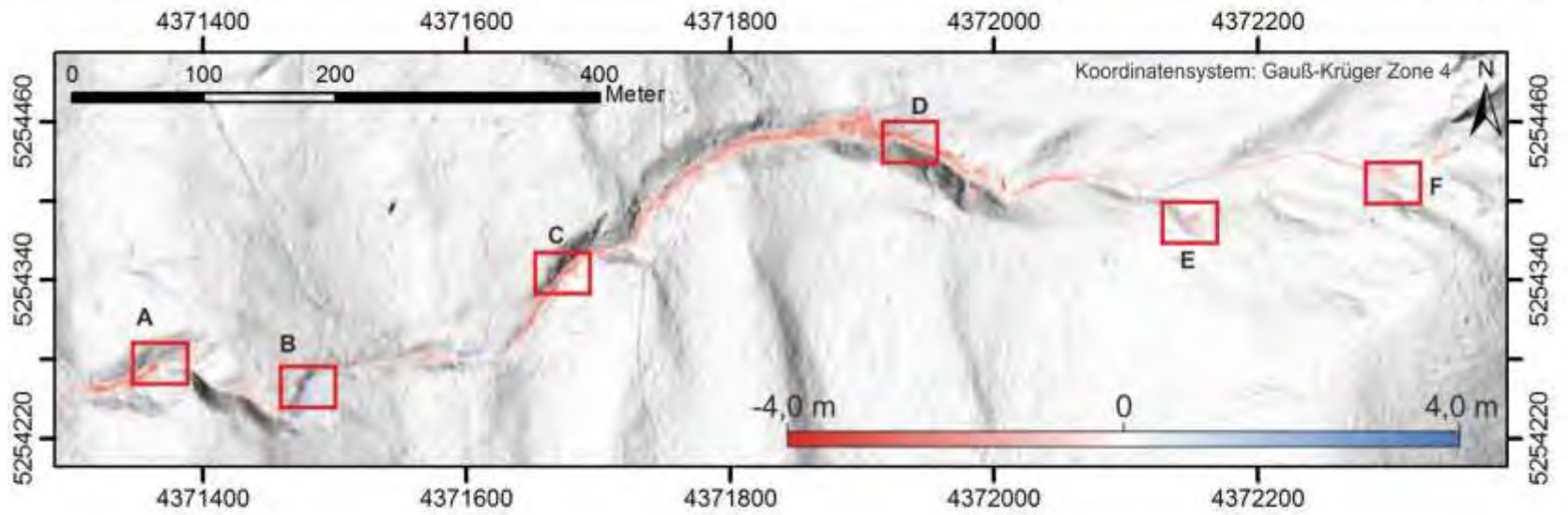


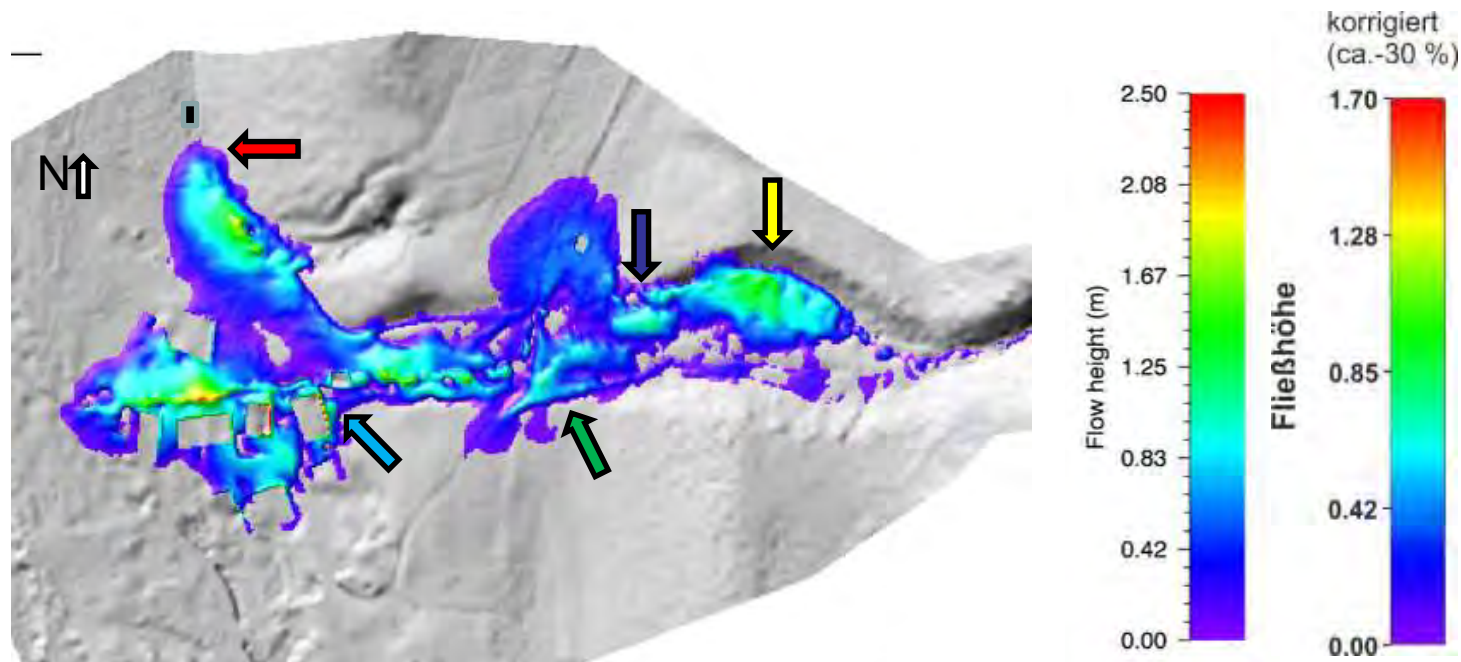
## Abschätzung zukünftiger Naturgefahren:

