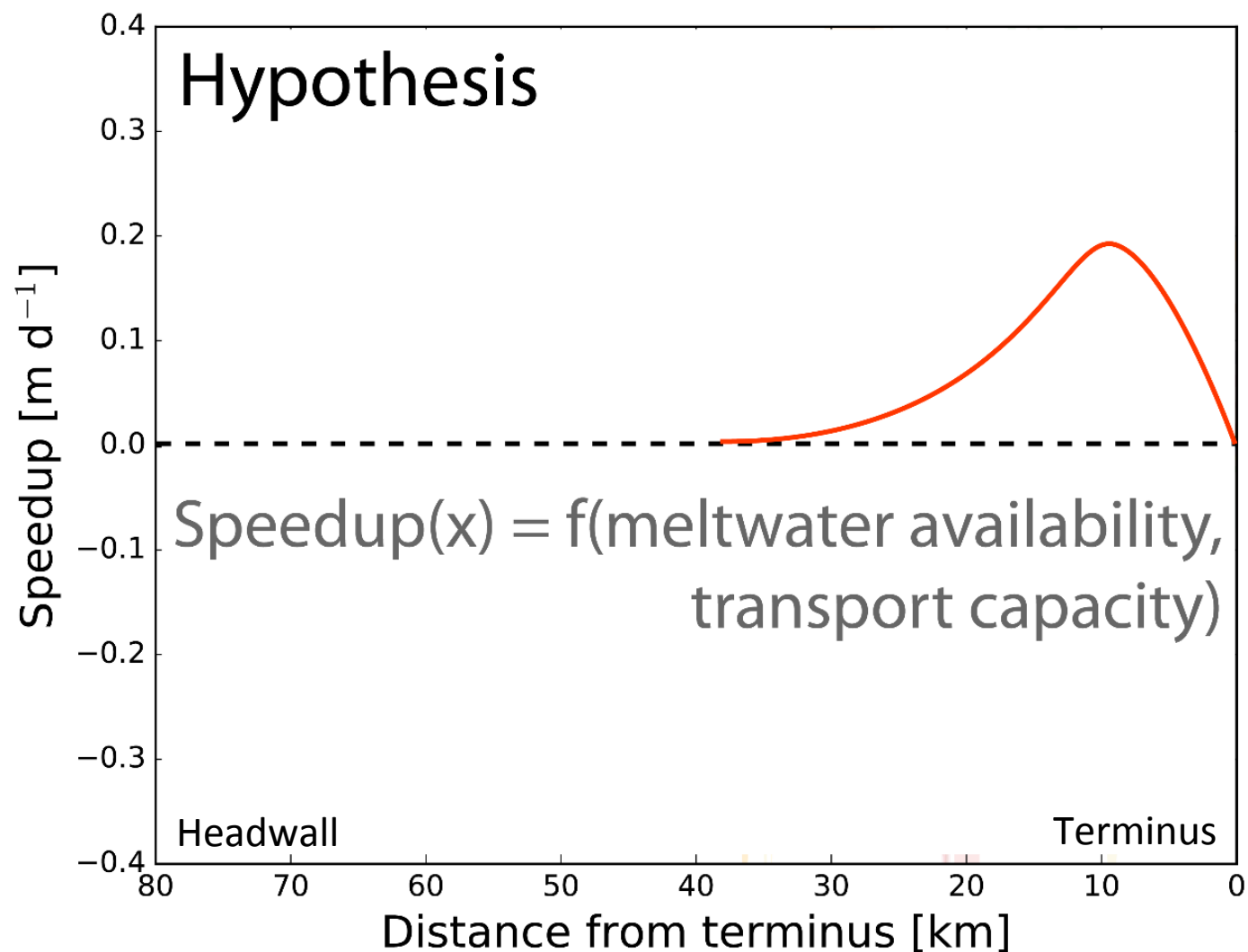
Glacier dynamics



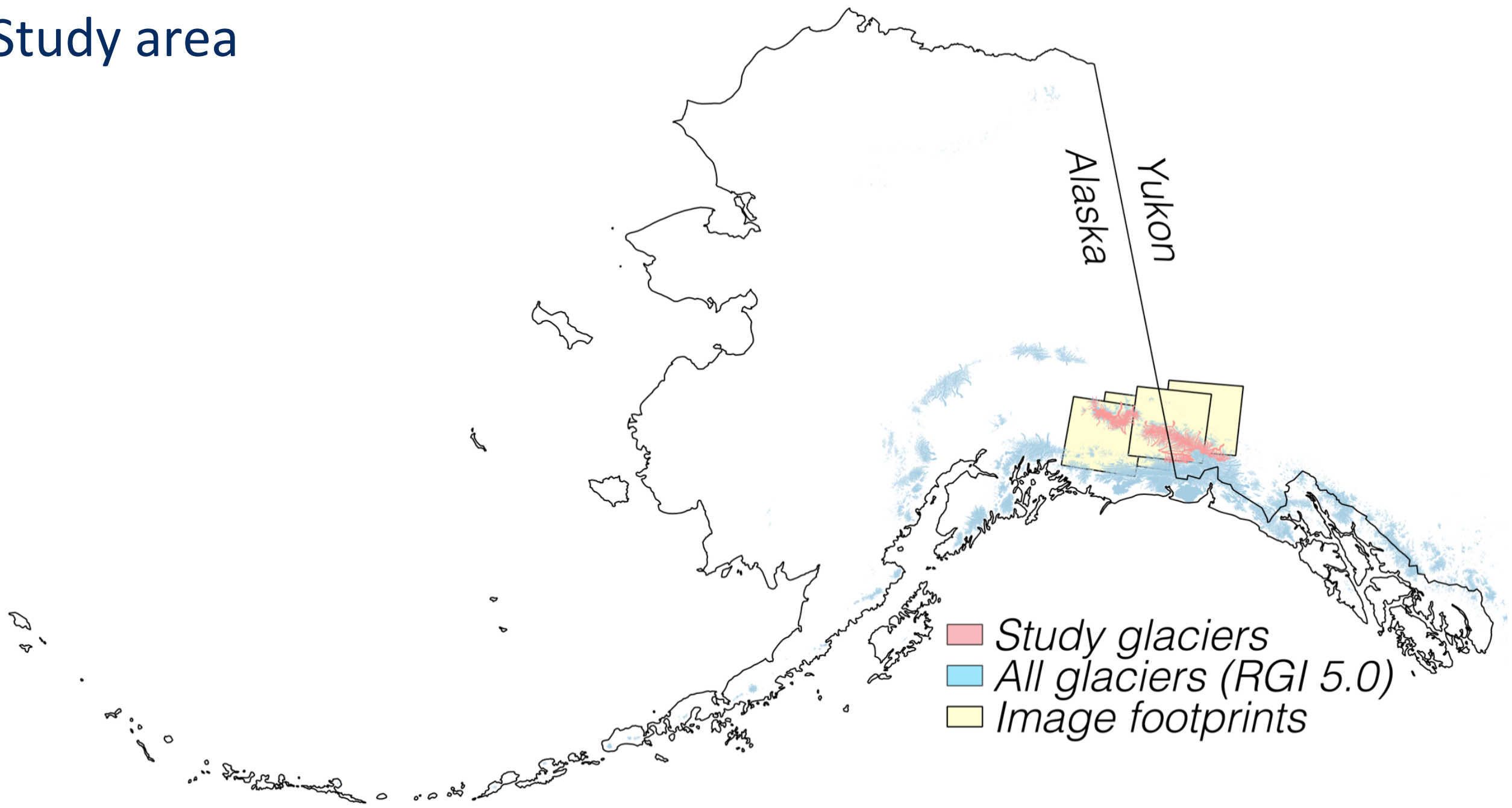
Glacier erosion

Research questions

- Are there consistent patterns of basal motion?
- What controls these patterns?
- Seasonal velocity fluctuations over large scale



Study area



Study area

- 43 glaciers
- 64 centerline profiles
- Wrangells, St Elias
- Largely land-terminating

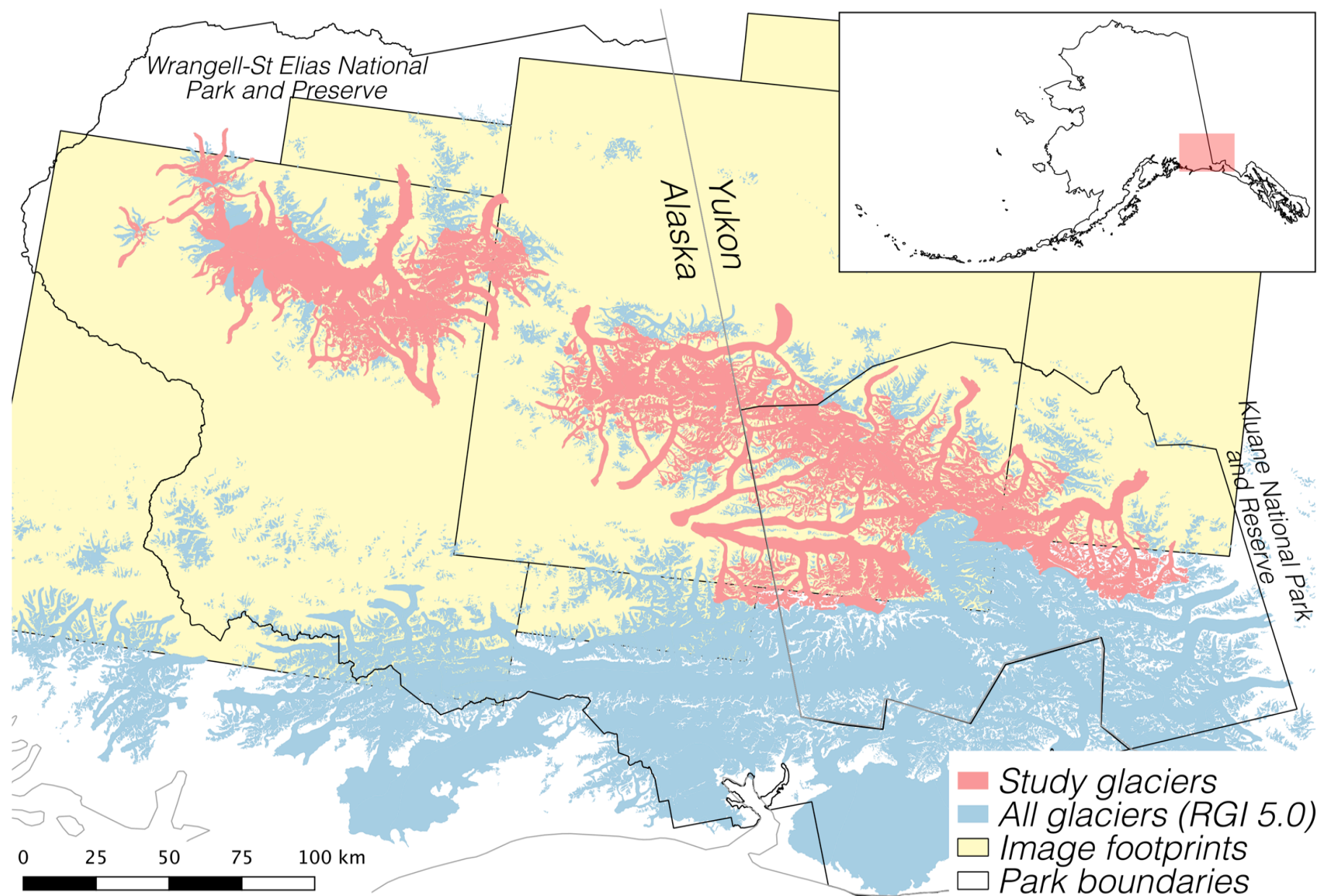
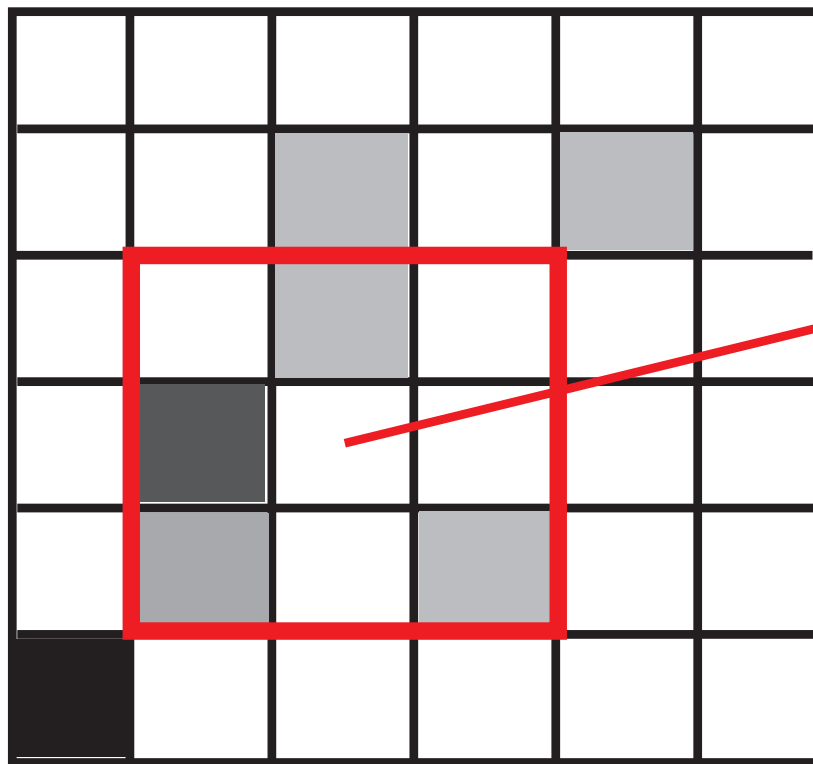


