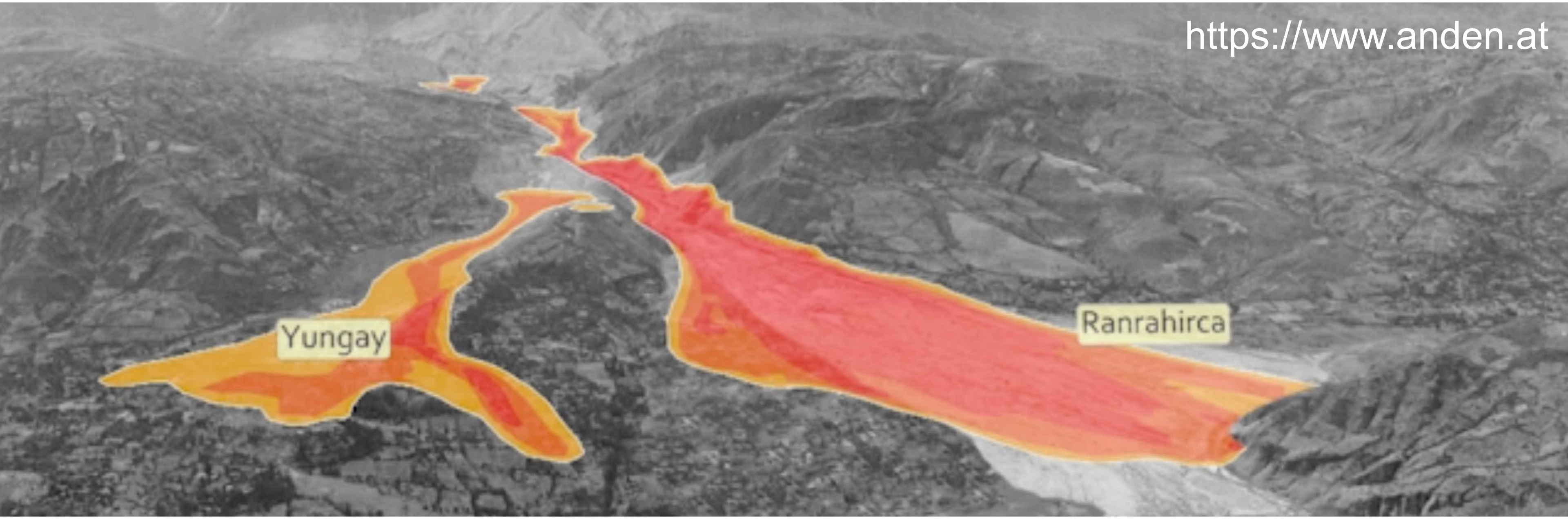


Towards the predictive simulation of high-mountain landslide cascades

Martin Mergili and Shiva P. Pudasaini

Institute of Applied Geology, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria | Department of Geography and Regional Research, University of Vienna, Vienna, Austria | Institute of Geosciences, Geophysics Section, University of Bonn, Bonn, Germany

