Climate change impacts on rockfalls and debris flows: will mountains become more dangerous?

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- Introduction
- Study sites
- Methods
- Results
- Discussion and conclusion

Mass movements In the Alps

Mass movements and climate

- Changing climate is thought to impact the frequency and magnitude of mass-movement processes.
- Impacts are expected to be particularly acute in mountain regions.
- Spectacular rockfalls occurred during the summer heat of 2003, massive debris flows happened in August 2005.
- Occurrence of various mass-movement events beyond historical experience.

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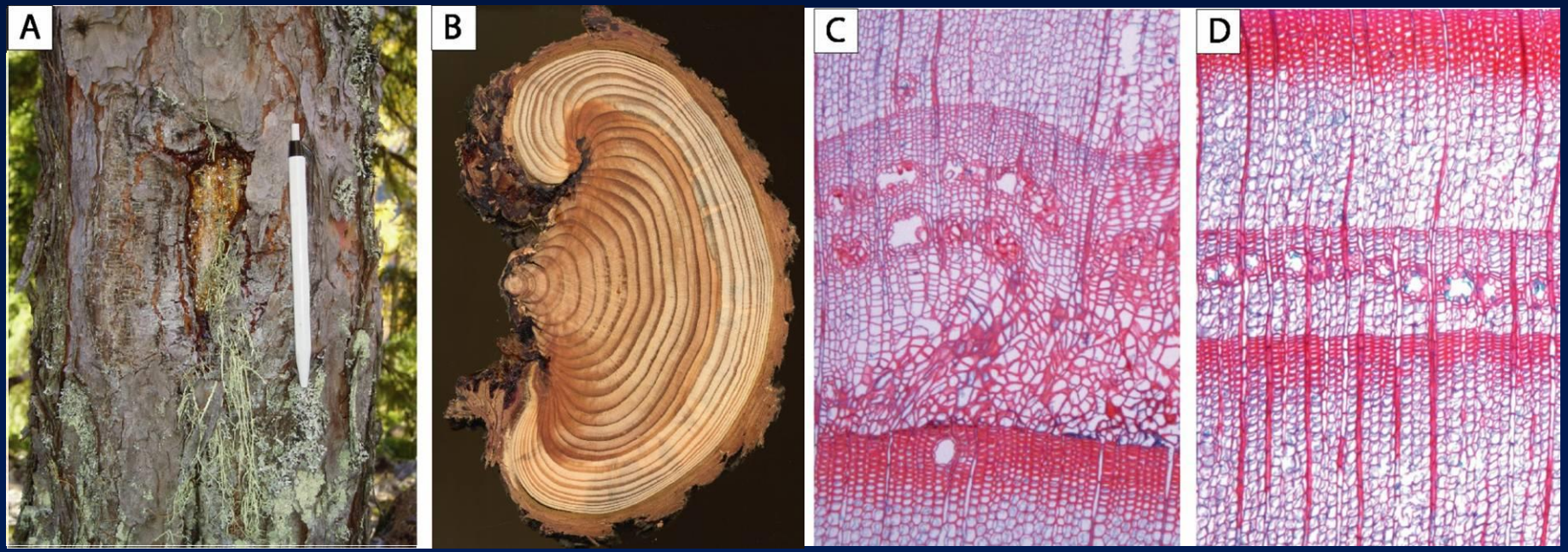
Dendrogeomorphic sampling



Stoffel and Bollschweiler, 2008, *Nat Hazard Earth Syst Sci* **8**

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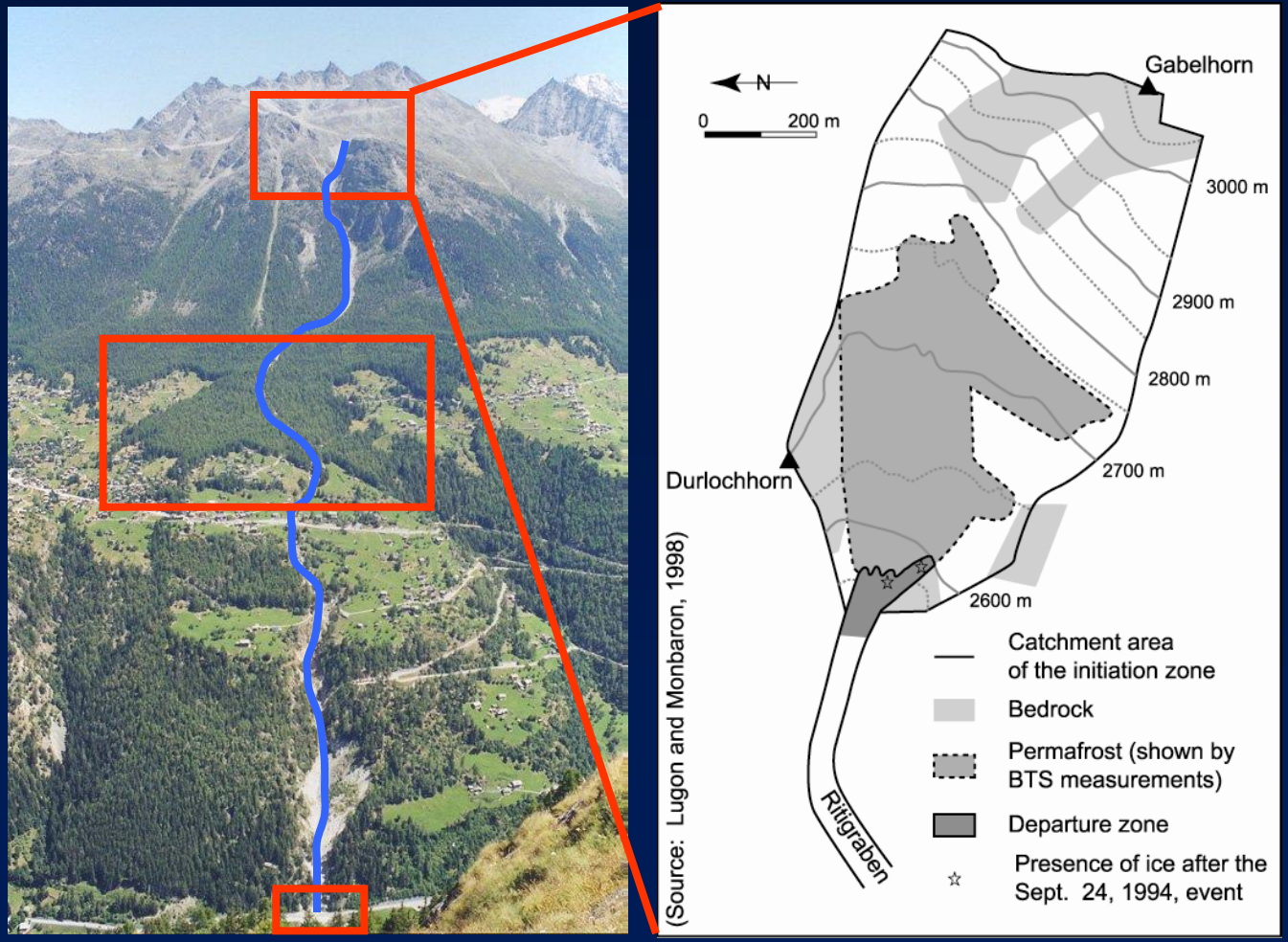
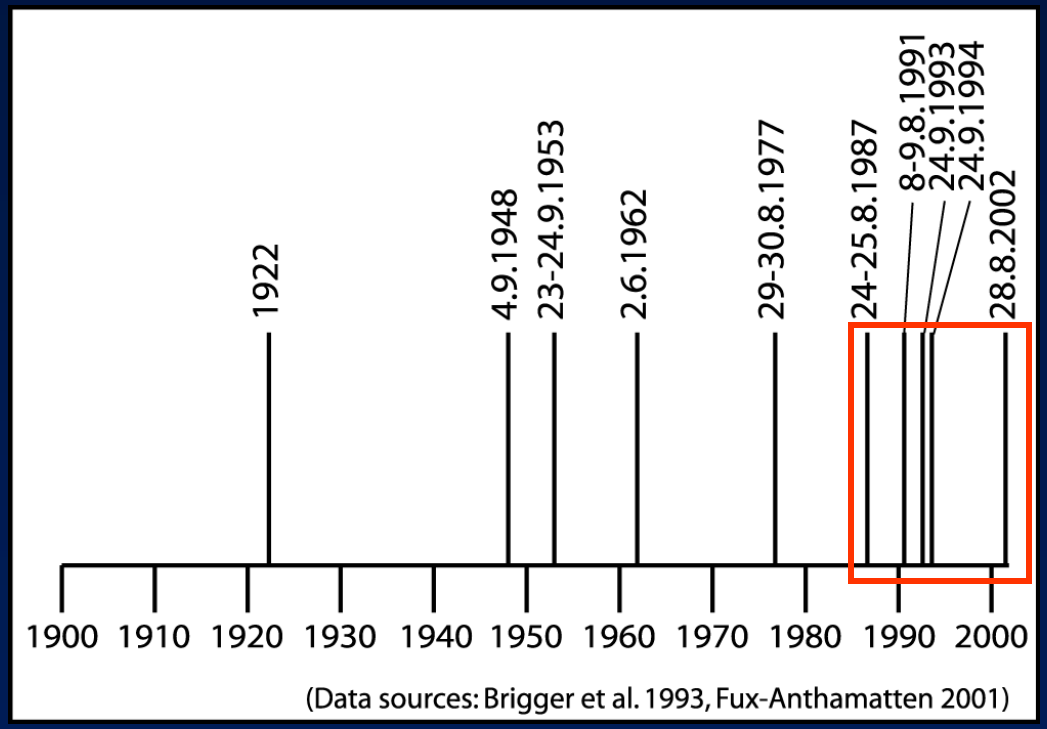
Ritigraben torrent, Swiss Alps