Image cross-correlation

- PyCorr software
- *Fahnestock et al., [2016]; Remote Sensing of Environment*

Time 1



Time 2

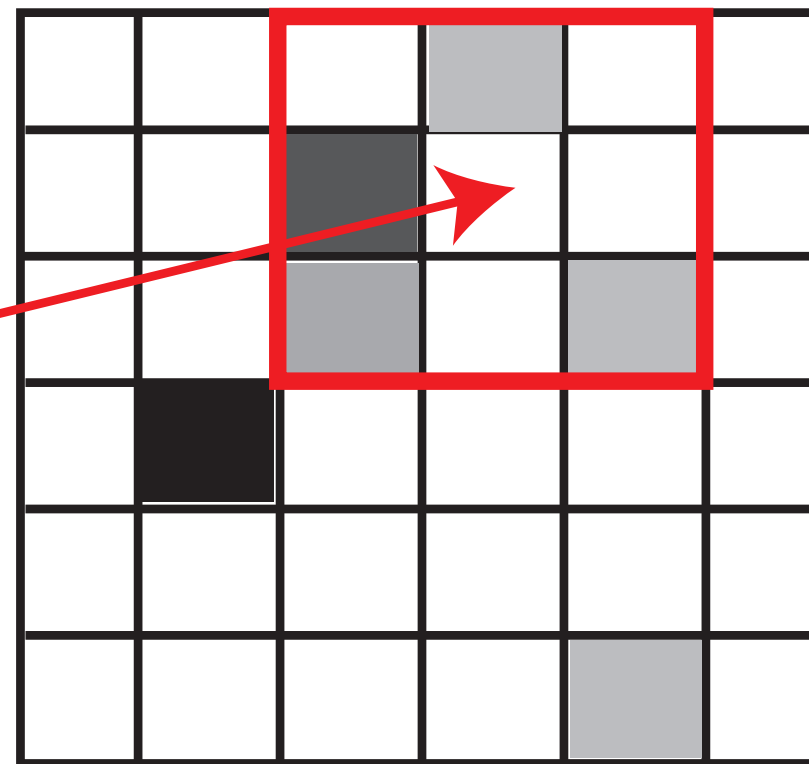


Image cross-correlation

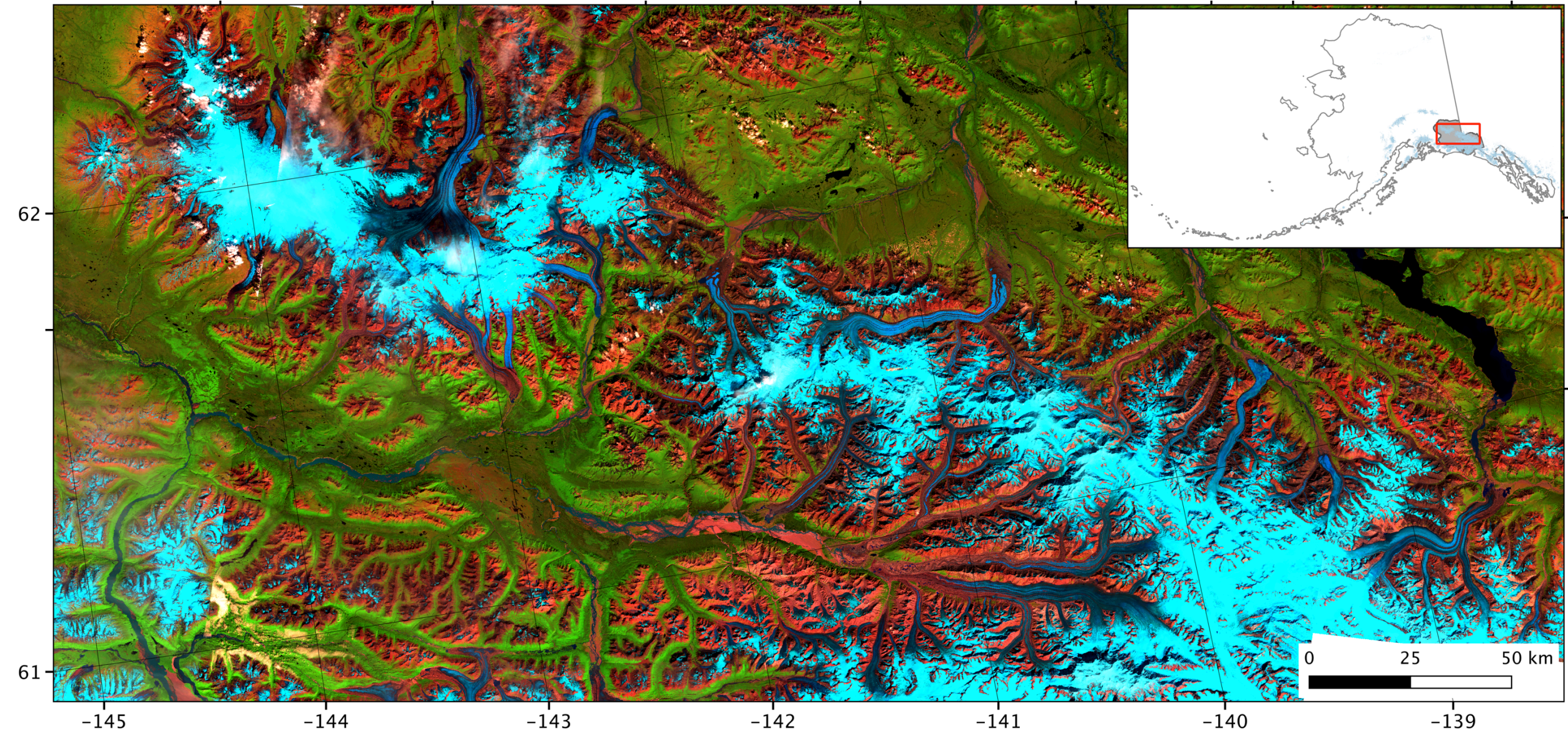


Image cross-correlation

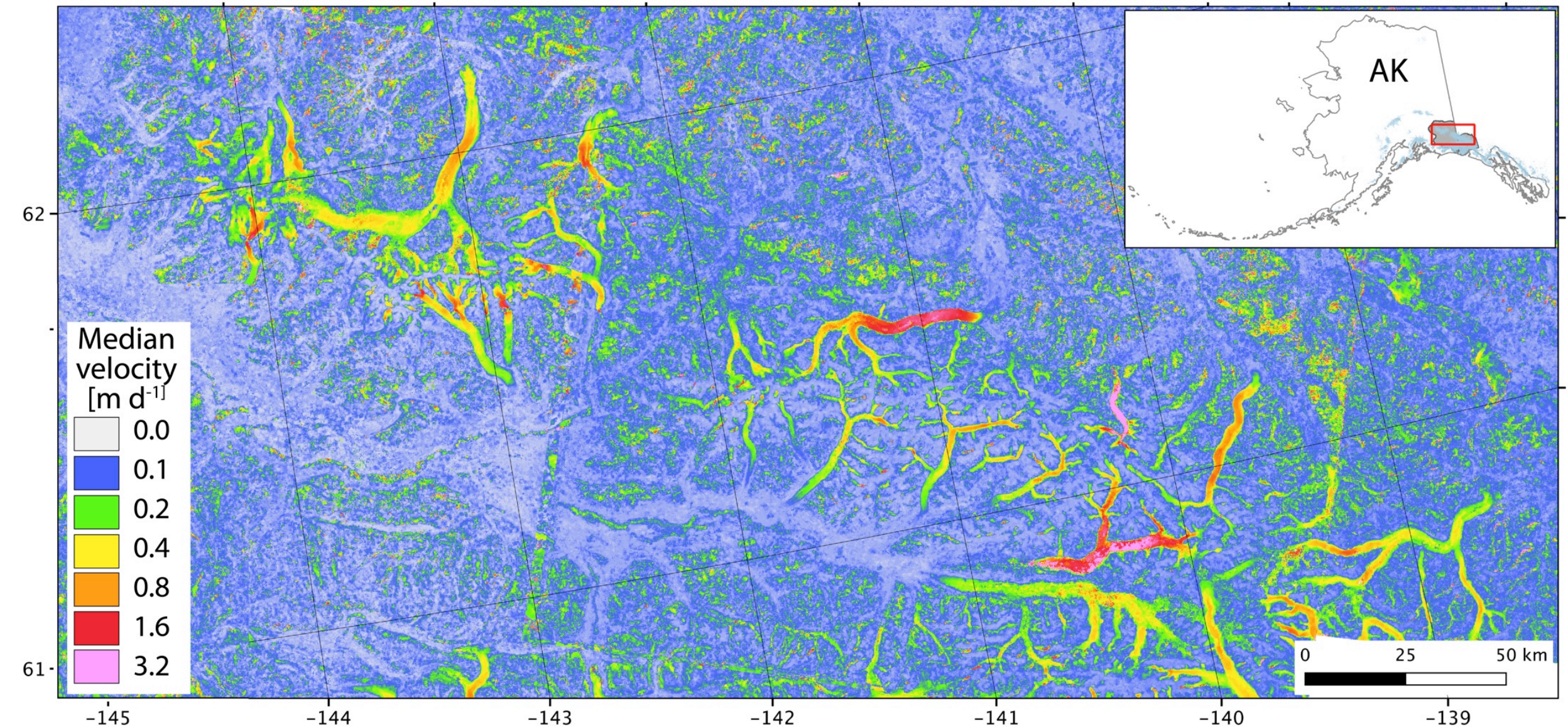
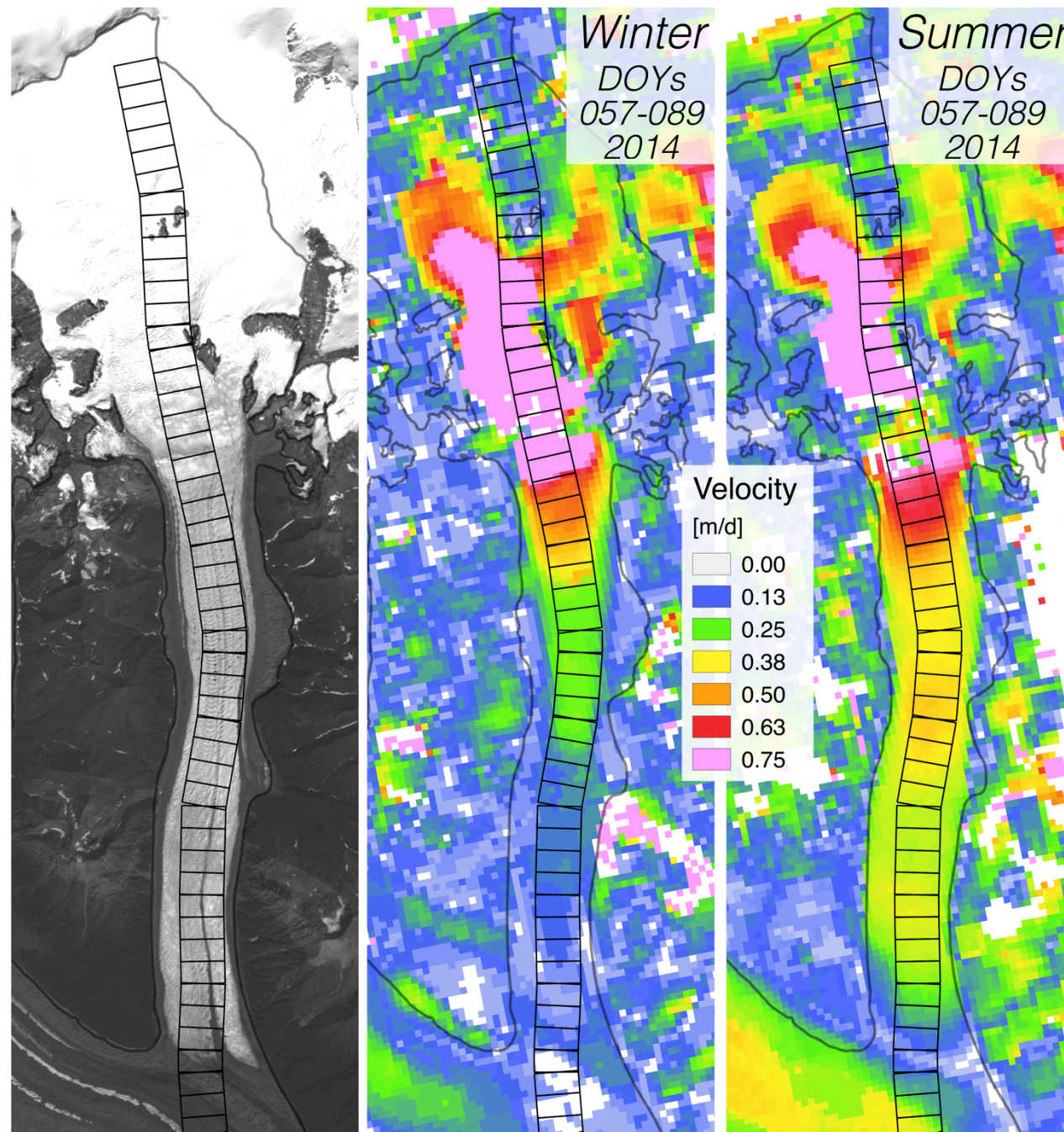


Image cross-correlation

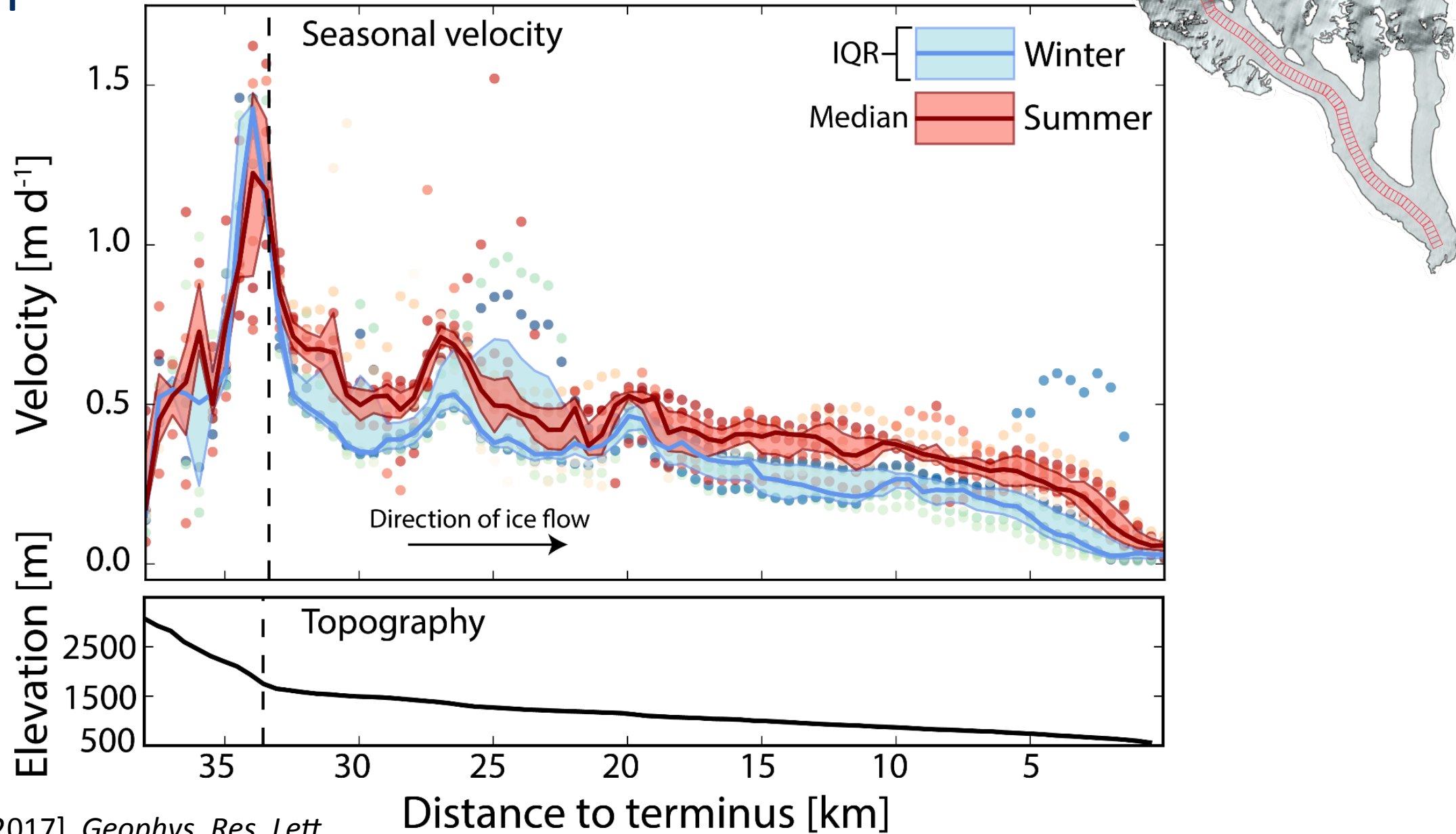


Swath profiling

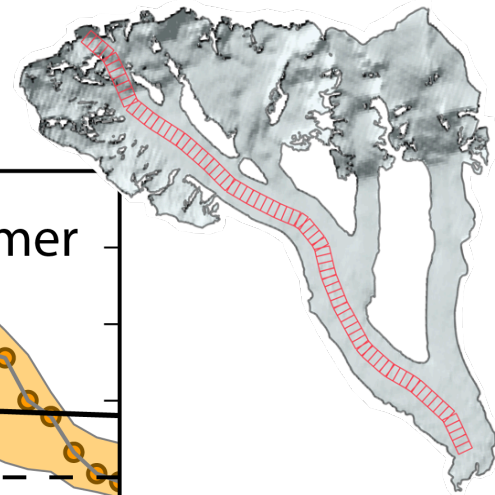
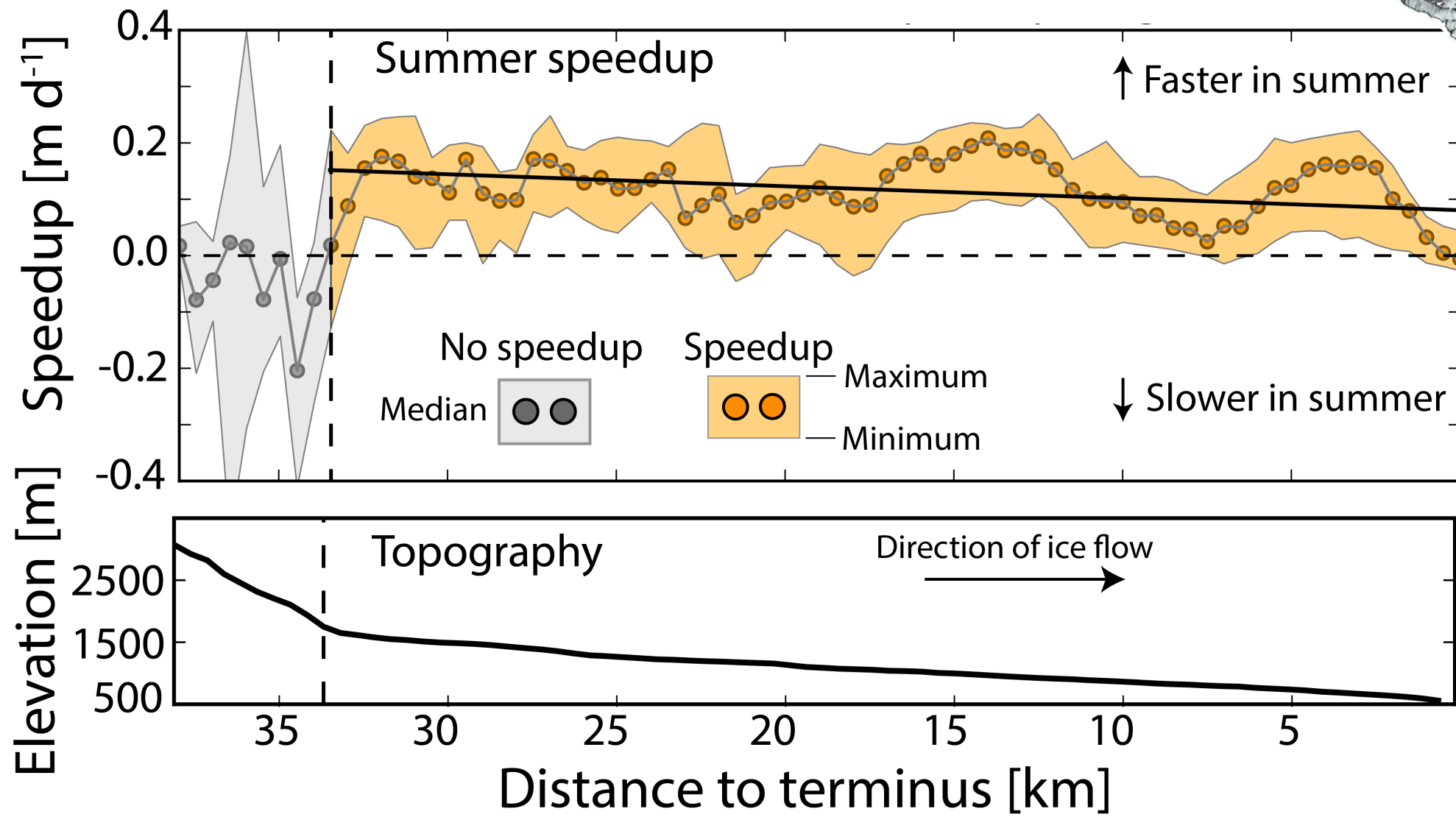
- Reduce noise by averaging over area
- $W \times L = 500 \times 1000$ m
- σ and n as quality filters
- Additional filtering from correlation results



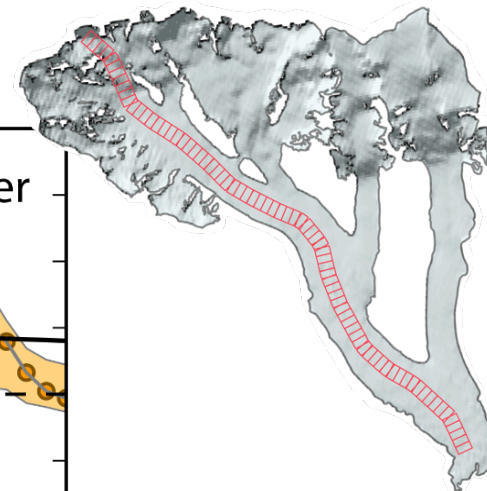
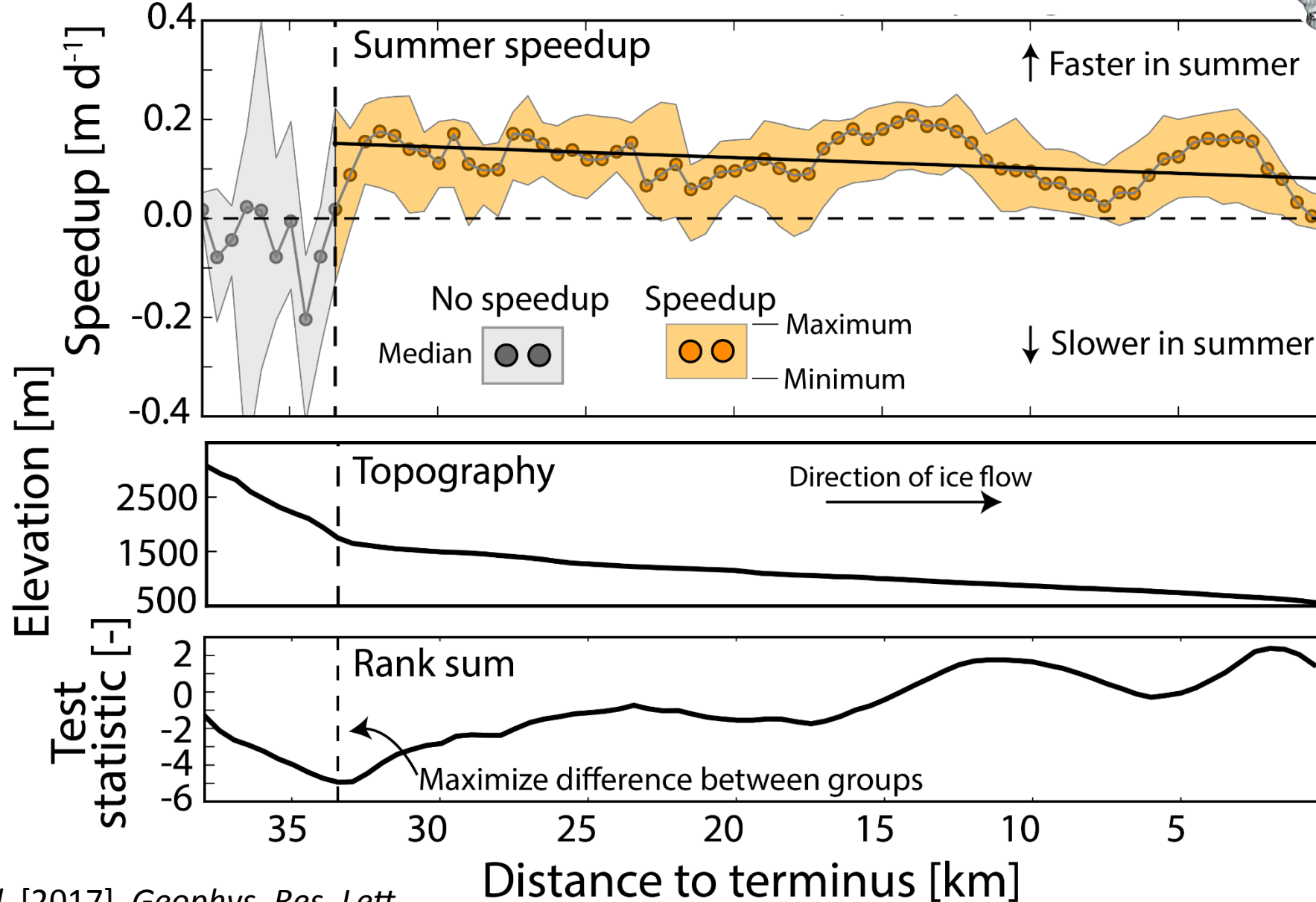
Speedup profiles



