

Debris cover and the thinning of Kennicott Glacier, Alaska

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and Dirk Scherler

See publication in The Cryosphere for detailed consideration of assumptions and uncertainties: <https://doi.org/10.5194/tc-15-265-2021>

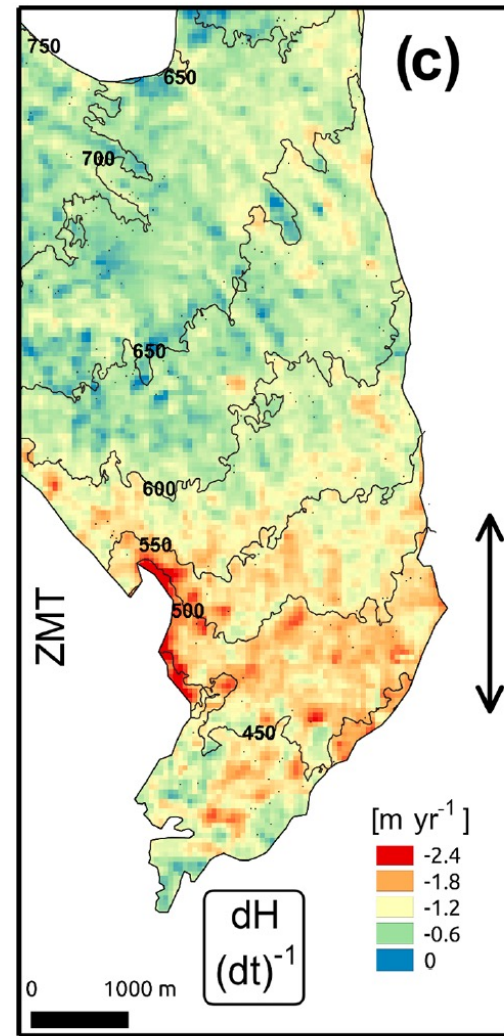
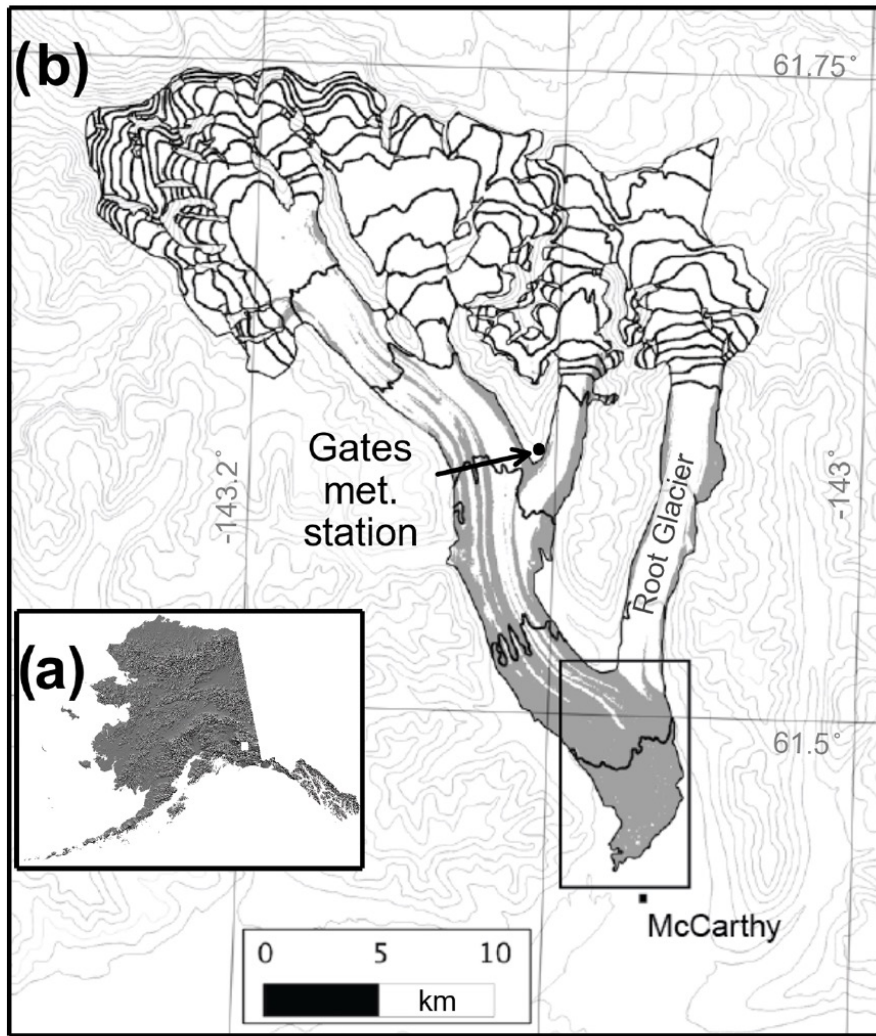
Take homes

- Melt across the debris covered tongue of a large Alaskan Glacier is estimated with rigorous uncertainty estimates for the summer of 2011
- Highest fractional area of ice cliffs (11.7 %) documented to date.
- Ice cliffs contribute 26% of total melt across the glacier tongue.
- New Adaptive Binary threshold method for delineating ice cliffs
- Although the *relative* importance of ice cliffs to area-average melt is significant as debris thickens, the *absolute* area-averaged melt is dominated by debris.
- At Kennicott Glacier, glacier-wide melt rates are not maximized in the zone of maximum thinning.
- Declining ice discharge through time explains the rapid thinning under debris cover.