Stoffel et al., 2005, *Arct Antarct Alp Res* **37**: 387

Ritigraben torrent, Swiss Alps



10 events recorded in archives since 1922

24.09.1993: 60‘000 m^3

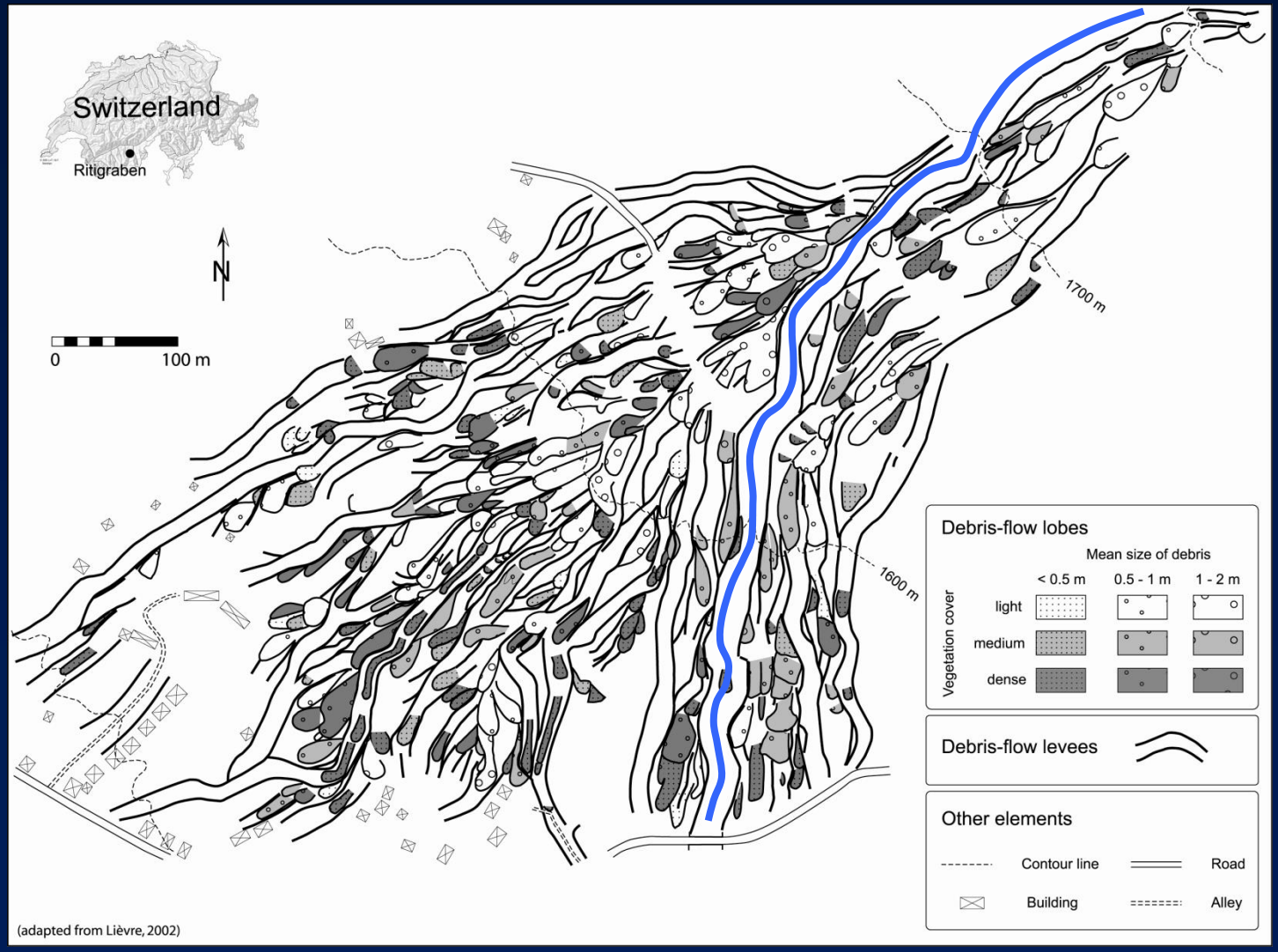
„increase in debris-flow frequency since 1987“

„no events during LIA and between 1850 and 1922 “

(NRP 31)