Challenges | Solutions? | Preliminary results | Conclusions | Perspectives

Challenges

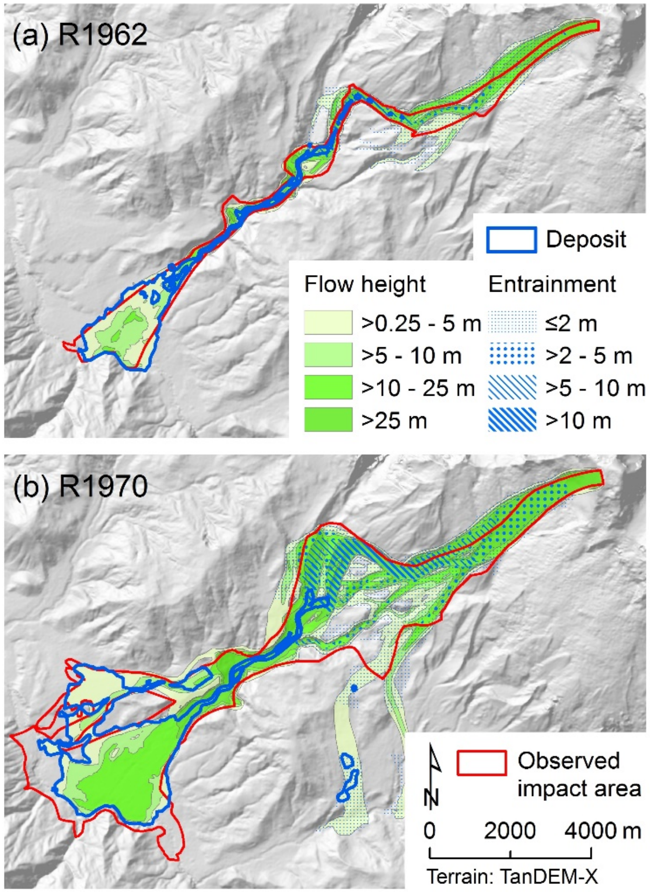
- **Complex landslide processes can be successfully back-calculated with the r.avaflow computational tool (https://www.avaflow.org)** Mergili et al. (2017, GMD), Pudasaini and Mergili (2019, JGR ES)

Year Place	Description	Reference
2012 Santa Cruz Valley (Cordillera Blanca, Perú)	Multi-lake outburst flood involving three lakes and the entrainment of a large amount of sediment, starting from a landslide from a moraine	Mergili et al. (2018, ESPL)
1962 and 1970 Huascarán (Cordillera Blanca, Perú)	Debris-mud-ice avalanches starting as rock-ice falls, entrainment of snow, ice, and debris, extremely high velocity and runout distance	Mergili et al. (2018, Geomorphology)
1941 Quilcay Valley (Cordillera Blanca, Perú)	Sudden drainage of Lake Palcacocha (breach of moraine dam), complex flow downstream leading to the drainage of another lake and excessive channel erosion	Mergili et al. (2020, HESS)
2017 Piz Cengalo – Bondo (Switzerland)	Initial rock slide-rock fall, entrainment and melting of glacier ice, resulting rock avalanche evolving into debris flow	Mergili et al. (2020, NHESS)
1967 Steinholtsdalur (Iceland)	Rock slide onto a glacier, entrainment of ice and drainage of proglacial lake, distal flood	Gylfadóttir et al. (2019, EGU)

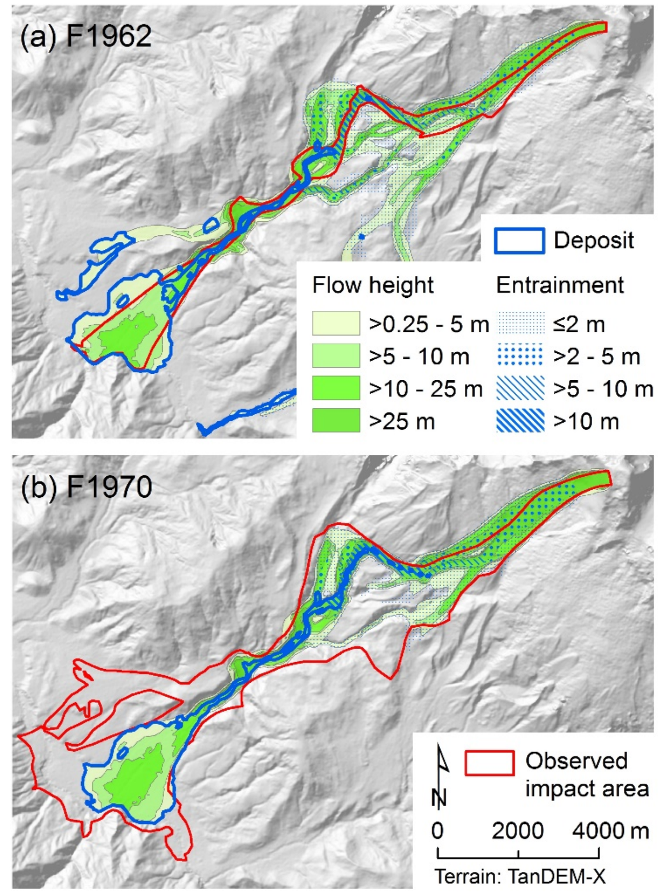
- **However, the transfer to forward simulations or predictive simulations remains a challenge**