Kennicott Glacier, Alaska

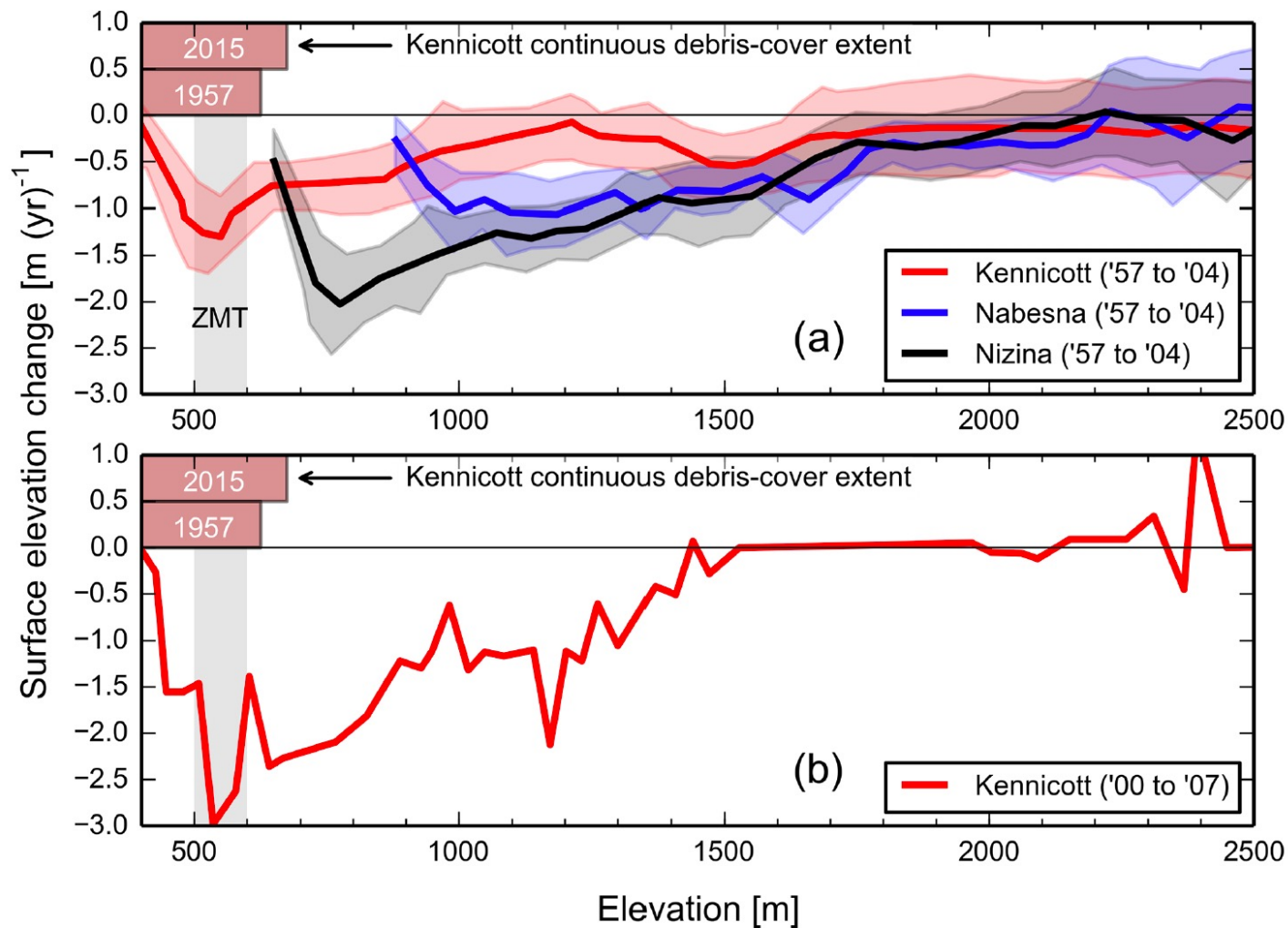
Study area
outlined in (b)
is as large as
the entirety of
Khumbu
Glacier

ZMT is the Zone
of Maximum
Thinning (across
the entire
glacier)

