Climate change impacts on high-mountain cryosphere

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Thanks to funding by:

Alexander von Humboldt Stiftung/Foundation

Tectonics Observatory
California Institute of Technology

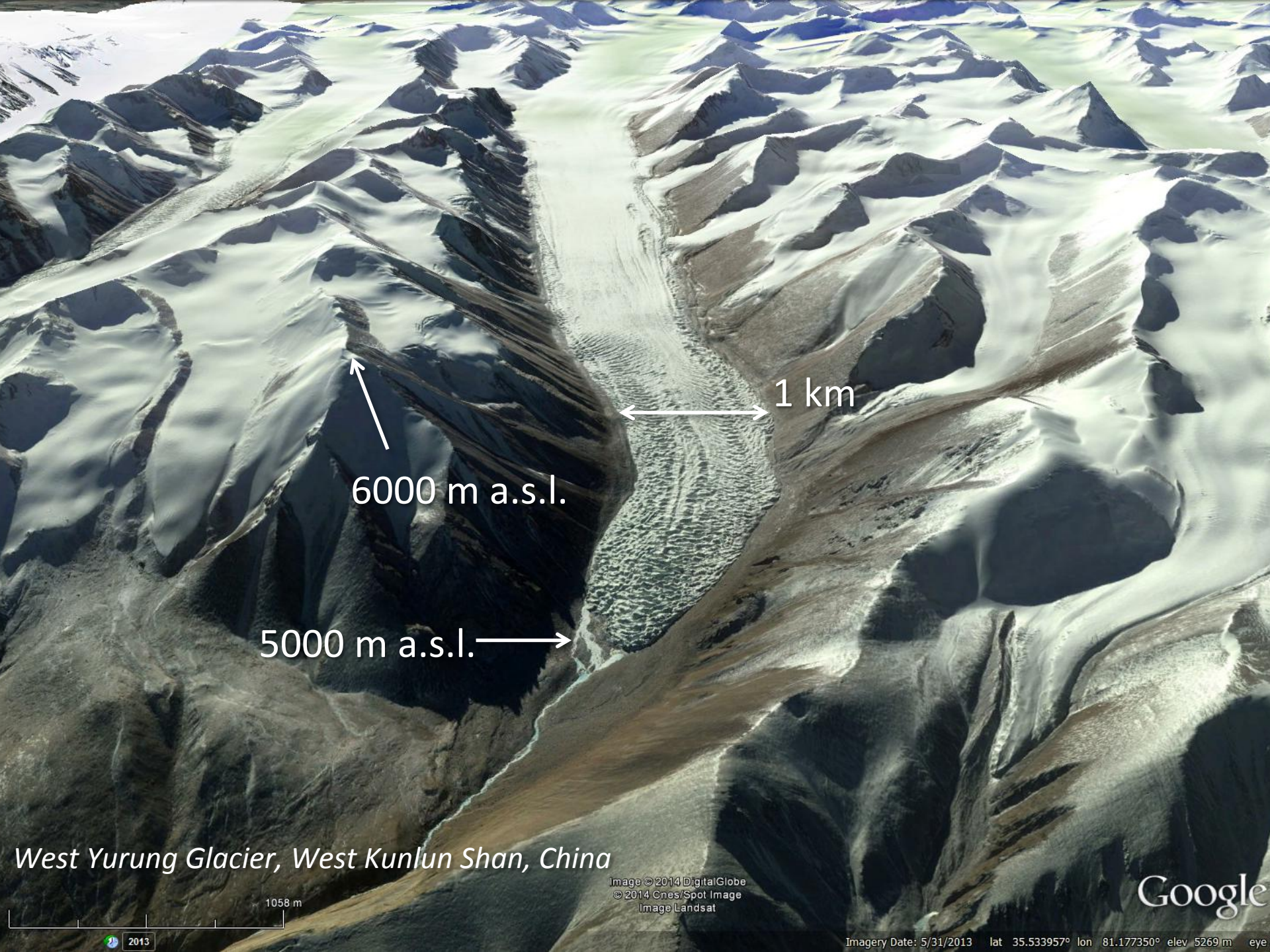
DFG Graduate School of Earth Sciences
Interactions between Tectonics, Climate and the Biosphere in the African-Asian Monsoonal Region
DFG GRK 1364 · Universität Potsdam · Germany

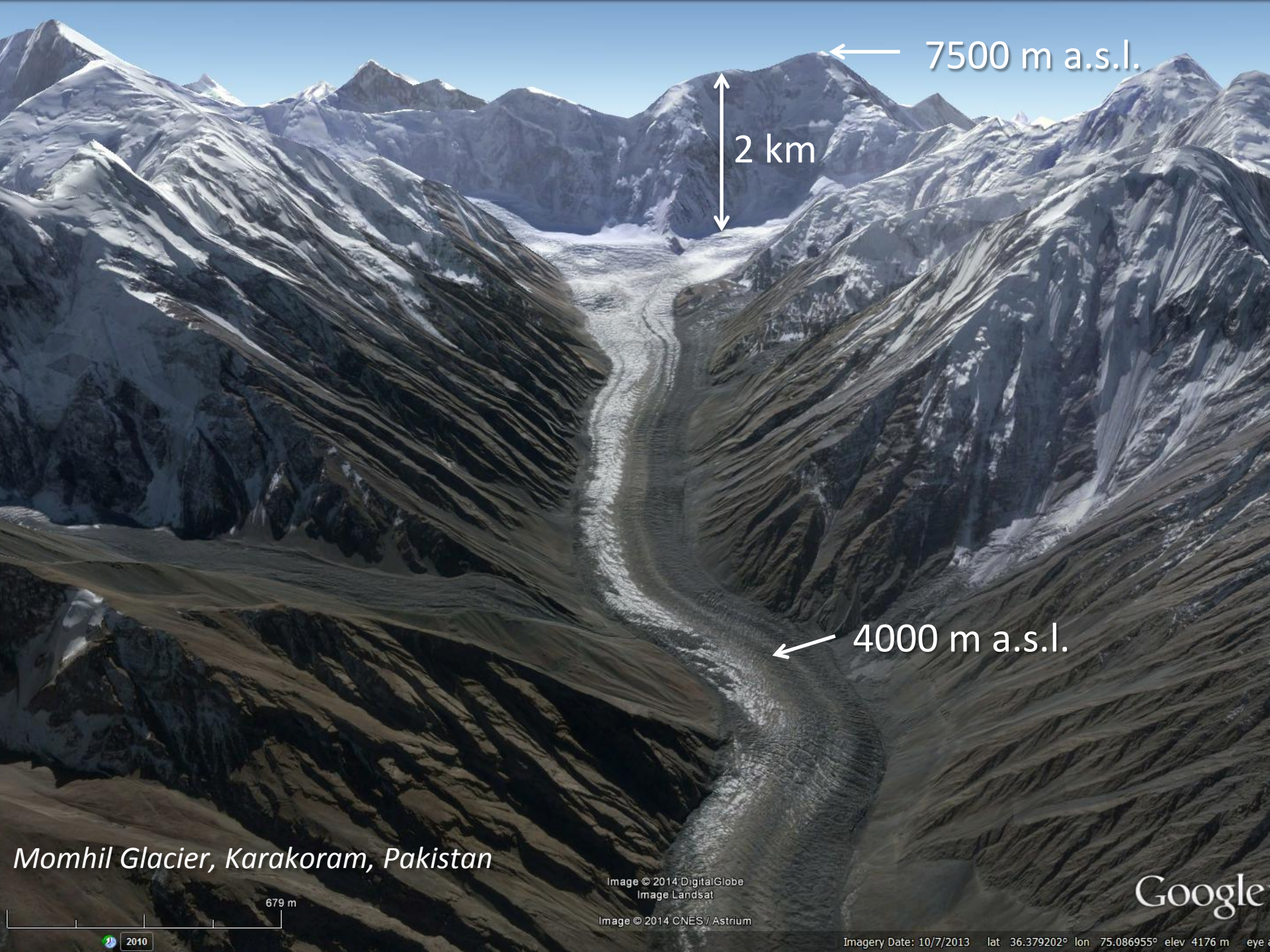
Bundesministerium für Bildung und Forschung

PROGRESS
Potsdam Research Cluster for Georisk Analysis, Environmental Change and Sustainability

Outline

- What comprises high-mountain cryosphere?
- Snow accumulation by avalanches
- Ice-melting beneath debris cover
- Stagnant and down-wasting glaciers
  - Moraine-dammed lakes and outburst floods
- Bedrock permafrost and rock falls


1 km
6000 m a.s.l.
5000 m a.s.l.
West Yurung Glacier, West Kunlun Shan, China
Image © 2014 DigitalGlobe
© 2014 Cnes/Spot Image
Image Landsat
Google
1058 m
2013
Imagery Date: 5/31/2013 lat 35.533957° lon 81.177350° elev 5269 m eye


7500 m a.s.l.
2 km
4000 m a.s.l.
Momhil Glacier, Karakoram, Pakistan
Image © 2014 DigitalGlobe
Image Landsat
Image © 2014 CNES / Astrium
679 m
2010
Google
Imagery Date: 10/7/2013 lat 36.379202° lon 75.086955° elev 4176 m


Snowline
Snow avalanches
Supraglacial debris cover
Momhil Glacier, Karakoram, Pakistan
Image © 2014 DigitalGlobe
Image Landsat
Image © 2014 CNES / Astrium
679 m
2010
Google
Imagery Date: 10/7/2013 lat 36.379202° lon 75.086955° elev 4176 m