1. Degradierung Permafrost
2. Murgangaktivität
3. Steinschlagaktivität

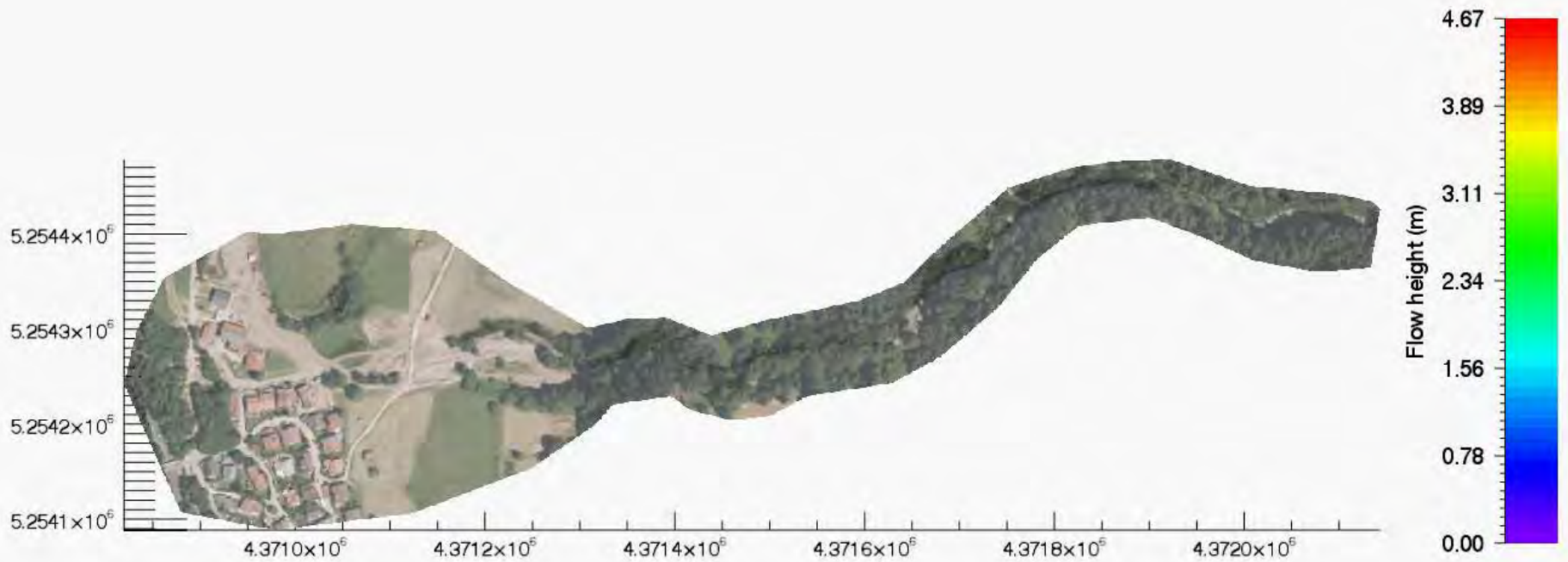


- 1 Volumenberechnung des mobilisierten Materials bei dem Murgang vom 14.06.2015
- 2 Simulation des Ereignisses vom 14.06.2015 mit RAMMS Debris Flow (= Kalibrierung)