Case-study site Ritigraben

Geomorphic mapping

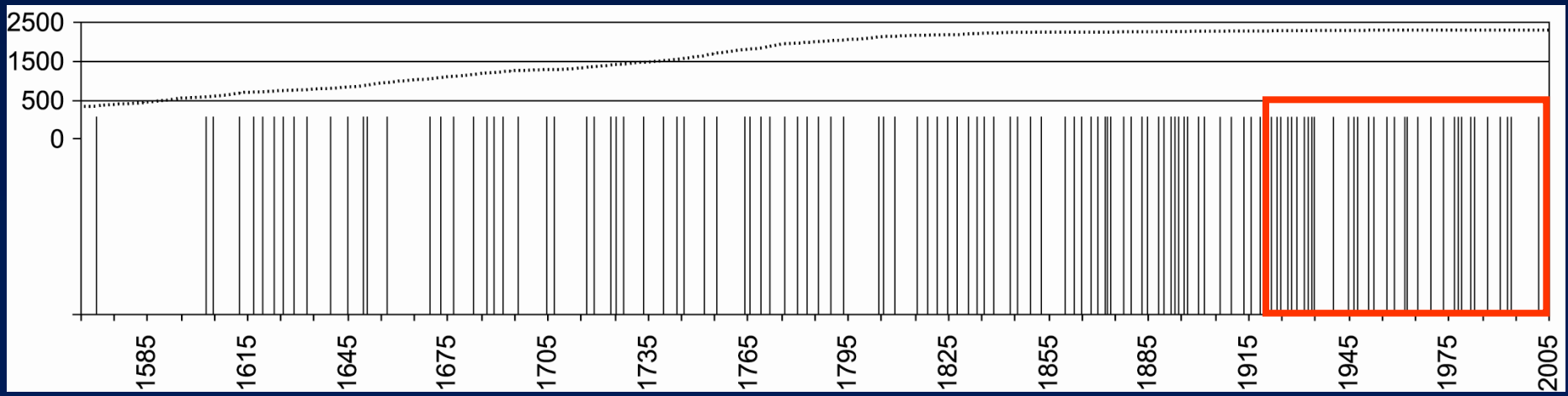


Stoffel et al., 2008 *Global Planet Change* 60: 228

Case-study site Ritigraben

Sampling: 2450 increment cores from 1102 conifer trees

124 events identified between AD 1570 and 2008



Stoffel & Beniston, 2006 *Geophys Res Letter* **33**: L16404