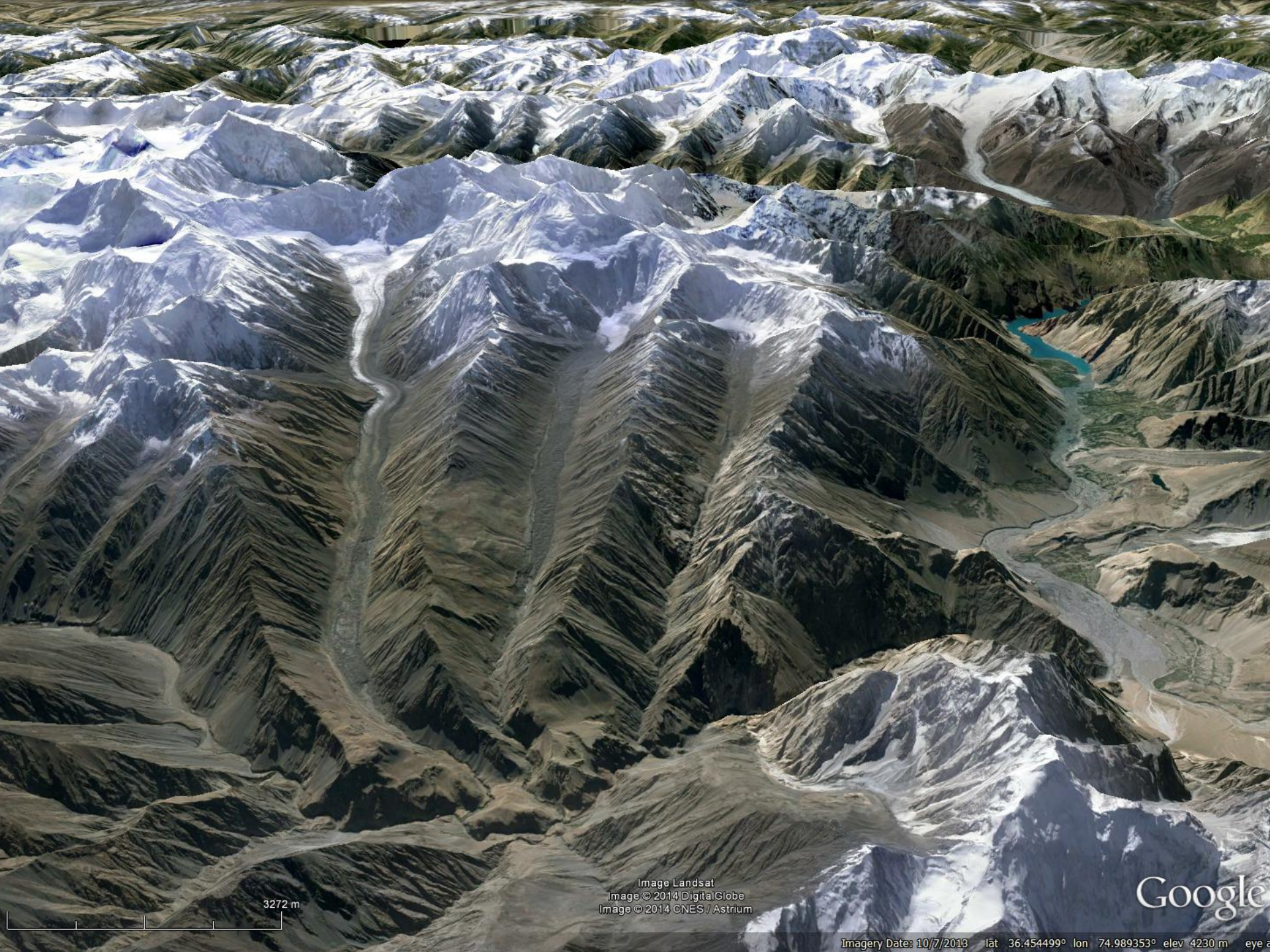
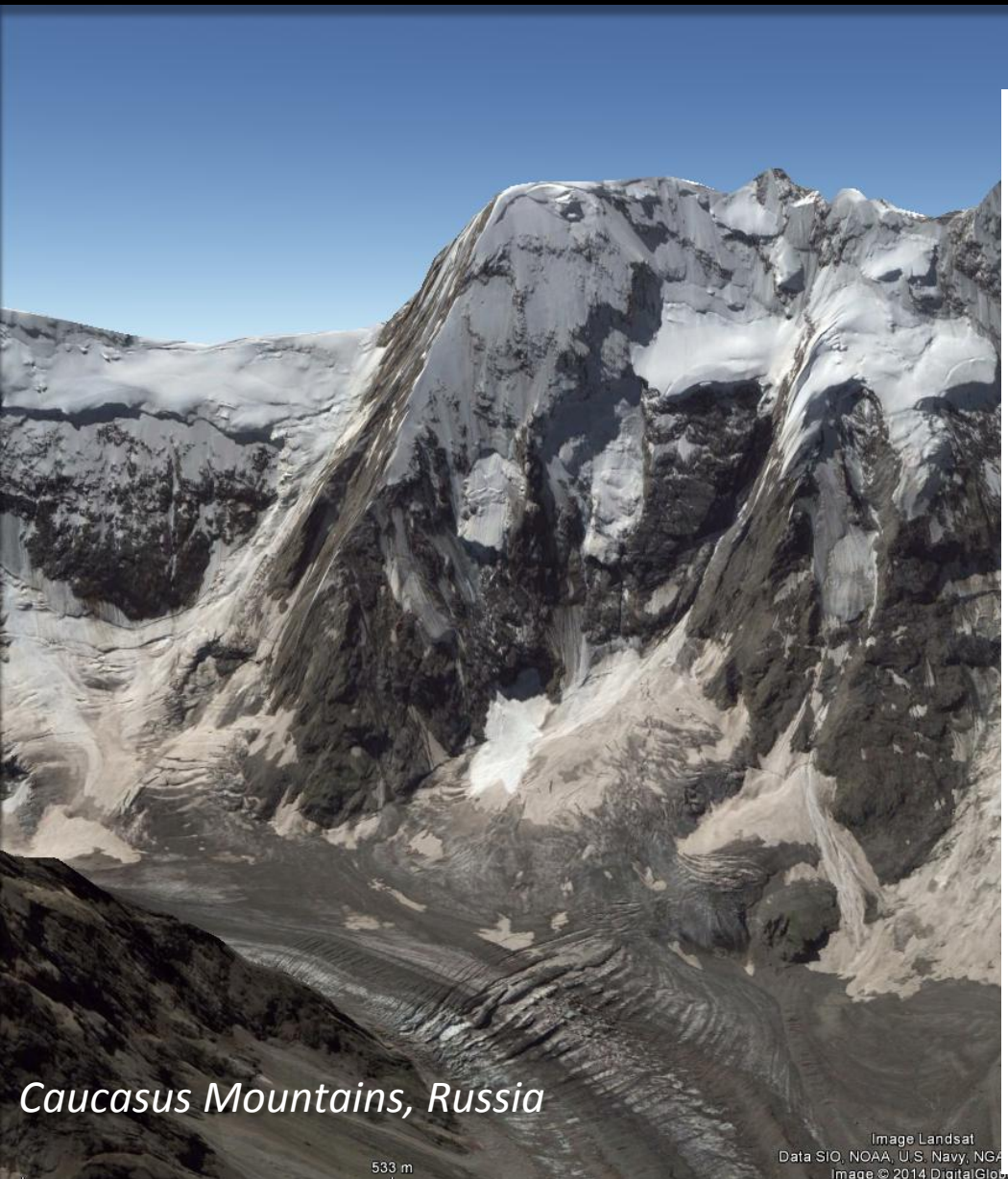
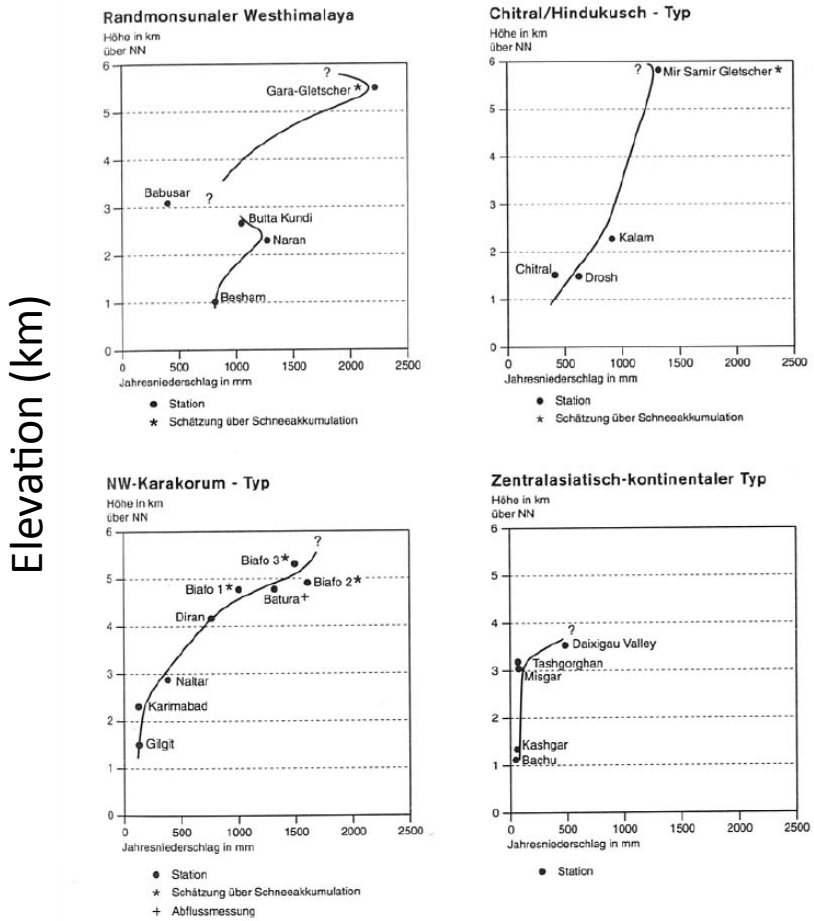