- 3 Simulation eines möglichen zukünftigen Ereignisses unter Berücksichtigung der geplanten baulichen Schutzmaßnahmen





Gute Übereinstimmung von tatsächlichen und simulierten Ablagerungshöhen



## Abschätzung zukünftiger Naturgefahren:

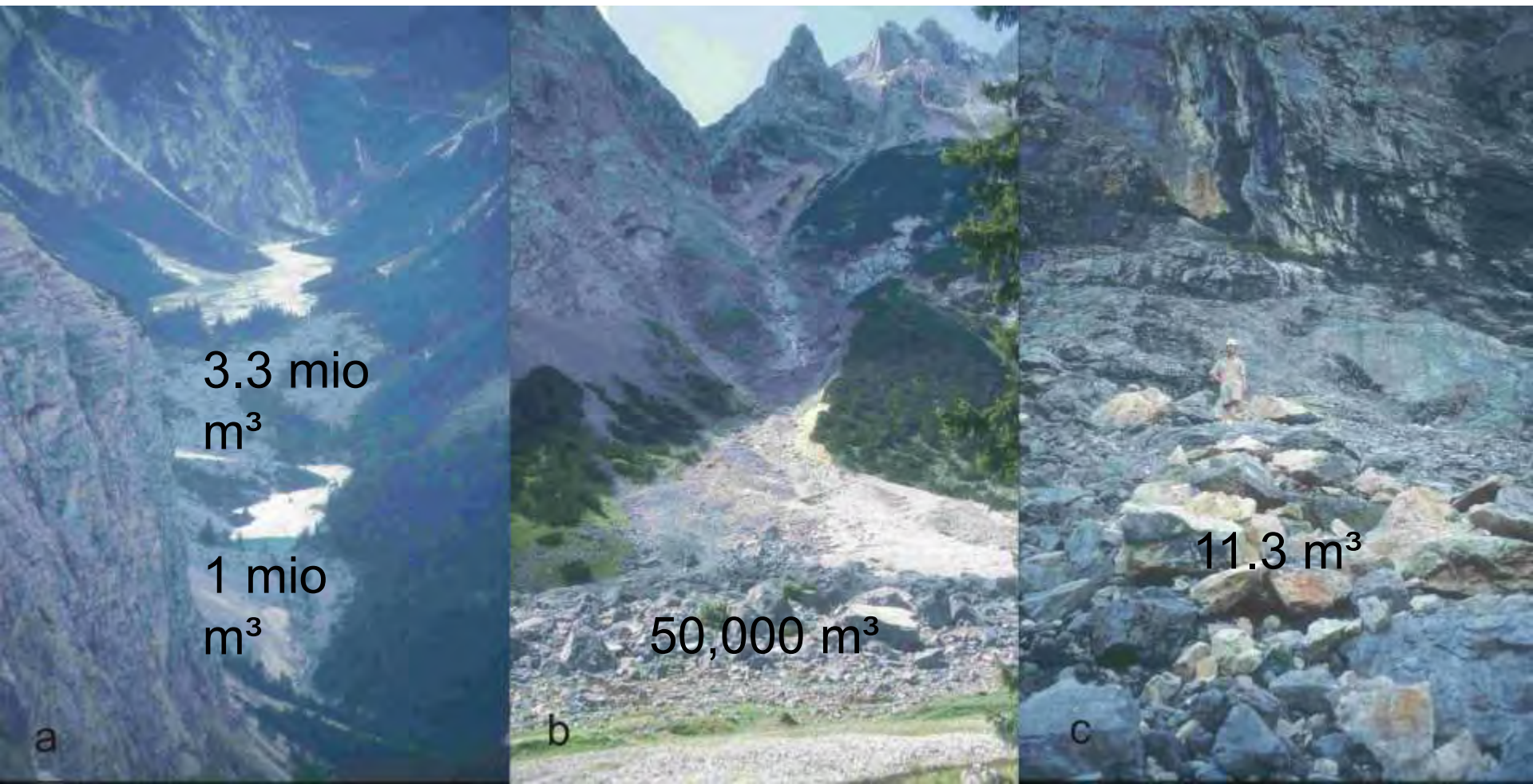
1. Degradierung Permafrost
2. Murgangaktivität
3. Steinschlagaktivität