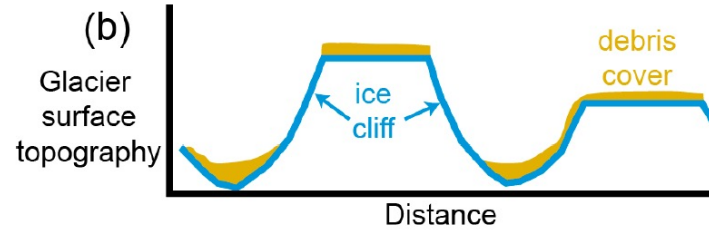
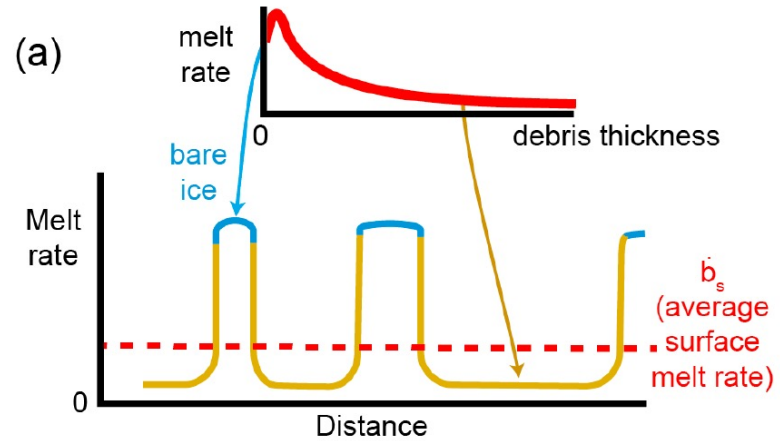


In panel (a) only
Kennicott Glacier
is debris covered.

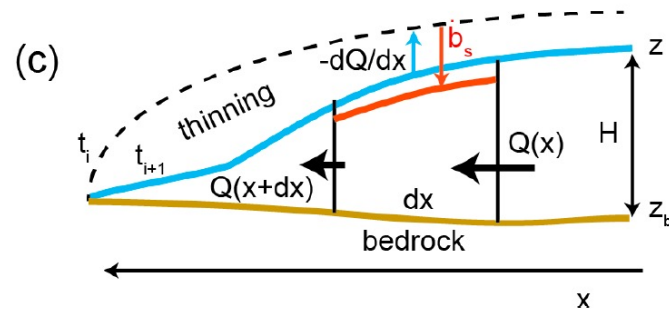
Data from
Das et al. (2014)
J. Glaciology
<https://doi.org/10.3189/2014JoG13J119>, 2014.



Schematic showing the role of ice cliffs in setting area-averaged melt rates.



Where ice is moving both melt and ice dynamics play a role in setting the thinning pattern.