Image Landsat
Image © 2014 DigitalGlobe
Image © 2014 CNES / Astrium
3272 m
Google
Imagery Date: 10/7/2013 lat 36.454499° lon 74.989353° elev 4230 m eye a

Snow accumulation by avalanches



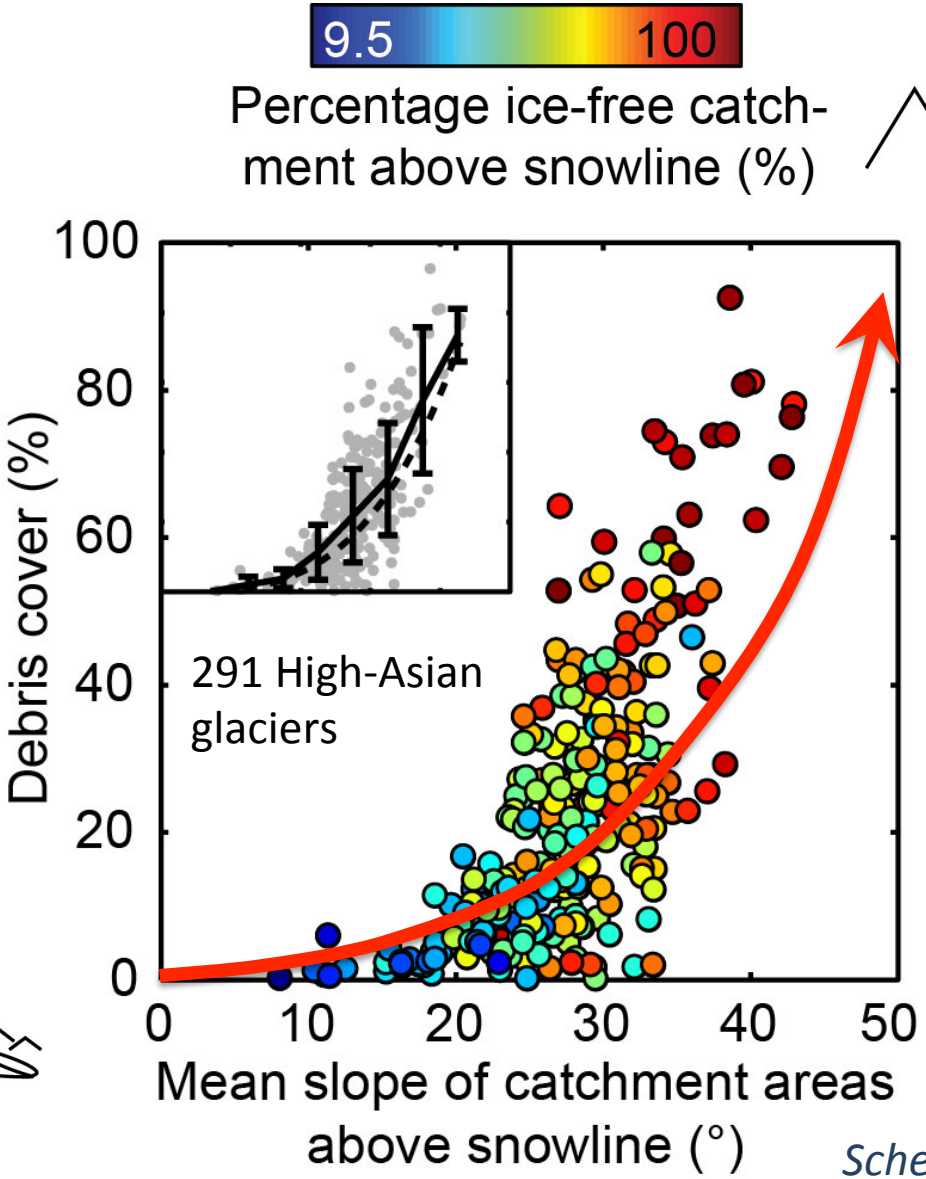


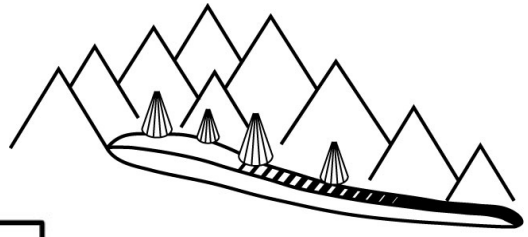
Weimers, 1995, showing data from various sources

