Holistic approach for assessing spatio-temporal patterns of soil degradation in Swiss alpine grasslands

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Many grassland areas in the Swiss Alps are strongly affected by soil degradation due to various processes of soil erosion, intensified by the extreme prevailing topographic and climatic conditions. Furthermore, climate change is predicted to have a pronounced impact on the alpine regions causing not only higher temperatures but also a change in frequency and intensity of precipitation events as well as strongly altered snow dynamics. Together with changing land-use practices, an increase in soil degradation is expected. As such, monitoring tools to map soil erosion features with spatial and temporal resolution are urgently needed.

In the past, scientific studies mostly focused on one or two types of erosion processes (e.g. landslides, or rill or gully or sheet erosion) due to the different formation processes and the varying methods applied to capture these processes (e.g. mapping, measurements or modelling). However, in alpine areas all erosion processes occur and cause soil degradation. Therfore, a holistic approach to identify and map erosion features in alpine grasslands is needed. The study is conducted on catchment scale (Urseren Valley, Canton Uri) and allows for analysis over space and time due to the use of multiple orthophotos taken between 2000 and 2016. To map the degraded soil areas we apply Object-based Image Analysis (OBIA) to the orthophotos (SwissImage). The semi-automated workflow profits from the high spatial resolution of the orthophotos (0.5 - 0.25m) and takes into account spectral, spatial, contextual and textural image properties as well as ancillary information gained from digital elevation models. In addition to the mapping of the erosion features, the sites are classified according to their prevailing erosion process (shallow landslides, sheet erosion) or their triggering factor (live-stock trails, management effects).

The temporal analysis of the mapped sites shows an overall increase in degraded areas for all erosion types in the Urseren Valley. Spatial analysis reveals a high dynamic within the catchment, highlighting areas especially prone to newly emerging erosion, such as lower areas on south-facing slopes intensely used for pasturing or steep slopes susceptible to landslides. Additionally, an increasing amount of live-stock trails is observed which will eventually lead to larger areas affected by sheet erosion over time through trampling and grazing.

The results provide an extensive understanding of the ongoing degradation processes over time as well as their spatial distribution and as such the technique may serve as a tool to improve our comprehension of the status and trends of alpine grassland soil degradation.