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Quantifying proglacial morphodynamics and sediment budgets - the PROSA approach

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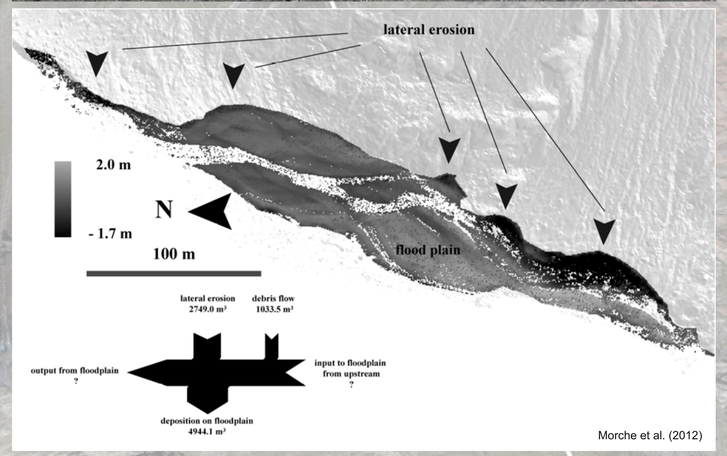
Process rates and budgets along the channel network



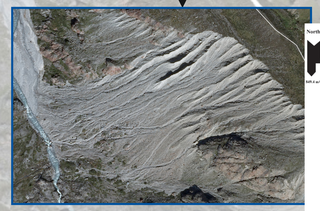
Morche et al. (2012)

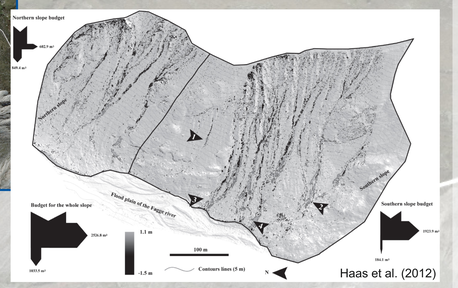
Marked channel changes following a 50-year flood in August 2011 are visible on photographs A DEM of difference (below photographs) indicates surface changes effected by the same event. Storage landforms east of the floodplain were undercut, and debris flows on the lateral moraines delivered sediment to the floodplain (see ‚debris flows' section).
While in- and output of this reach are unknown, these results indicate that the floodplain acted as a sediment storage (Morche et al., 2012). The braidplain reaches will be monitored by repeat LiDAR surveys.

Process rates and budgets on hillslopes: Debris flows, rill erosion, slope wash

Repeat terrestrial LiDAR measurements will be conducted in order to detect and quantify surface changes on the heavily dissected lateral LIA moraines. Monitoring will also reveal the degree to which slopes and channel are coupled.

Preliminary results (Haas et al. 2012) show that debris flows are triggered by heavy rain. The figure below shows a summary of surface changes and the sediment budgets on two slopes (c. 0.3 km² in total), quantified using scour-and-fill analysis of two terrestrial LiDAR DEMs (August 25th, 2010 and September 24th, 2011). The investigation period contains, among others, a rainstorm which triggered a flood with a return period of c. 50 years. The same event triggered small debris flows on the steep lateral moraines which amount to c. 3560 m³. Lateral connectivity appears to be low, resulting in 71% of this volume being redeposited on secondary paraglacial fans at the footslope of the lateral moraine, while only 29% reached the channel network.