Soot and dust

NW Himalaya, India

Hillslope source of debris cover

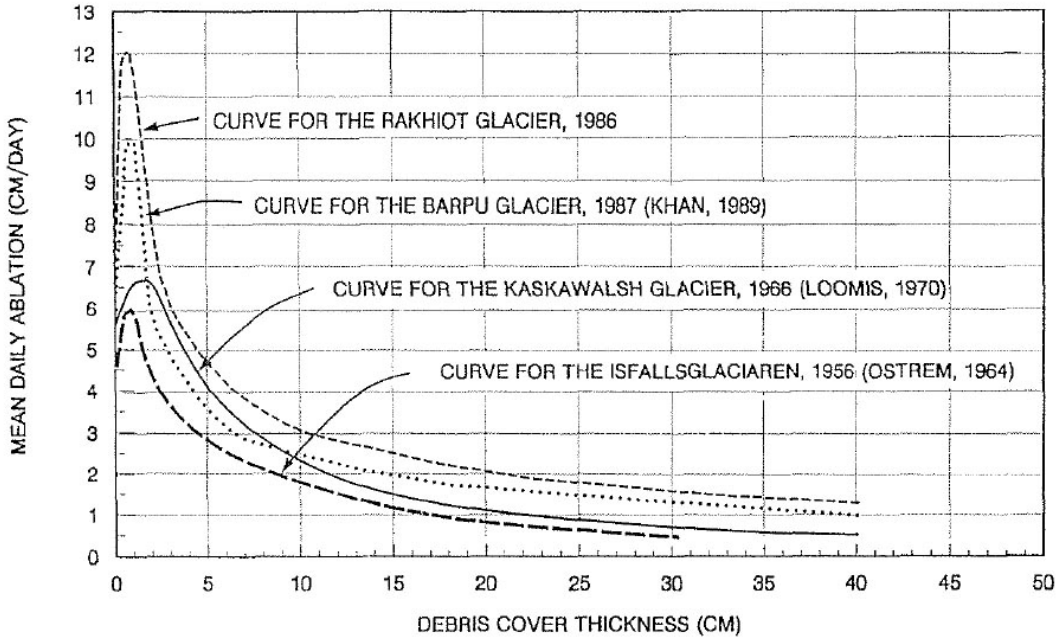




Increasing steepness and hillslope flux

Scherler et al., 2011, JGR

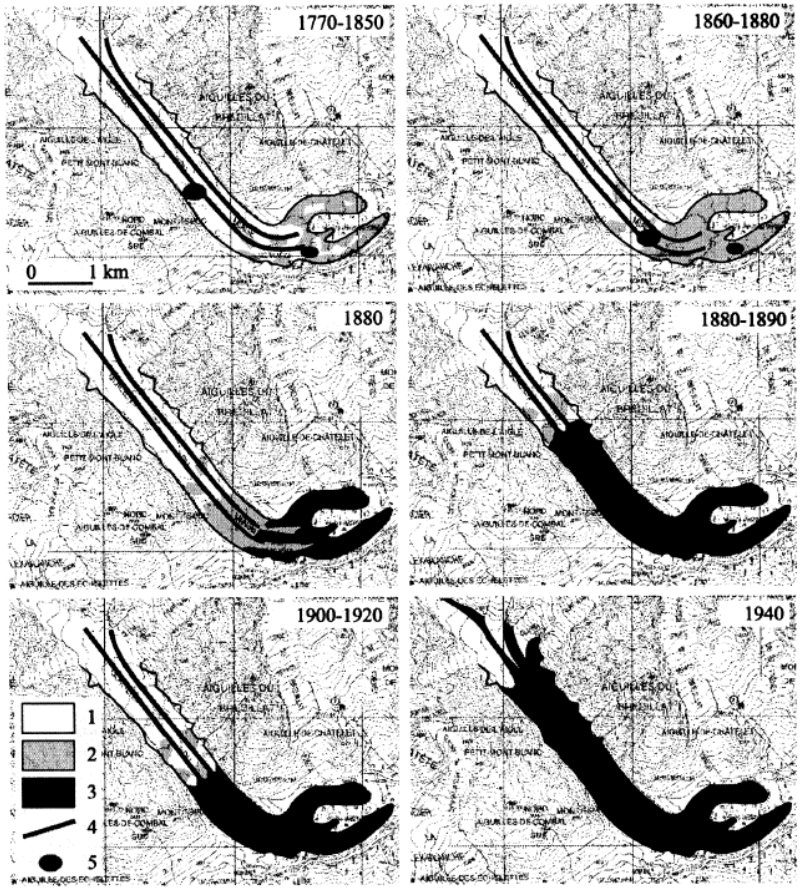
Ice-melting beneath debris cover



Mattson et al., 1993, IAHS

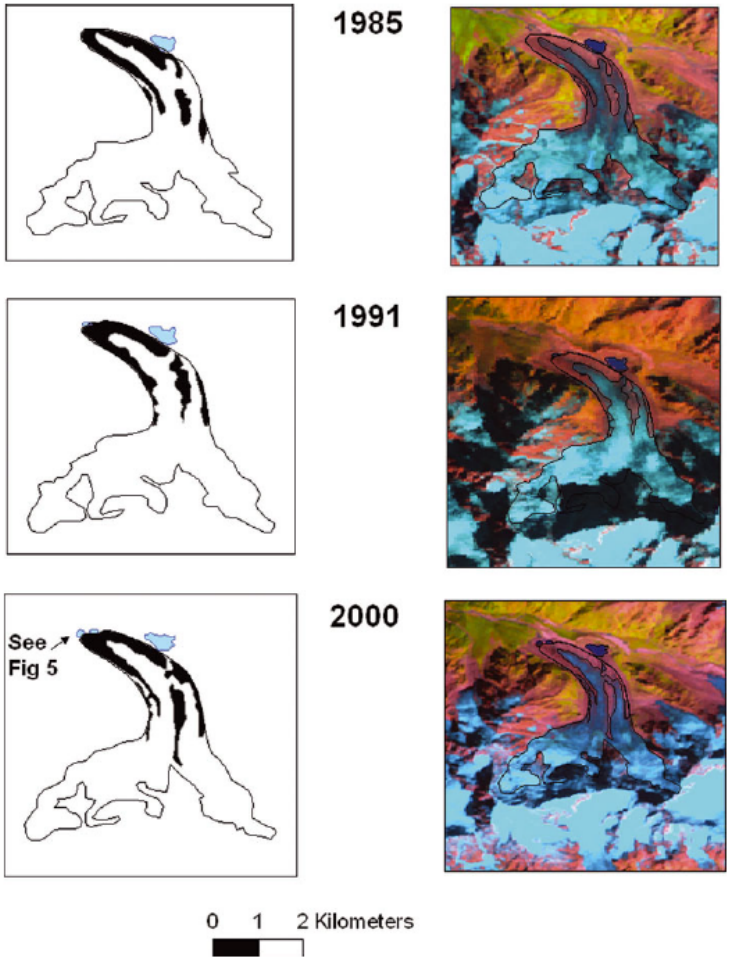
Evolution of debris covers

Miage Glacier, Italy



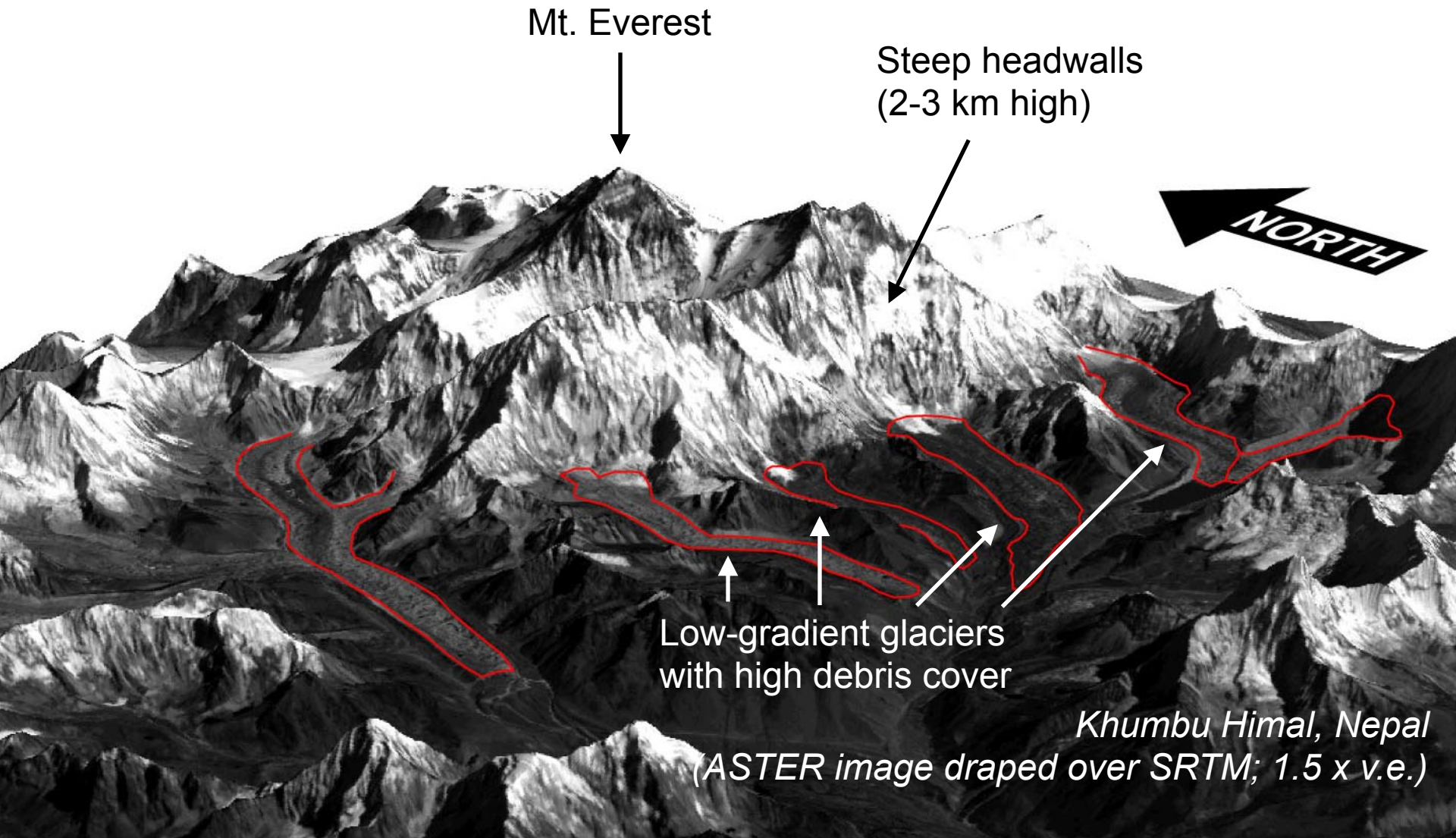
Deline, 2005, The Holocene

Bashkara Glacier, Caucasus

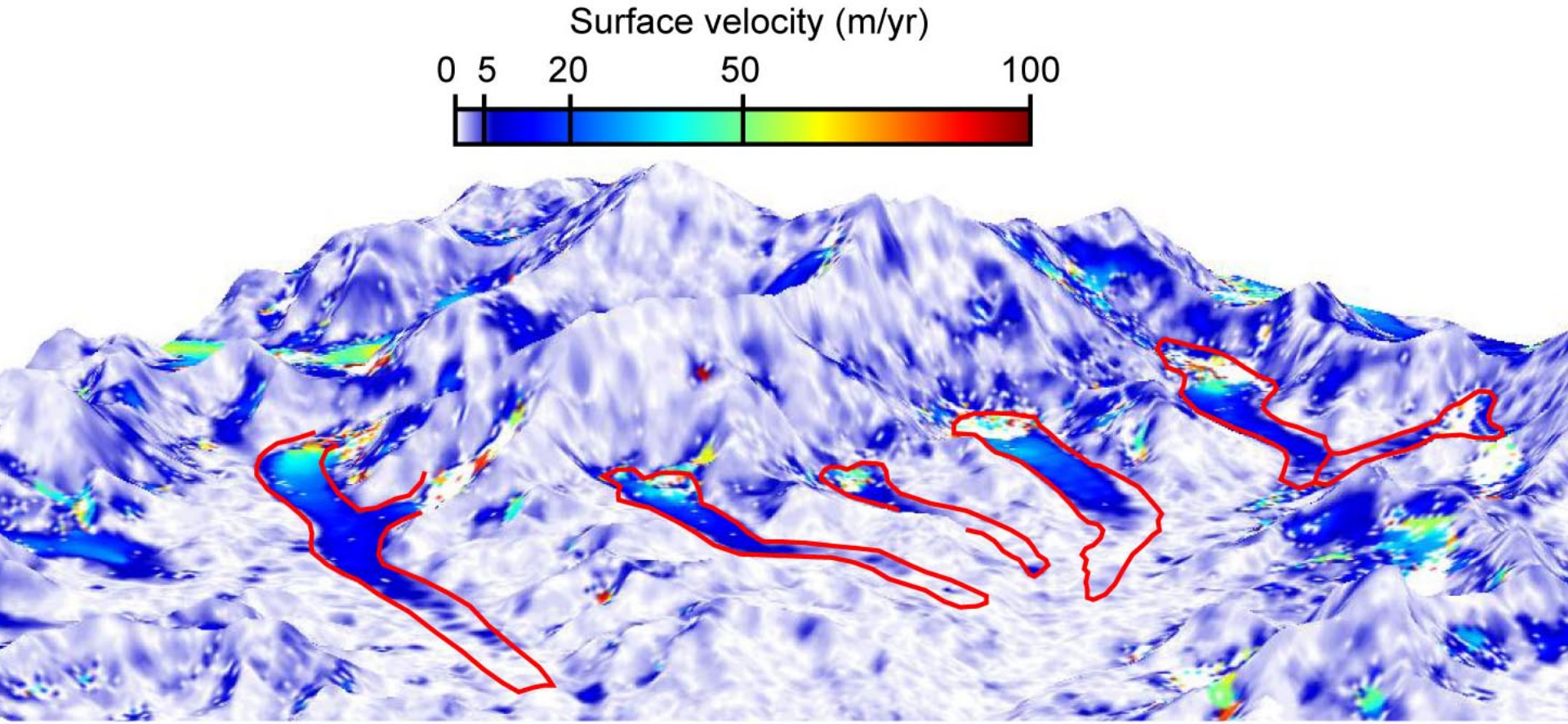


Stokes et al., 2007, Ann. Glaciol.