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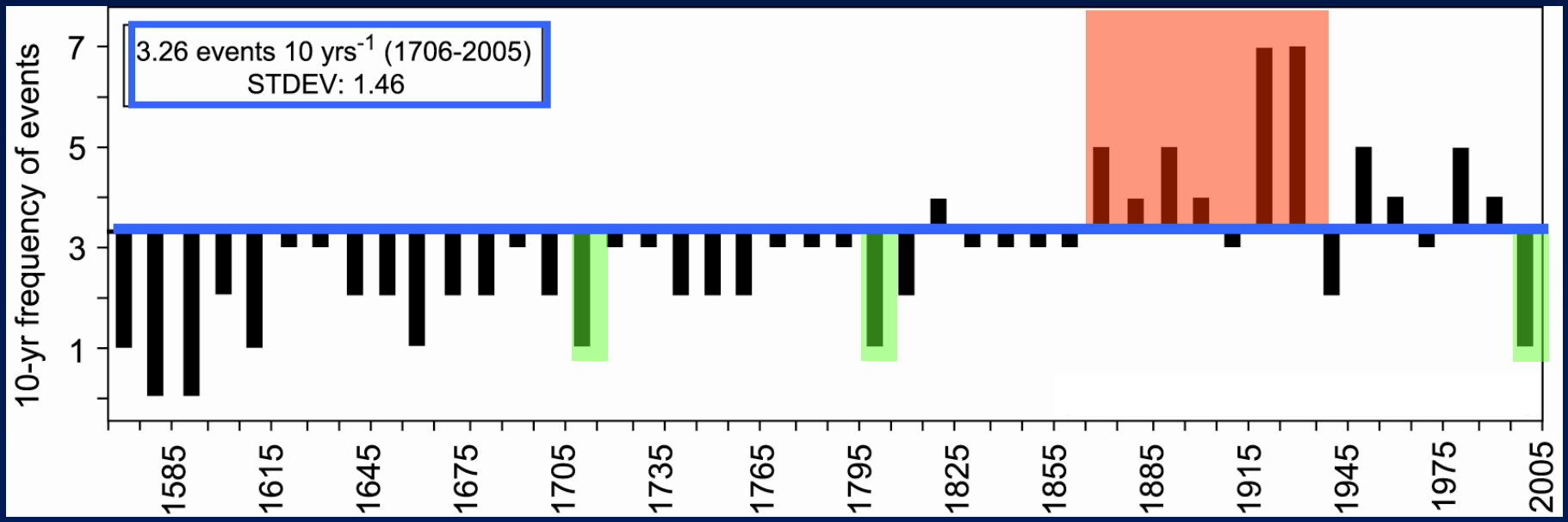
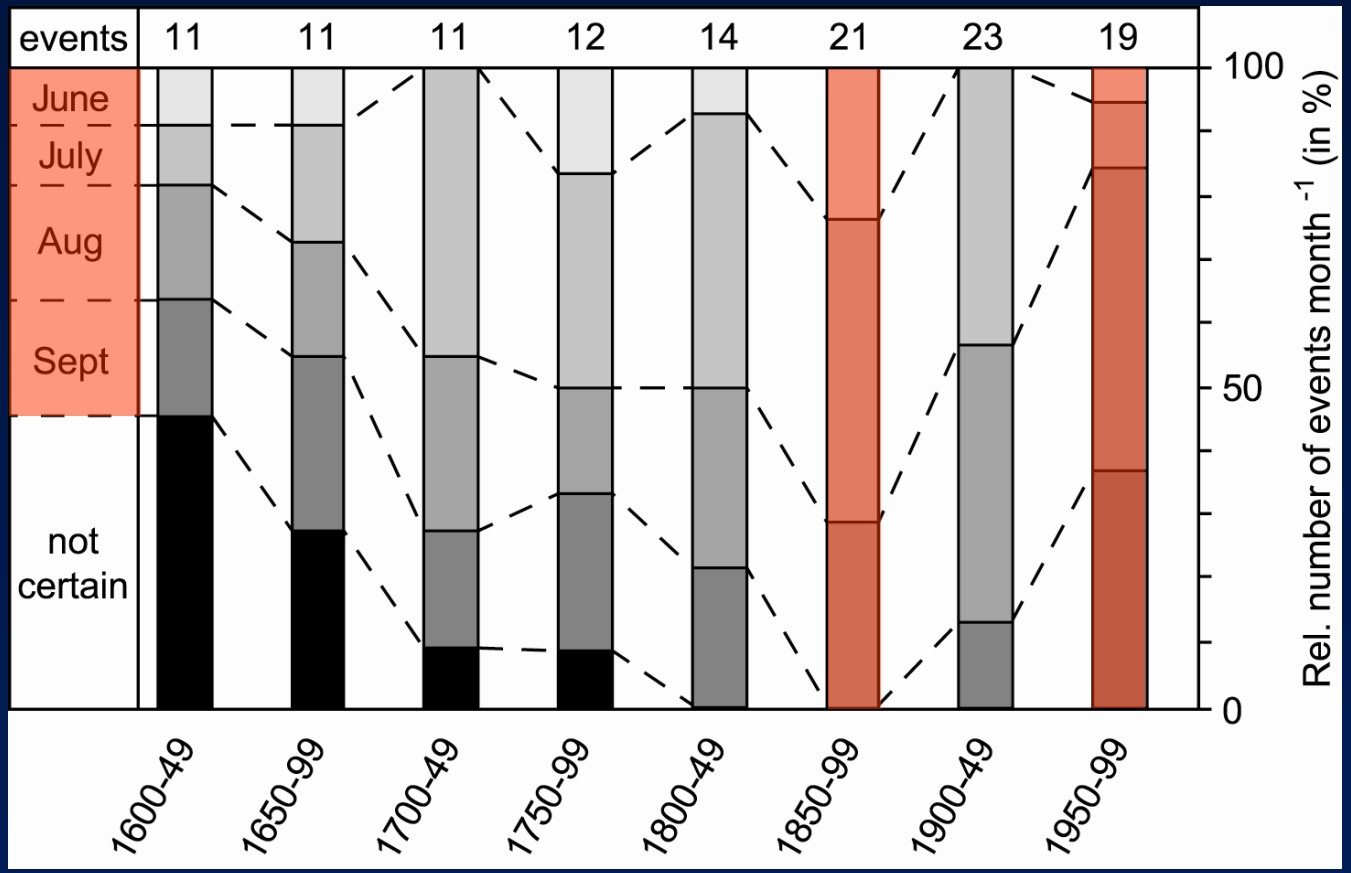


Stoffel & Beniston, 2006 *Geophys Res Letter* **33**: L16404

Seasonality of debris flows



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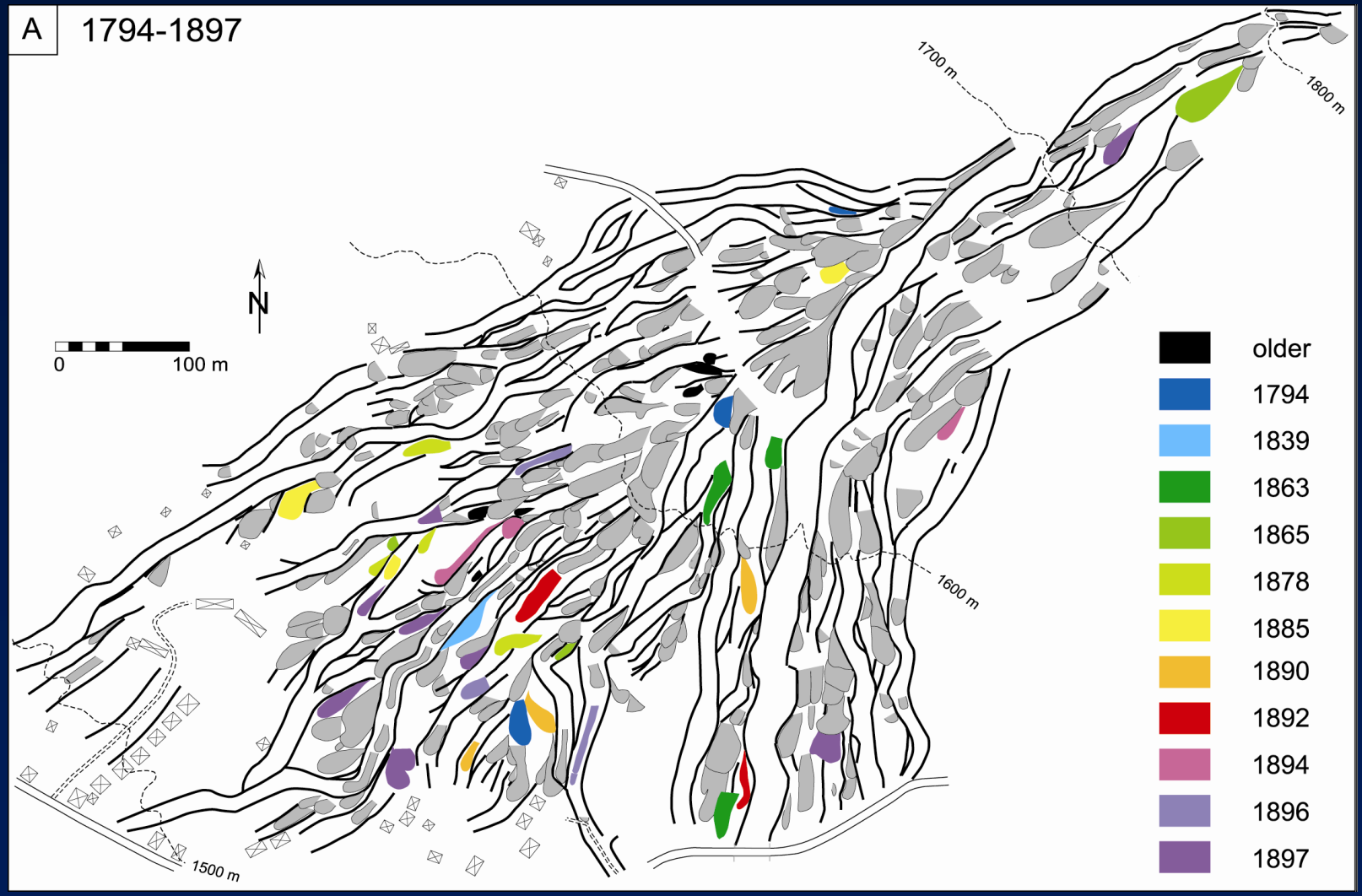
Debris-flow deposits (*where?*)



