Analysis of erosion rates and geomorphological processes on Little Ice Age lateral moraines

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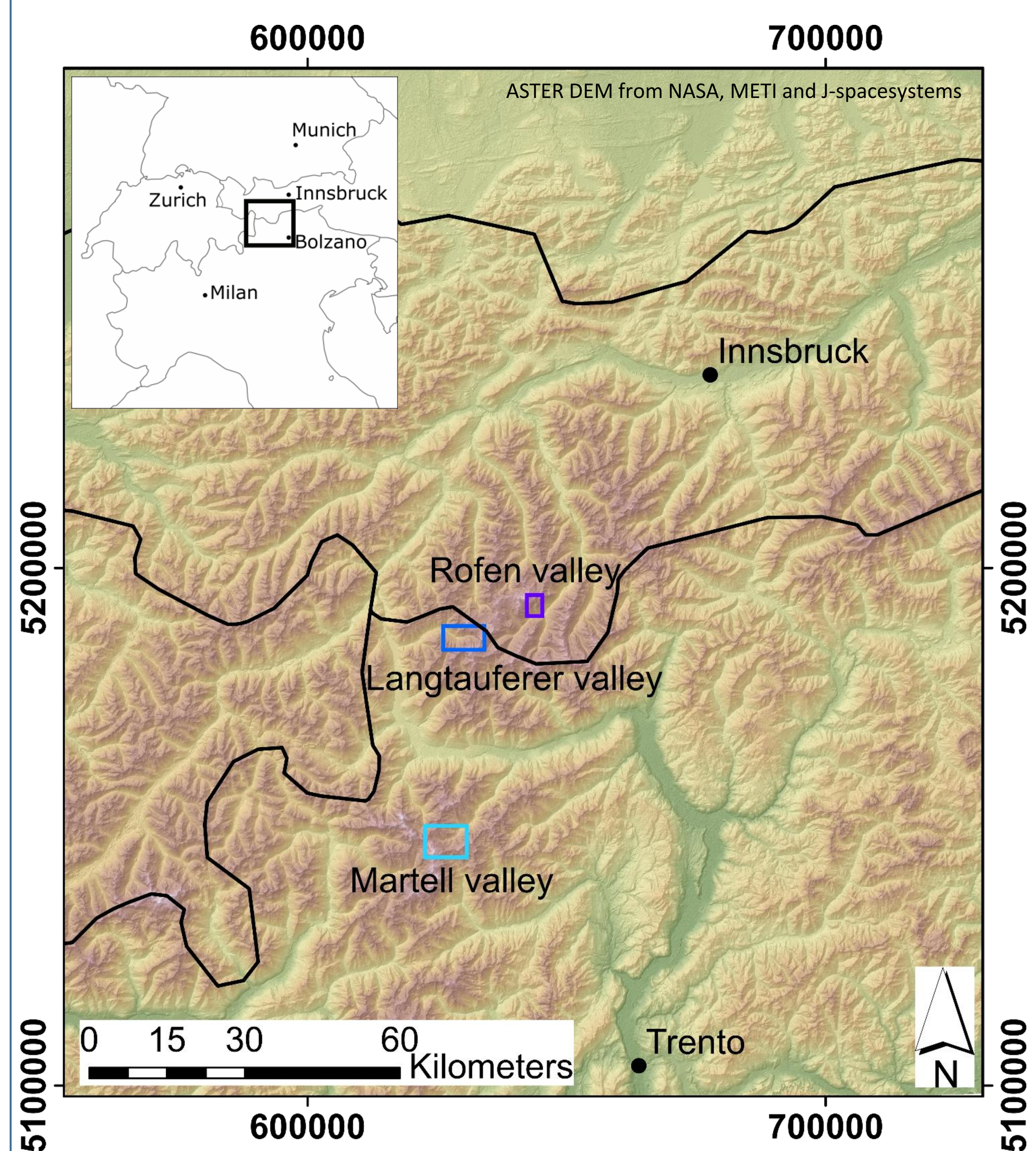
1 Background

Several processes are involved in the reworking of sediment on steep lateral moraines after deglaciation, e.g. sheet erosion by snow gliding, debris flows and gullying [1, 2, 3]. The temporal development of the morphodynamics after deglaciation depends on the abundance of loose sediment, the presence of dead ice in the slope and the altitude a.s.l. of the respective slope, amongst others. We analysed geomorphological activity and processes occurring on test areas situated at different distances from the present-day glacier termini in three glacier forefields in order to gain deeper insight into the dependence of the morphodynamics on the time since deglaciation.