Stagnant glaciers in eastern Nepal

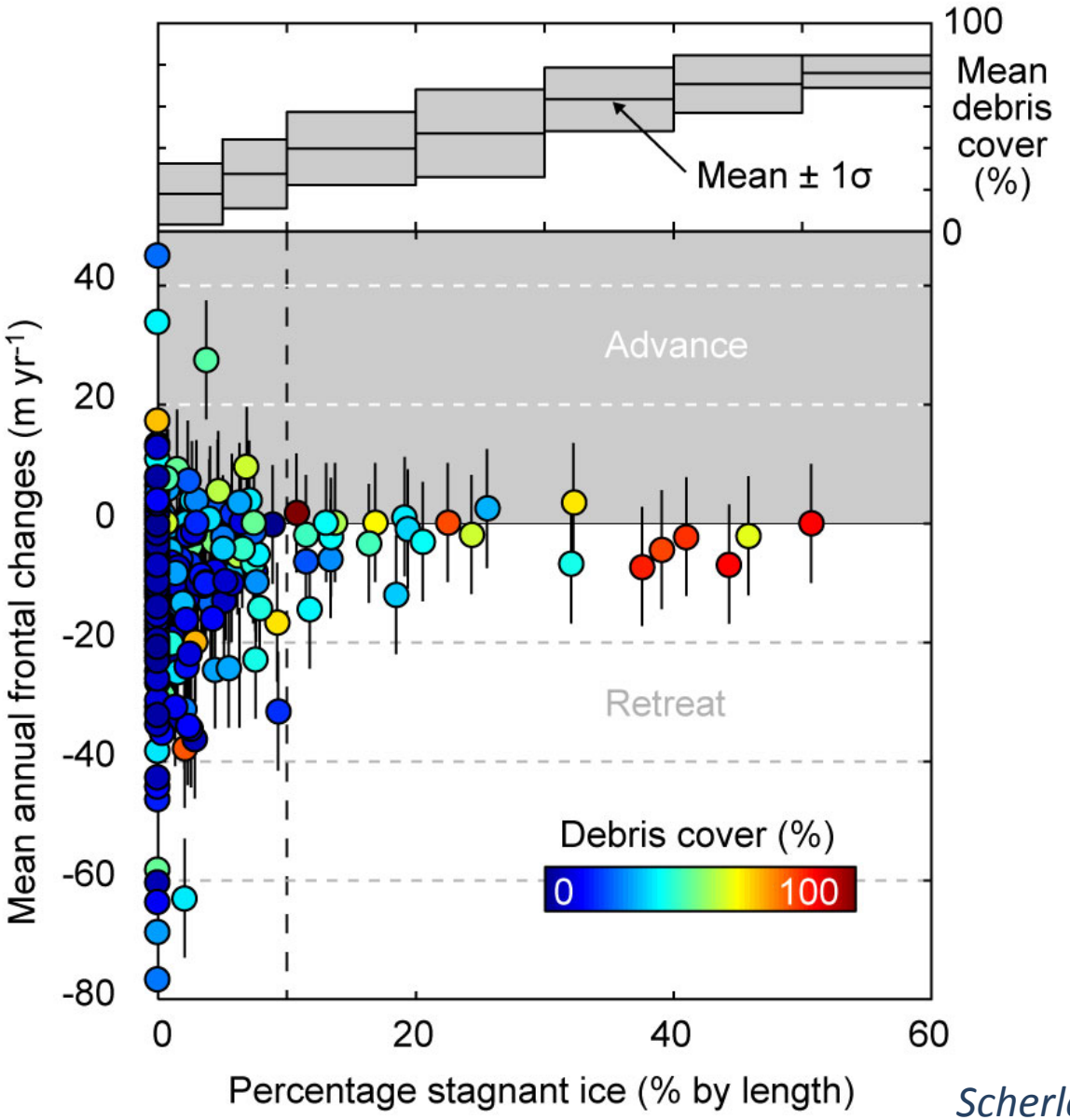


Stagnant glaciers in eastern Nepal



Khumbu Himal, Nepal
(surface velocity from ASTER image cross-correlation draped over SRTM; 1.5 x v.e.)