Huascarán events

Successful back-calculations



Failed forward calculations



Mergili et al. (2018, Geomorphology)

Solutions?

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Analysis of back-calculated results of many case studies

↓

Derivation of guiding parameter values

↓ ↓

Differentiation by geomorphological characteristics	Differentiation by the characteristics of the landslide itself

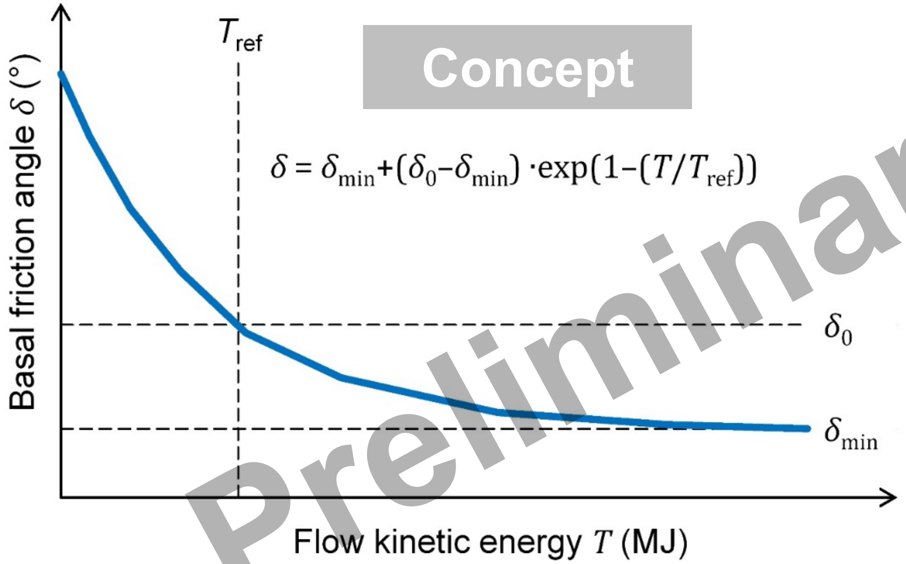
Static parameter ranges

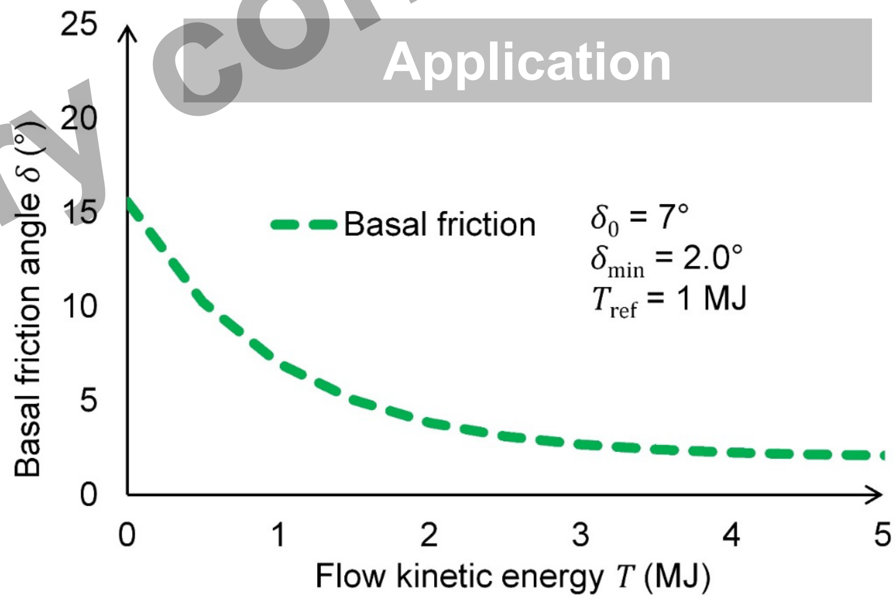
	Class	δ	C_{AD}	C_{FF}	C_E (d)	C_E (i)
A	Steep mountain slope, fall-like movement of rock and/or ice	2, 13, 16, 20	0.01*, 0.1, 0.2	0–0.00025, 0.0005		