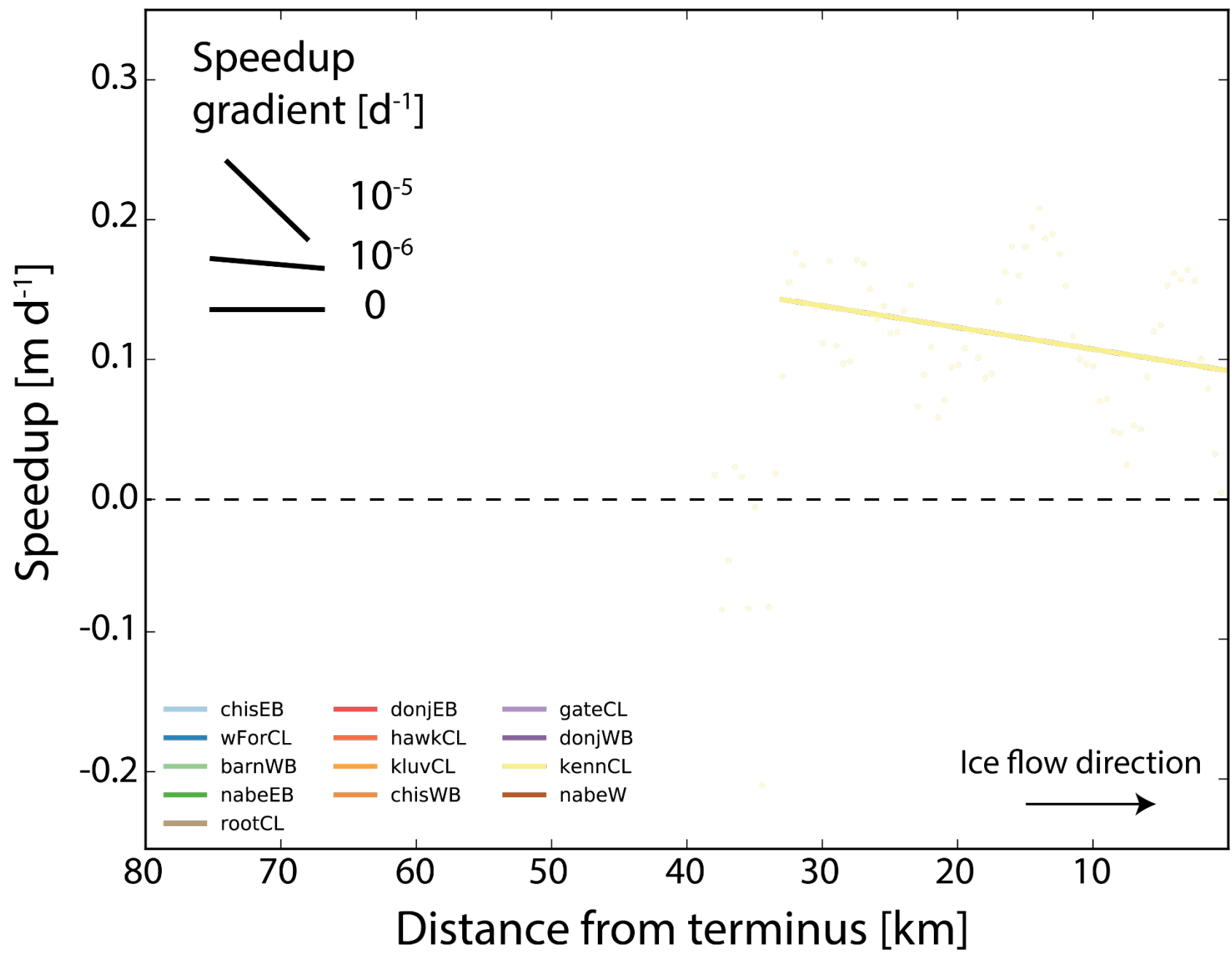
Speedup profiles



Speedup profiles

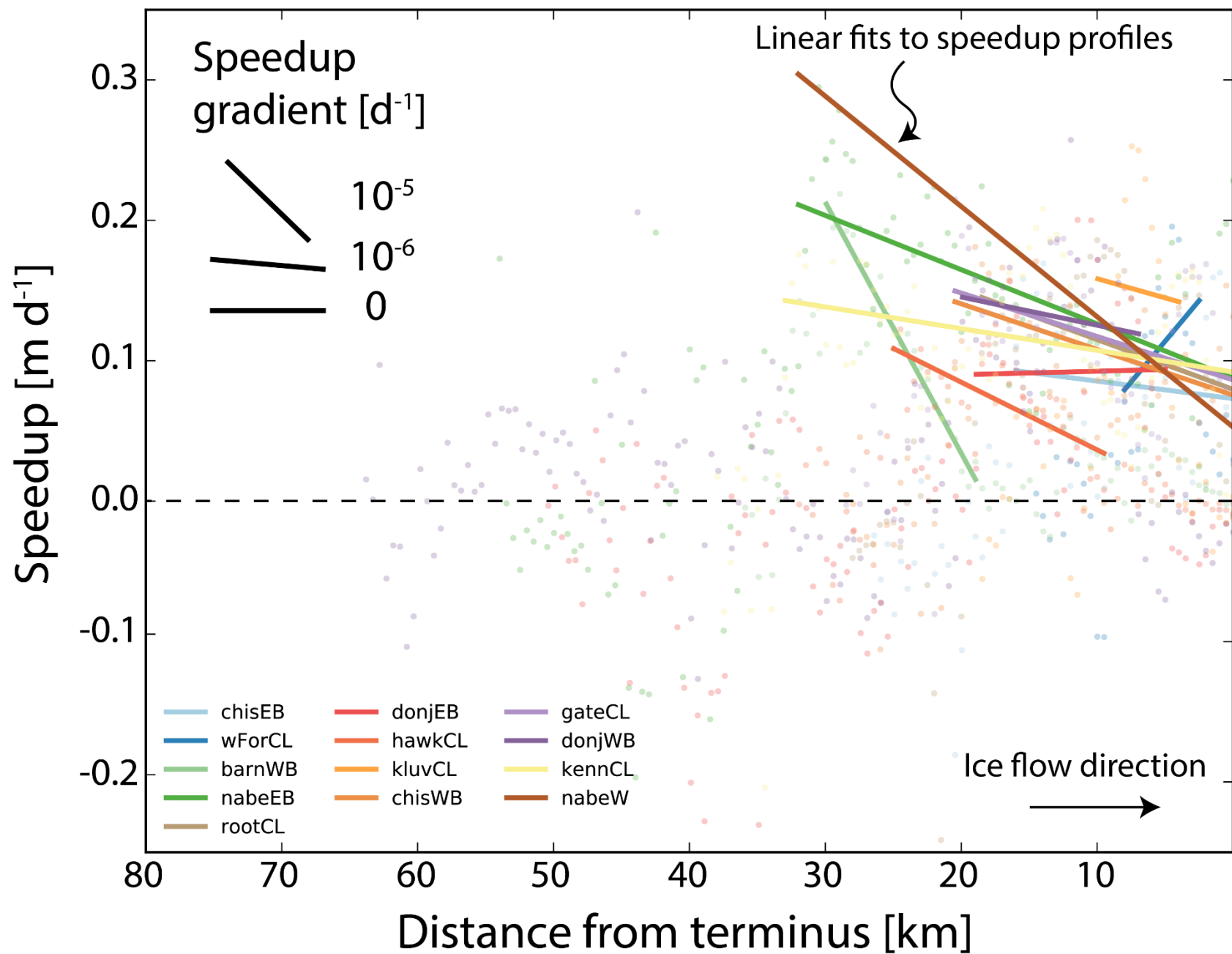


Speedup profiles



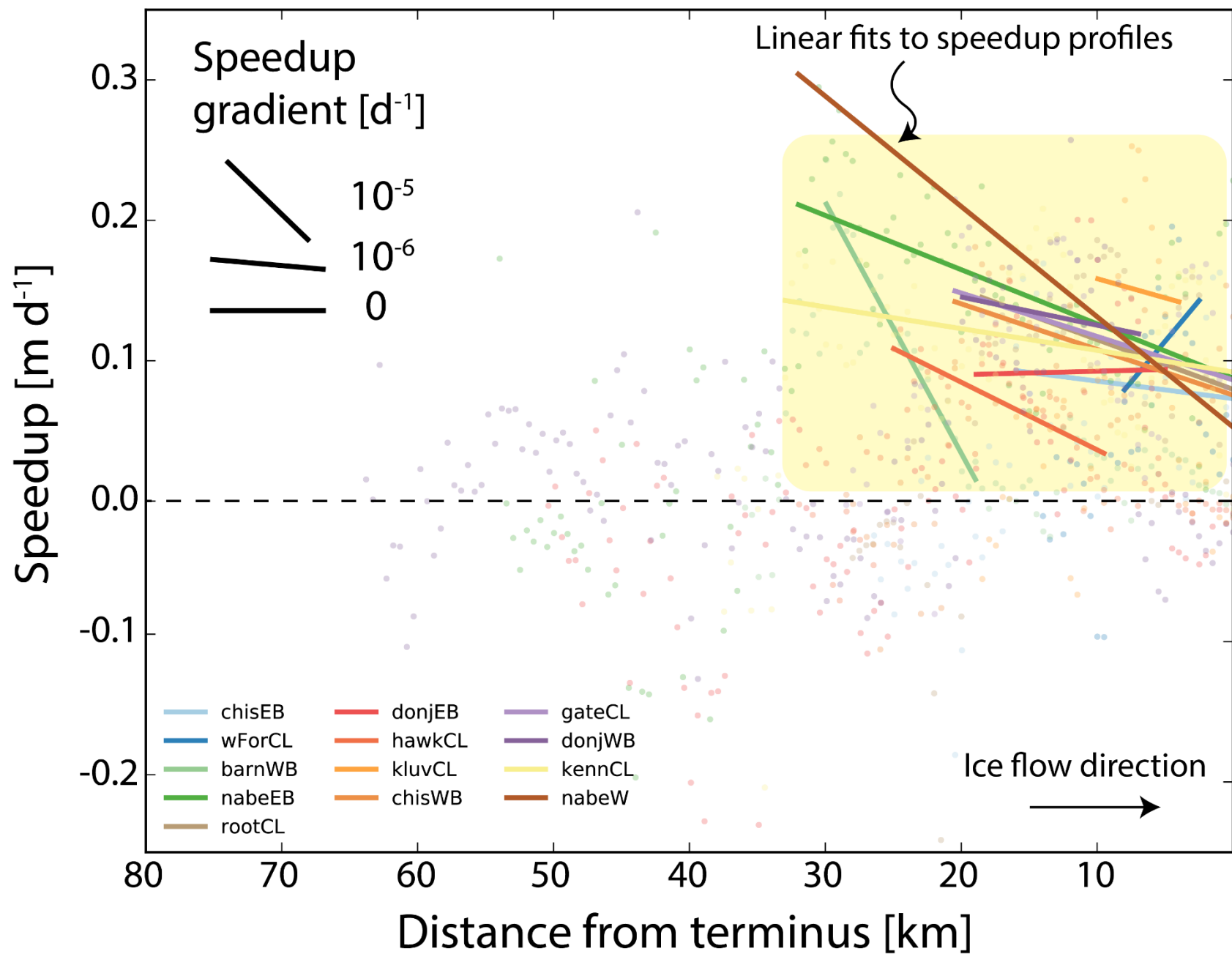
Speedup profiles

- Identify behavior on 19/64 glaciers
- 0.11 m d^{-1} speedup on average
- Abrupt transition to ~ 0 seasonal change
- Quasi-uniform speedup $3 \times 10^{-6} \text{ d}^{-1} = 0.3 \text{ cm d}^{-1} \text{ km}^{-1}$



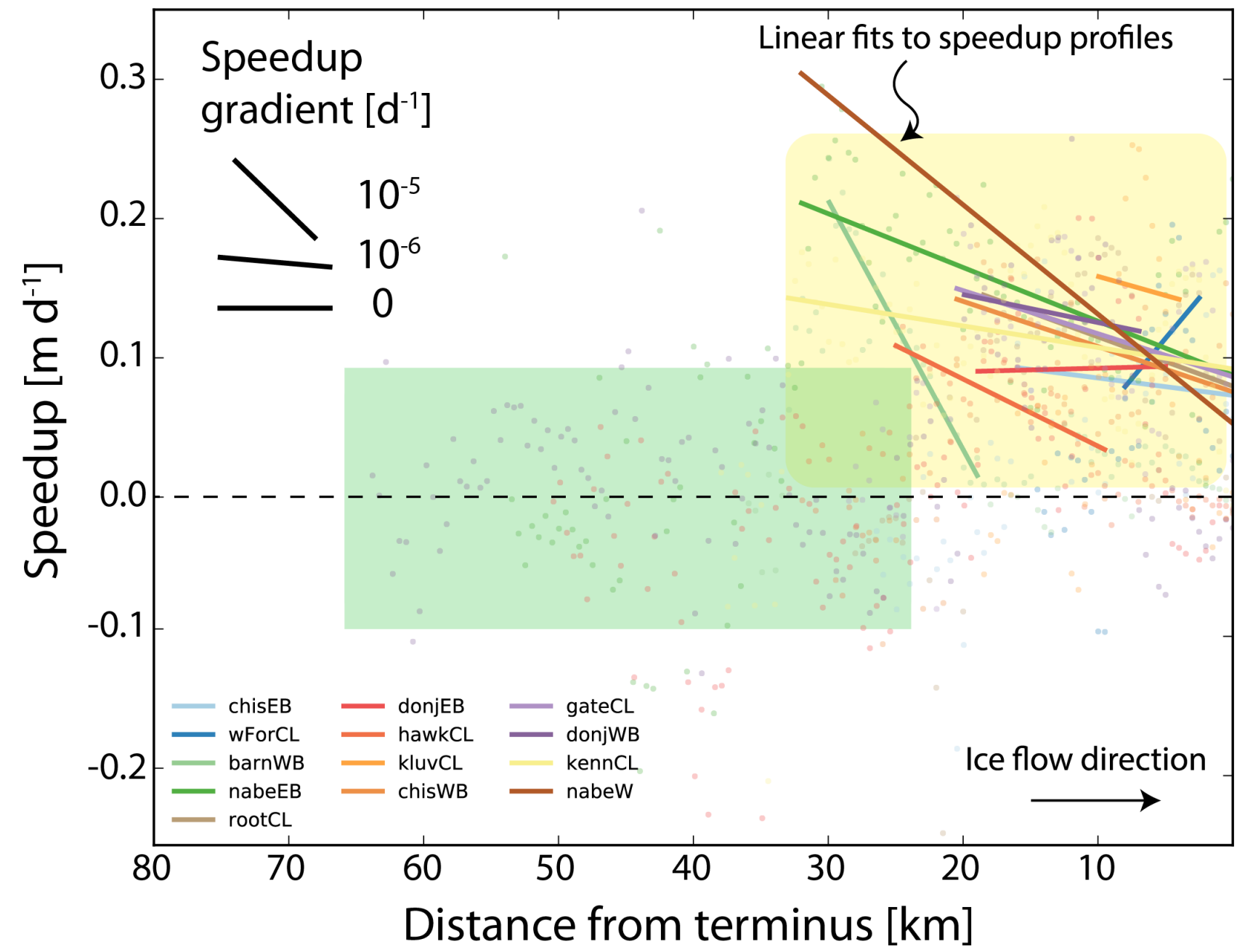
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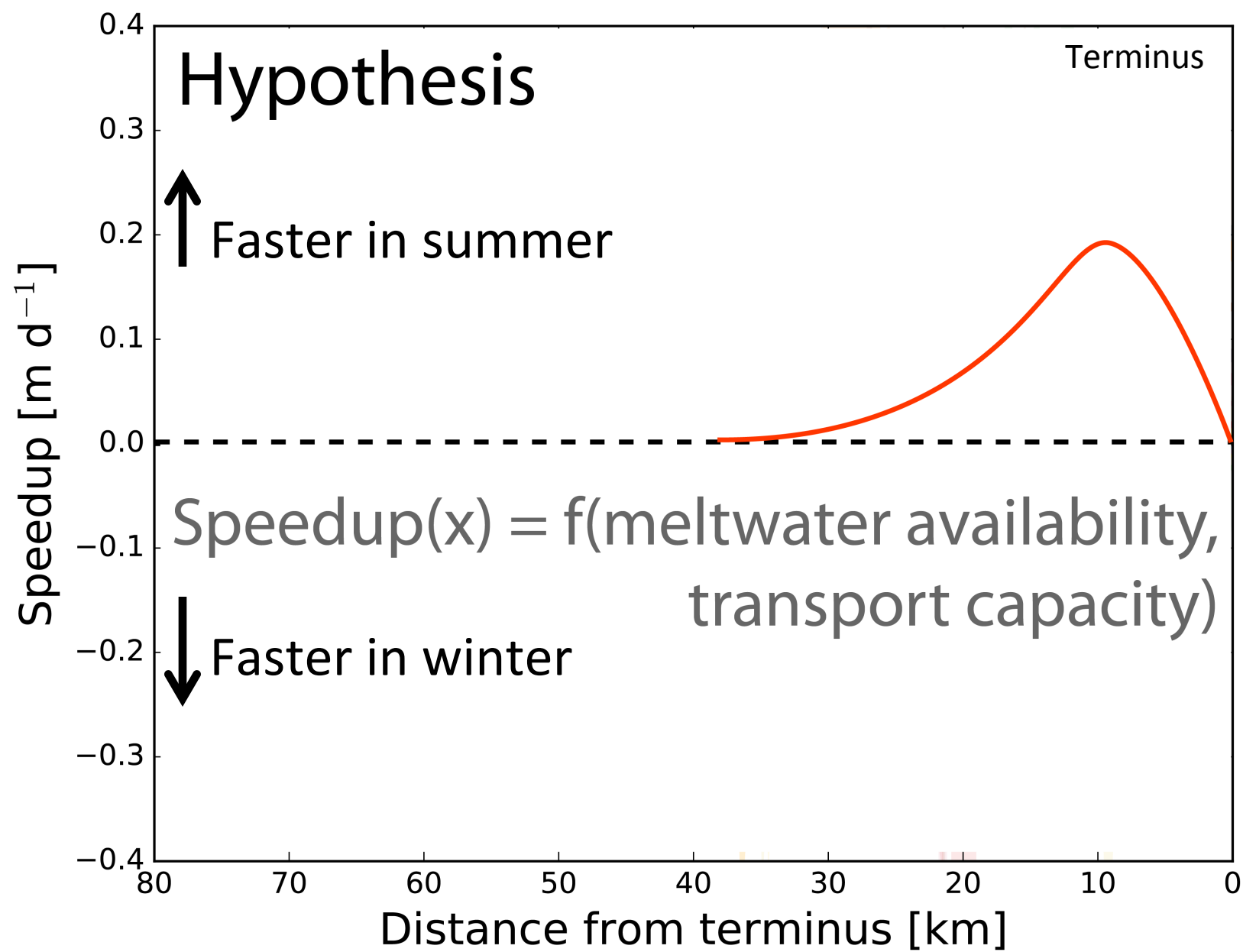