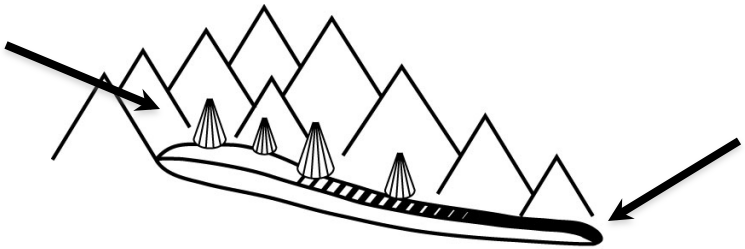
Stagnant glaciers and debris cover



Scherler et al., 2011, Nature Geoscience

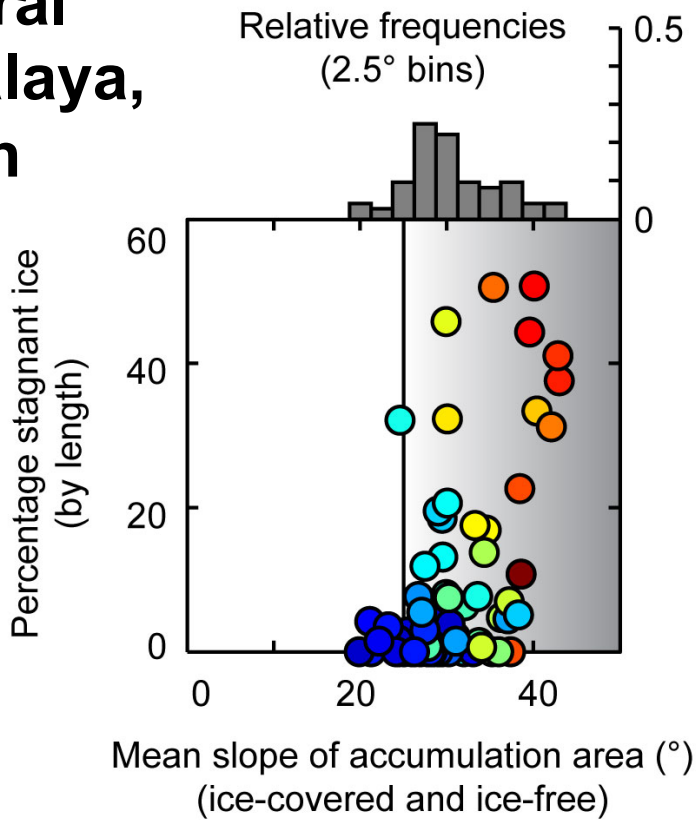
Conditions for stagnant glaciers

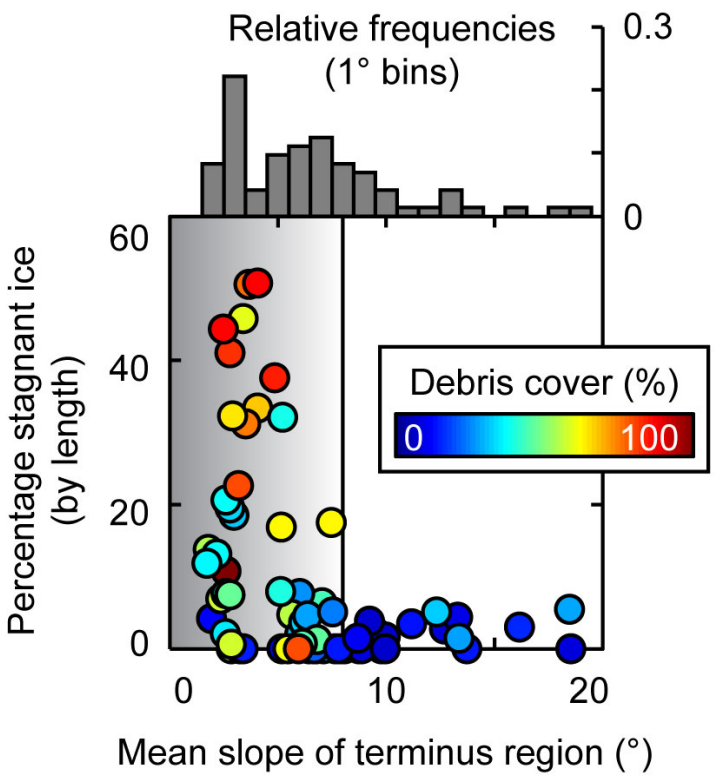
Steep accumulation areas



Gentle sloping terminus regions

Central Himalaya, south



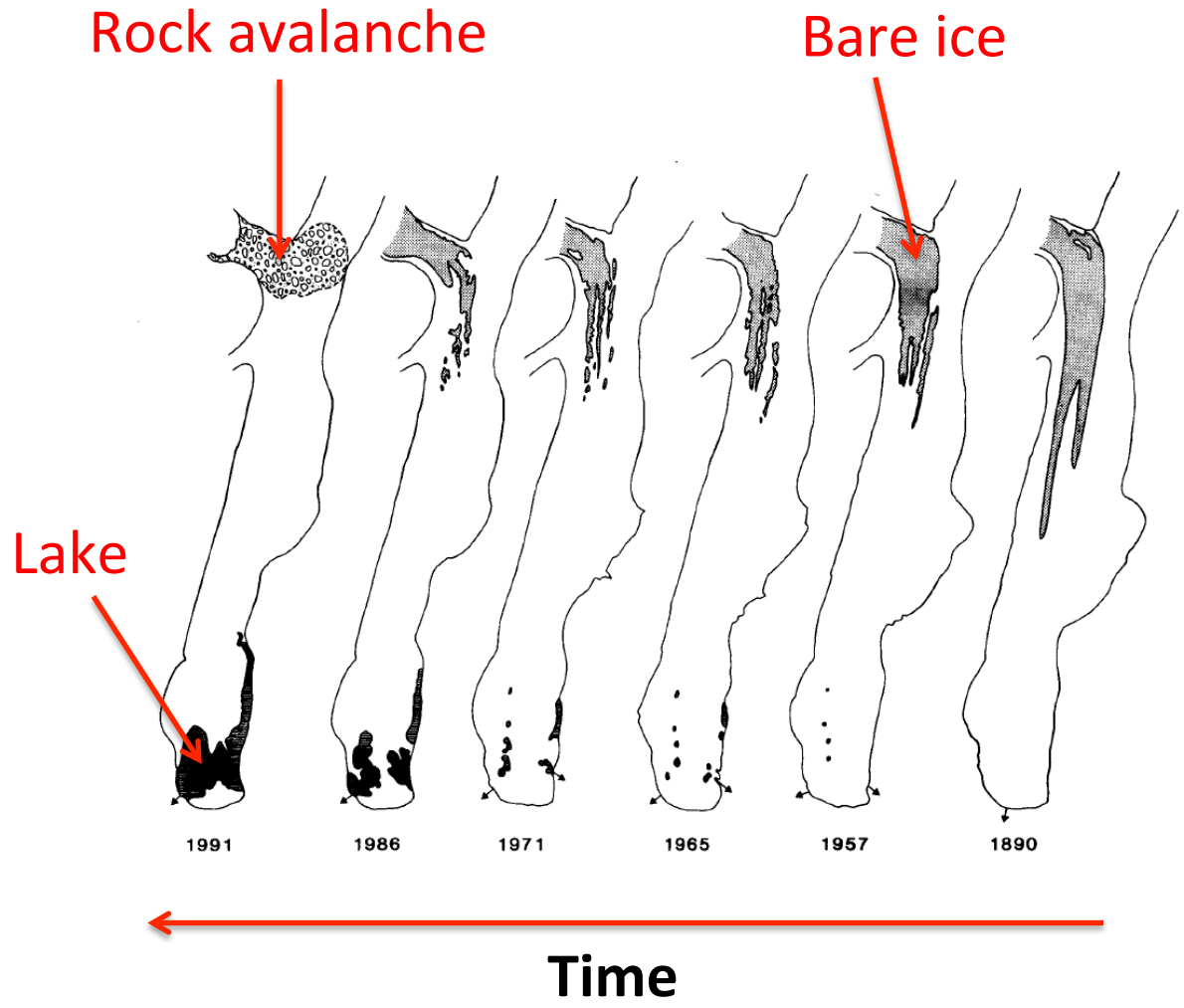


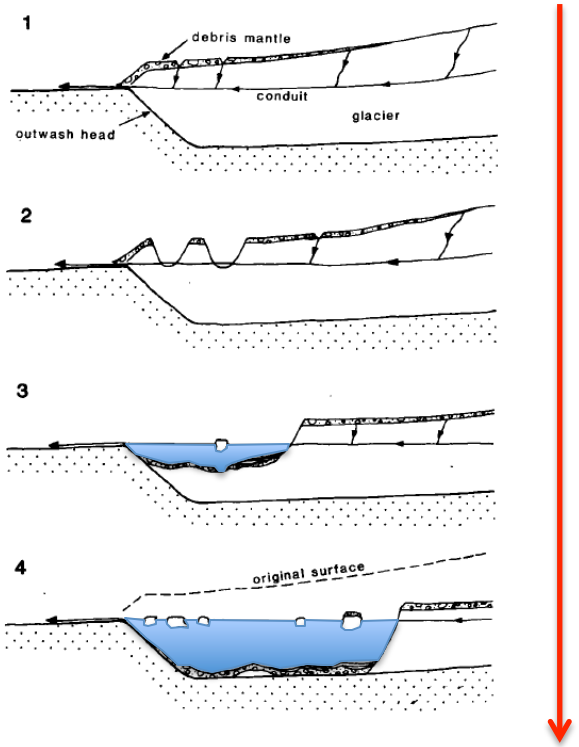
Scherler et al., 2011, Nature Geoscience