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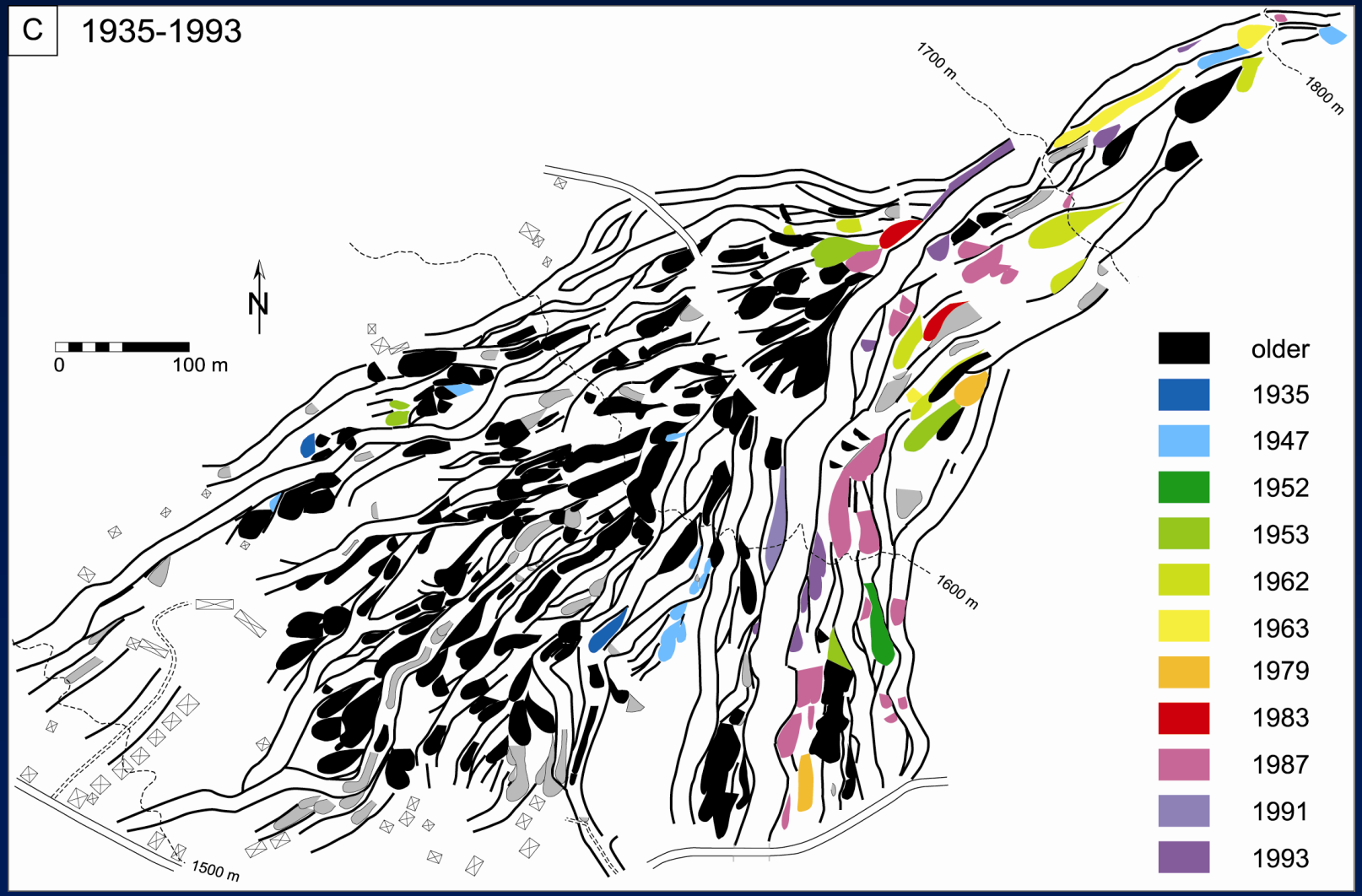

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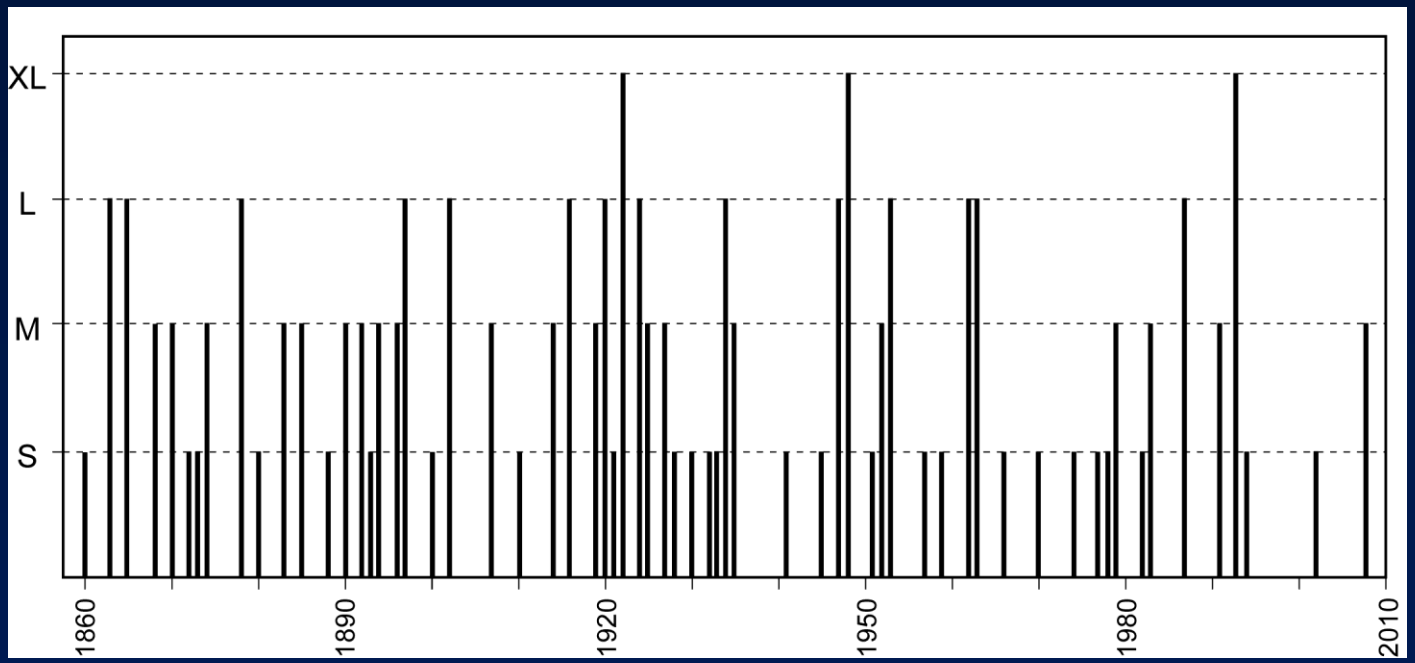
Magnitude-frequency relationship