Speedup profiles

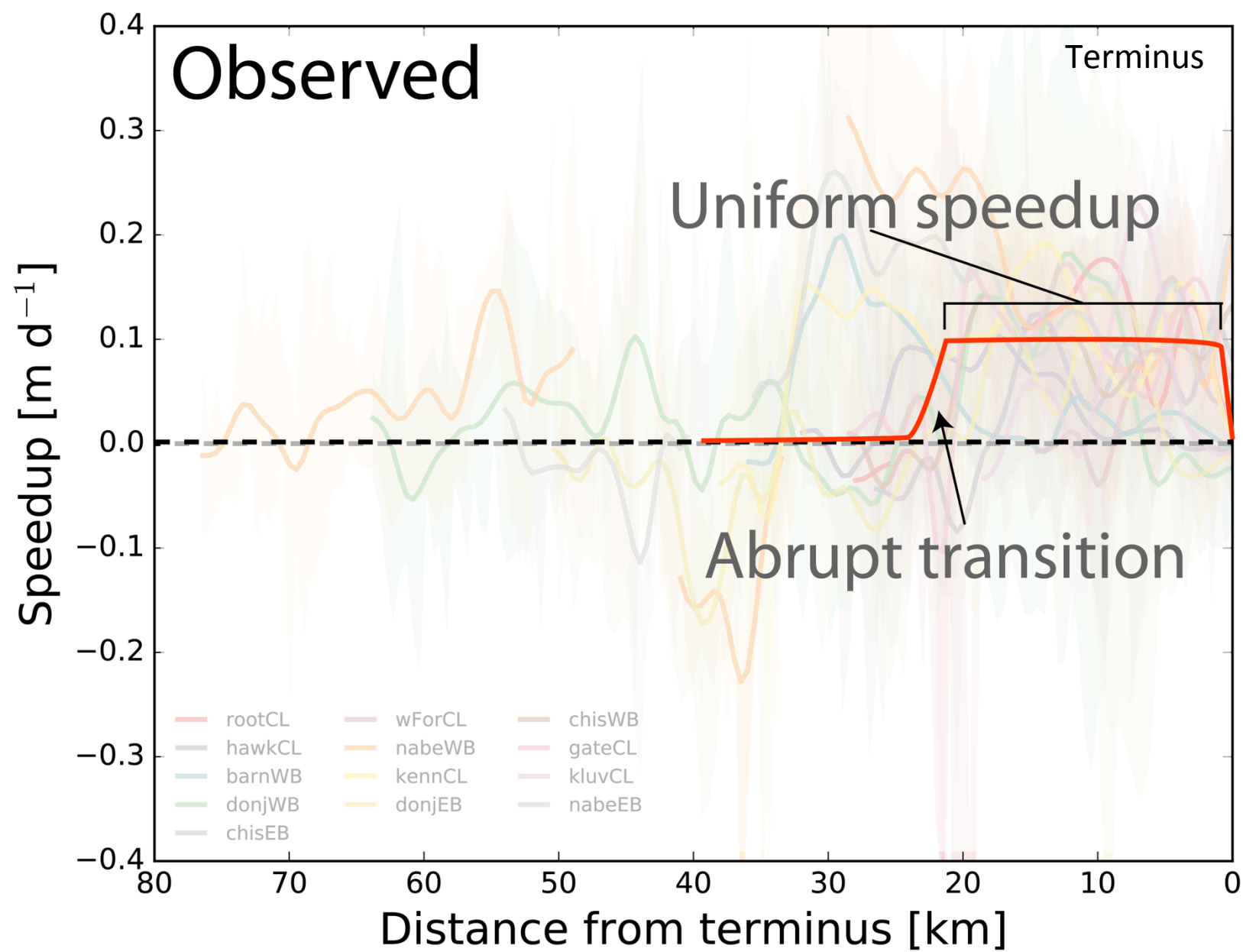
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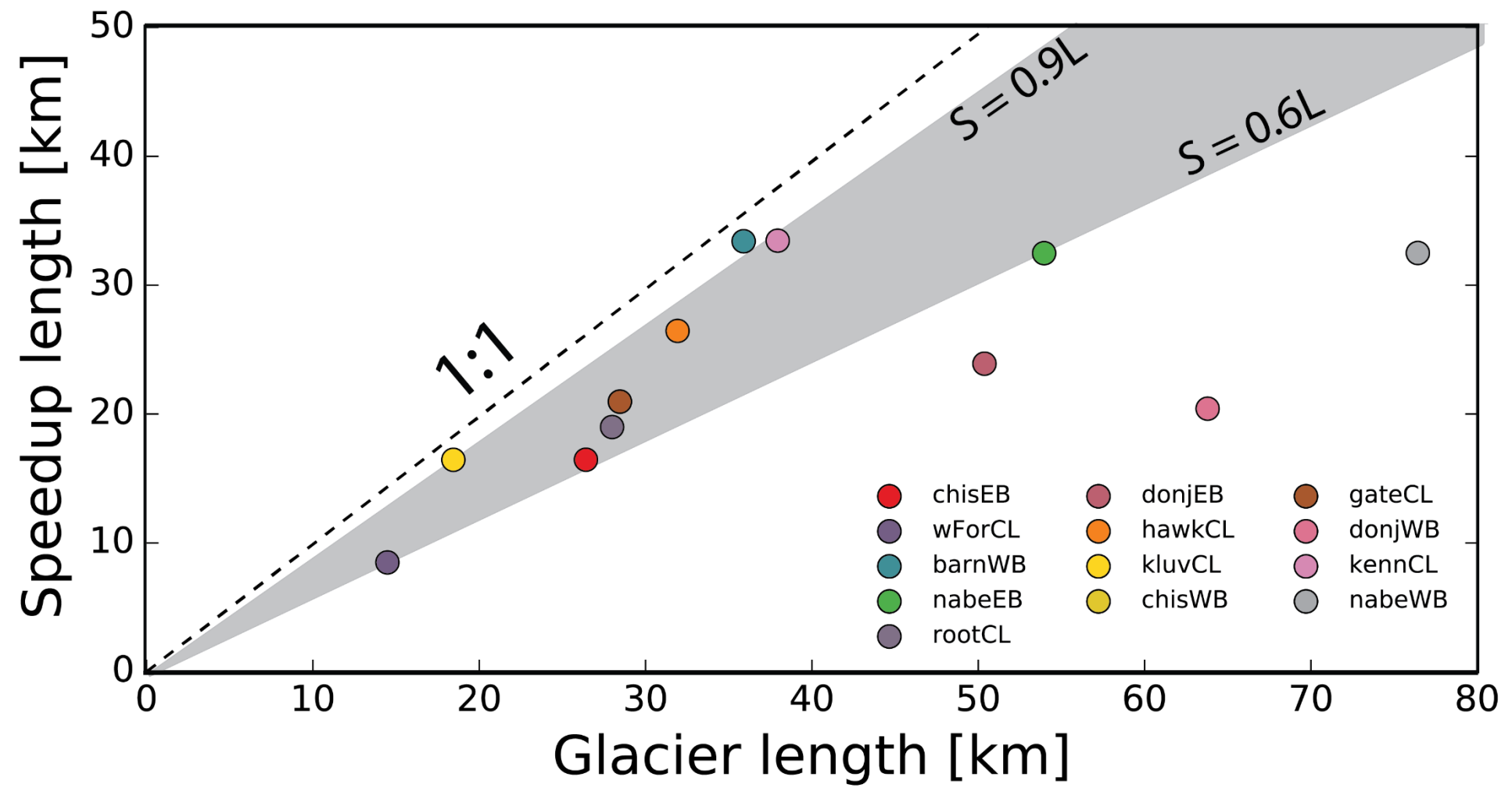
Speedup profiles