B	Rock(-ice) avalanche over glacier	5, 6, 6, 8	0.005*, 0.01, 0.02	0–0.00025, 0.001, 0.0005		-6.5, -8.2
C	Rock(-ice) avalanche over debris slope	5–8, 10	0.005*	0–0.0001	-8.0 – -6.5	
D	Channelized high-energy flow of debris, mud, and/or ice	2–5	0.001*	0–0.00025		
E	Channelized debris flow	8–20, 20, 12, 7, 16 (11)	0.04, 0.005*, 0.01	0, 0.004, 0.0005	-6.75, -7.15	
F	Channelized water-dominated flow	8–20, 0, 12, 7, 16 (11)	0.04, 0.005*, 0.01	0, 0.004, 0.0005	-7.15	
G	Flow through narrow gorge	20	0.04	0.5		
H	Flow spreading on debris cone	8	0.001*	0.00025		

Preliminary values

Dynamic parameterization

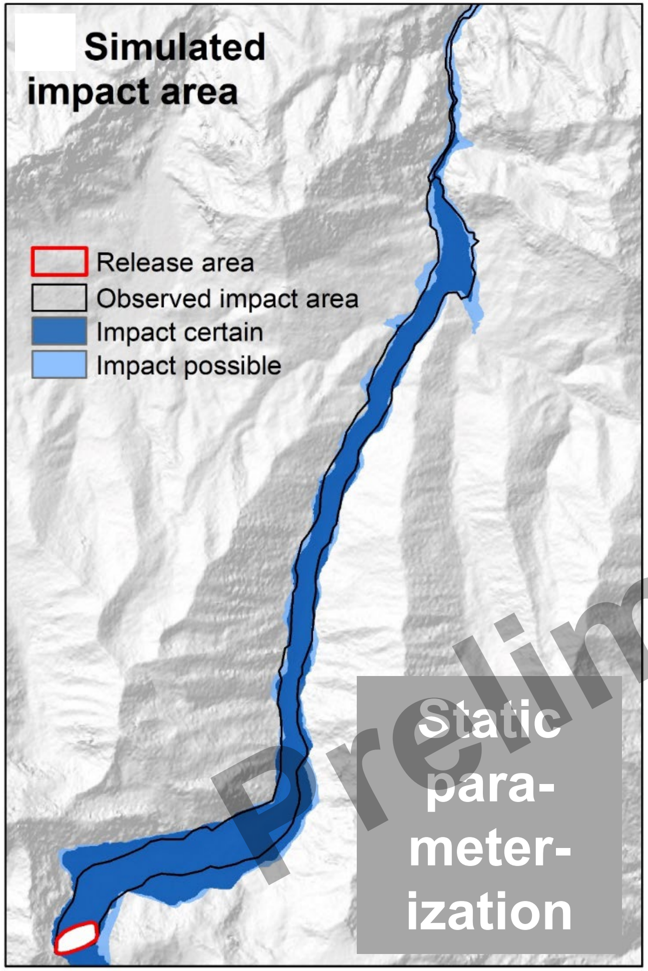
Dynamic adaptation of friction to flow kinetic energy

