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Denudational surface processes and trends of relief development in mountain valleys in western Norway

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The various rates at which mountain landscapes are changing today are a response to (i) the long-term landscape history, (ii) the contemporary imprint of current tectonic activity, (iii) climate variability and (iv) anthropogenic influences. Large areas of the Norwegian mountainous fjord landscapes are today occupied by hillslopes which reflect the influence of glacial inheritance from the Last Glacial Maximum (LGM) as a direct response to climate variability during the Pleistocene. This study deals with the quantitative analysis of denudational slope processes and relief development occurring in selected mountain valleys in western Norway from the end of the LGM until today. The main focus of this research is two-fold: (i) analyzing the complexity of hillslope development since the LGM in glacially formed valleys, and (ii) assessing the spatio-temporal variability, controls and rates of relevant denudational slope processes operating under Holocene to contemporary environmental conditions in western Norway.

Five years of research (2009-2013) were conducted in two steep, parabolic-shaped and glacier-connected neighbouring drainage basins, Erdalen (79.5 km2) and Bødalen (60.1 km2), located on the western side of the Jostedalsbreen ice cap in western Norway. The process-based approach applied encompasses techniques and methods for geomorphic process analysis of past (e.g. DEM/GIS based spatial data analysis, geophysical investigation of slope storage) and contemporary (process monitoring in field, in-depth studies of relevant slope processes) denudational process activity.

The main results of this work reveal that the Holocene to contemporary slope processes and the connected relief development during this time period are primarily controlled by the imprint of the glacial history of the study areas which can be seen as a direct response to climate variability. Apart from that, a significant influence of the Little Ice Age (LIA) glacier advance on hillslope morphometry was discovered, with the LIA glacier advance causing higher intensities of post-LIA denudation on hillslope systems affected by the LIA glacier advance as compared to non-affected hillslope systems. Distinct differences are found between single headwater systems of the Erdalen and Bødalen drainage basins (i) regarding the absolute and relative importance of different contemporary slope processes as well as (ii) with respect to the importance of sediment delivery from headwater systems for the sedimentary budgets of the entire drainage basin systems. The detected differences are seen as a direct consequence of the varying glacially inherited valley morphometries which determine hillslope storage capacity, the average process transport distances and the intensity of hillslope-channel coupling.

A comparison to geomorphic process rates published for other cold climate environments situated at high latitudes of the northern hemisphere permits the statement that the general intensity of present-day denudational processes in Erdalen and Bødalen is in a comparable range of magnitude. Even though denudational slope processes are leading to an ongoing valley widening, the Holocene modification of the inherited glacial relief until today is regarded to be minor. The results from the two selected typical drainage basins are considered to be representative on a regional scale for the mountainous fjord landscape in western Norway.