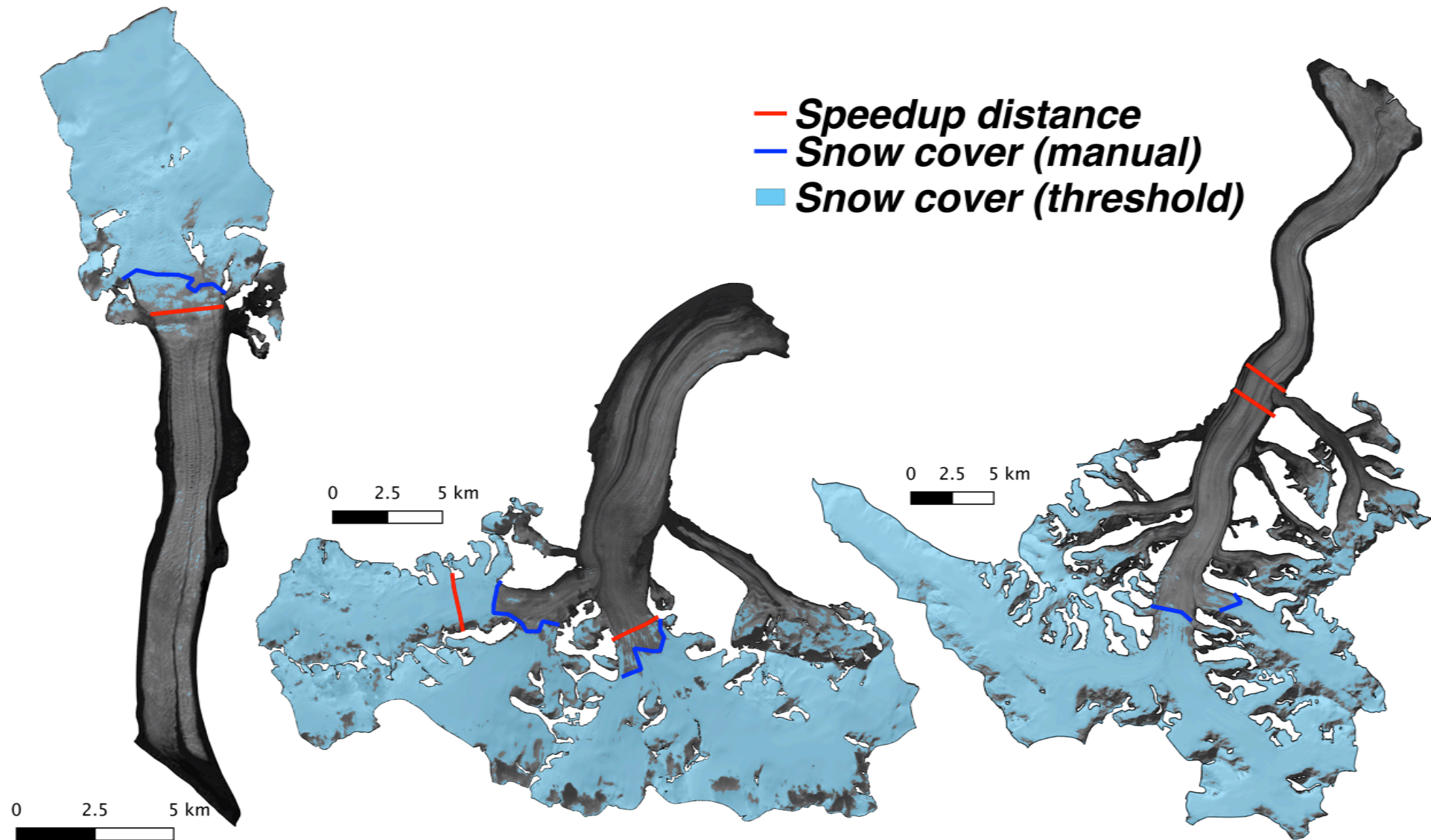
Speedup profiles



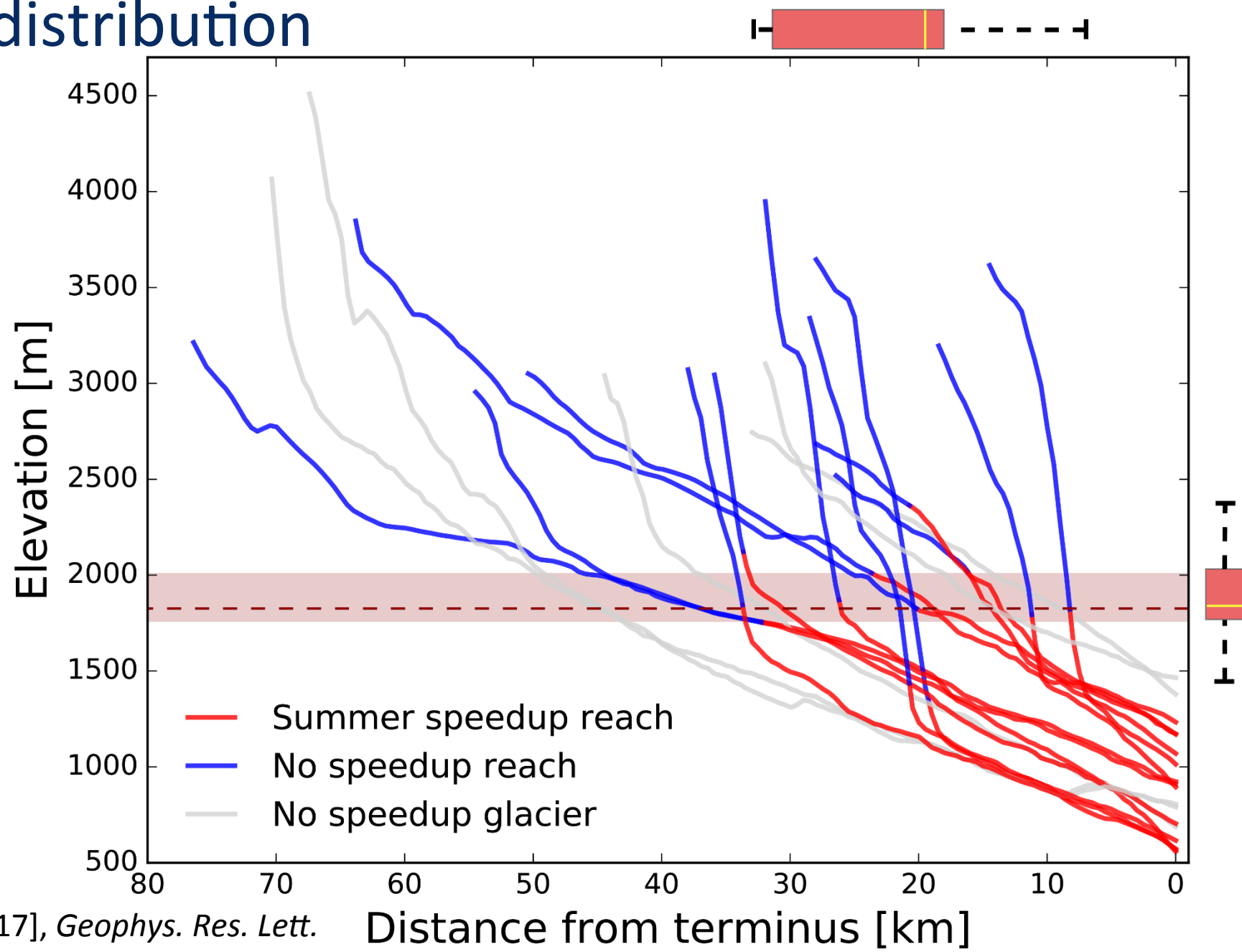
Speedup scaling



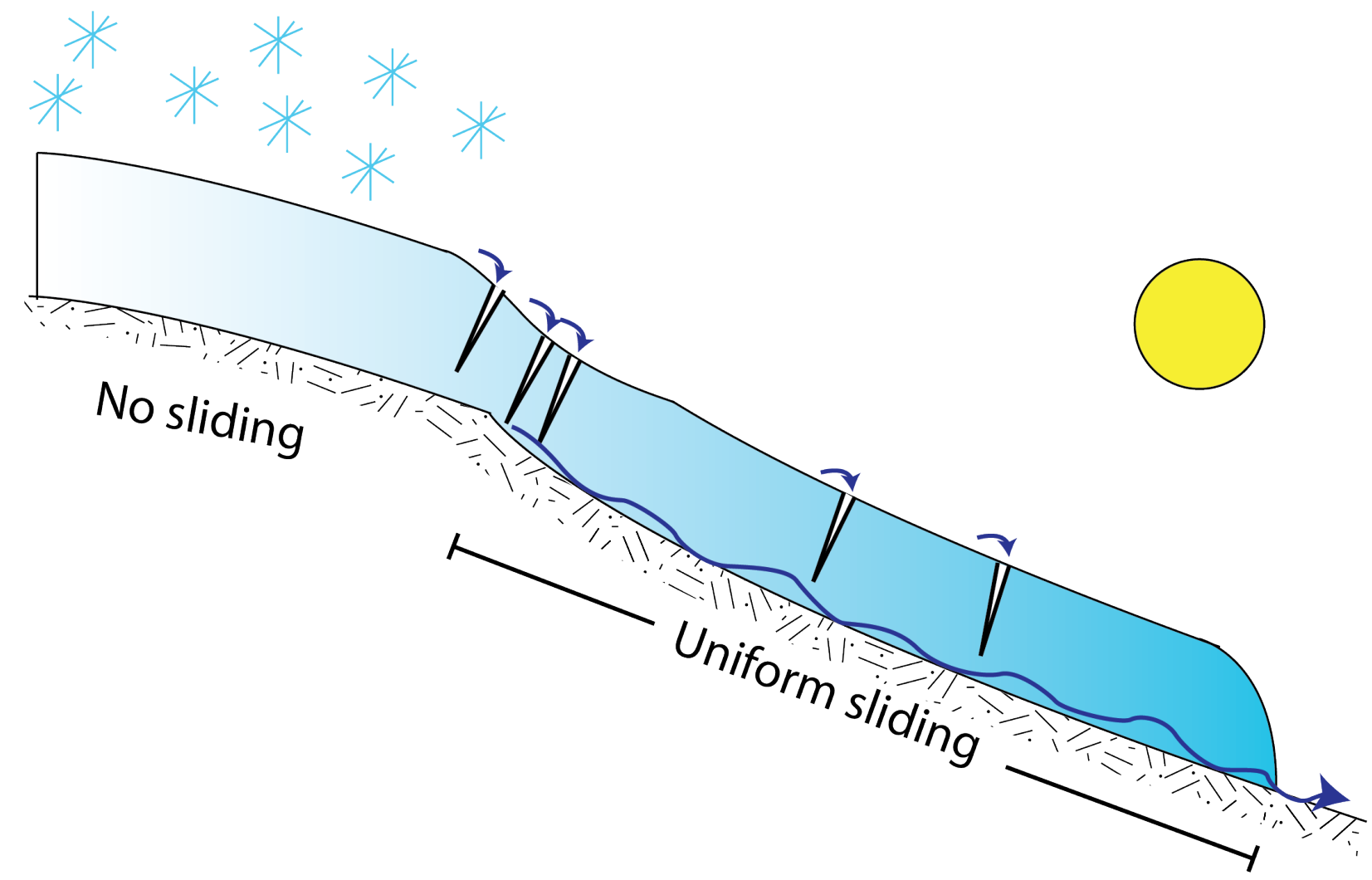
Controls on speedup length



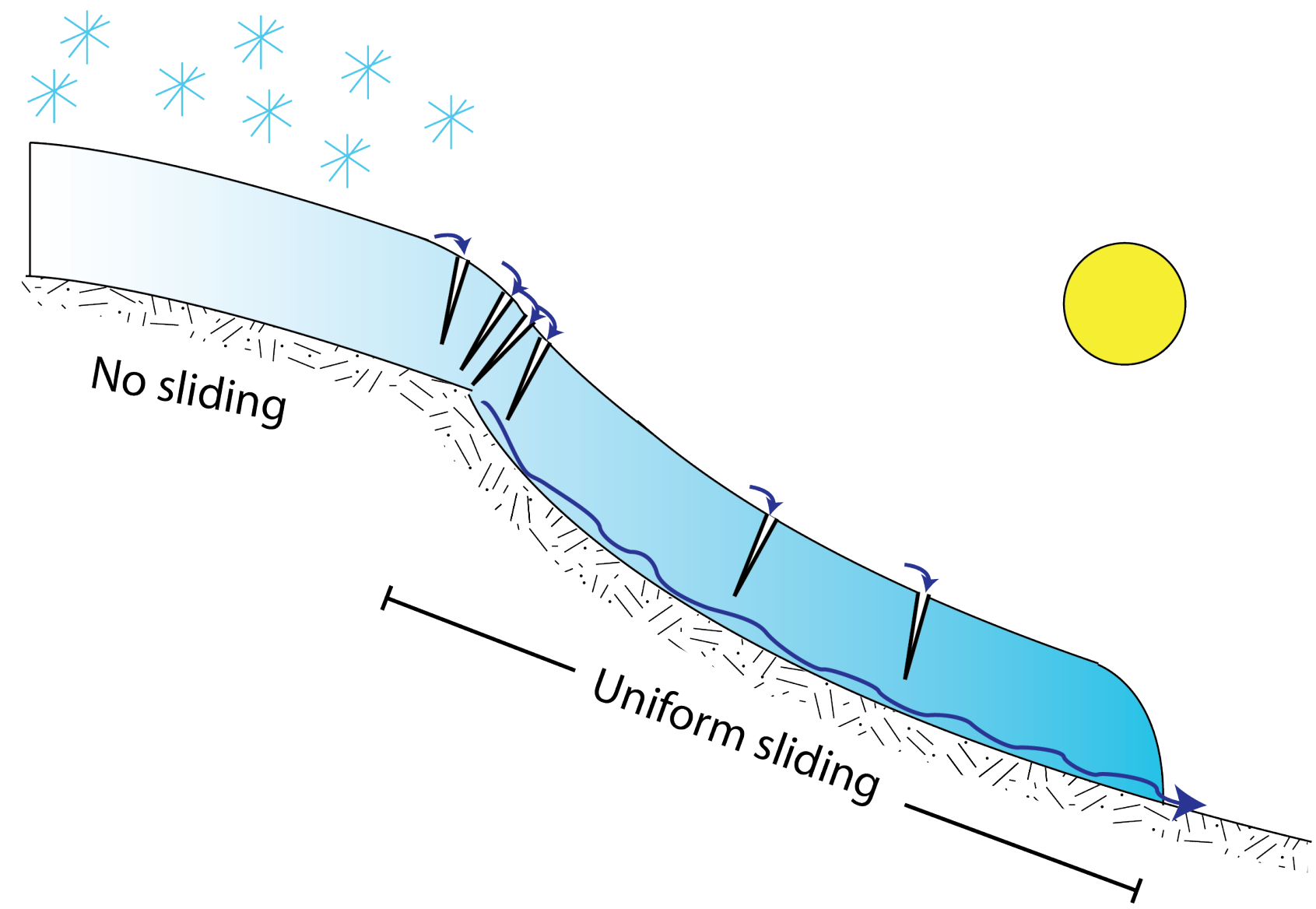
Elevation distribution



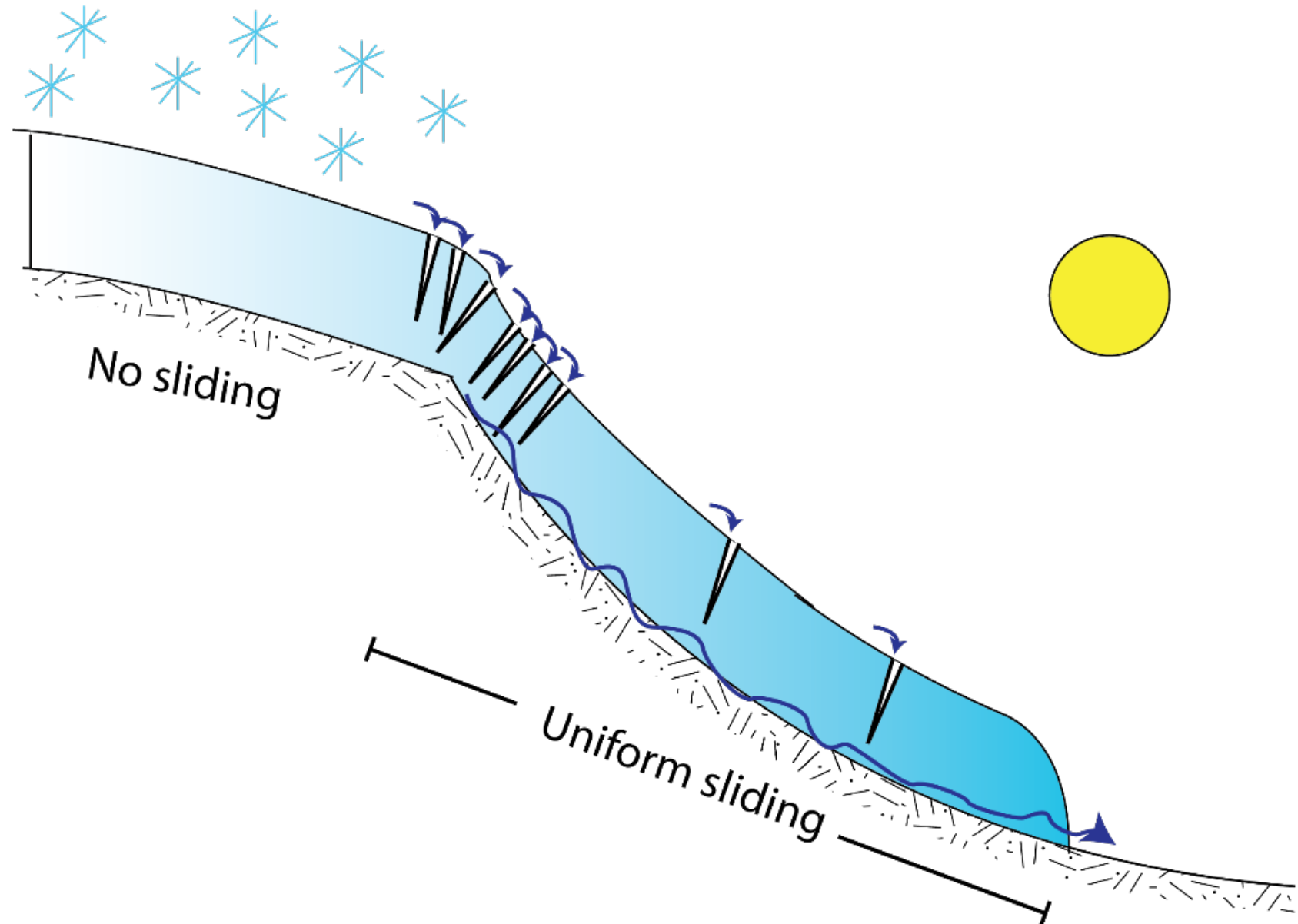
Icefall evolution



Icefall evolution

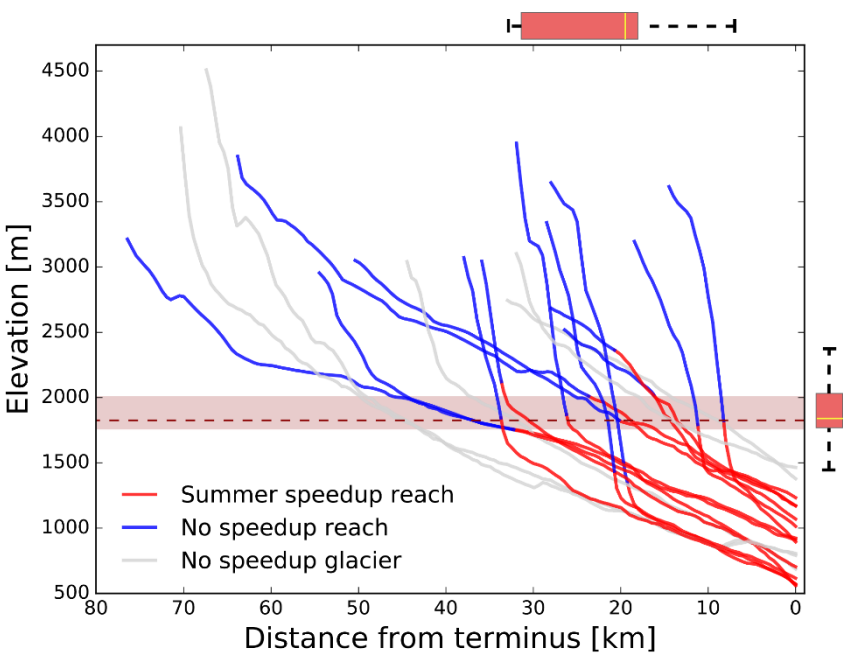
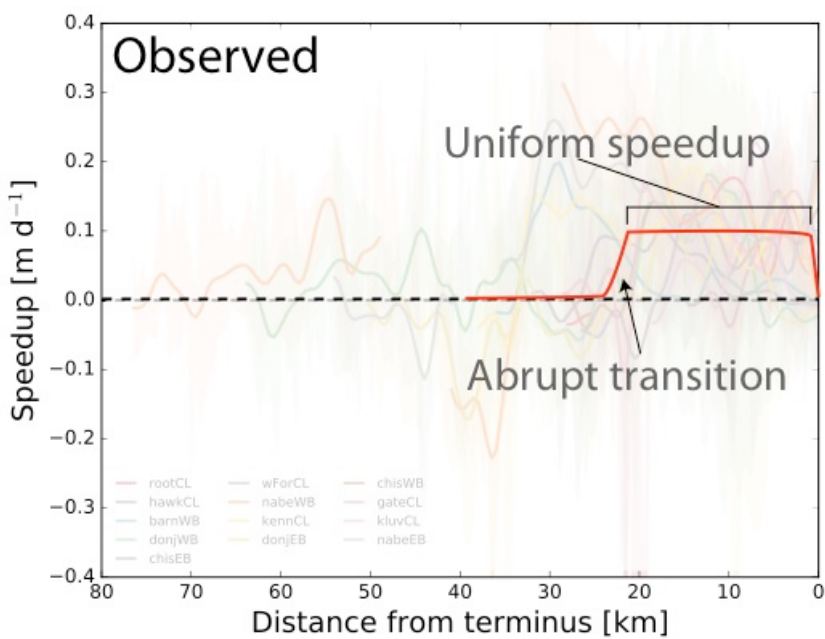


Icefall evolution



Conclusions

- Uniform summer speedup over 10s of km, with hint of upglacier limit
- Association of speedup length and icefall location – change in dynamics?
- Feedback for icefall formation?



Thanks!

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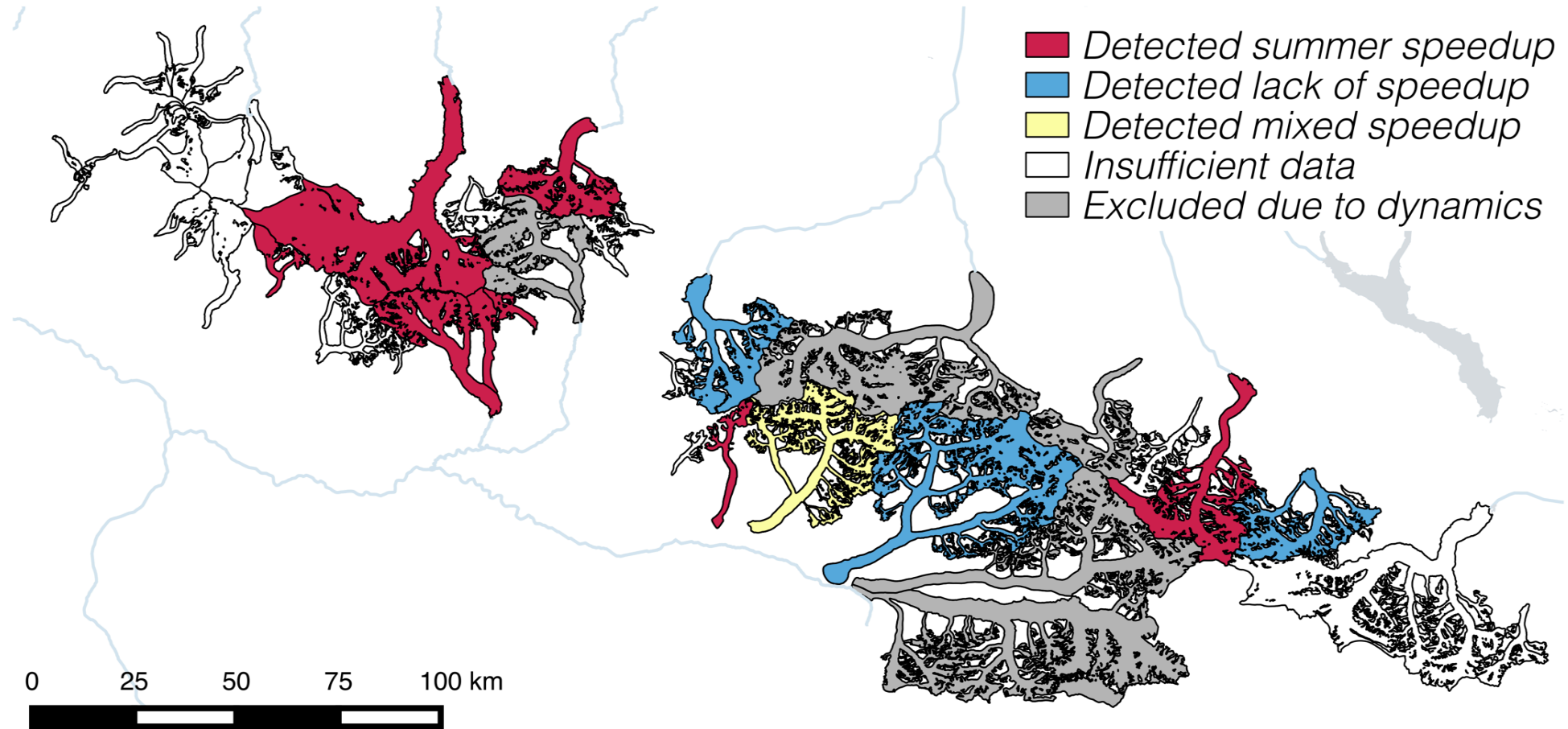