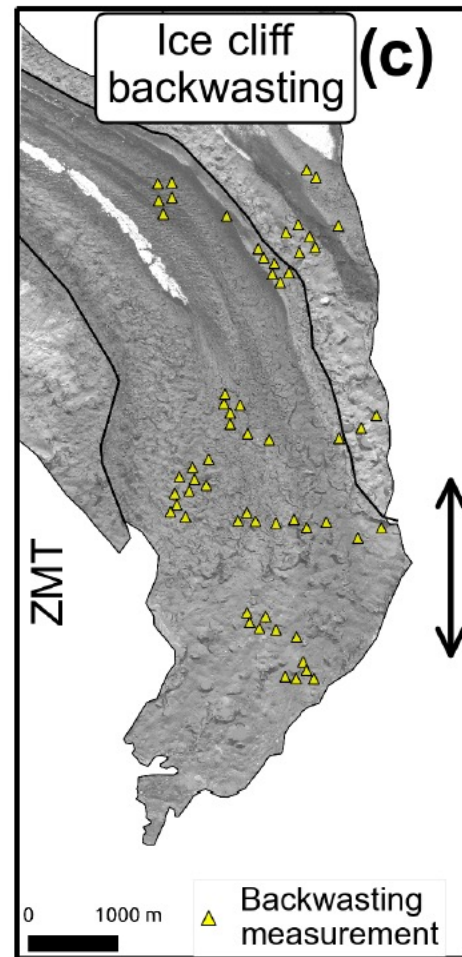
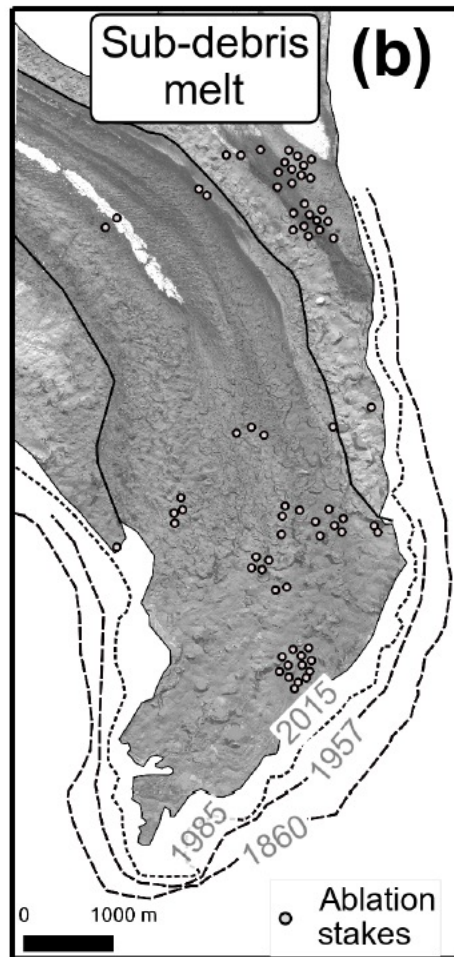
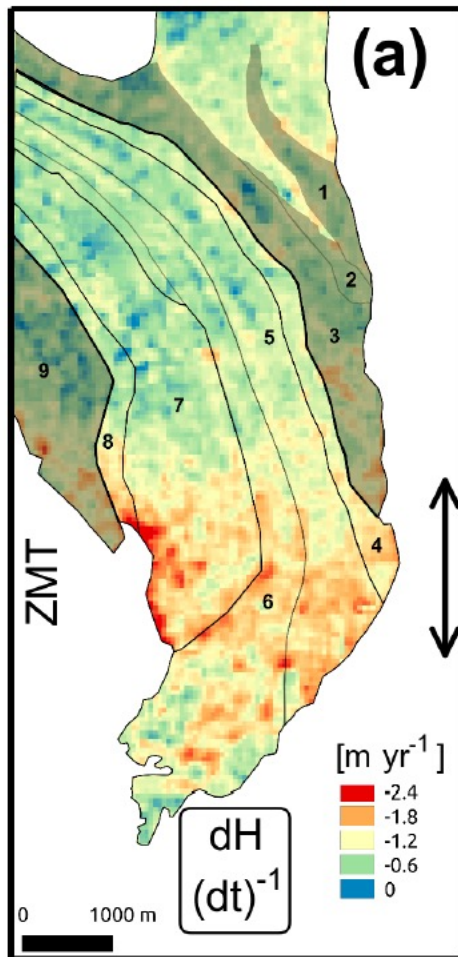
9 medial moraines on the glacier surface

