Geomorphic Signatures of Catastrophic Glacier Detachments

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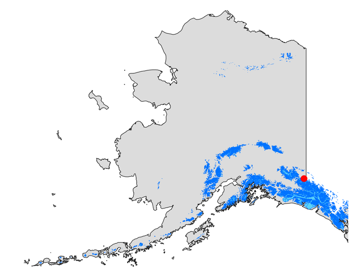
Motivation



- In two large detachments in 2013 and 2015, Flat Creek Glacier in Alaska's St.Elias Mountains lost roughly 50% of its area. Ice and debris reached the White River, 12 km downstream.
- Recent observations from Russia[1], Tibet[2], Argentina[3] and China[4] suggest that large-scale glacier detachments are becoming more frequent.
- To assess the frequency of such events over longer time periods, we need to understand the signs they leave in the landscape.
- We investigate the deposits left at Flat Creek to assess whether such deposits can be distinguished from other glacio-fluvial deposits.

Methods

- To characterize deposits at the landscape level we use image analysis and DEM differencing.
- We fingerprint the deposits' internal structure with electrical resistivity tomography (ERT), and analyze how their grain size distributions and orientations differ from other glacio-fluvial deposits in the area.

Preliminary results

- Relative to the surrounding landscape, event deposits are characterized by a higher content of fines < 1 mm.
- The samples lack the expected sorting that leads to a higher content of fines with increasing distance from the source.
- The abundance of grains oriented vertically relative to the surface of the deposit indicates a rapid and chaotic emplacement of the debris.
- The remaining glacier has spread out rapidly, filling the trough left by the detachment, masking it almost completely.

Discussion

- Comparison of our results against other documented glacio-fluvial deposits will show how well large-scale glacier detachment deposits can be identified in the field.
- The quick response of Flat Creek Glacier shows that on the glacier, the detachment may quickly be masked. We will use DEMs and satellite images from Tibet and Russia to investigate the larger-scale landscape responses following detachments.

References:

[1] Haeberli et al., 2004. The Kolka-Karmadon rock-ice slide of 20 September 2002: An extraordinary event of historical dimensions in North Ossetia, Russian Caucasus. *J. Glaciology*; Evans et al., 2009. Catastrophic detachment and high-velocity long-runout flow of Kolka Glacier, Caucasus Mountains, Russia in 2002. *Geomorphology.*
[2] Kääb et al., 2018. Massive collapse of two glaciers in western Tibet in 2016 after a surge-like instability. *Nature Geoscience*; Gilbert et al., 2018. Mechanisms leading to the 2016 giant twin glacier collapses, Aru Range, Tibet. *Cryosphere.*
[3] Falaschi et al. 2019. Collapse of the 4 Mm^3 of ice from a cirque glacier in the Central Andes of Argentina. *Cryosphere.*
[4] Paul 2019. Repeat glacier collapses and surges in the Amney Machen Mountain range, Tibet, possibly triggered by a developing rock-slope instability. *Remote Sensing.*