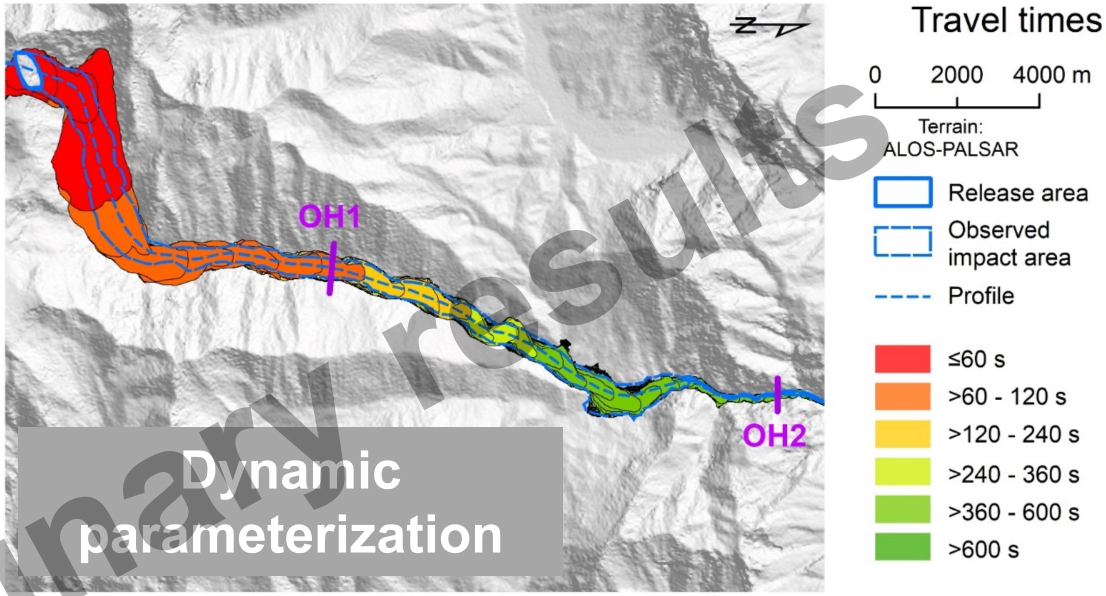


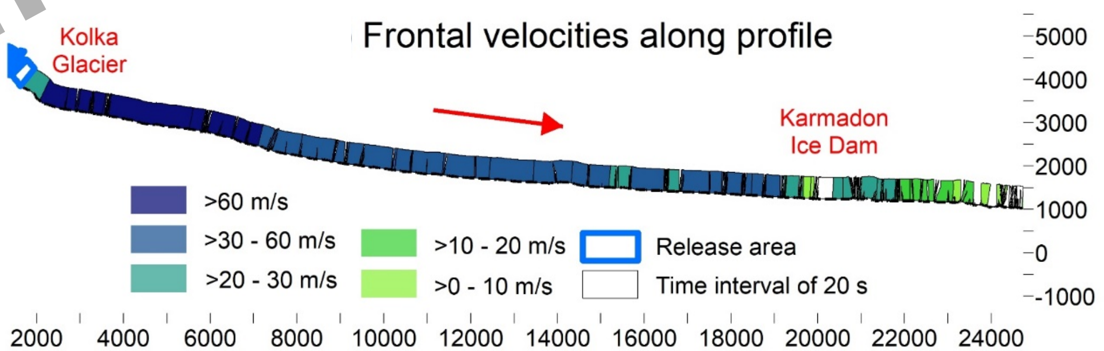


Preliminary results

Kolka-Karmadon 2002







Huascarán events