Study site: Reintal, German Alps, 1050-2700 m a.s.l.



# Mid and high-magnitude rockfalls

- Bergsturz events ( $> 1$  mio.  $m^3$ ): C14 dating and historical documents
- Cliff falls: ( $10,000 m^3$ - $1$  mio.  $m^3$ ) scientific record since 1920 (Leuchs, 1921)
- Block falls: ( $100$ - $10,000 m^3$ ): detailed volumetric record 1998-2003 (overall  $1,500 m^3$ )
- Boulder falls: ( $10$ - $100 m^3$ ): detailed record 2002 and 2003





# Measurement of small-scale rockfall – spatial upscaling



## Measurements:

- 8 rockfall collector and 4 distance collectors
- Total 940 m<sup>2</sup>
- Measurement 2000-2003; daily to weekly measurements in 2002 und 2003
- 140 t rockfall

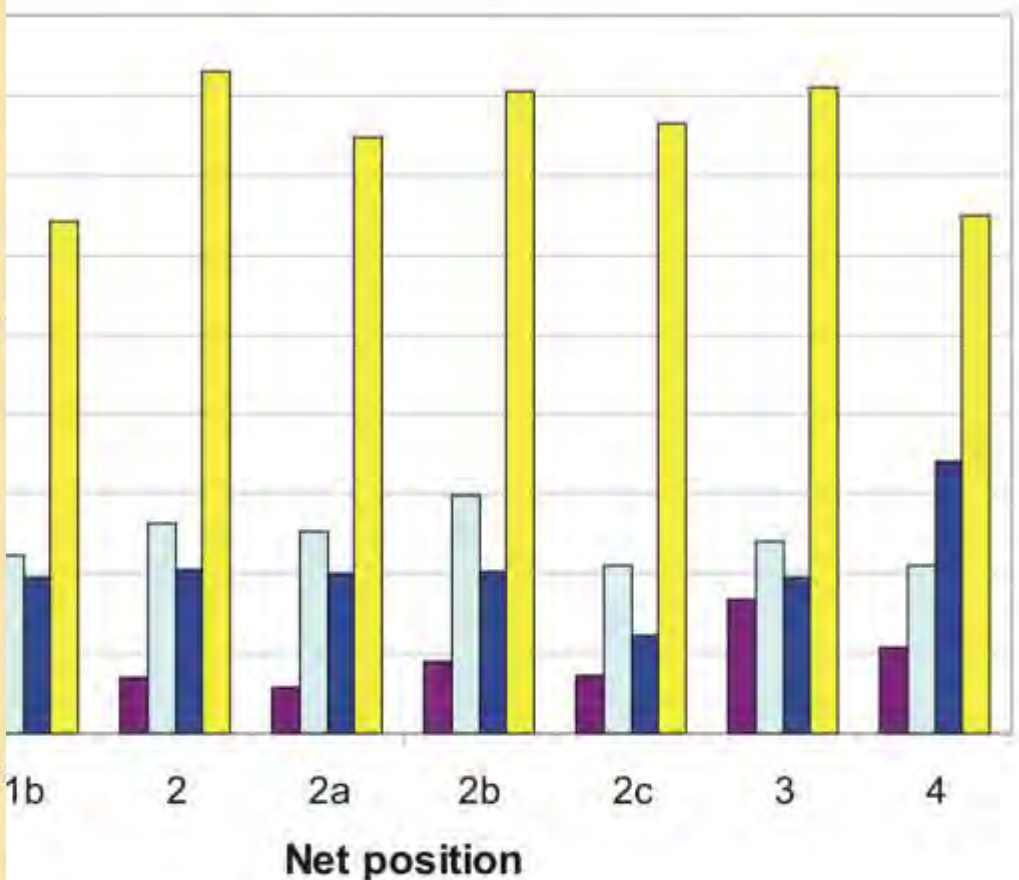
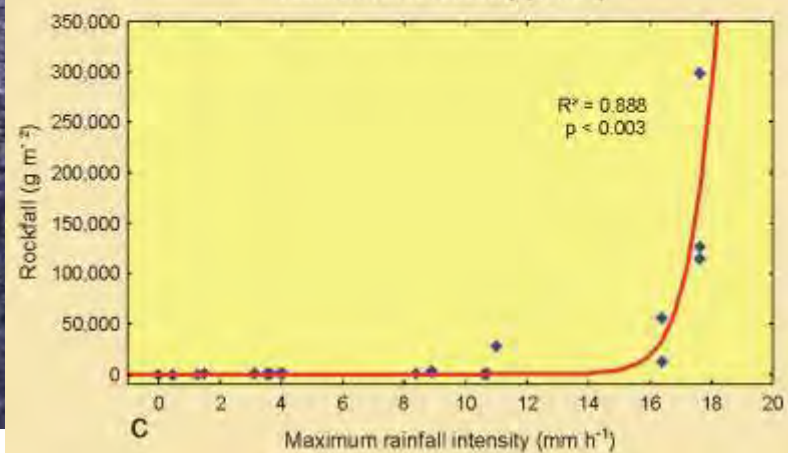
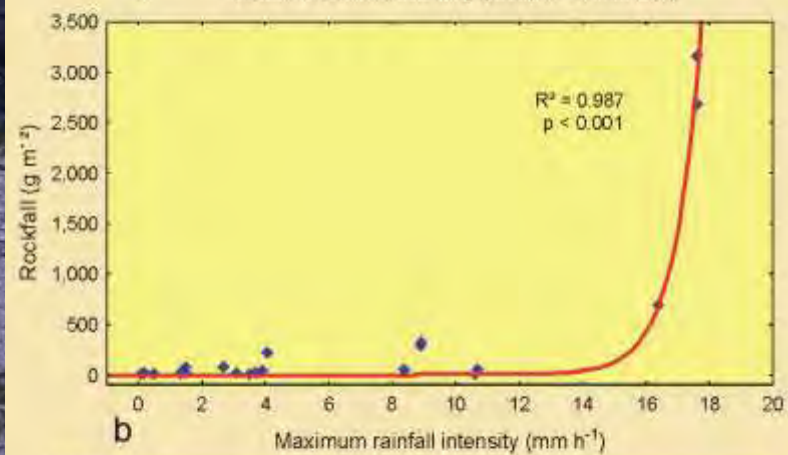
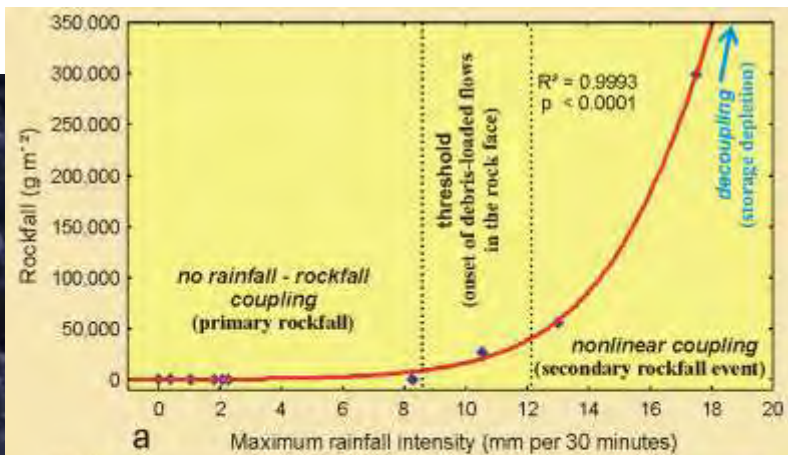
## Upscaling:

- Empirical function of distal reduction of rockfall with distance from the rock face.
- Rockfall intensity function independent of collector dimensions and -position.
- Upscaling-prone rockfall function for daylighted and horizontal bedding (two rock face sections).

*Krautblatter et al. 2012, Geomorphology*

56 tons of rockfall in net 1a, June 14, 2003





under conditions (no frost action, little or no precipitation)  
 value of a year without a rainstorm exceeding 10 mm/30 min  
 freeze-thaw conditions (net 4 receives direct sun radiation)  
 "secondary rockfall event" (rainstorm >13 mm/30 min)

# Zusammenfassung

## Permafrostdegradierung im Bereich alpiner Infrastruktur

- Geophysikalisches Monitoring ermöglicht schnelles Erkennen
- Mechanische Versuche zur Abschätzung der Wirkung
- Mechanische Fels-Eis mechanisches Modell in Entwicklung

## Murgangaktivität

- Modelle zur Abschätzung der Murgangmobilisierung und des –Impakts

## Steinschlagaktivität

- Verbesserte Vorhersage über „radar nowcast“ und kinematische Versagensmodelle in Zukunft

**Enge Zusammenarbeit Bau Geo Umwelt im Bereich alpine Naturgefahren für bessere Planungssicherheit beim Bauen im alpinen Raum**

## Mechanics:

- Pudasaini, M. & Krautblatter, M. (2014). **A two-phase mechanical model for rock-ice avalanches.** *J. Geophys. Res. – Earth Surface*.
- Krautblatter, M., Funk, D. & F.K. Günzel (2013): **Why permafrost rocks become unstable: a rock-ice-mechanical model in time and space** *Earth Surf. Process. Landforms* 38, 876-887.

## Seismics in permafrost rocks:

- Krautblatter, M. and Dräbing, D. (2014). **Pseudo 3D - P-wave refraction seismic monitoring of permafrost in steep unstable bedrock.** *J. Geophys. Res. – Earth Surface* VOL. 118, 1–13.
- Dräbing, D. and Krautblatter M. (2012). **P-wave velocity changes in freezing hard low-porosity rocks: a laboratory-based time-average model.** *CRYOSPHERE*, 6 (5), 1163-1174.