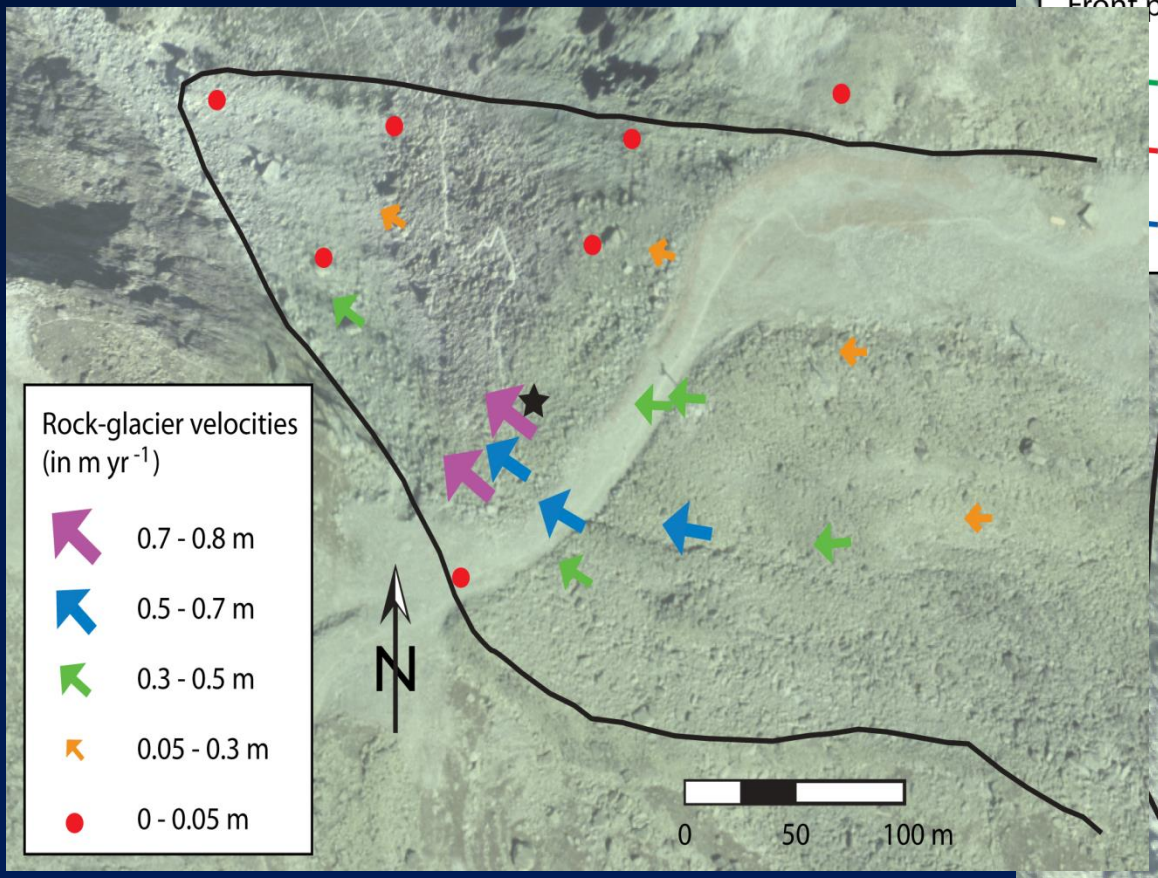


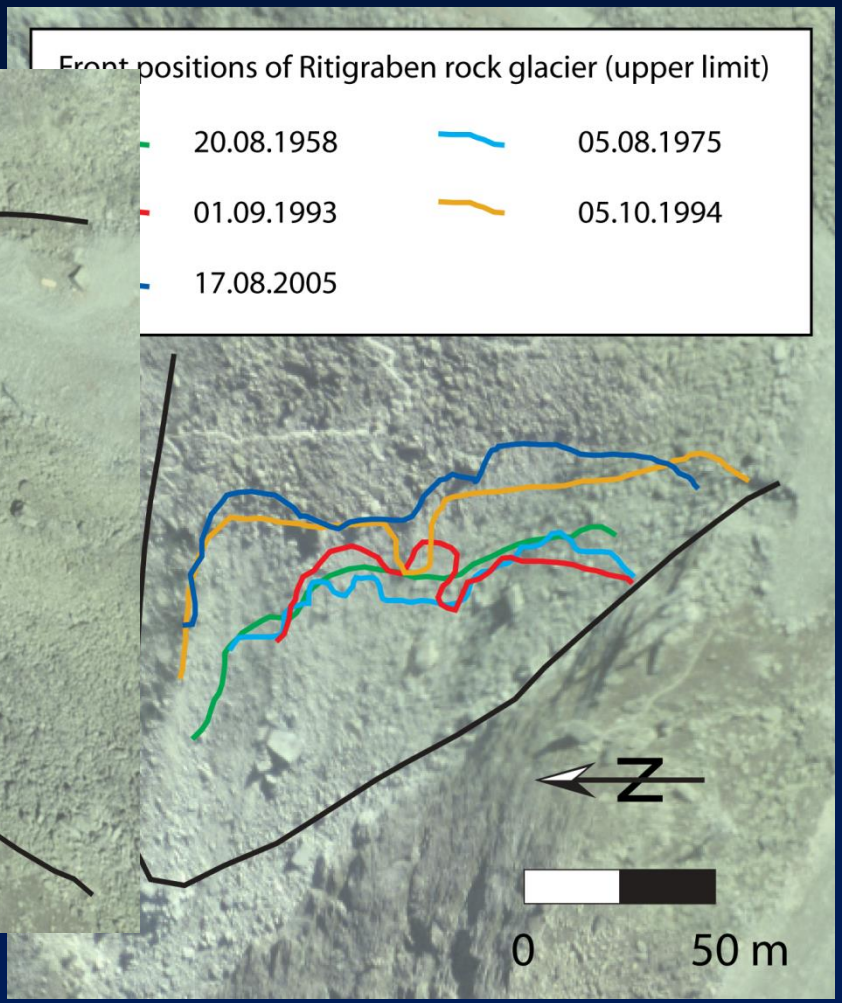
Stoffel, 2010 *Geomorphology*

Return periods of events

S = pluriannual M = subdecadal L = decadal XL = multidecadal

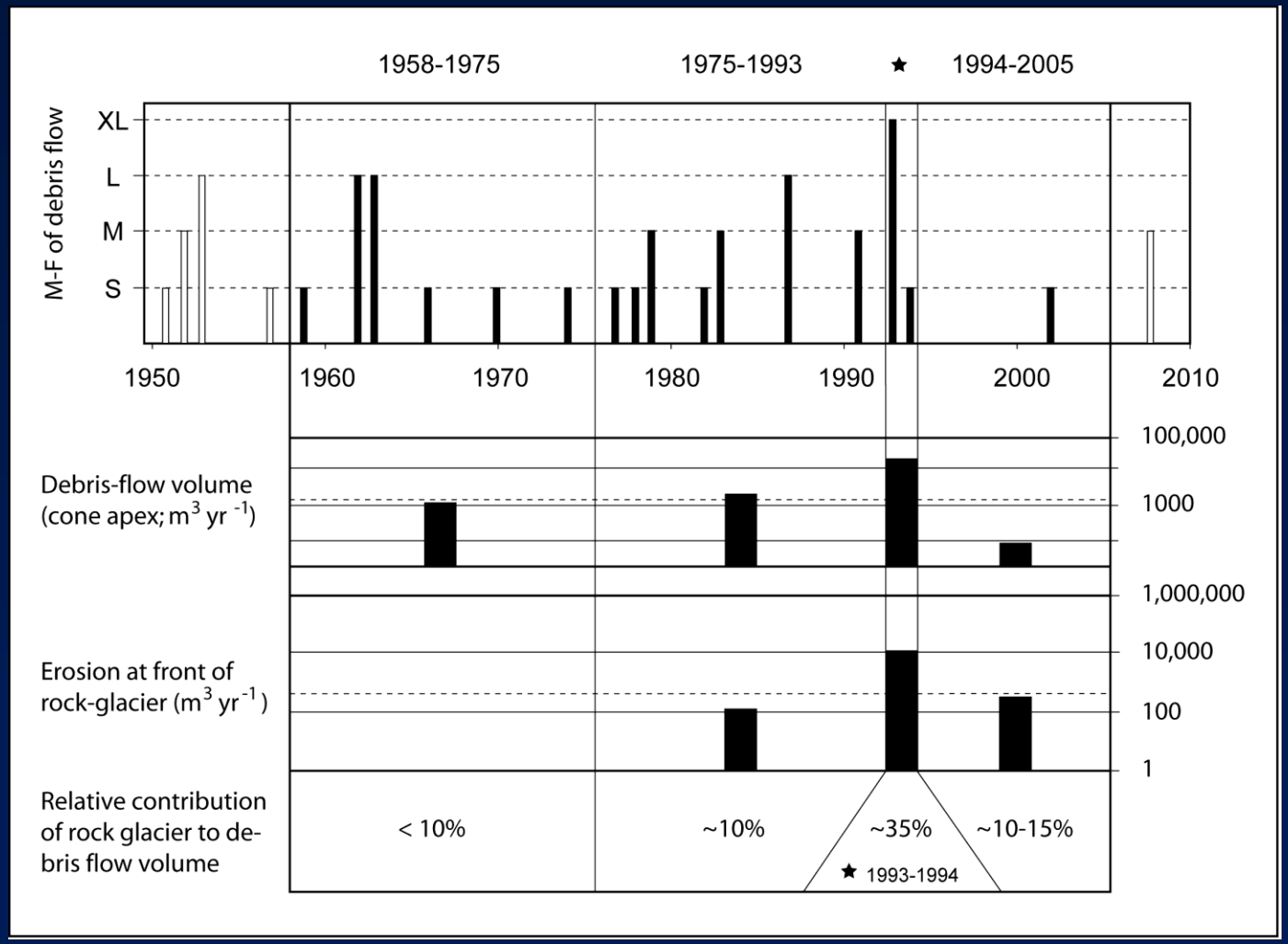
Source-to-sink processes





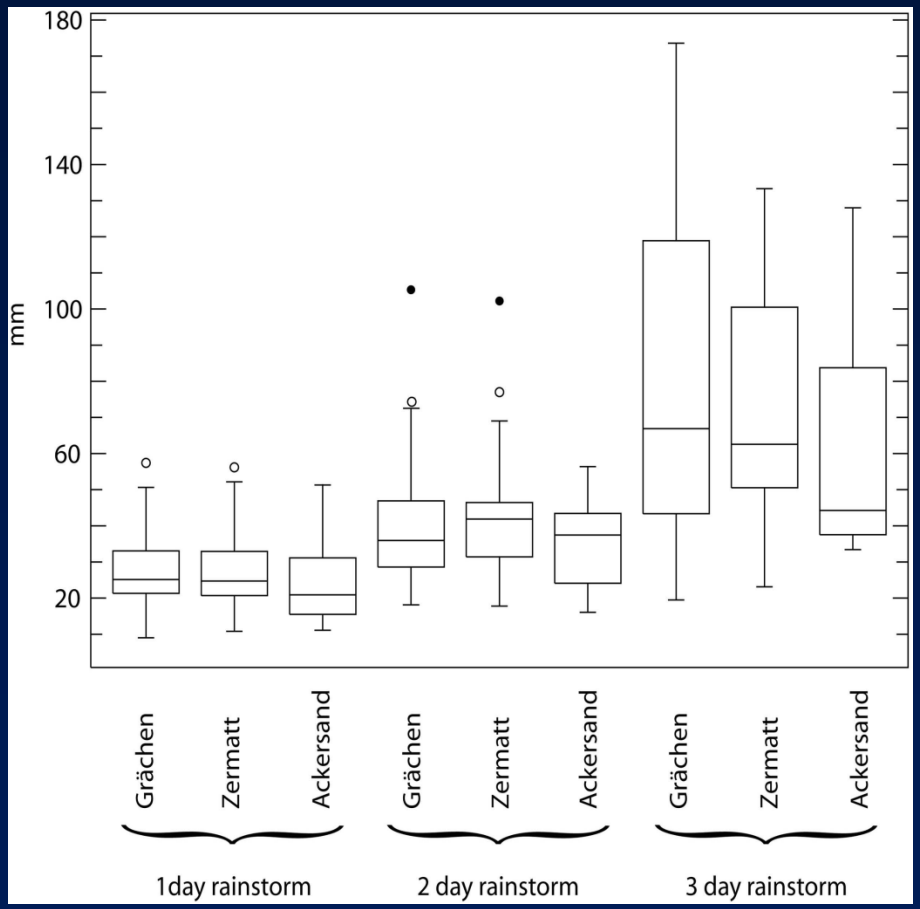
Lugon & Stoffel, 2010 *Global Planet Change* **73**: 202