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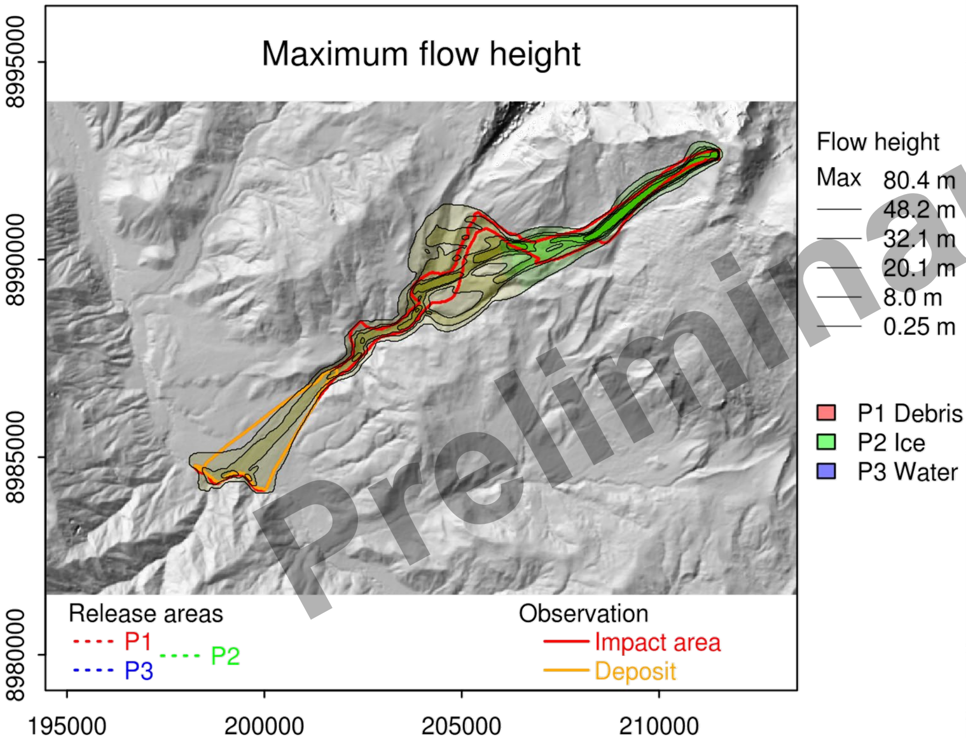
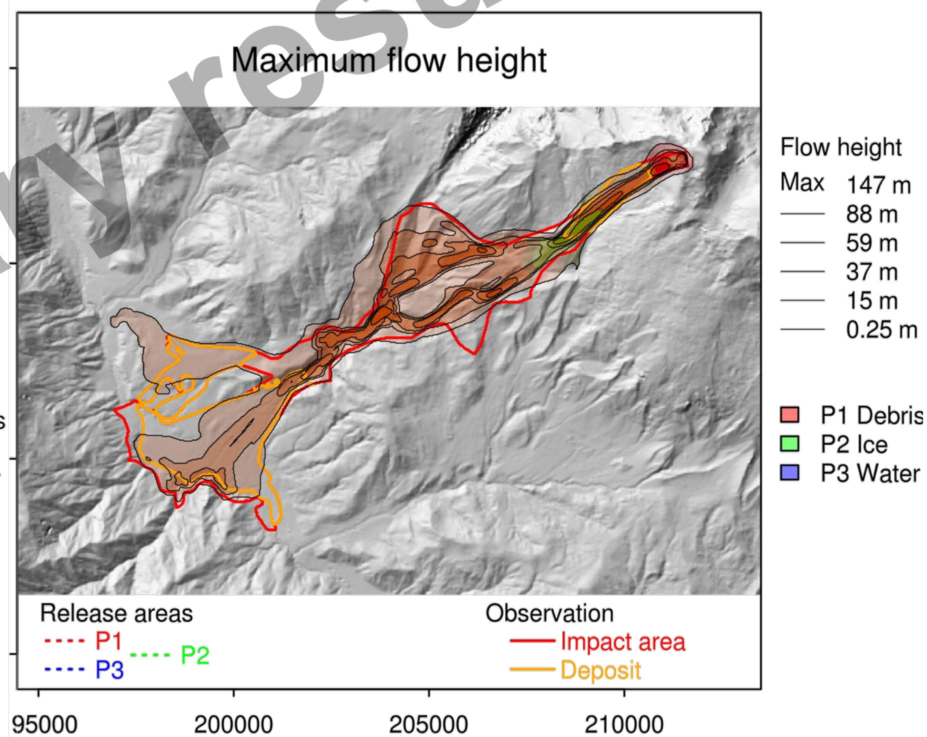
Huascarán 1962