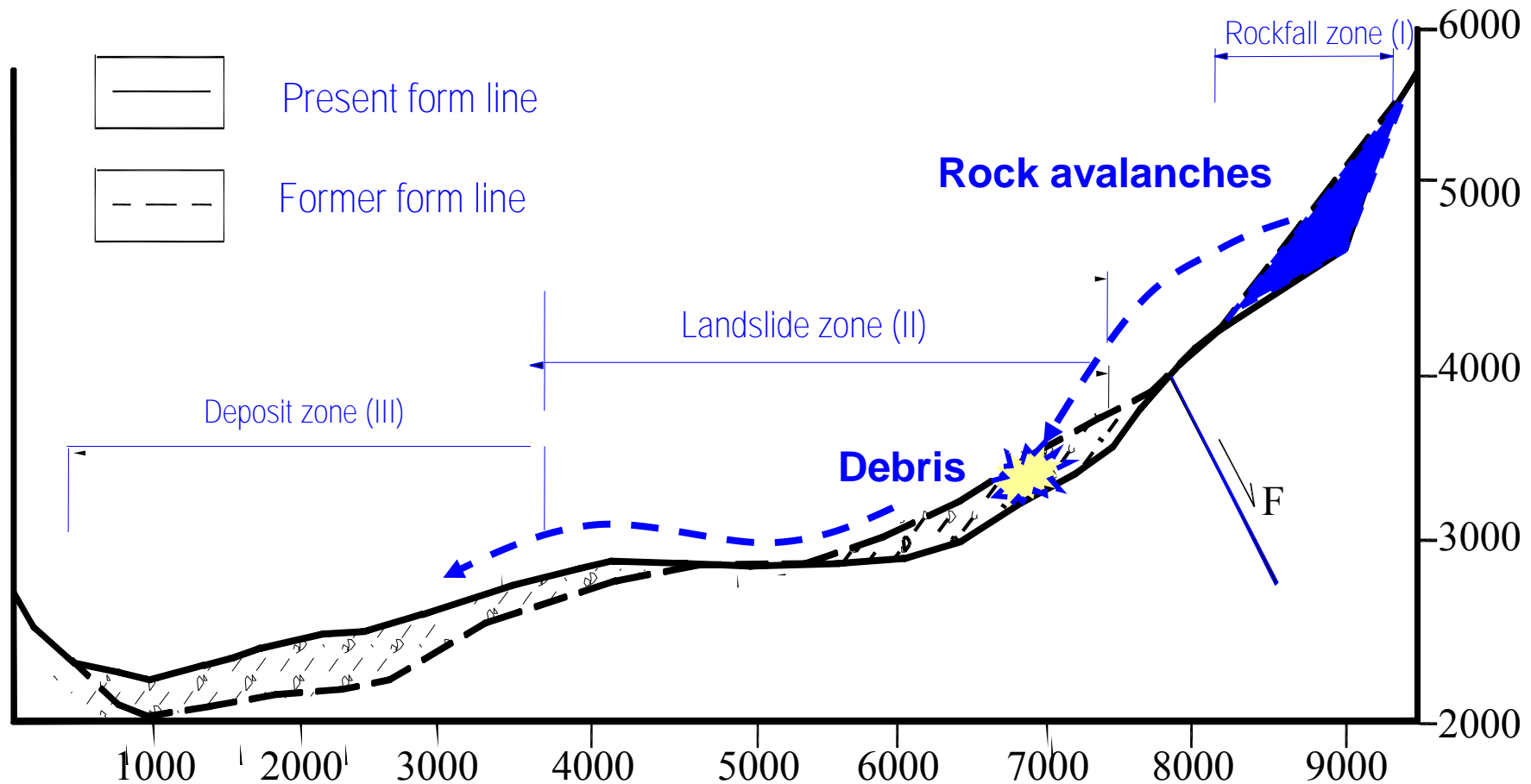
## Electrical resistivity tomography:

- Krautblatter, M., Verleysdonk, S., Flores-Orozco, A. and Kemna, A. (2010). **Temperature-calibrated imaging of seasonal changes in permafrost rock walls by quantitative electrical resistivity tomography (Zugspitze, German/Austrian Alps).** *J. Geophys. Res. - Earth Surface*.
- Krautblatter, M. and Hauck, C. (2007): **Electrical resistivity tomography monitoring of permafrost in solid rock walls.** *Journal of Geophysical Research - Earth-Surface*, 112.

## System:

- Krautblatter, M. and Moore J. (2014). **Rock slope instability and erosion: toward improved process understanding.** *Earth Surface Process. Landforms*.
- Krautblatter, M., Huggel, C., Deline P. and Hasler A. (2012): **Research perspectives for unstable high-alpine bedrock permafrost: measurement, modelling and process understanding.** *Perm. and Periglac. Process*.

by Runqiu Huang



Rockfall at the top of the mountain  $\triangleright$  Avalanches to the bottom of the gully, the falling distance is almost 1500m  $\triangleright$  punching the debris in the gully , produce **excess pore water pressure**  $\triangleright$  long distance travelling and **air-cushion mechanism** involved.