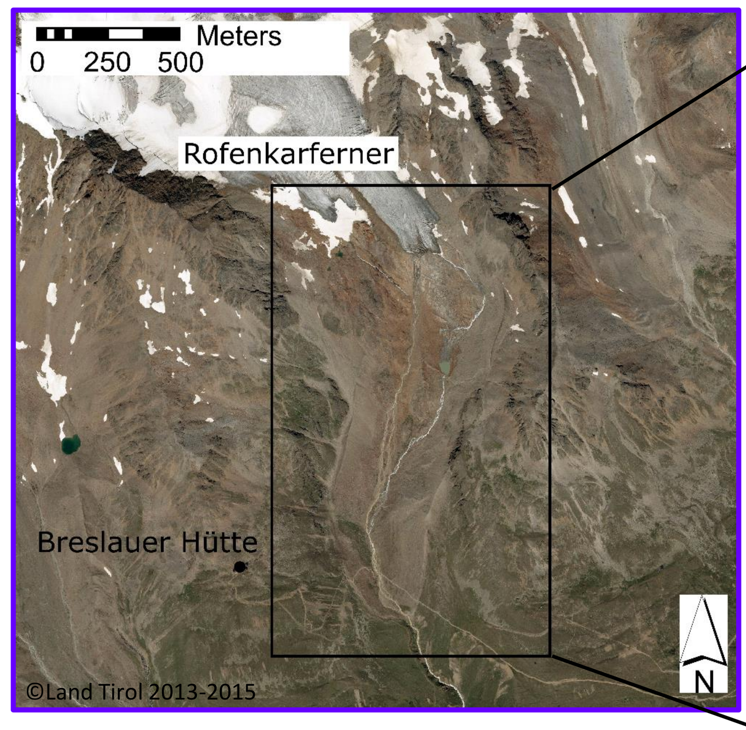
2 Study Area

The three investigated moraine tracts are situated in the Rofen valley (Rofenkarferner, Oetztal), the Langtauferer valley (Langtauferer Ferner) and in the Martell valley (Hohenferner).
All catchments are characterized by an inner-alpine climate and metamorphic rocks (Oetztal complex and Ortler-Campo Crystalline, respectively).