Huascarán 1970

Dynamic parameterization





Preliminary results

Conclusions and perspectives

- First results are promising – both the static and the dynamic parameterization of predictive simulations yield plausible results for the two test cases
- Parameter constraints and function for dynamic adaptation of friction have to be refined
- More back-calculations are necessary to make the guiding parameters more reliable
- Testing, testing, testing ...

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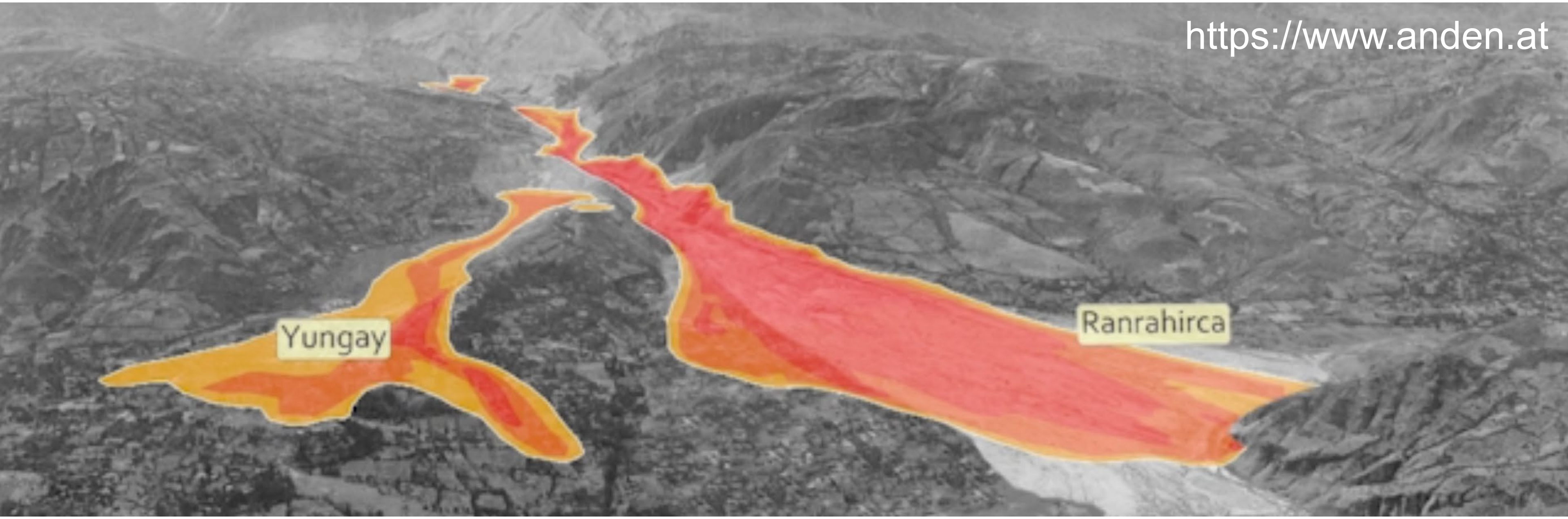

Thank You for your participation!

martin.mergili@boku.ac.at

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