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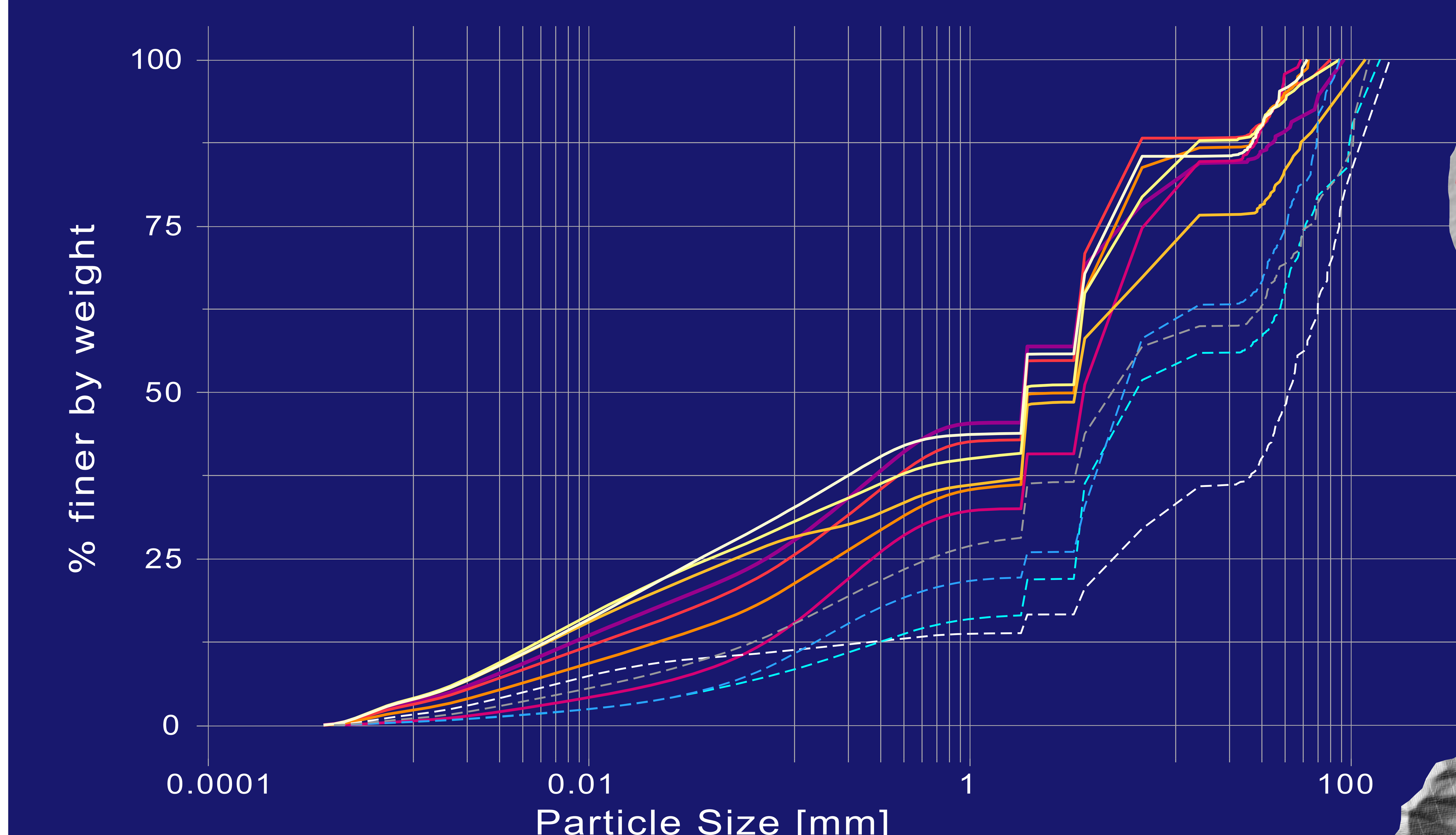
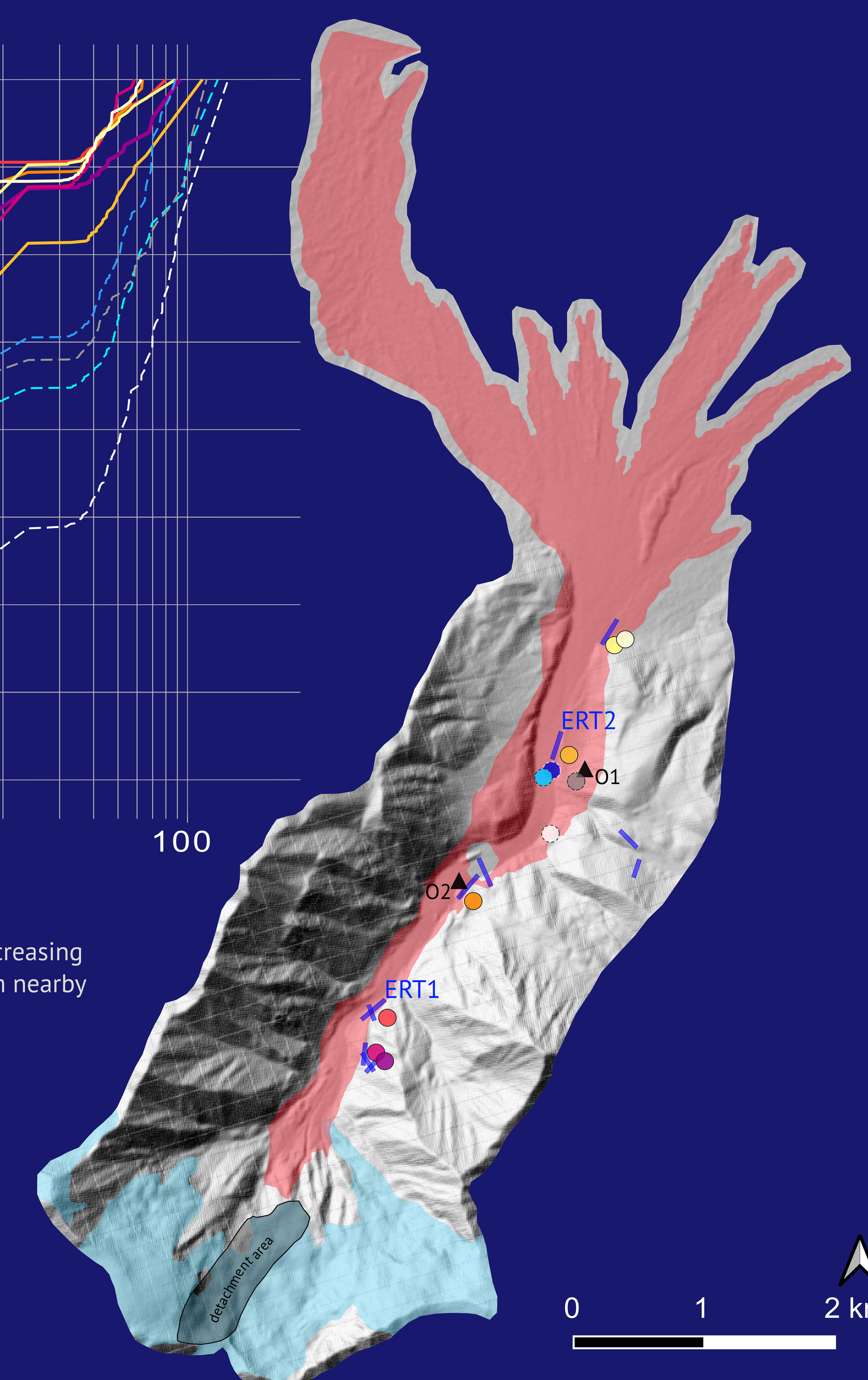
Deposits left by **large-scale glacier detachments** may be distinguishable from other glacio-fluvial deposits by the **lack of grain-size sorting** and **grain orientation**.