Measurements from summer 2011:

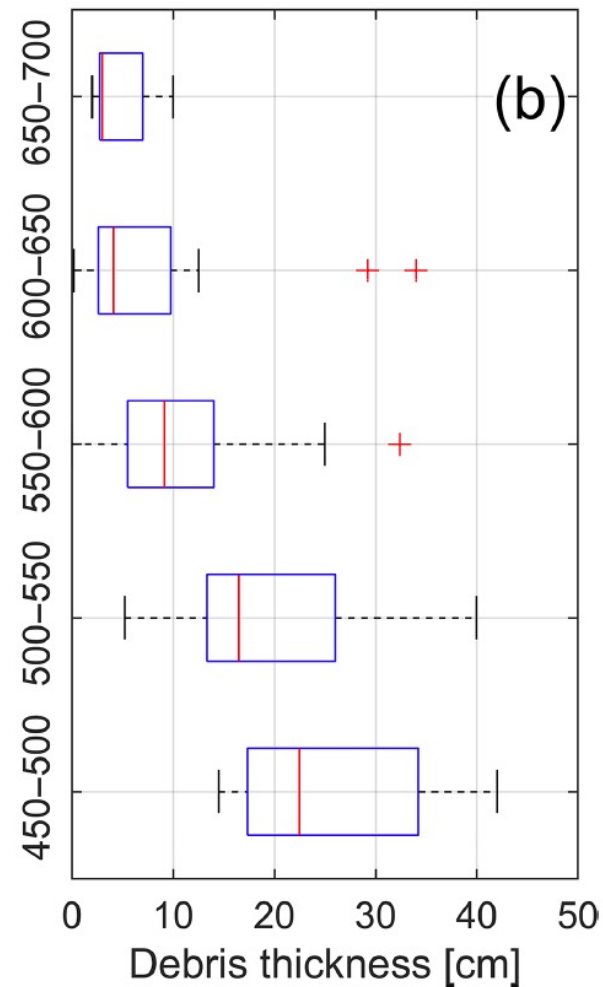
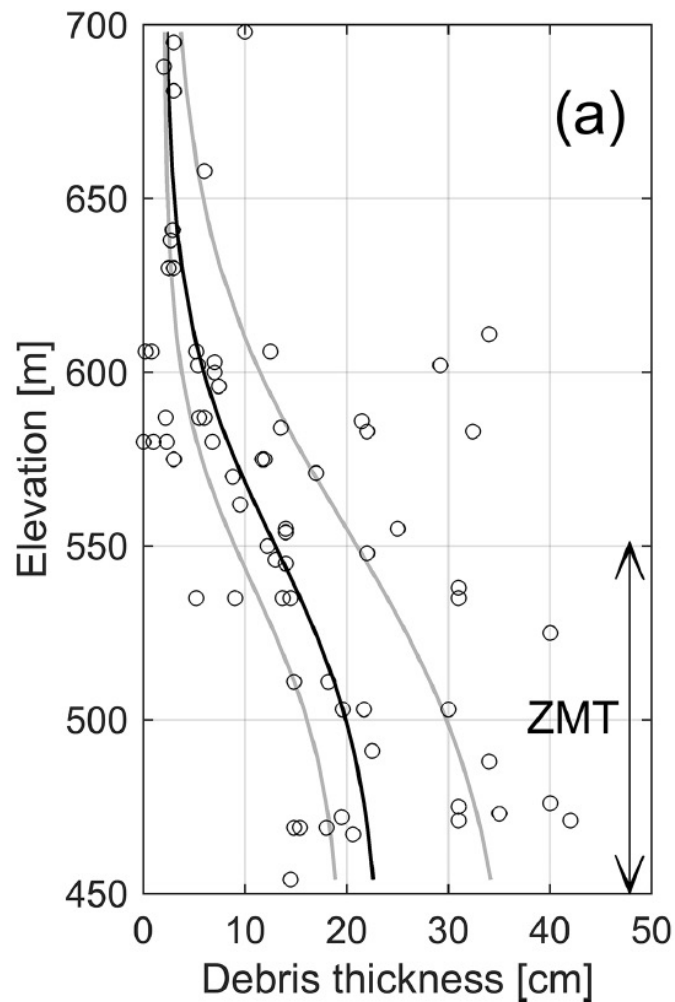
109 debris thickness