Haas et al. (2012)

The PROSA approach to establishing the proglacial sediment budget

Objectives Tools Challenges

We expect important results with respect to these research problems:
* Contribution and relative importance of different geomorphic processes, e.g. glacial vs. non-glacial processes, to sediment budget
* Dependence of sediment flux/yield on time since deglaciation
* Potential impact of continuing glacier retreat on process activity and downstream sediment transport

	Tools	Challenges
Quantification of the sediment flux within the study area. Comparison of rates of different geomorphic processes Morphodynamics depending on time since deglaciation	Field measurements: * surveying (terrestrial LiDAR, dGPS, total station * gauges * extensiometers * collector nets * ... Chronosequences (space-for-time-subst.)	* Field methods operate on the plot/hillslope scale * Accuracy, precision and resolution of measurements to reveal short-term surface change and small morphodyn. differences * coregistration of TLS epochs
Upscaling of local findings to catchment scale	* measurement on catchment scale (aerial LiDAR) * geomorphological map * numerical models that delineate (potential) process domains	* Precision and resolution of measurements * coregistration of TLS and ALS data (multiple epochs) * Calibration of models
Combining results to establish a sediment budget of the proglacial area	* Connectivity assessment based on geomorph. map and modelling * gauging sediment yield at the outlet of the proglacial area * balancing results with annual delta aggradation in Gepatsch reservoir	* contribution of local sediment flux to sediment budget depends on connectivity

Background

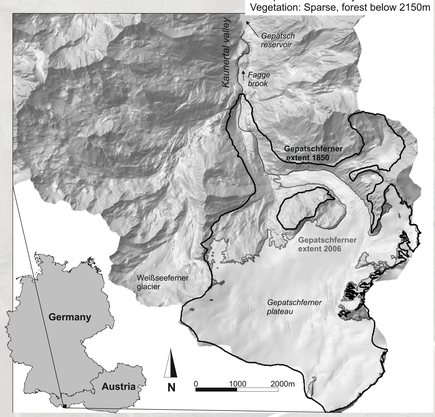
The formation of paraglacial sediment storage landforms from the erosion or (re-)mobilisation of glacigenic sediments (e.g. moraines), and the successive reworking of the latter, are being witnessed at great intensity in the forefields of alpine glaciers, within the area that has become ice-free since the end of the LIA, which we refer to as the proglacial area.
While single processes have been the subject of several case studies, field studies of proglacial areas including multiple processes, their rates and interactions are rare.

The PROSA joint project (High-resolution measurements of morphodynamics in rapidly changing **PRO**glacial **S**ystems of the **A**lps; 2011-2015) aims at establishing the proglacial sediment budget with respect to different geomorphic processes. It will employ high-resolution surveying methods to quantify surface changes and sediment fluxes, including terrestrial and aerial LiDAR. Hillslope-scale results will be upscaled using geomorphological maps and modelling approaches. Sediment output will be gauged at the outlet of the proglacial system and at a delta within the Kaunertal reservoir which can be LiDAR surveyed when the lake level is lowered in a controlled manner.

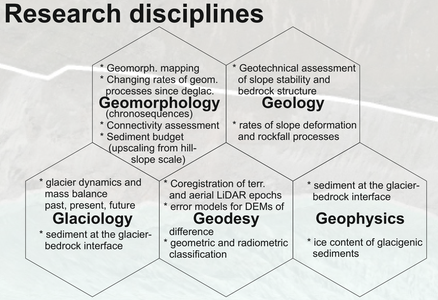
Study Area

Kaunertal / Gepatsch glacier

Catchment area: 62.5 km²
35% glaciated
Lithology: Siliceous para- and orthogneisses
Relief: 1759-3539 m
Precipitation: 800 mm/yr
Vegetation: Sparse, forest below 2150m



Research disciplines



Objectives

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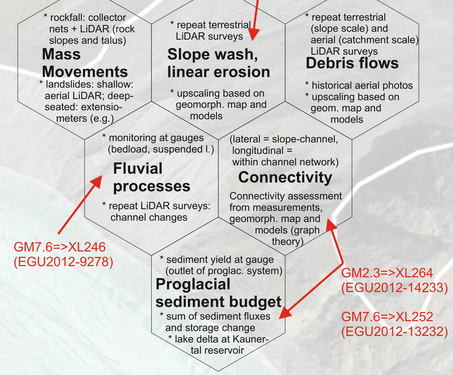

2009 glacier extent

LIA glacier extent