Red-yellow lines: Grain size distributions from event deposit, with dark - light progression indicating increasing distance from source; dashed blue lines: samples from river bed; dashed gray/white lines: samples from nearby hillslopes. Sampling positions are indicated in the map on the right.



Scan the QR codes to read more about the Flat Creek Glacier detachments.

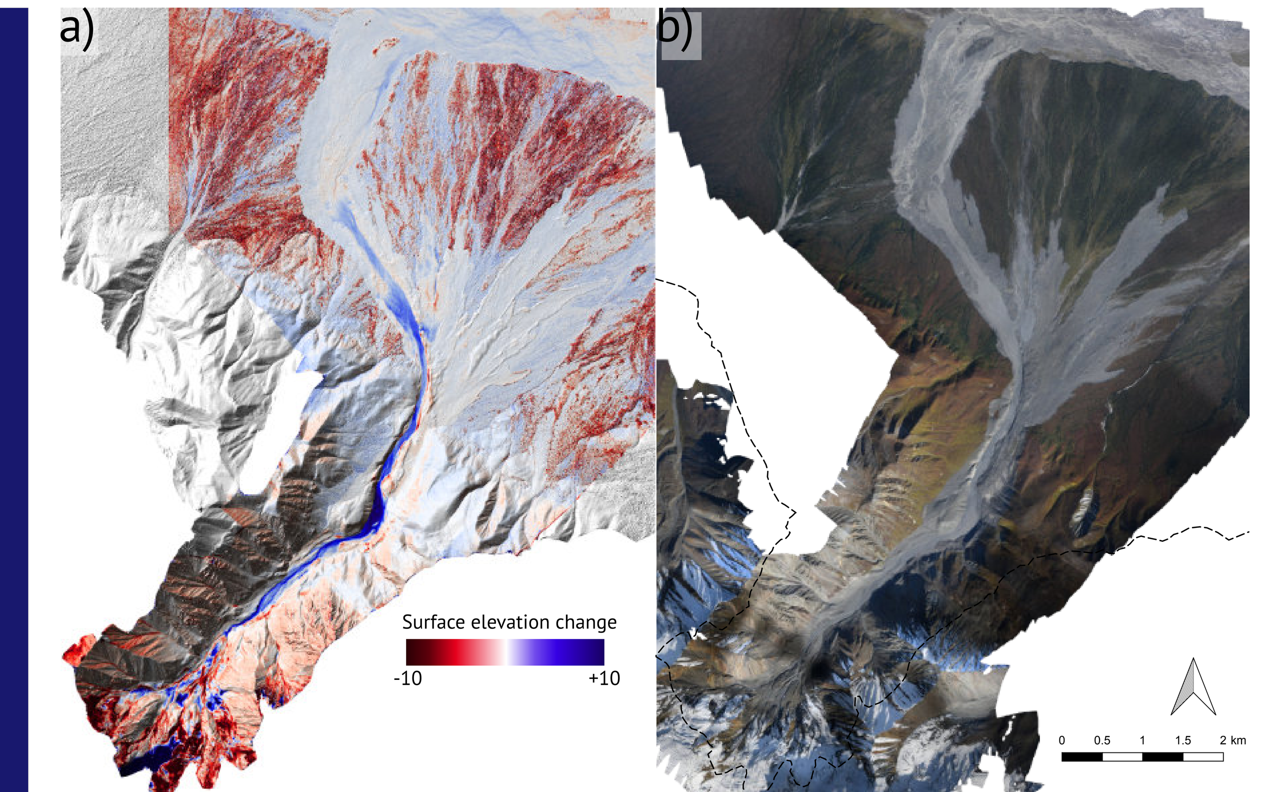


Figure 1: a) Difference of July 2016 and August 2019 DEMs generated using structure-from-motion. b) Orthophoto mosaic from August 30, 2019. The dashed line indicates coverage in image a).