74 sub-debris melt

60 ice cliff backwasting

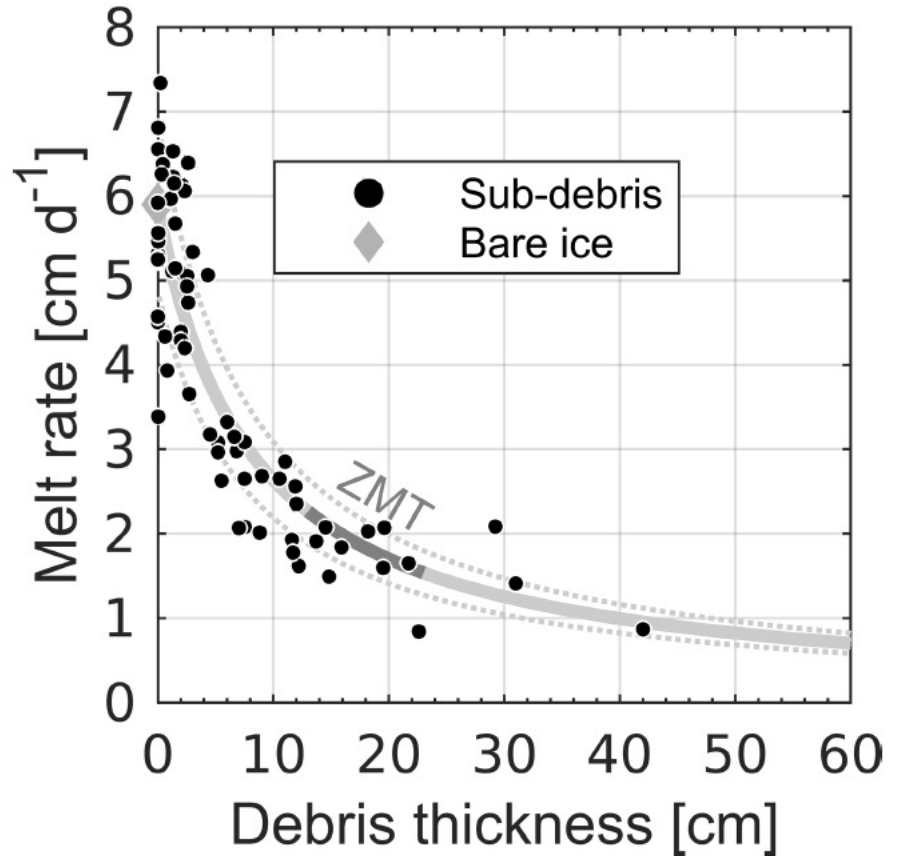


Debris thickness with elevation

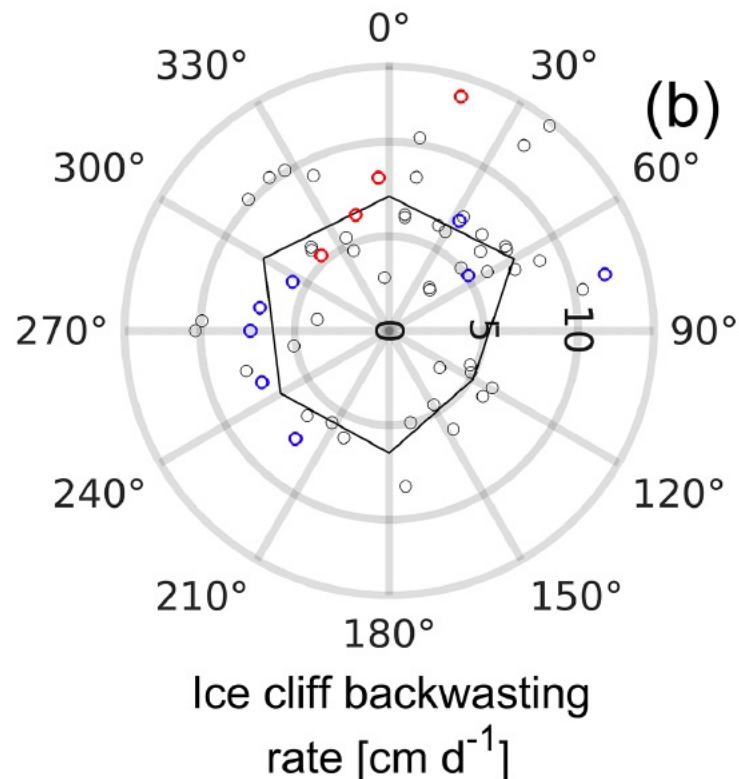
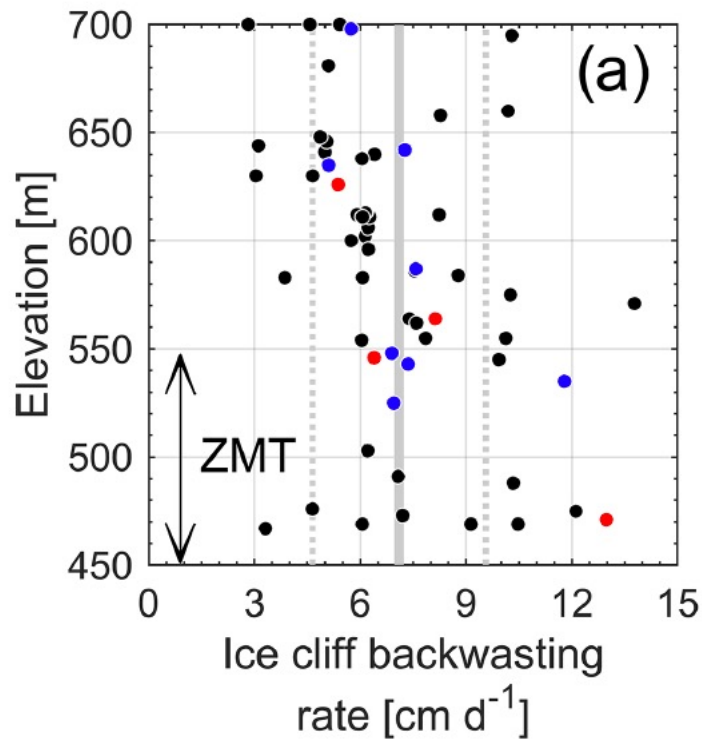


Debris thickness—
melt relationship
for Kennicott Glacier

ZMT is the
Zone of
Maximum
Thinning
(across the
entire glacier)

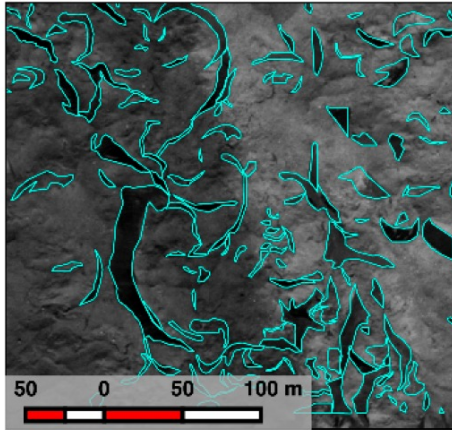


Ice cliff
backwasting
as it varies
with elevation
and aspect.

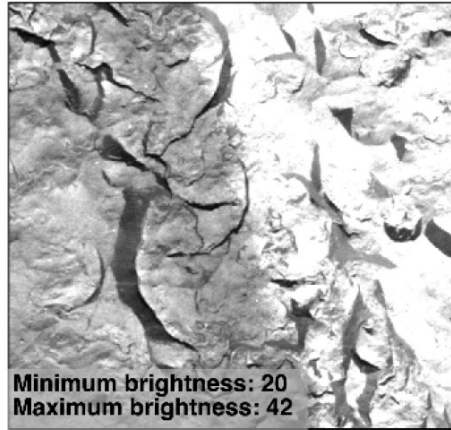


A new highly effective method for delineating ice cliffs from high resolution satellite imagery, with a 79% of ice cliff pixels detected.