Downwasting of debris-covered glaciers

Jaundhar Glacier, Himalaya, India

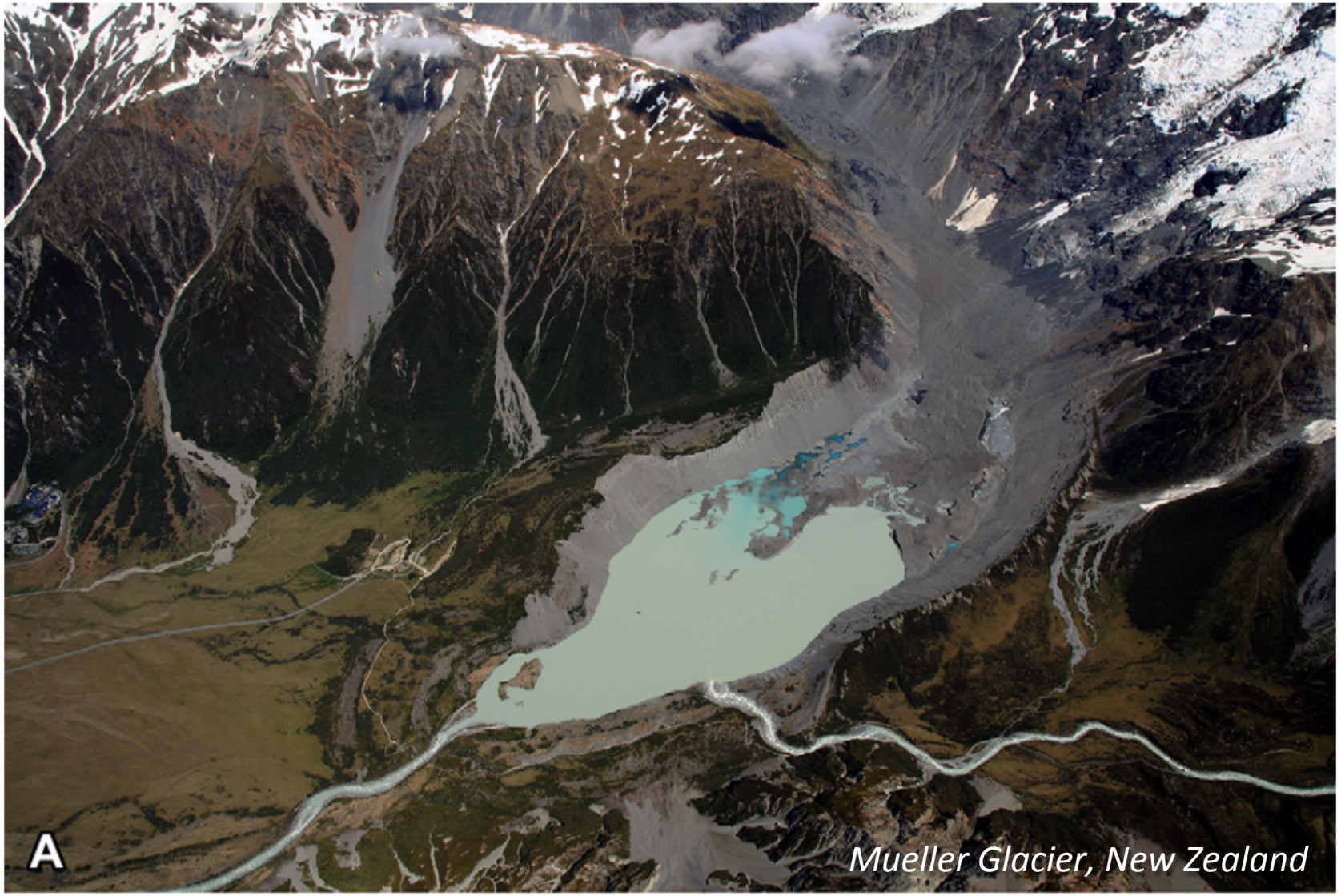
Downwasting of debris-covered glaciers





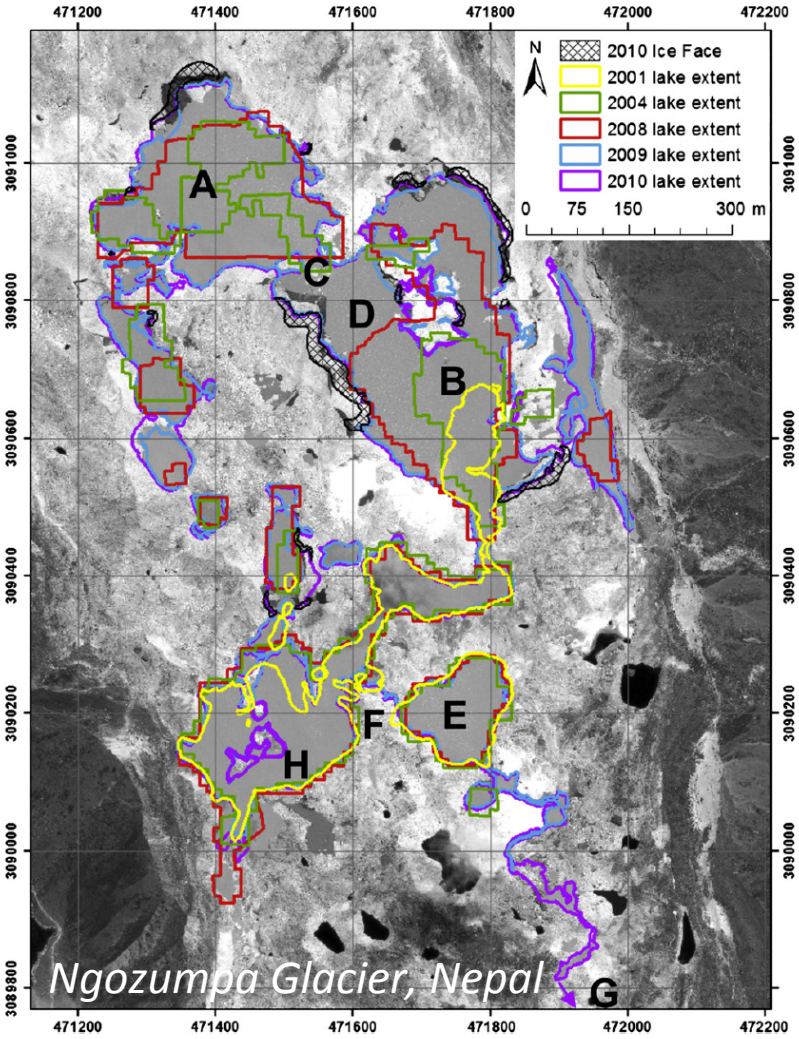
Kirkbride, 1993, The Holocene

Downwasting of debris-covered glaciers



Kirkbride and Winkler, 2012, QSR

Downwasting of debris-covered glaciers



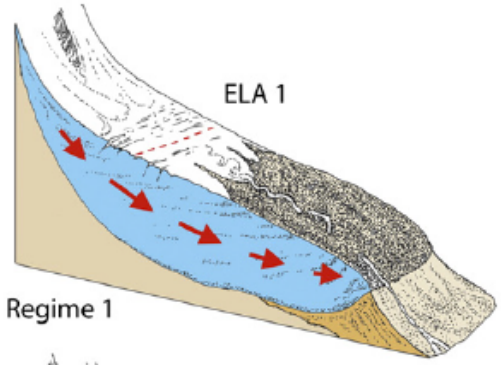
Thompson et al., 2012, Geomorphology

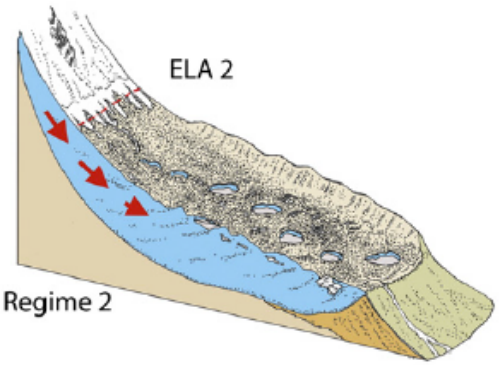

Bhutan
21.4 km
Image © 2014 DigitalGlobe
Image ©2014 CNES / Astrium
© 2014 Cnes/Spot Image
Image Landsat
Google
Imagery Date: 4/29/2014 lat 27.917601° lon 90.357823° elev 4723 m eye a

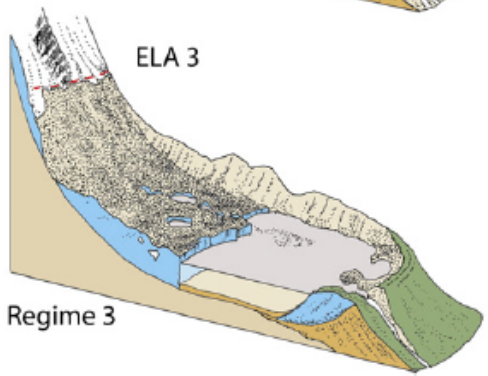

Nepal
Image © 2014 DigitalGlobe
564 m
2008
Google
Imagery Date: 12/18/2012 lat 27.824918° lon 86.951468° elev 5620 m eye

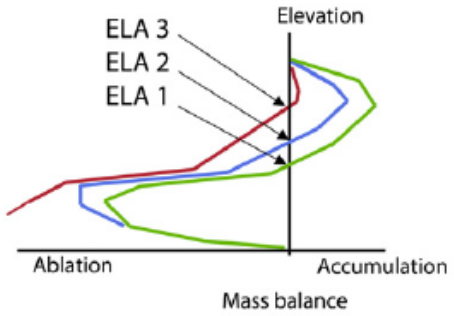
Glacial-lake outburst floods

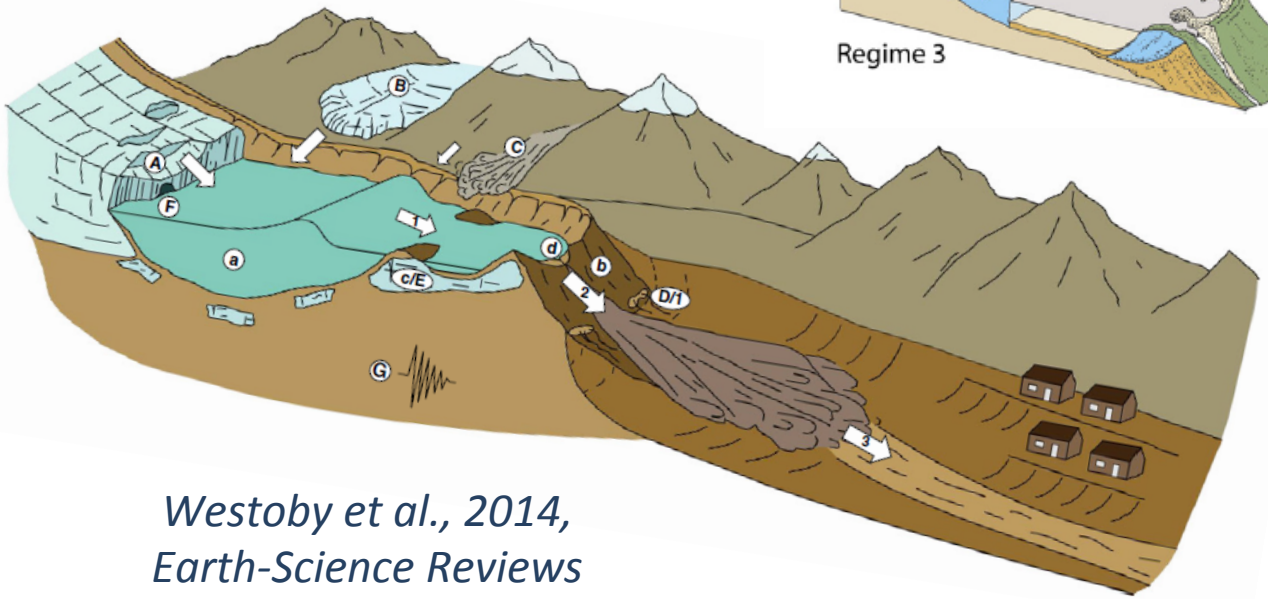
Benn et al., 2012,
Earth-Science Reviews