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Spatial distribution



Icefalls and snowline

- Difficult to disentangle from snowline

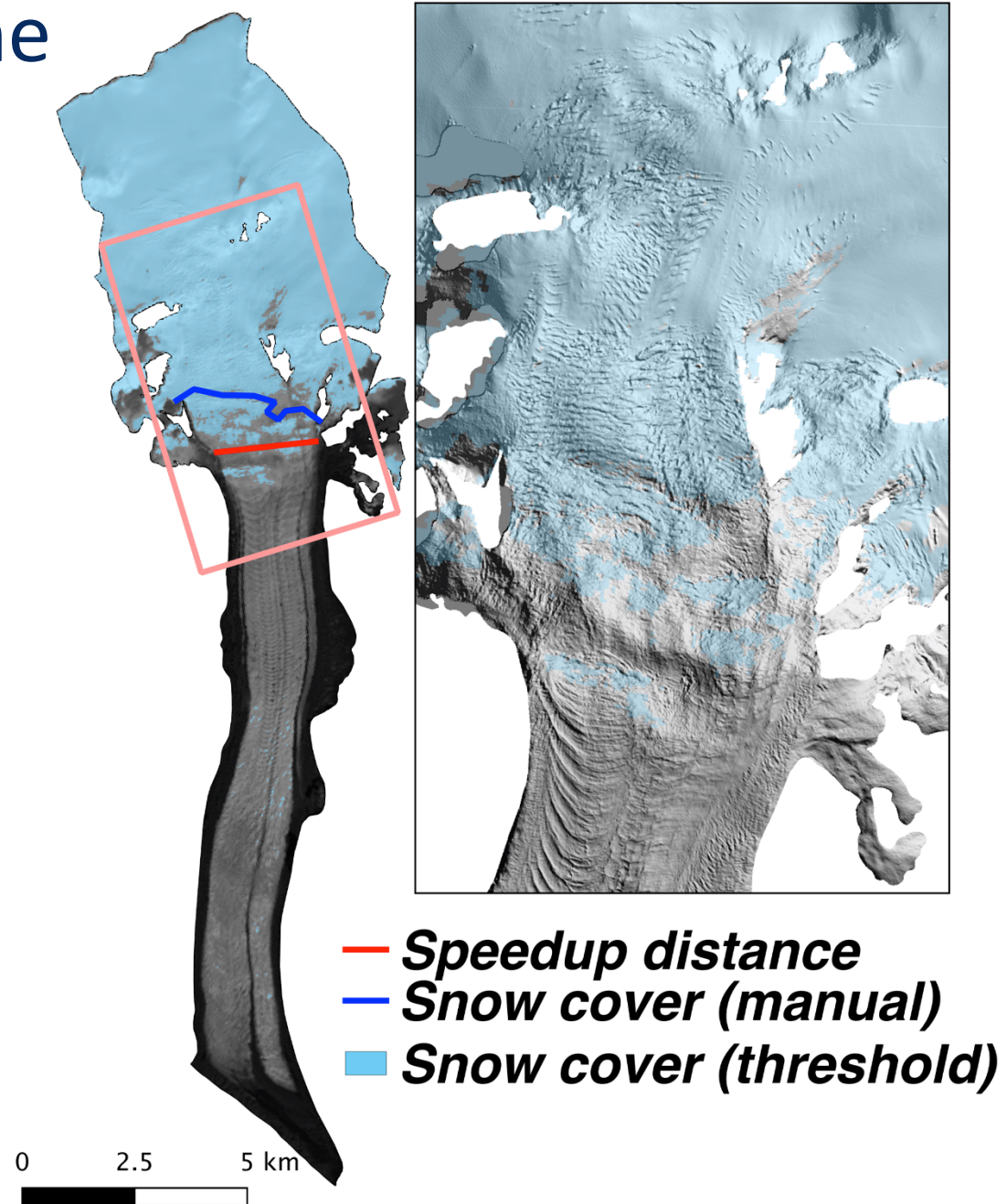
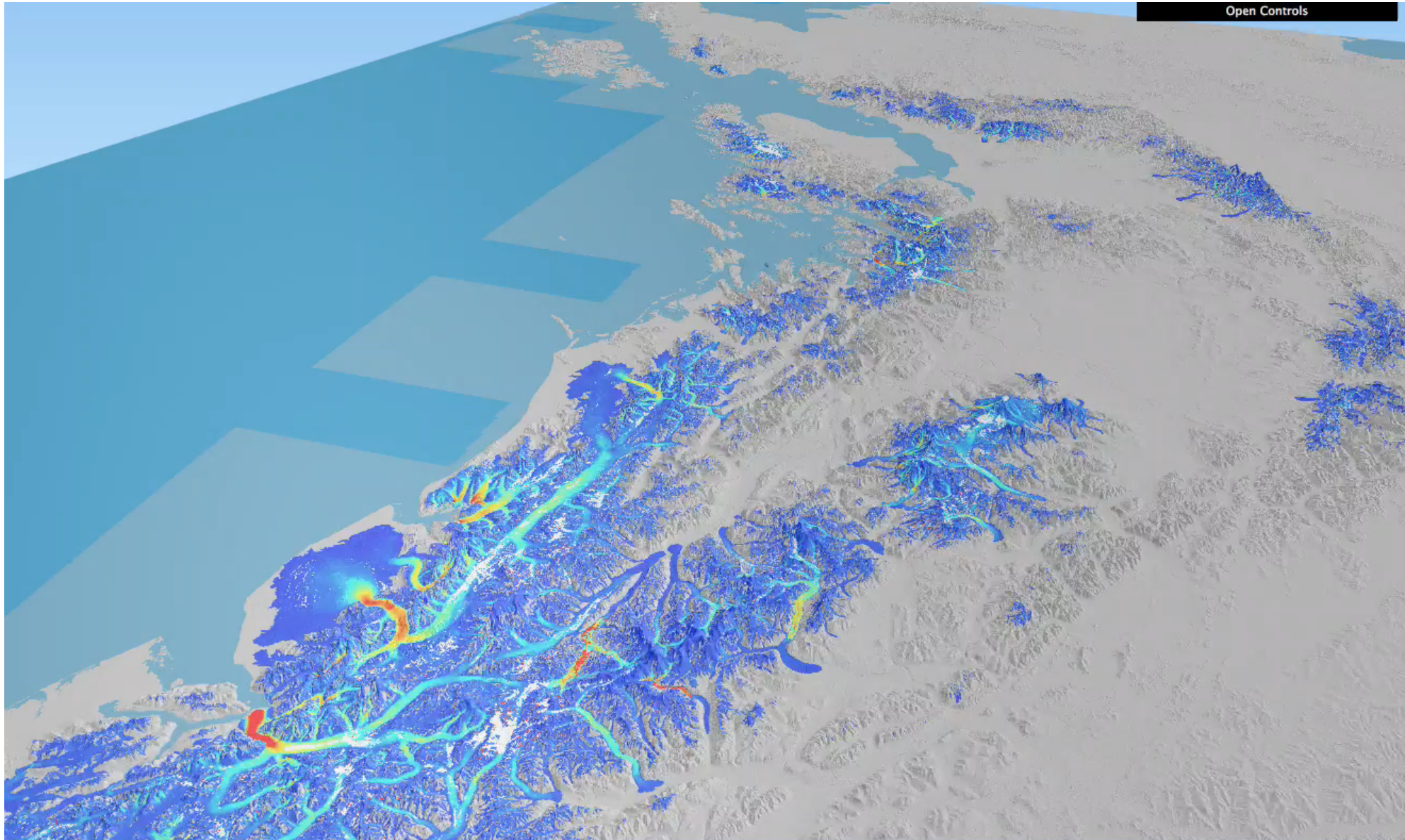
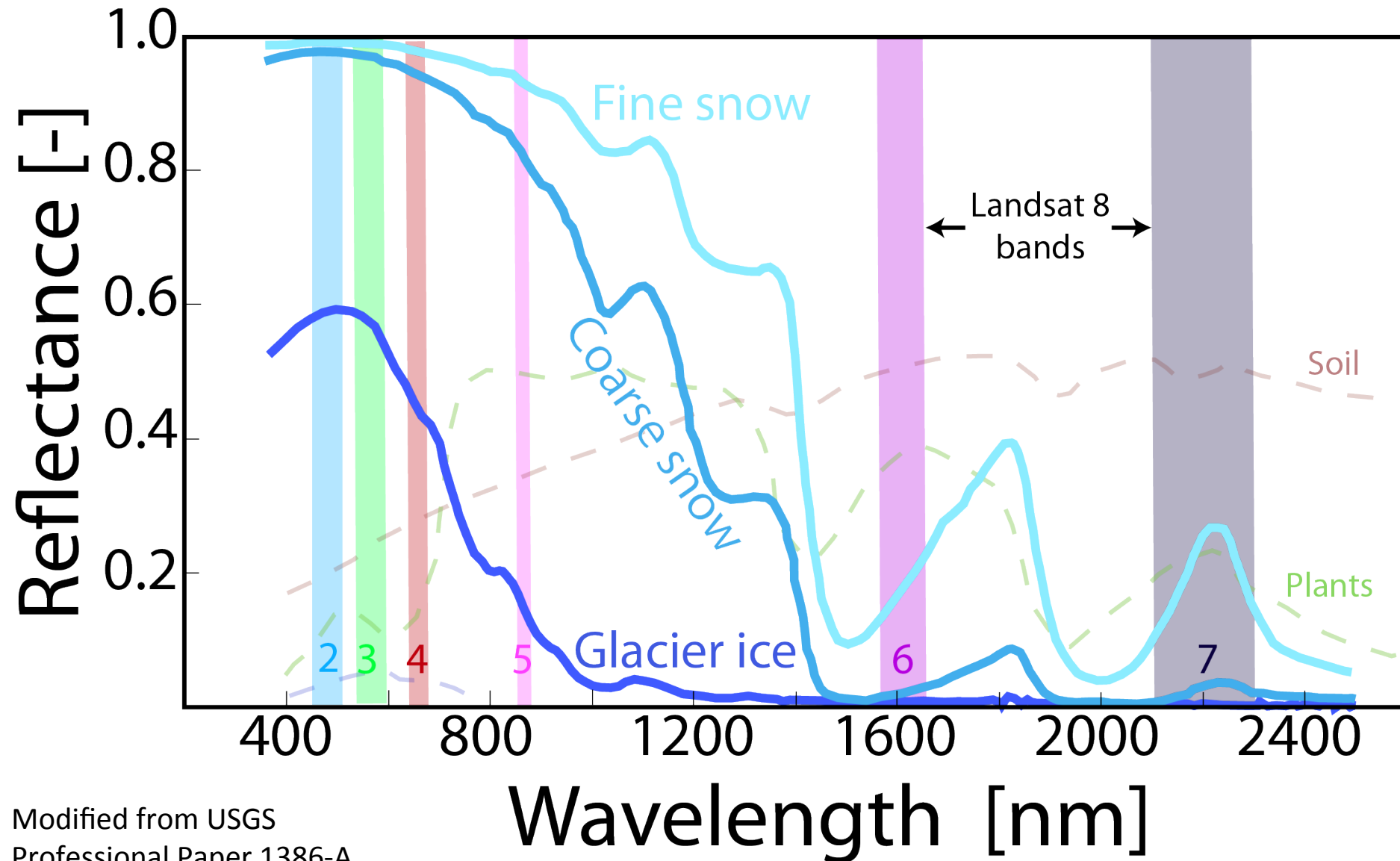


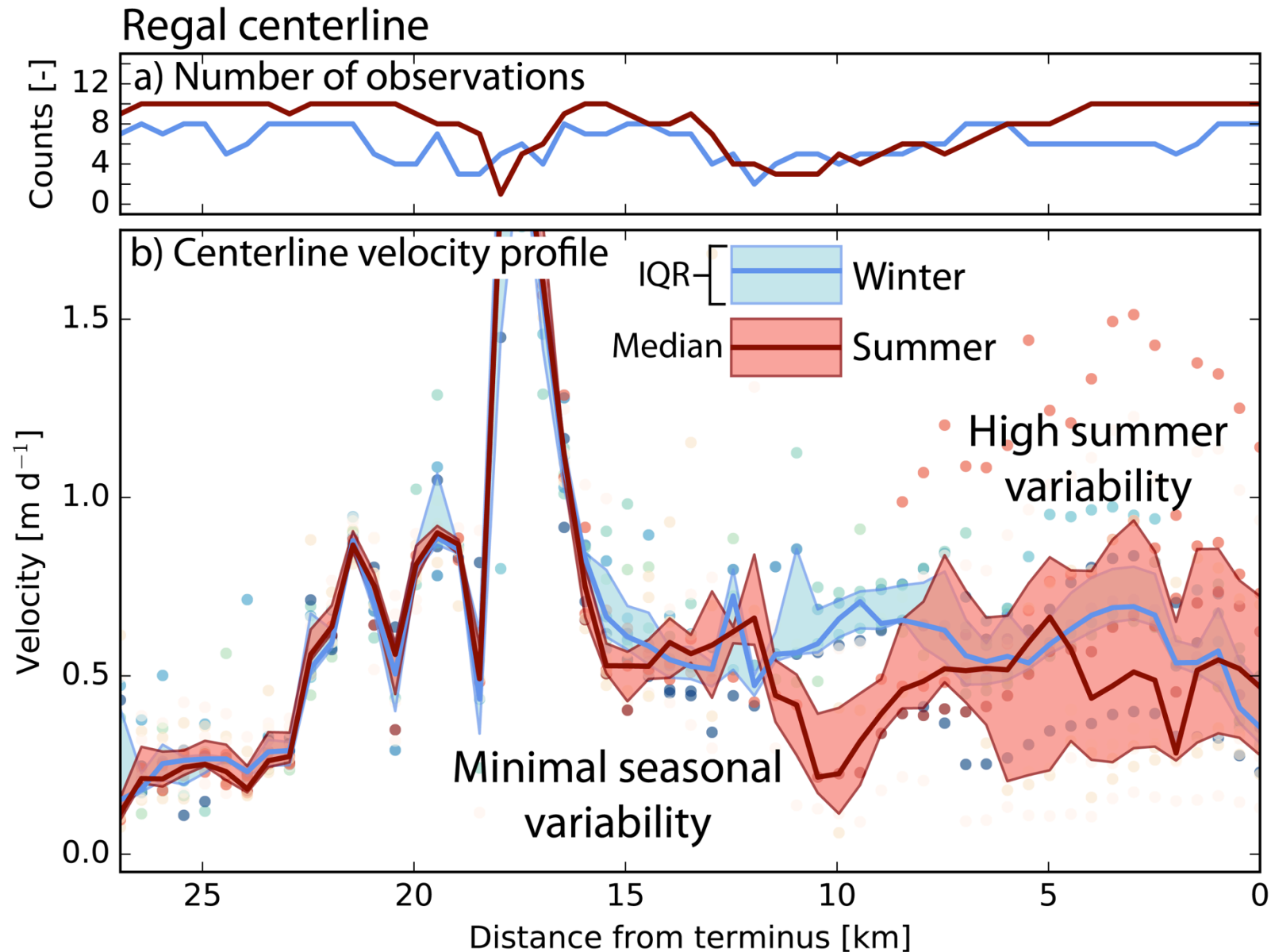
Image cross-correlation



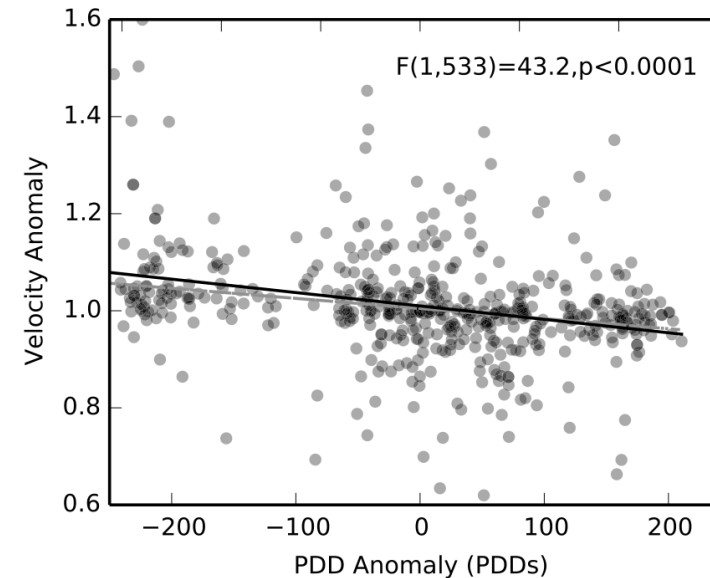
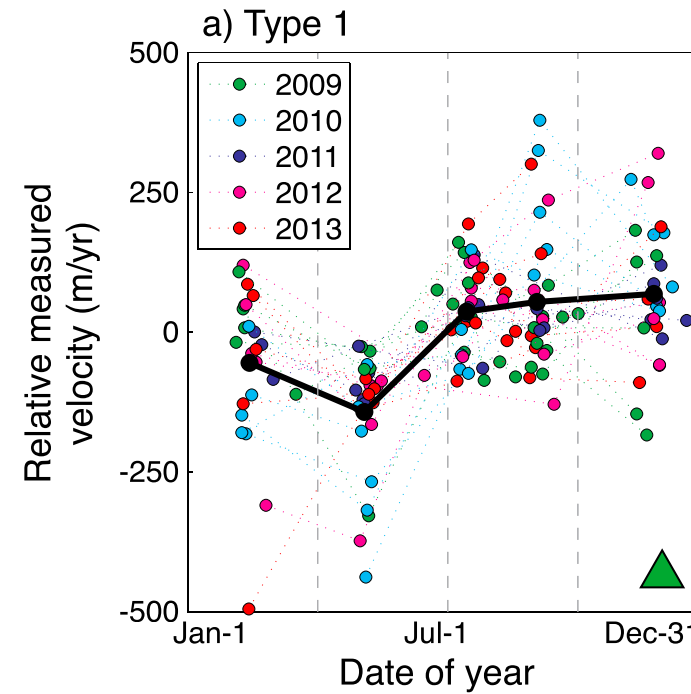
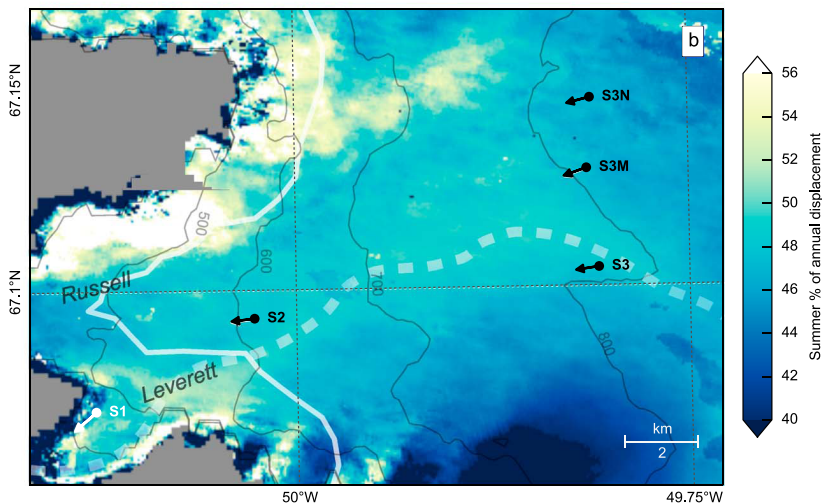
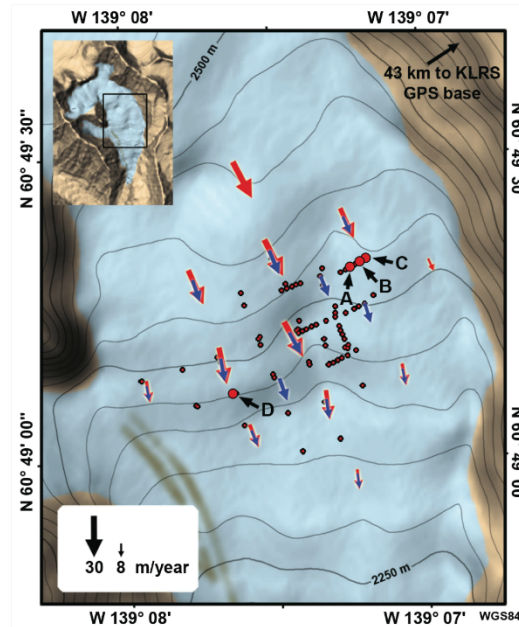
Association with late summer snowline