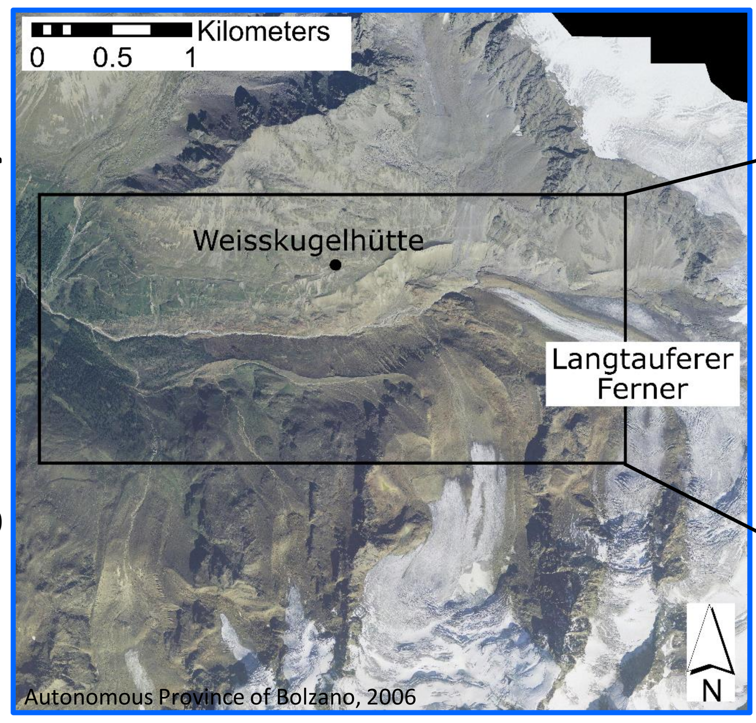


The glaciers show different aspects: While Rofenkarferner is south-exposed, Langtauferer Ferner is west-exposed and Hohenferner north-exposed, with corresponding exposition of the moraine tracts. In each glacier forefield two sections of the moraine tract were selected as test areas for further analyses.

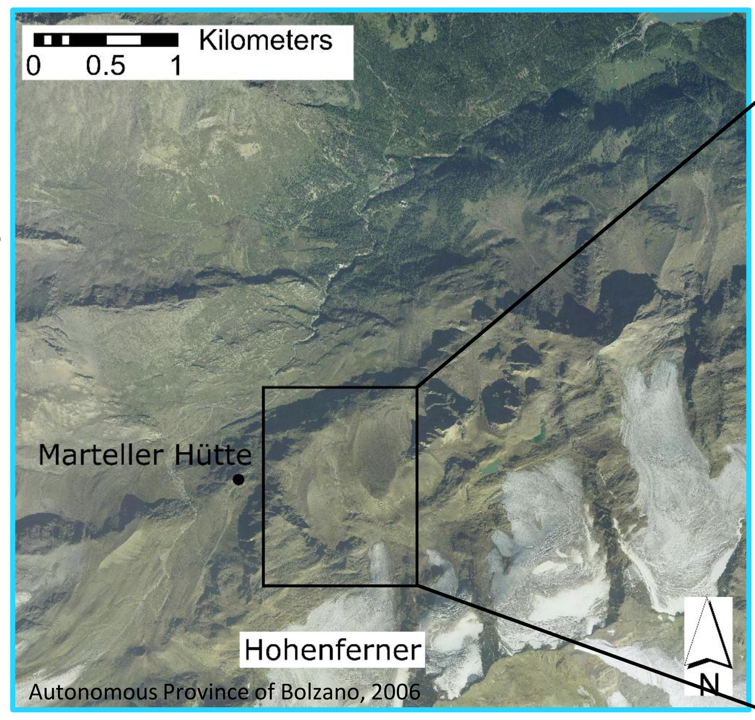
Rofen valley



Langtauferer valley



Martell valley



3 Methodology

Tachymeter + GPS:
In the field, ground control points were measured with a tachymeter and a GNSS antenna.

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Drone and Historical Images:
For each test area, aerial photographs were taken by a drone (Phantom 4 Pro) in summer 2017 and 2018. Moreover, aerial historical images were analysed.