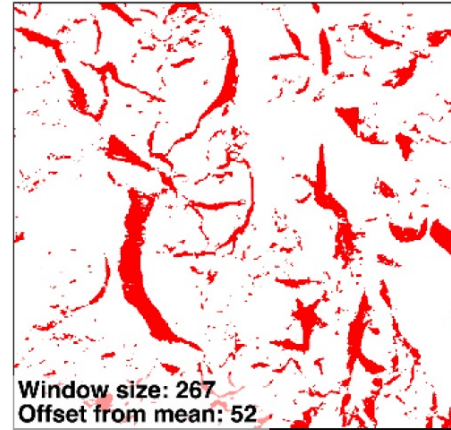
(a) Original orthoimage



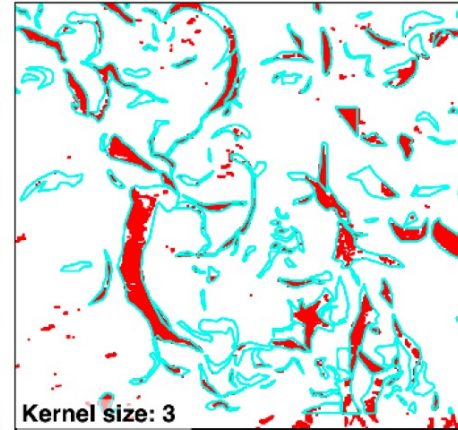
(b) Stretched orthoimage



(c) Adaptive binary threshold

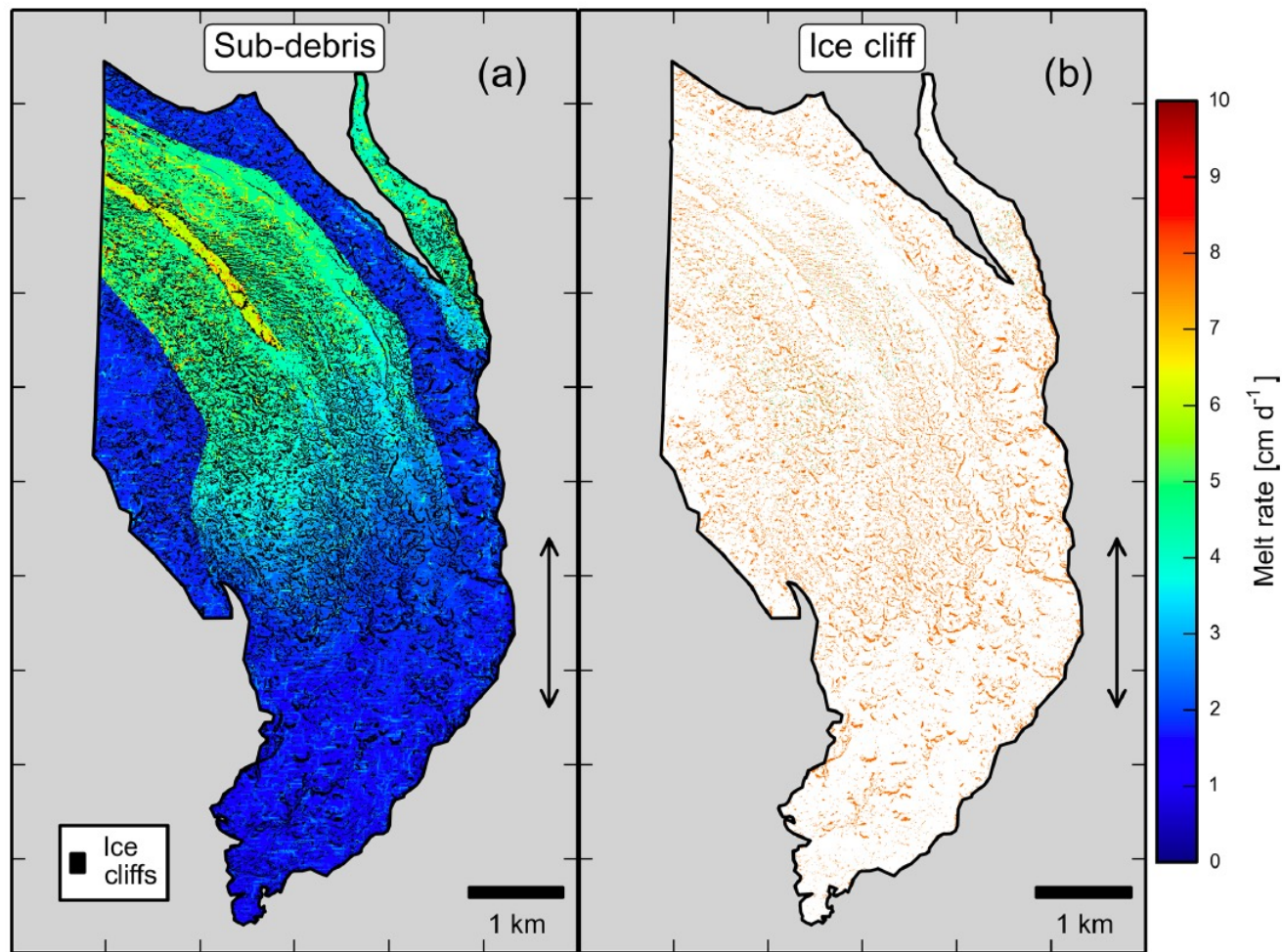


(d) Morphologic opening on c

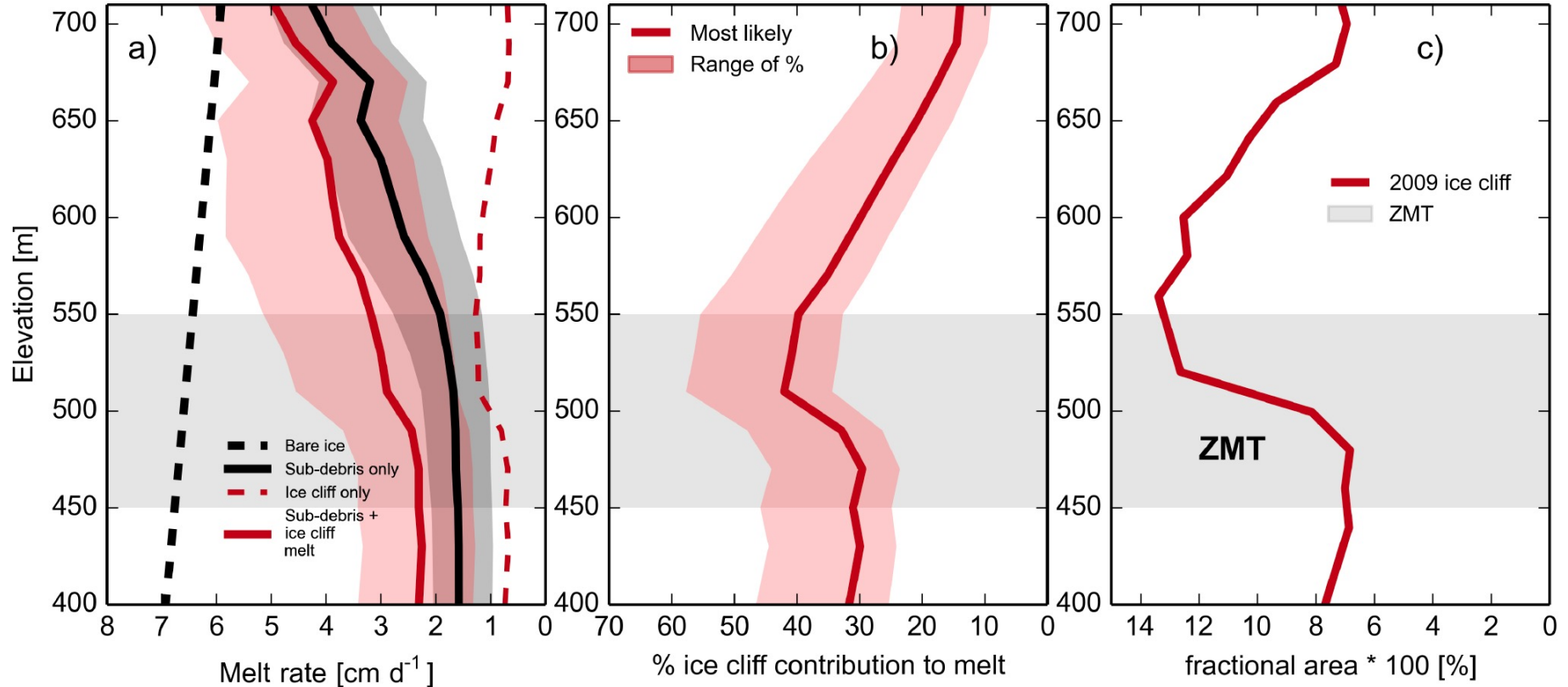


Using the Adaptive binary threshold method.

Distributed melt rates estimates based on the melt elevation relationships and medial moraines shown above.



(a) Melt with elevation for summer 2011. The red envelopes cover 98.4% of possible melt scenarios. Ice cliffs do not compensate for the melt reducing effects of debris in area-averaged melt rates



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