Lake-terminating glaciers

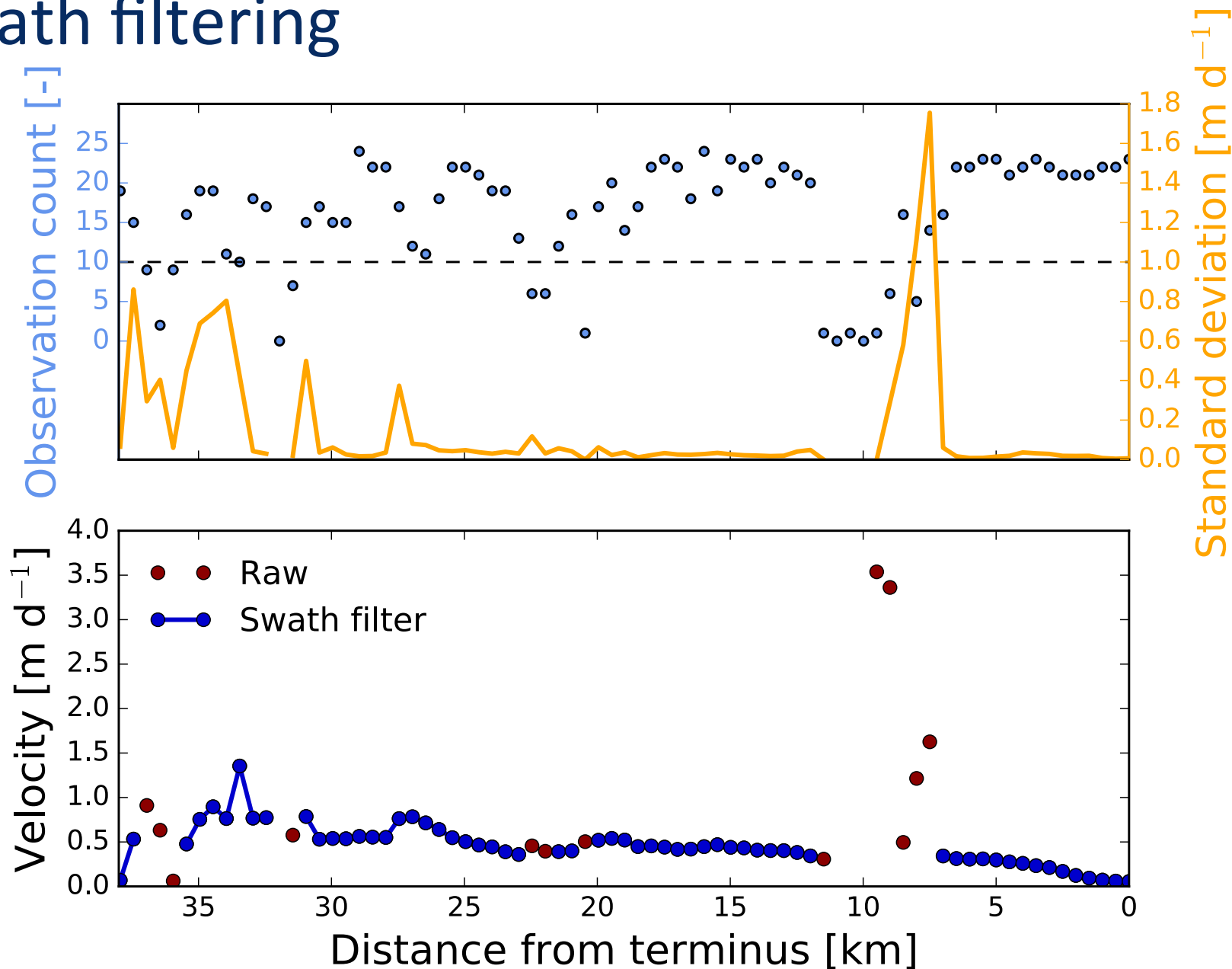


Scientific context

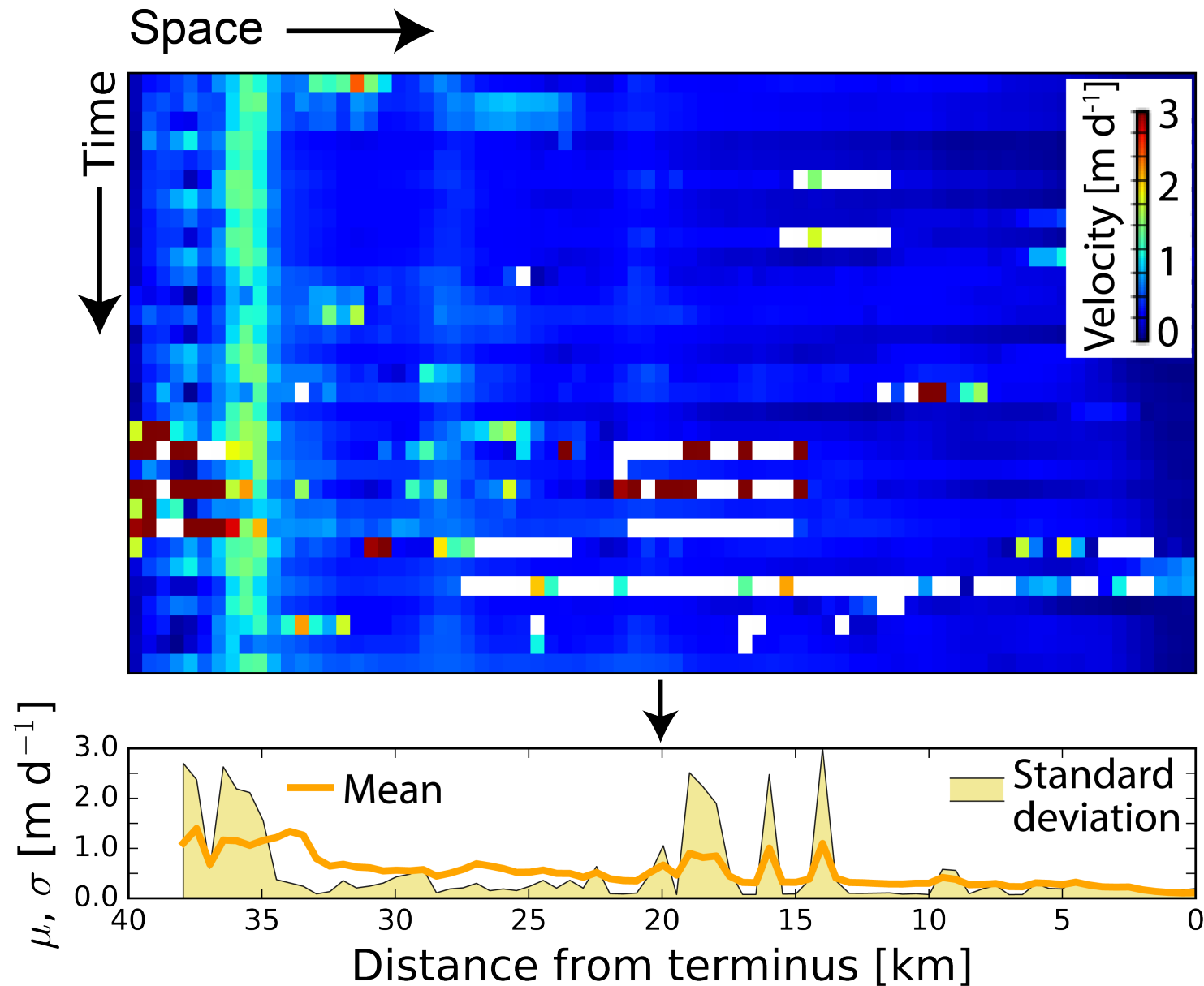


Figures modified from *Burgess et al. [2013]*; *Flowers et al. [2014]*; *Moon et al. [2014]*; *Tedstone et al. [2014]*