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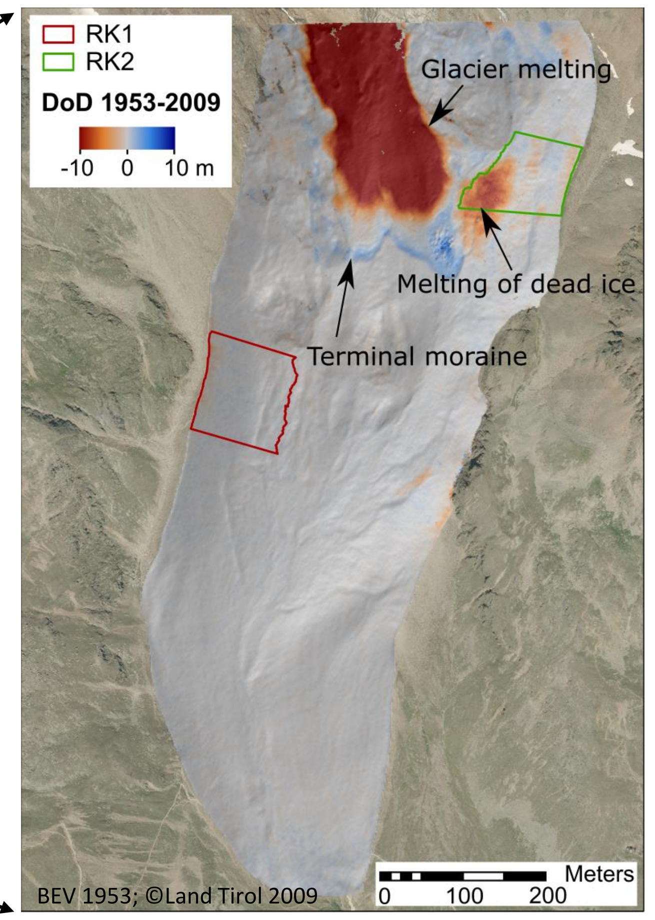
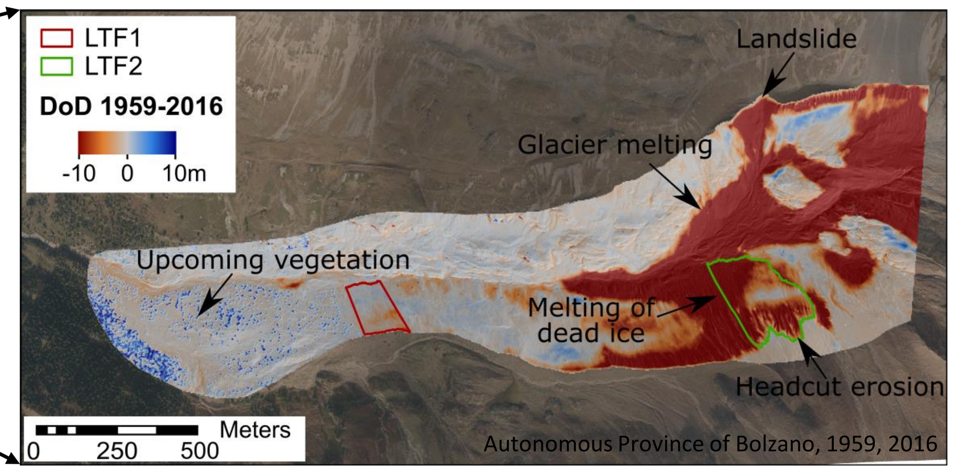
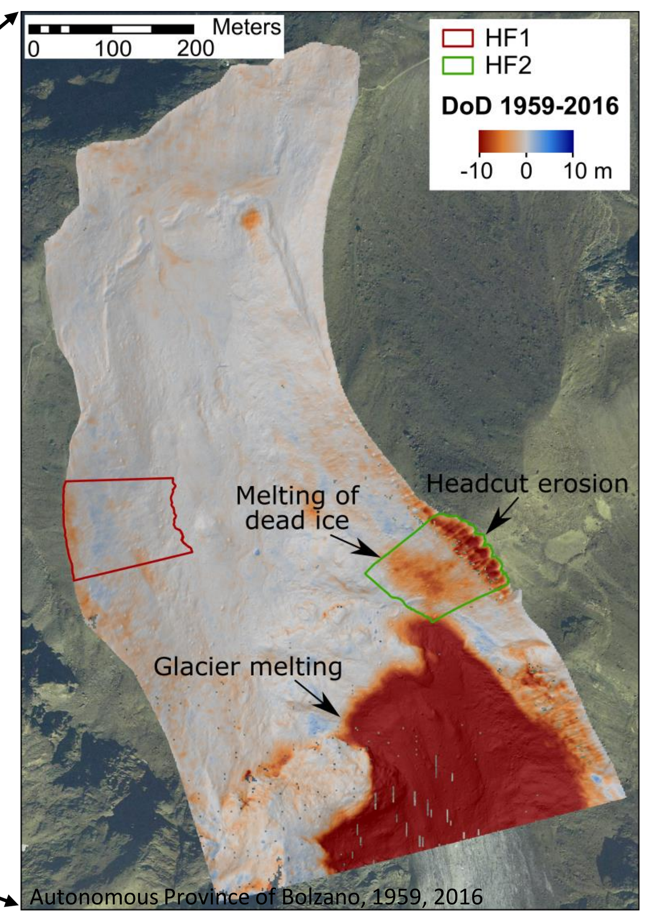
Photogrammetry:
All the aerial images were processed in Agisoft Photoscan and Digital Elevation Models (DEMs) and DEMs of Difference (DoDs) were generated.