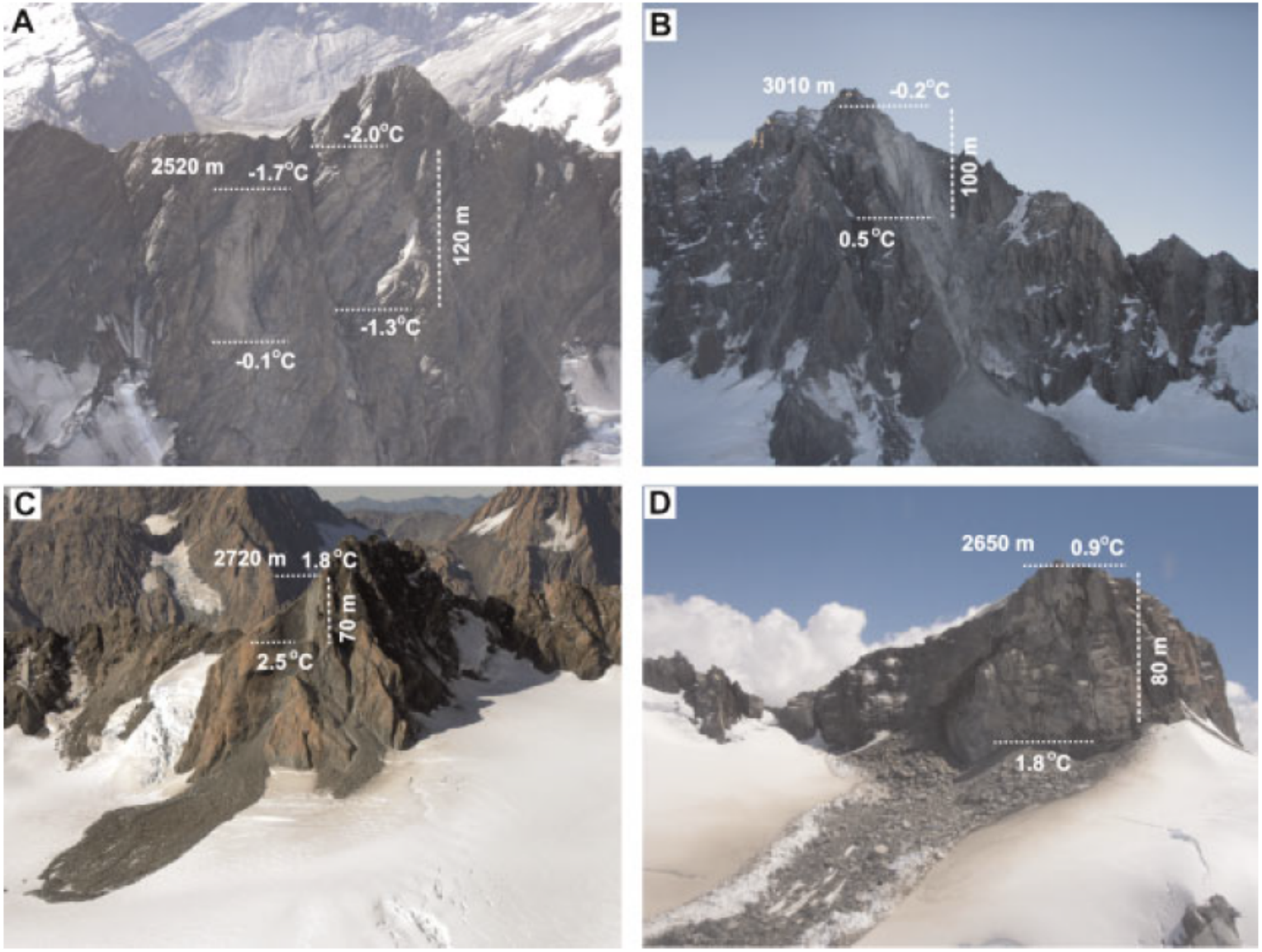


Westoby et al., 2014,
Earth-Science Reviews

Bedrock permafrost

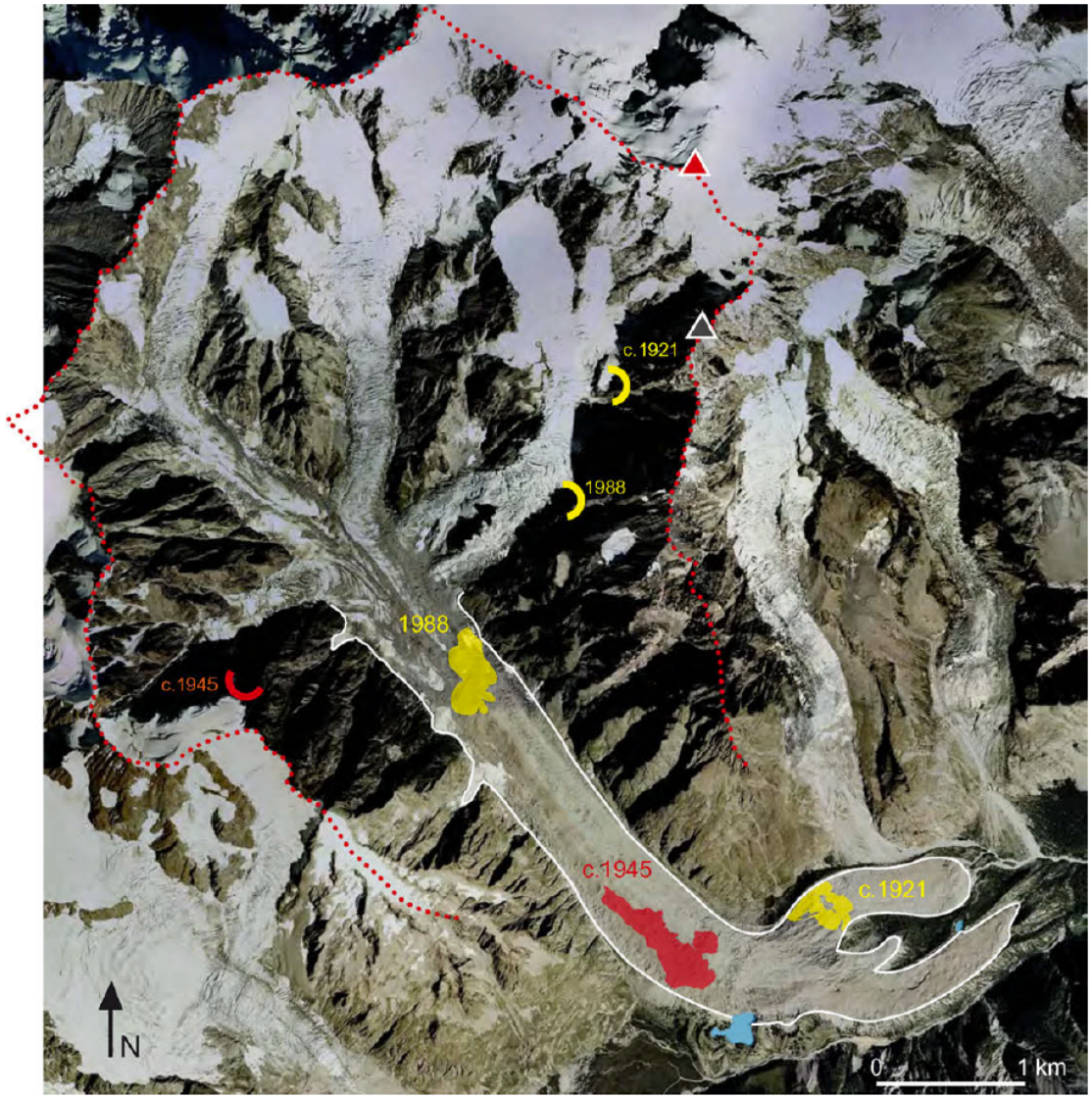
Bedrock permafrost

Slope failures/rock falls and climate change



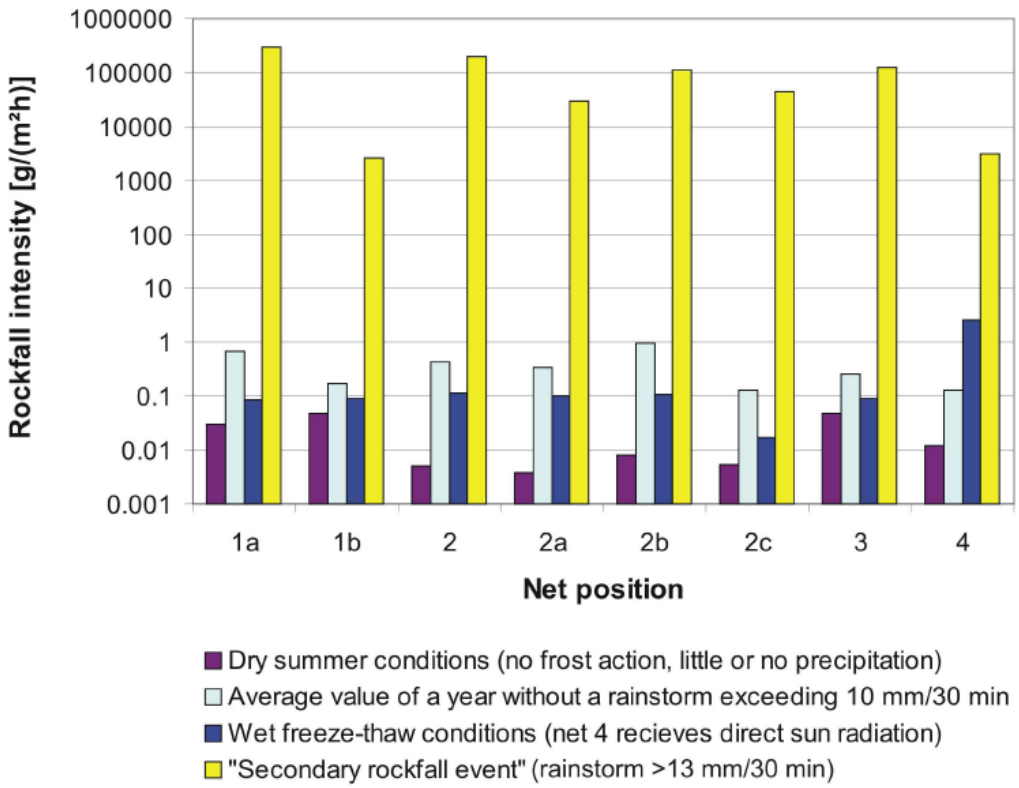
Allen et al., 2009, PPP

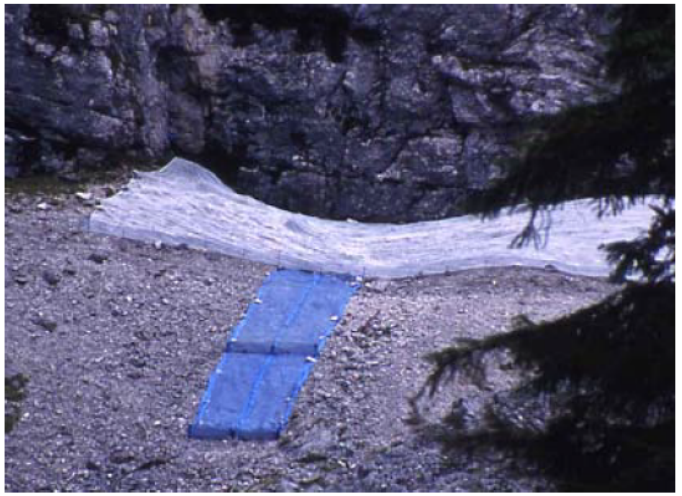
Slope failures/rock falls and climate change



Deline, 2009, QSR

Rock falls and precipitation





Krautblatter and Moser, 2009, NHESS

Outline

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  - Moraine-dammed lakes and outburst floods
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