Source-to-sink processes

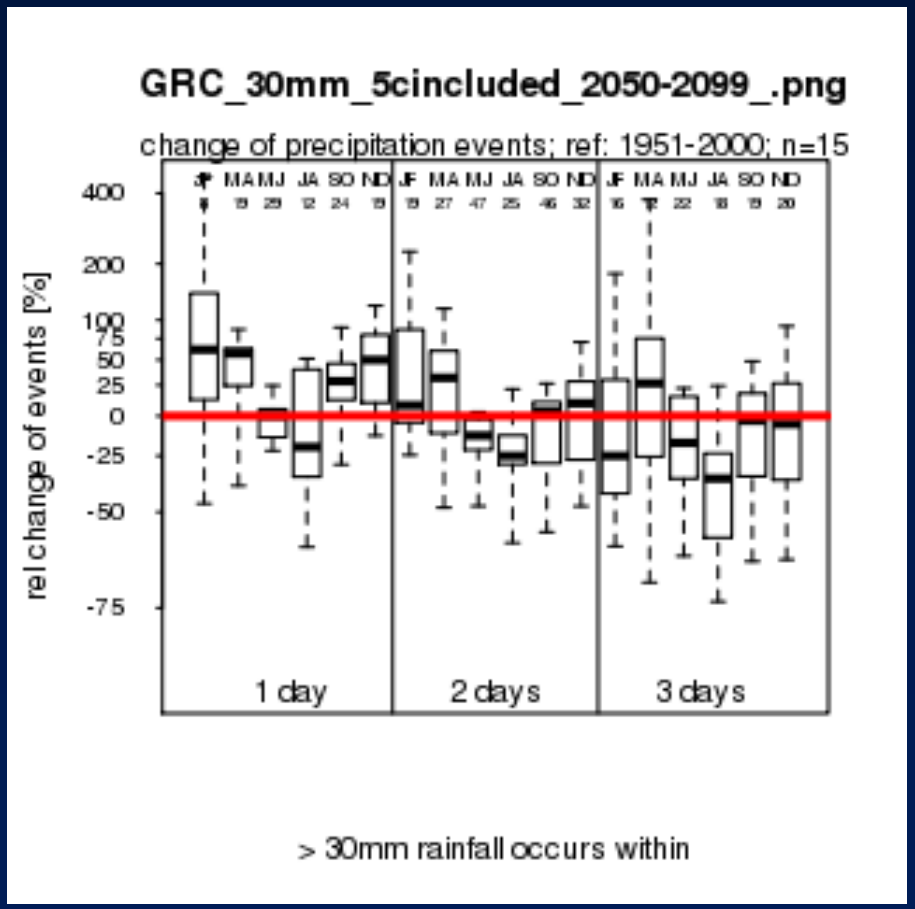


Lugon & Stoffel, 2010 *Global Planet Change* **73**: 202

Triggers and future evolution in debris-flow activity

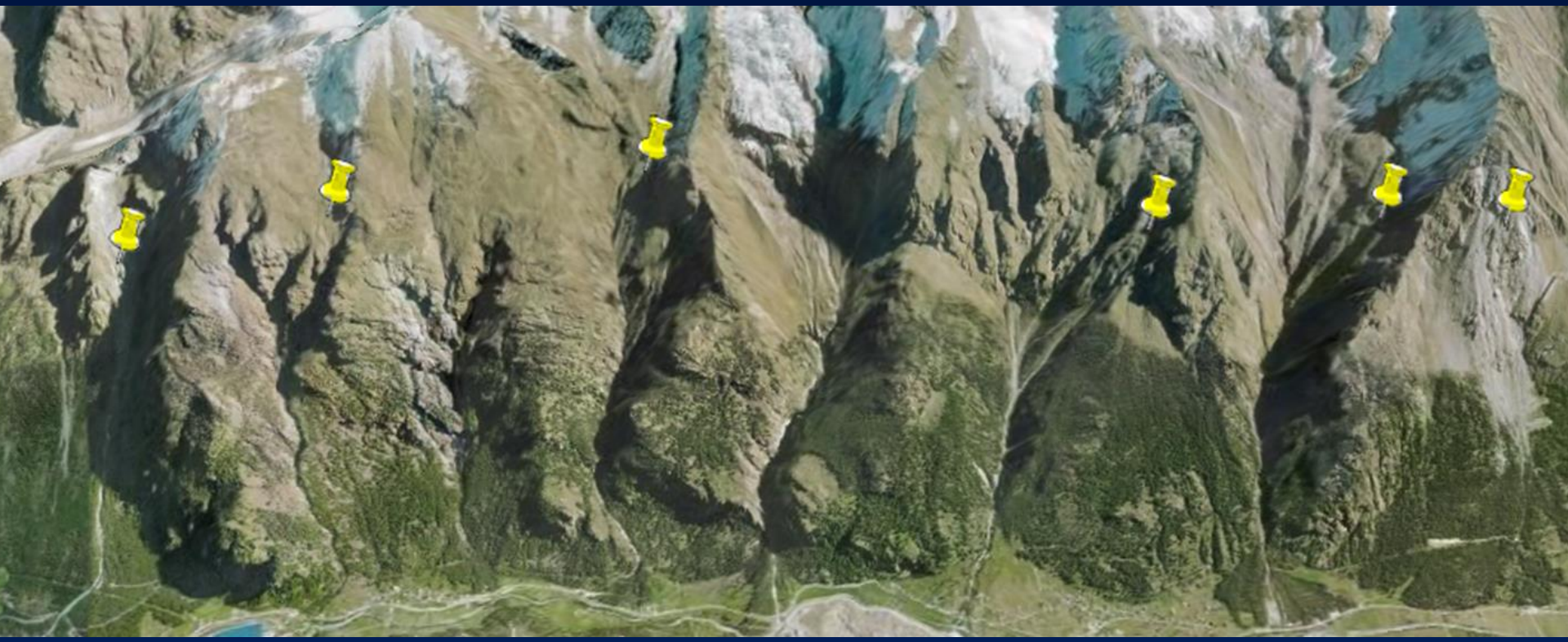


Schneuwly-Bollschweiler and Stoffel., 2012. *J Geophys Res*



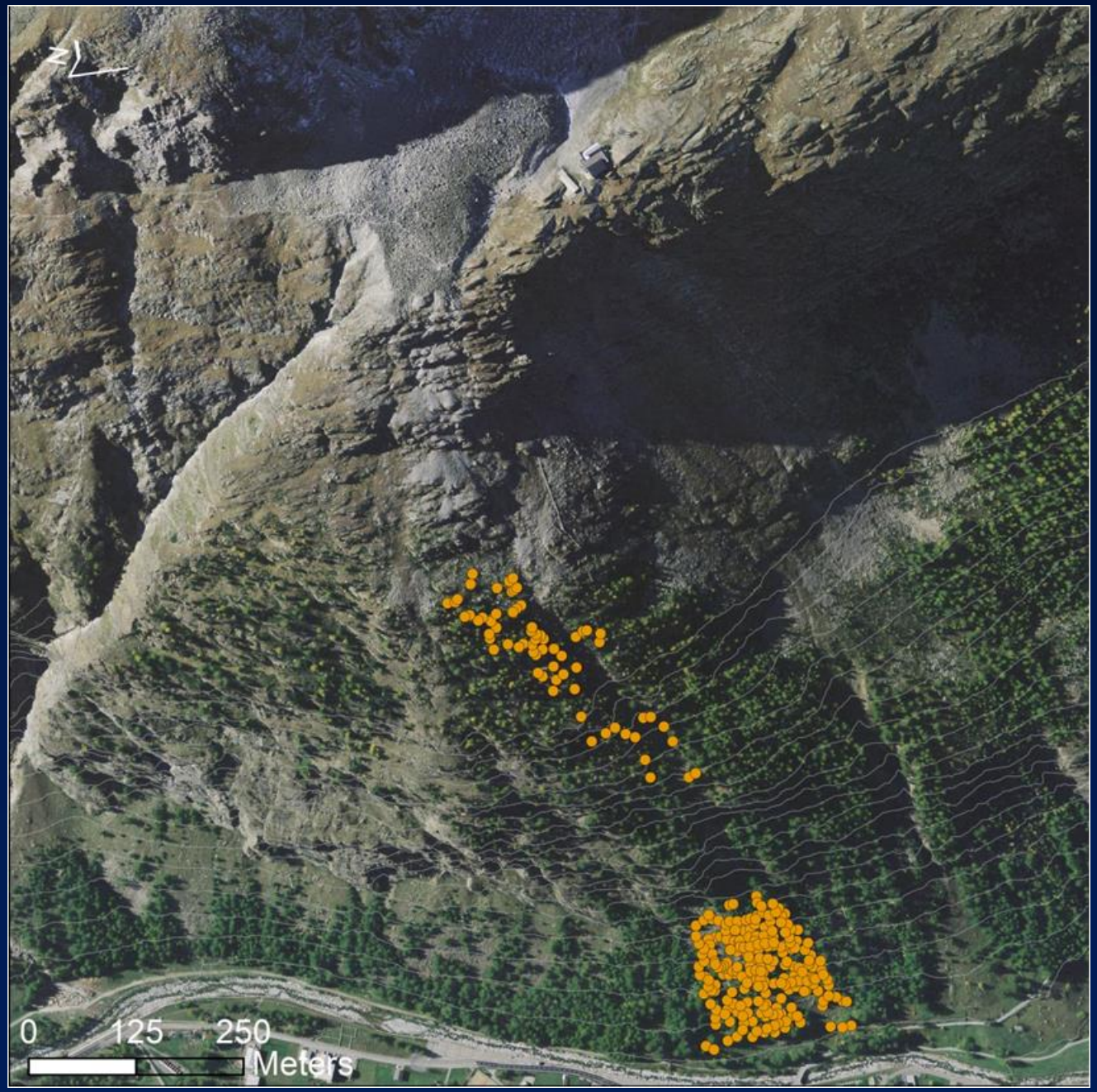
Stoffel et al., 2014. *Clim Change*

Regional debris-fow frequency



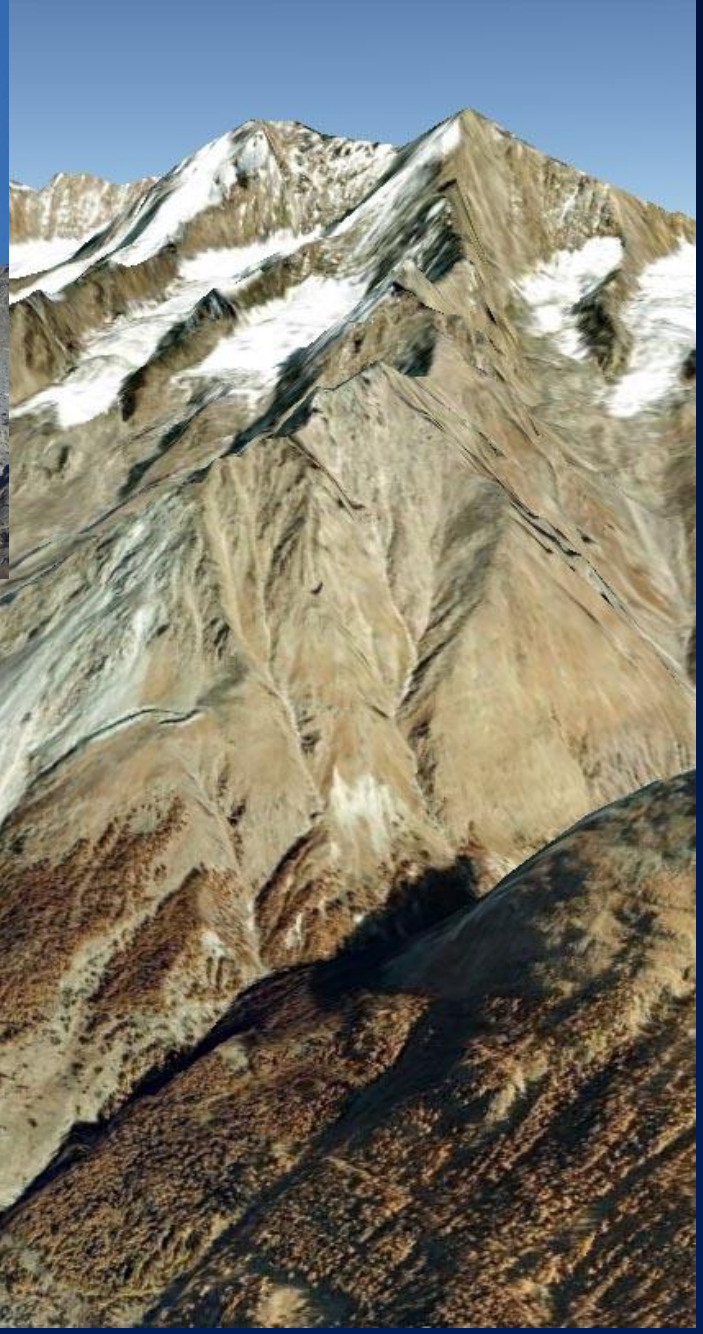
Future perspectives

Plattje



Plattje

Rockfalls at Täschgufer

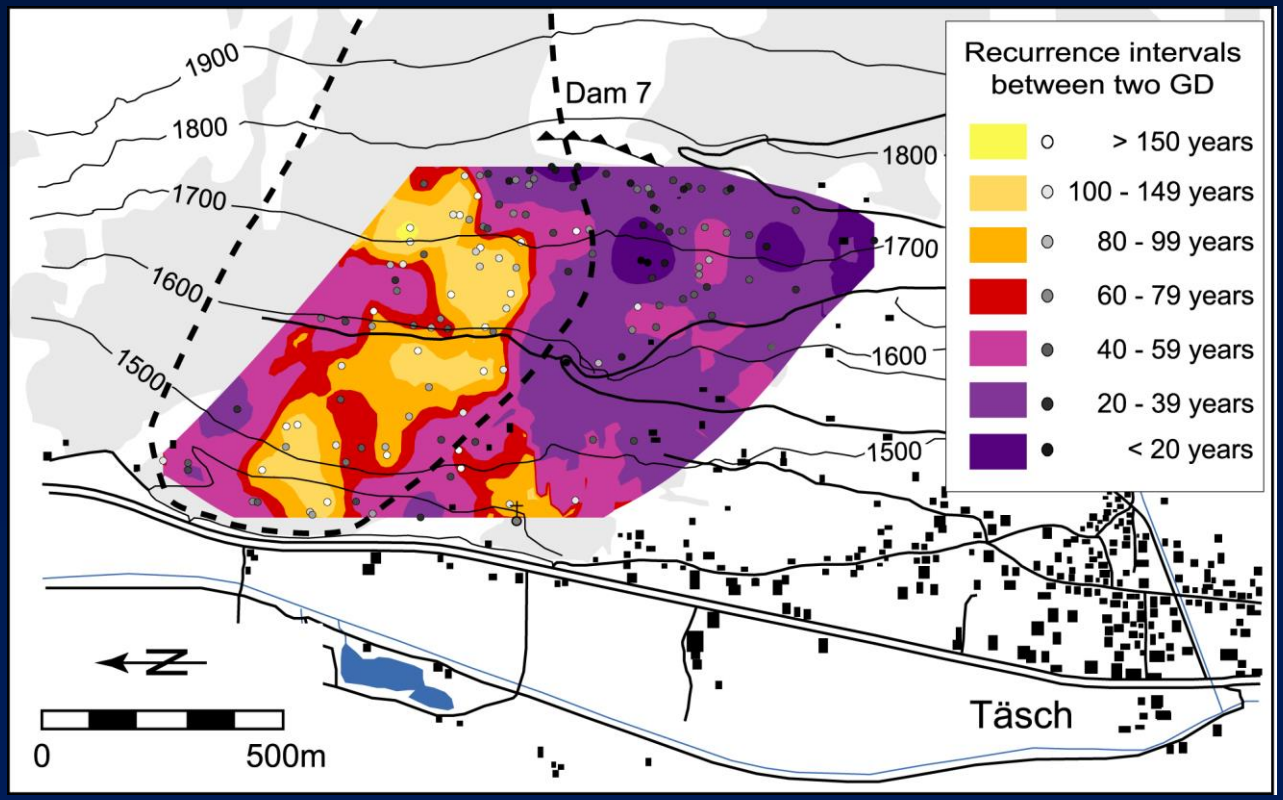


Täschgufer, VS

Täschgufer

Rockfall frequency (*how often?*)

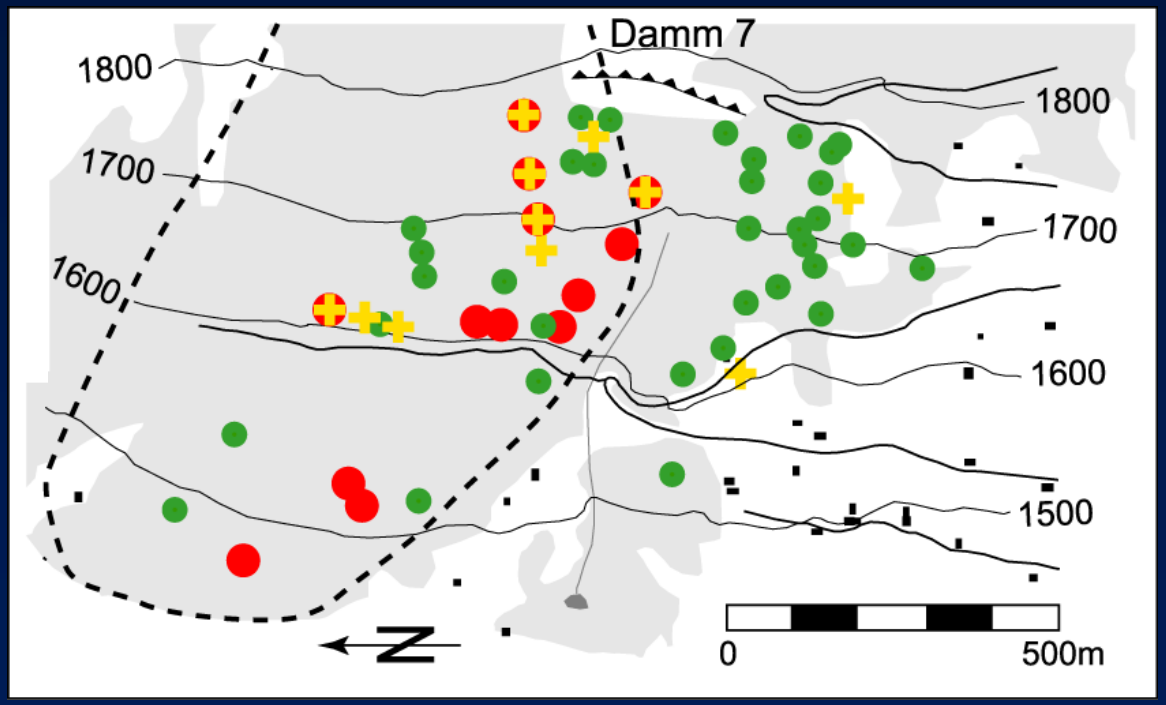
Dated injuries: 786 for the period 1394–2002
Rockfall occurs in the form of **isolated rocks and boulders**…



Stoffel et al., 2005 *Geomorphology* **68**: 224

Rockfall magnitude (*how much?*)

… only one high magnitude – small frequency event dated to **1720** AD



Stoffel et al., 2005 *Geomorphology* **68**: 224

11 trees **injured,** 13 trees with **growth release** after 1721, every forth tree **growing up** between 1725 and 1759

Rockfalls and MSAT

The illustration on climate-rockfall interactions has been removed as this is work in review.