4 Results

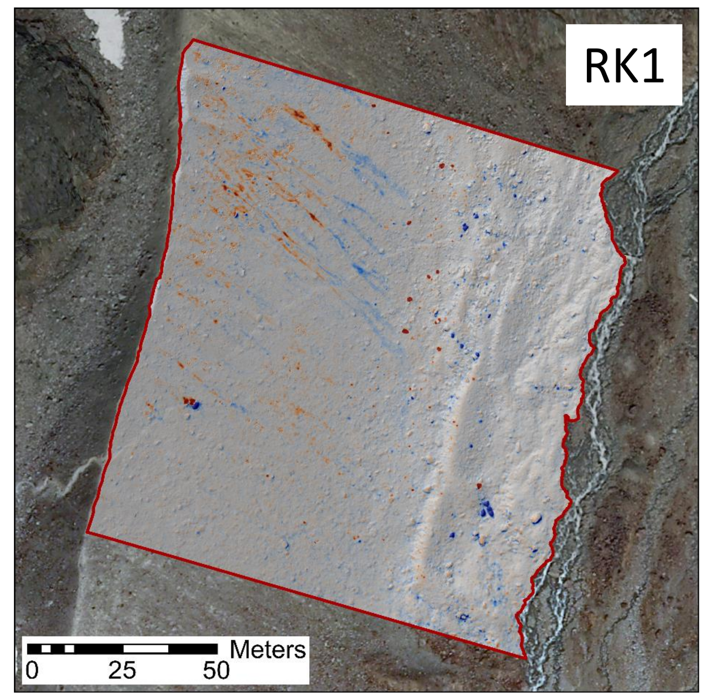
Historical images (1950s-2000s)