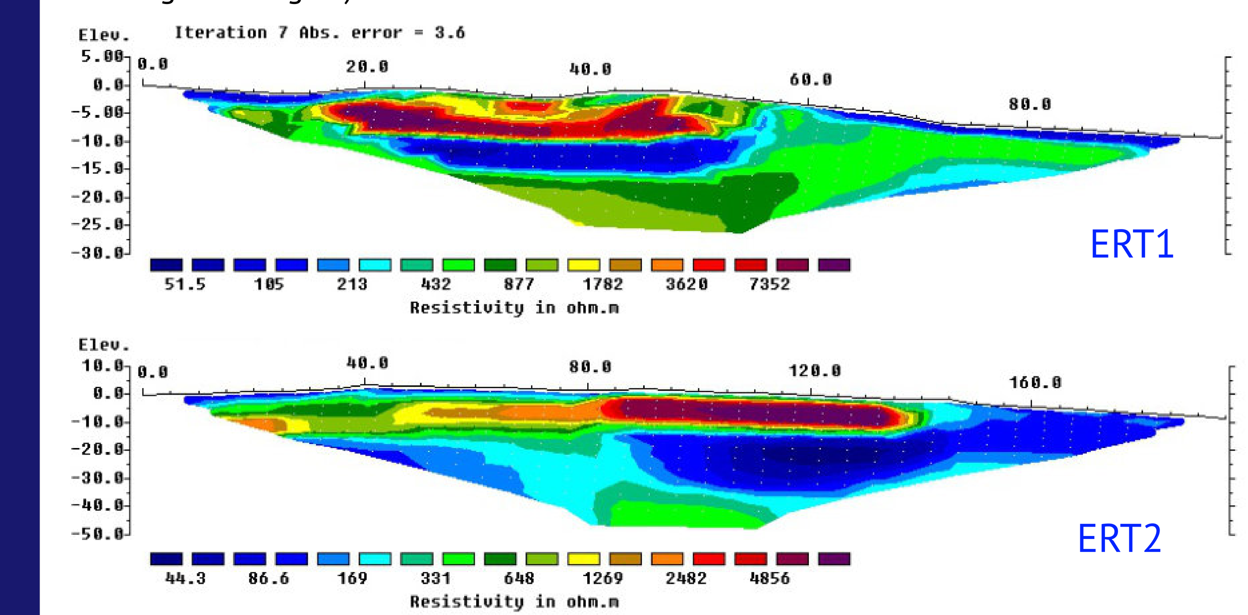


Figure 2: ERT lines across the Flat Creek deposits. Blue-green colors indicate high conductivity, red colors indicate high resistivity interpreted as remnant ice.

Figure 3: a) Proximal, ice free deposit; b) large melting ice bodies and associated slumping; c) ice-sediment conglomerate found further downstream; d) subsidence on deposits from local ice melt.

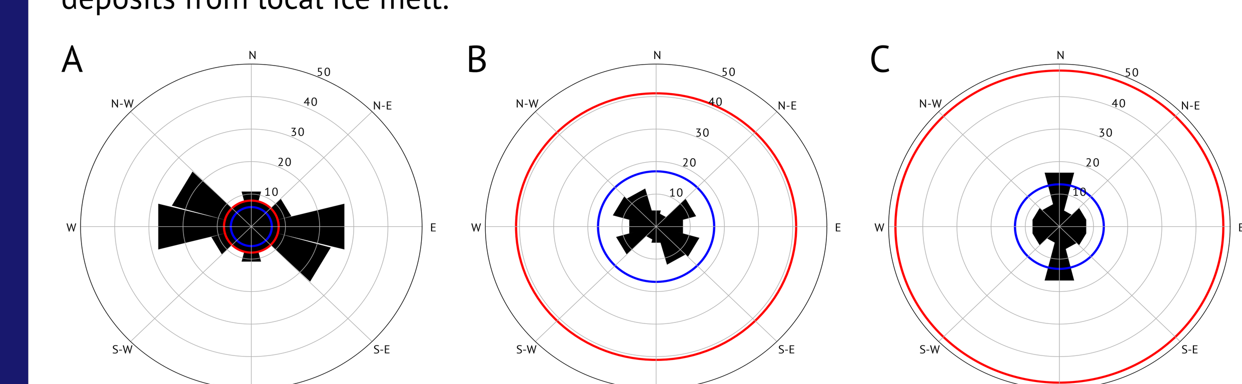


Figure 3: Grain orientations at sites O1 (sample A & B) and O2 (sample C). Sample A is from the original hillslope, samples B and C are from the event deposit. The red circles indicate the number of grains oriented near-vertical with respect to the deposit surface. The blue circle indicates the number of grains that lacked a longitudinal axis. At each site we measured the orientation of 100 clasts (excluding round ones).

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