Please check Nature Geosciences or dendrolab.ch web sites for updates

Stoffel et al., in prep *Nature Geoscience*

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Conclusions

- Unusually dense records of rockfall or debris-flow activity at periglacial sites spanning several centuries.
- Reconstructed time series represent «real» changes in activity.
- Periglacial rockfall (in terms of frequency) is driven clearly by temperature; debris flows show mixed reactions.
- Debris flows – unless driven by huge sediment input from unstable permafrost bodies – will not necessarily occur more frequently, but with larger magnitudes.
- CC impacts on rockfall and debris flows are clearly visible in periglacial environments, but not at lower elevations.

Thank you!

Universities of Geneva and Bern

Characteristics of debris-flow classes

Characteristics	S	M	L	XL
travel distance	1630 m	1600 m*	1560*	1080
spread	low	low	medium	large*
seasonality	JAS	JJAS	JJAS	AS
precipitation	convective	convective	adv. / conv.	advective
block sizes (Ø)	< 0.5 m	0.5–1 m	0.5–1 m	1–2 m
events	26	20	14	3
magnitude (m^3)	**10^2–10^3**	**10^3–5×10^3**	**5×10^3–10^4**	**10^4–5×10^4**

⇒ size determination for 63 events since AD 1860 (S, M, L, XL)

Characteristics of debris-flow classes