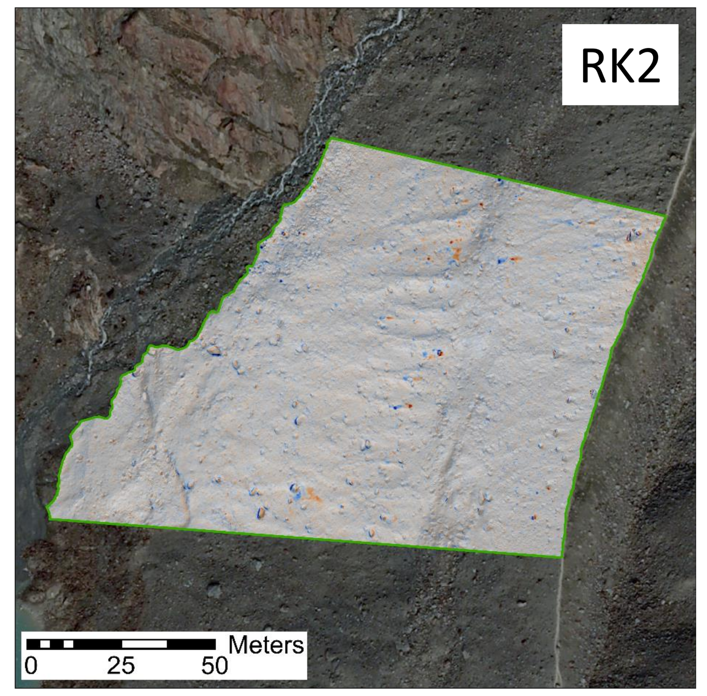


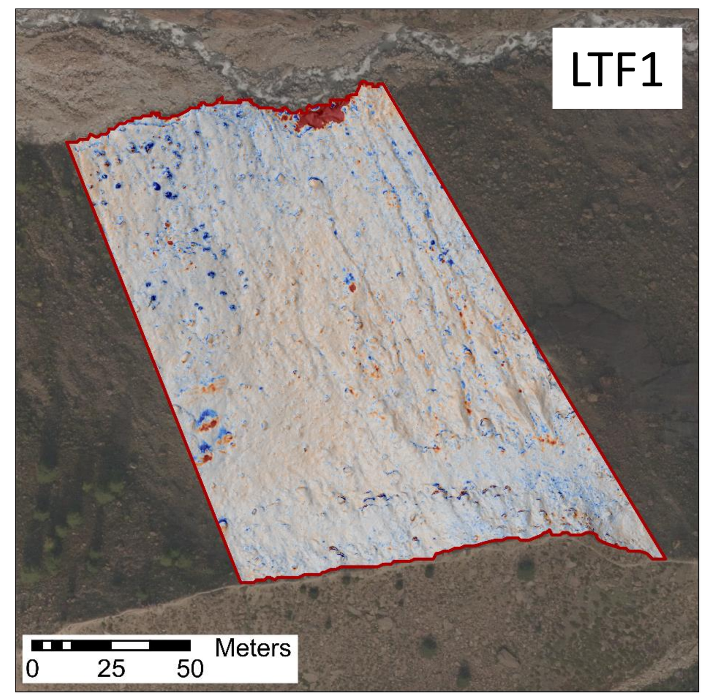


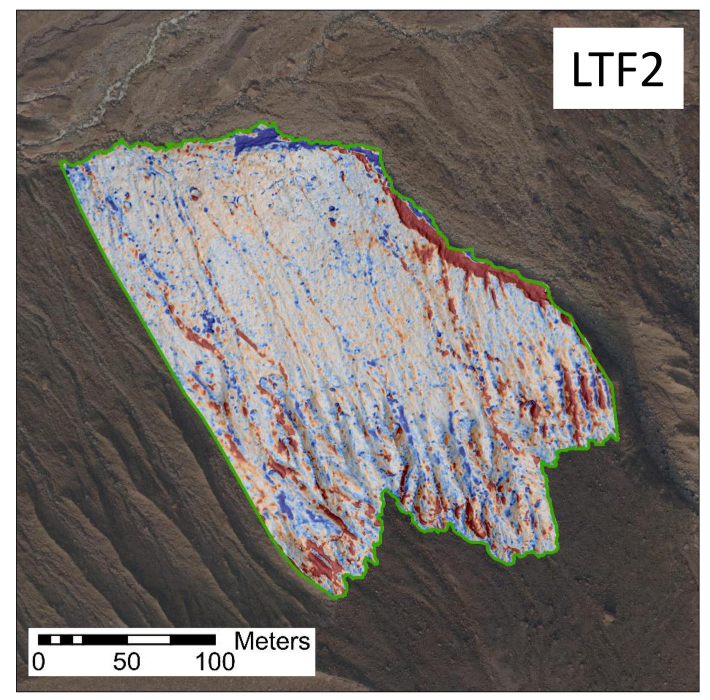


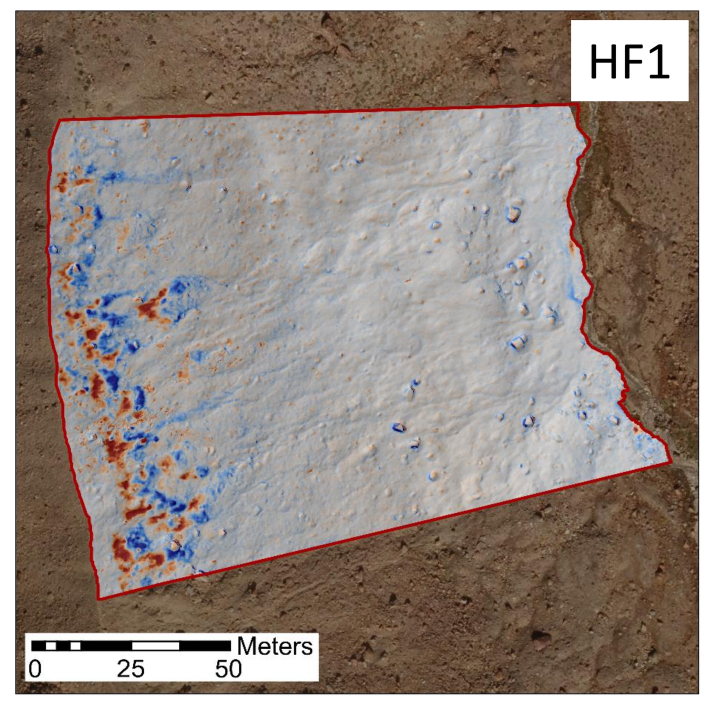
Drone images (2017-2018) -0.3 0 0.3 m

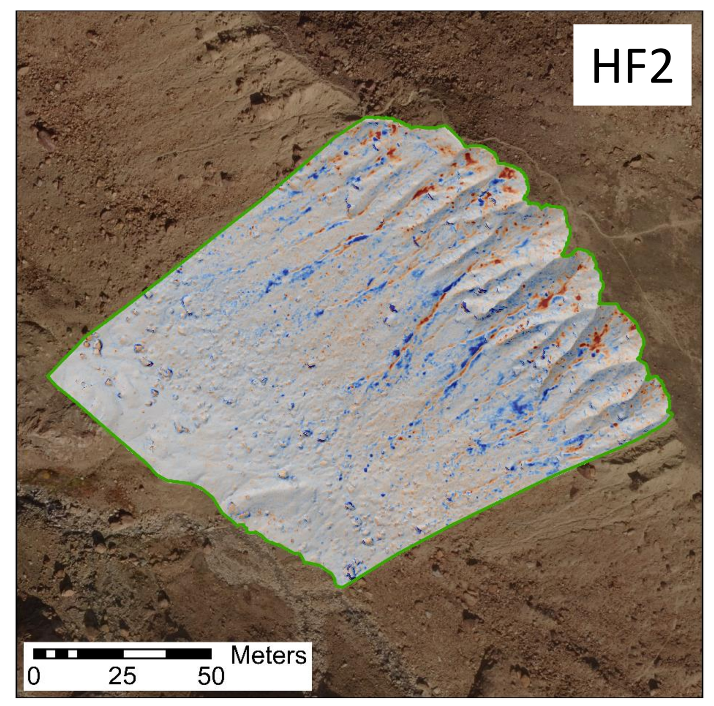












Altitude a.s.l., time since deglaciation; prevailing processes 2017-2018

RK1 (2757-2856 m a.s.l.; 90-120 yrs):
Small fluvial processes

RK2 (2856-2962 m a.s.l.; 28 yrs):
Only displaced stones

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Never high morphodynamics

LTF1 (2183-2320 m a.s.l.; 102 yrs):
Undercutting by the stream

LTF2 (2380-2601 m a.s.l.; 59 yrs):
Debris flows, headcut erosion, undercutting by the stream

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One area stabilized, the other not yet

HF1 (2658-2734 m a.s.l.; 76 yrs):
Sheet erosion by snow

HF2 (2710-2796 m a.s.l.; 21 yrs deglaciated):
Debris flows, headcut erosion

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Both areas not yet stabilized

5 Discussion

- Some moraine slopes stabilize decades after deglaciation; however, other moraine sections deglaciated a long time ago keep staying active
- Thawing of dead ice leads to a destabilization of the slopes implicating high morphodynamics and it can have an influence for many decades
- Factors as the altitude a.s.l. have an influence on the processes occurring, but several other parameters also influence the morphodynamics

References: [1] Ballantyne, C. K. (2002): Paraglacial geomorphology. – Quat. Sci. Rev. 21 (18): 1935-2017.
[2] Curry, A. M. (1999): Paraglacial modification of slope form. – Earth Surf. Process. Landf. 24 (13): 1213-1228.
[3] Mortara, G. & Chiarle, M. (2005): Instability of recent moraines in the Italian Alps. Effects of natural processes and human intervention having environmental and hazard implications. – G. Geol. Appl. 1: 139-146.