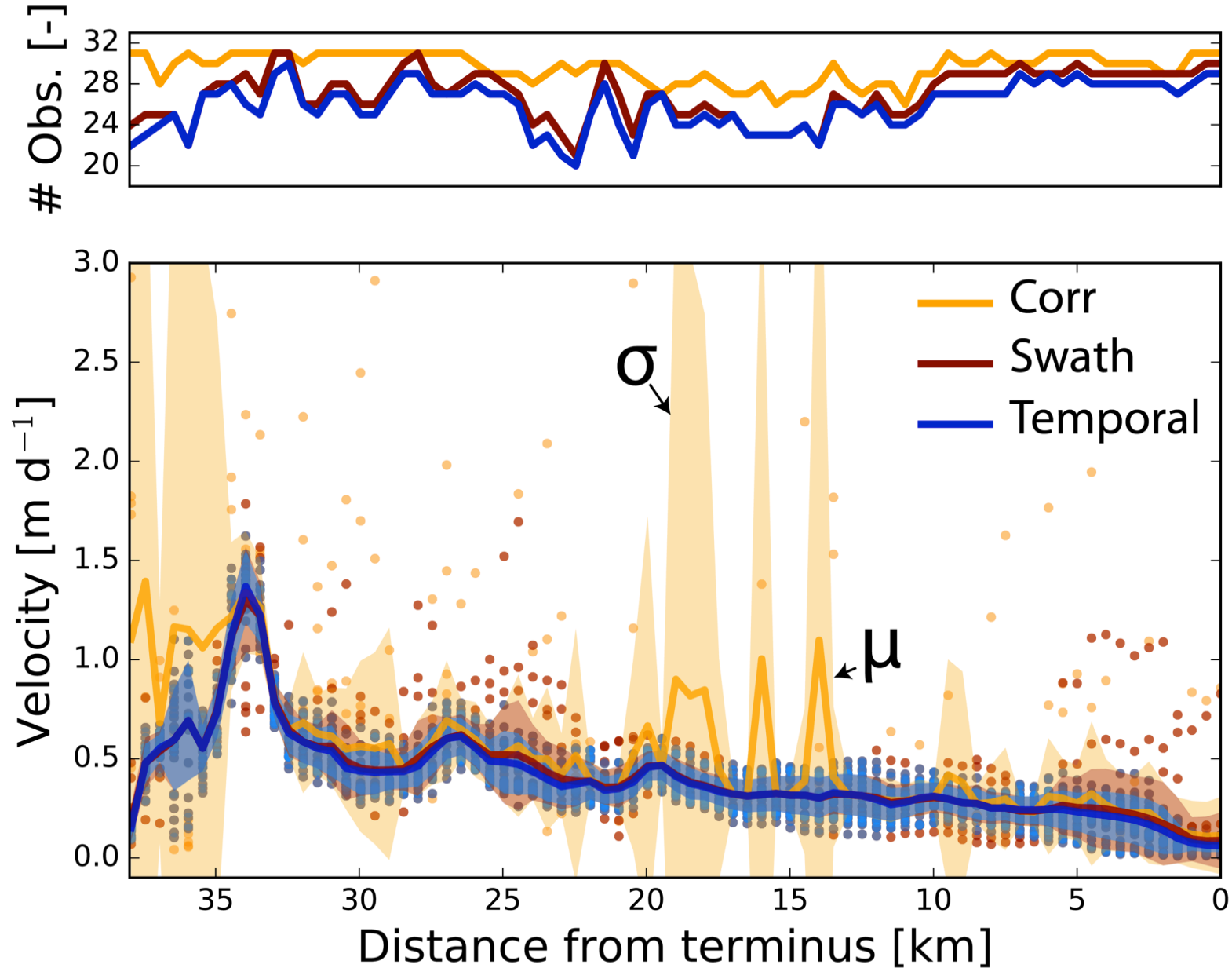
Swath filtering



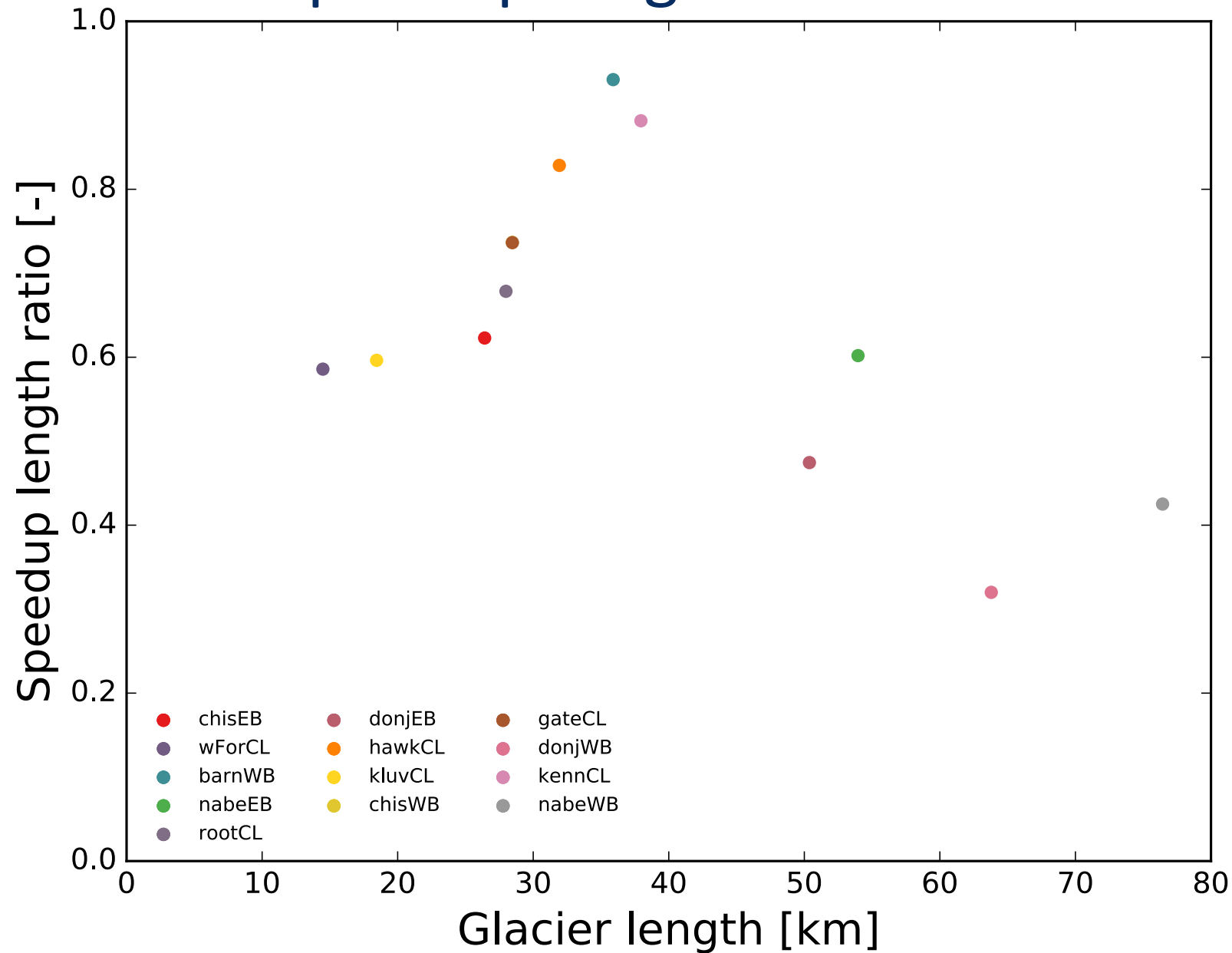
Temporal filtering



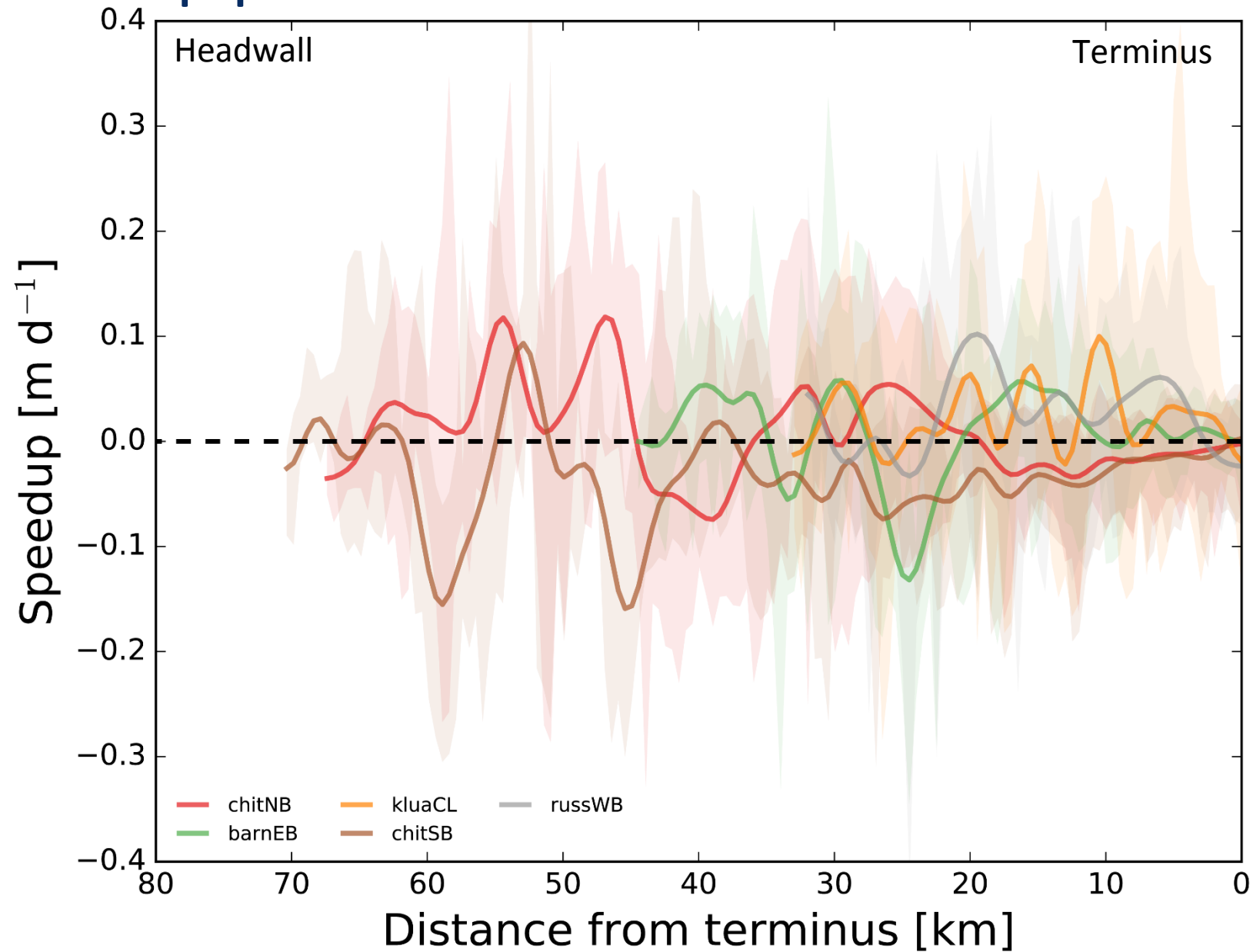
Filtering methods



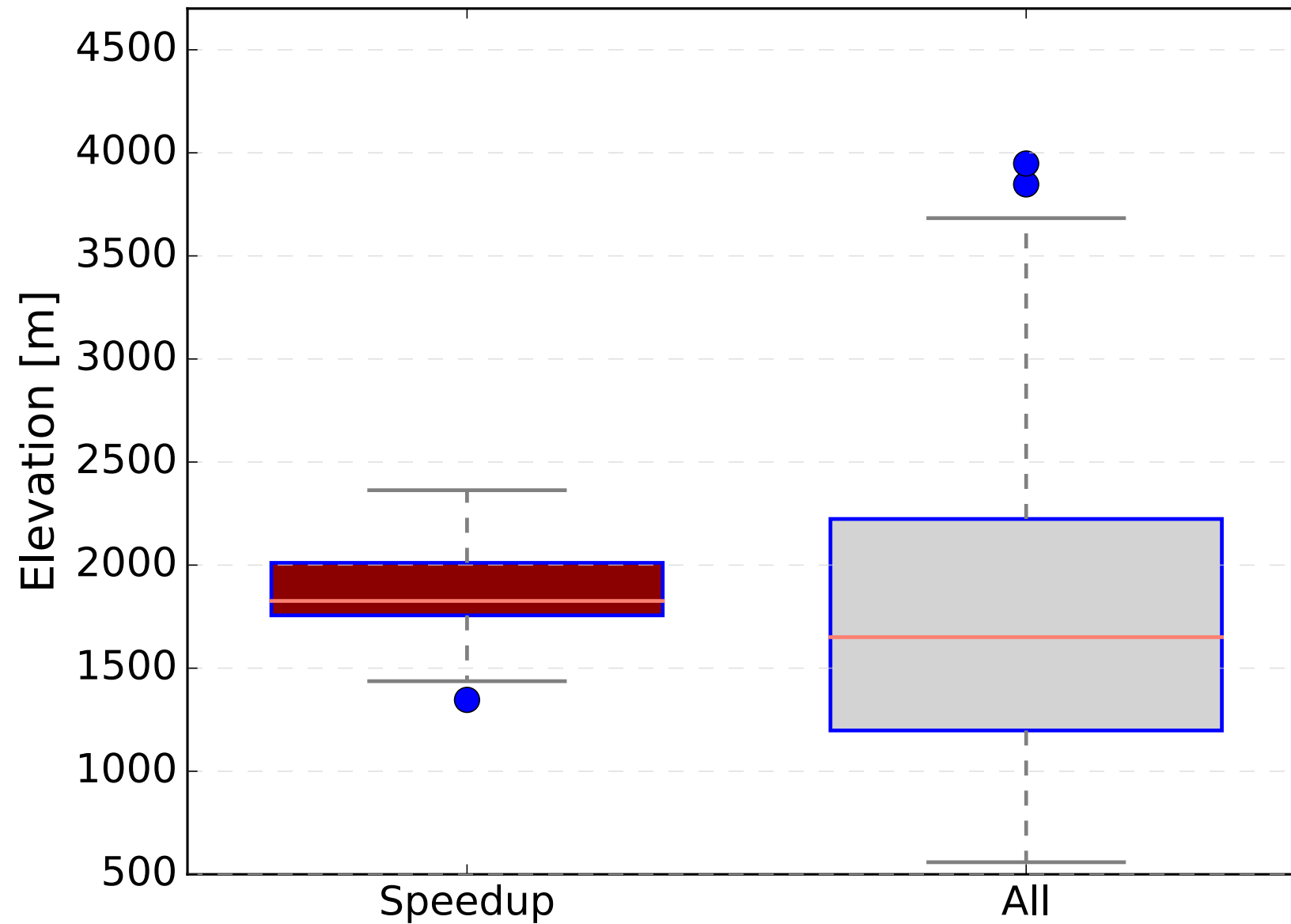
Normalized speedup length



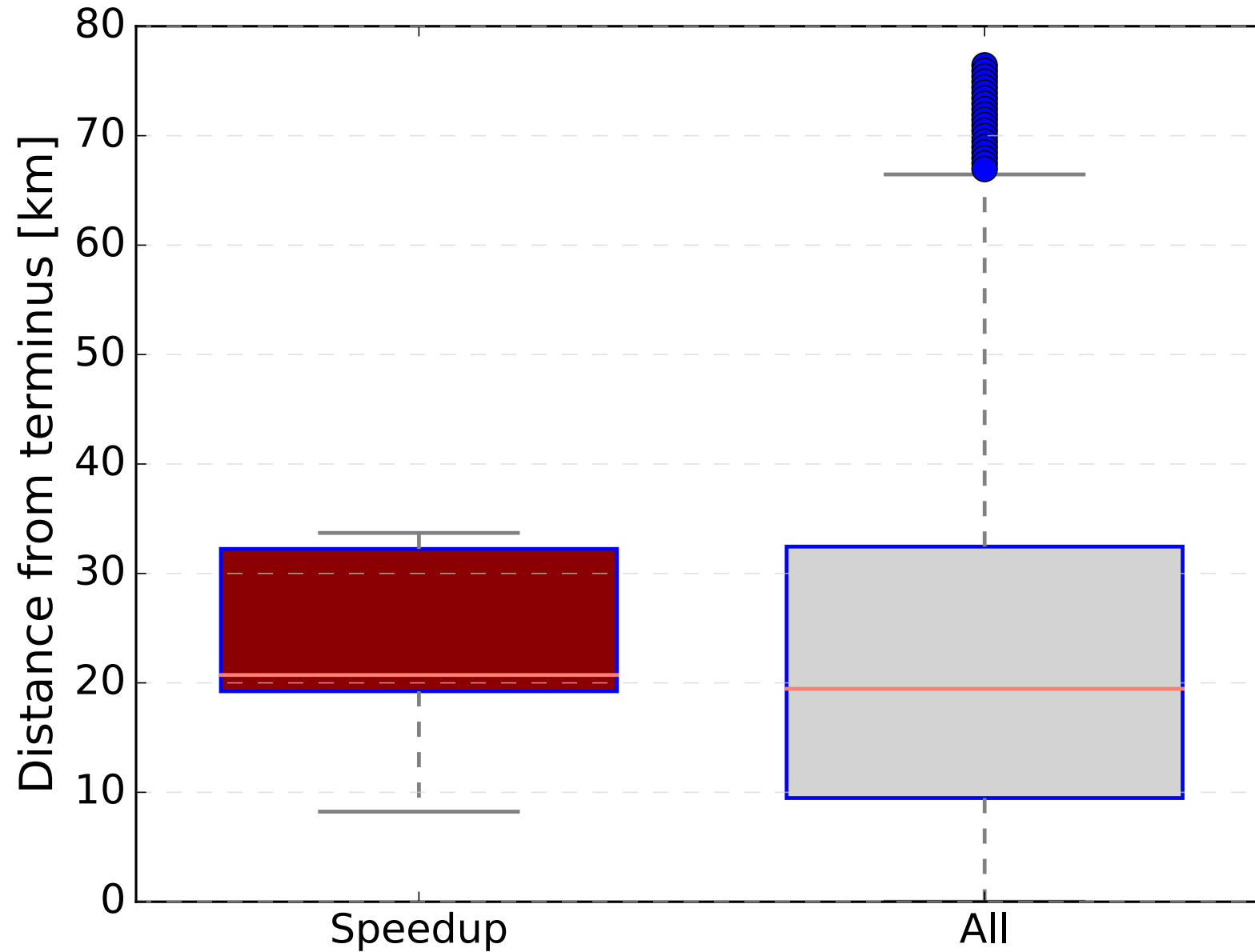
Speedup profiles



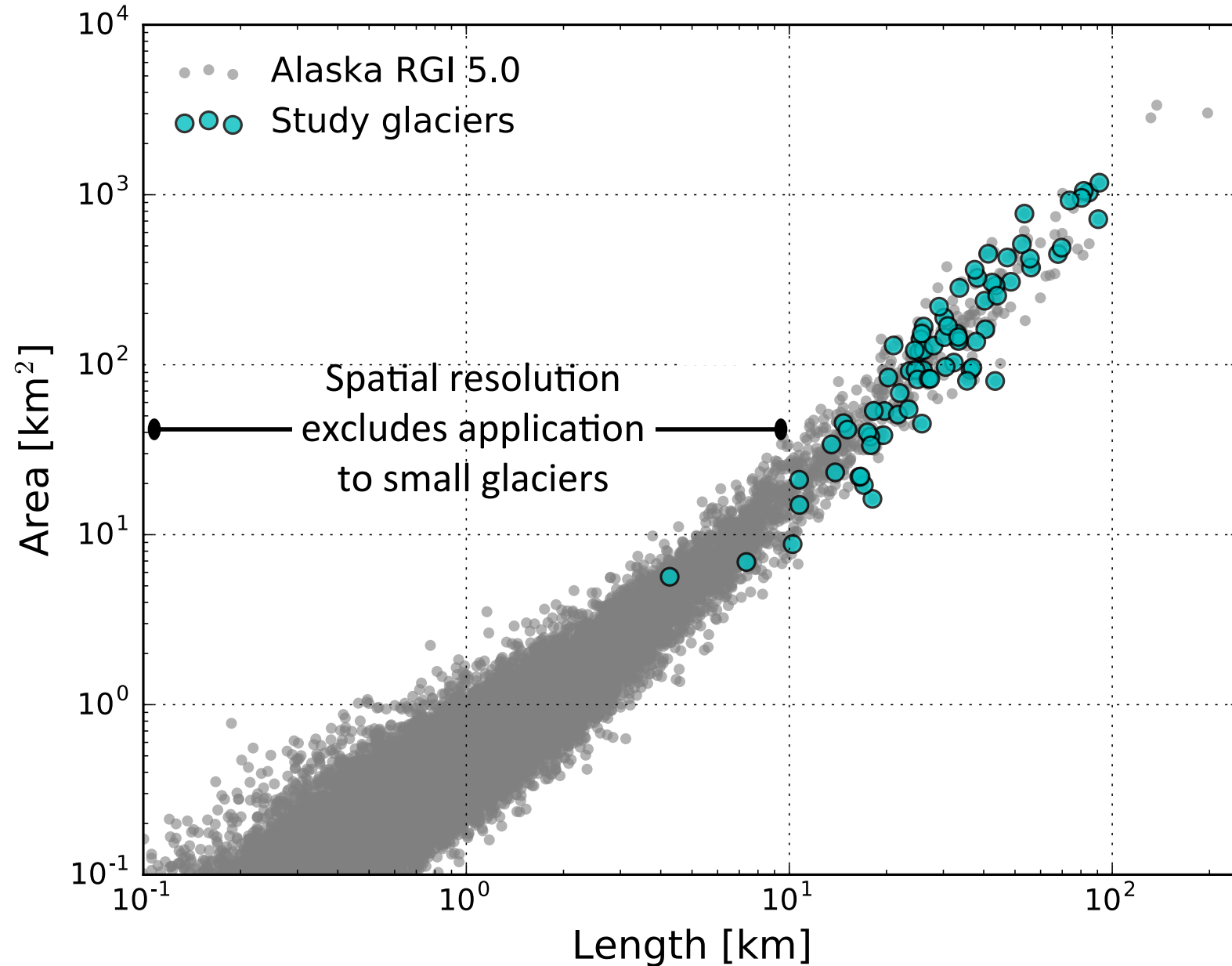
Elevation distribution



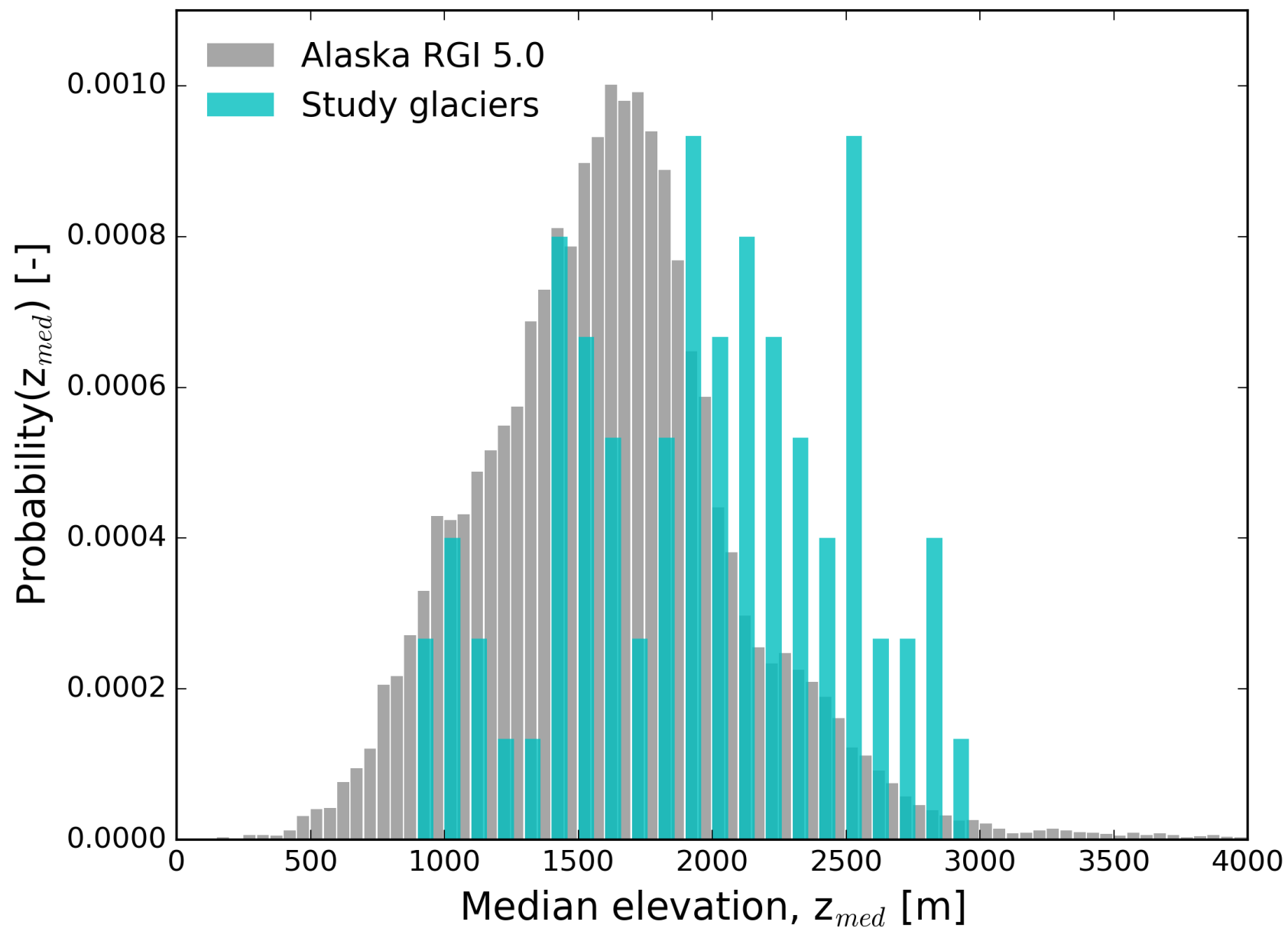
Distance distribution



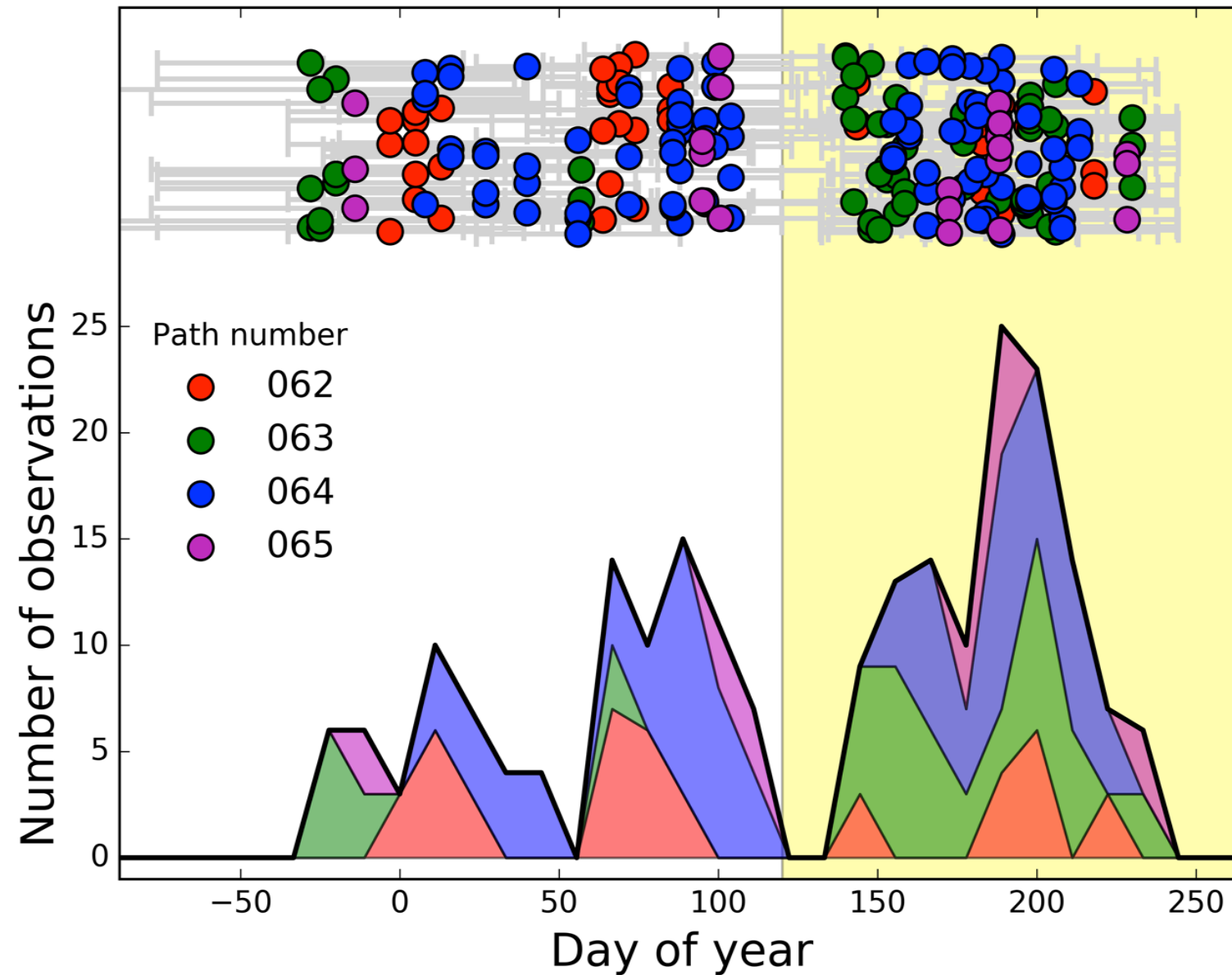
Glacier representation



Elevation distribution

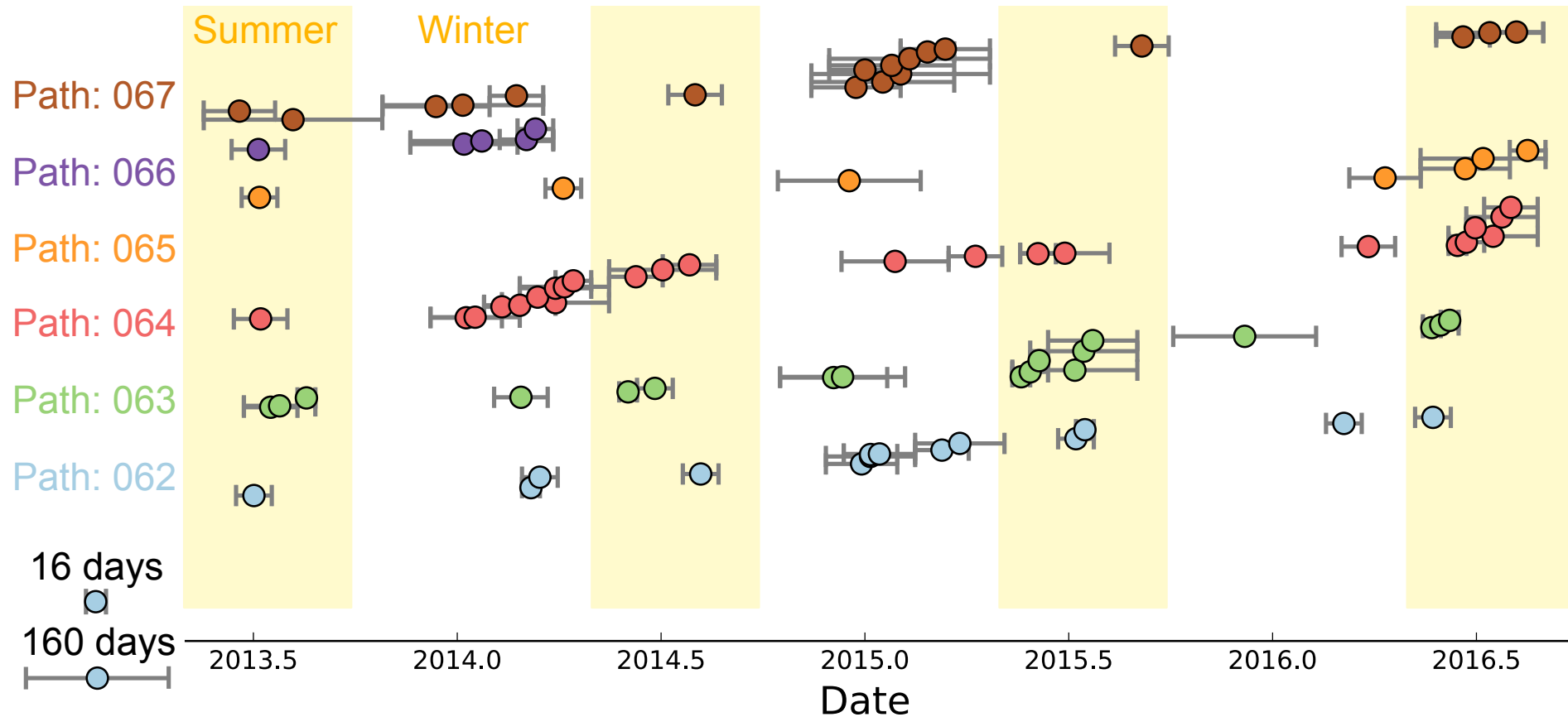


Temporal coverage



Temporal resolution

- Majority ≤ 48 days
- Maximum = 160 days



Temporal resolution

