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Long-term vegetation development in context of morphodynamic processes since mid-19th century

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The availability of comprehensive aerial photography is limited to the mid-20th century, posing a challenge for quantitatively analyzing long-term surface changes in proglacial areas. This creates a gap of approximately 100 years, spanning the end of the Little Ice Age (LIA). Employing digital monoplotting and historical terrestrial images, our study reveals quantitative surface changes in a LIA lateral moraine section dating back to the second half of the 19th century, encompassing a total study period of 130 years (1890 to 2020). With the long-term analysis at the steep lateral moraines of Gepatschferner (Kauner Valley, Tyrol, Austria) we aimed to identify changes in vegetation development in context with morphodynamic processes and the changing climate.

In 1953, there was an expansion in the area covered by vegetation, notably encompassing scree communities, alpine grassland, and dwarf shrubs. However, the destabilization of the system after 1980, triggered by rising temperatures and the resulting thawing of permafrost, led to a decline in vegetation cover by 2020. Notably, our observations indicated that, in addition to morphodynamic processes, the overarching trends in temperature and precipitation exerted a substantial influence on vegetation development. Furthermore, areas with robust vegetation cover, once stabilised, were reactivated and subjected to erosion, possibly attributed to rising temperatures post-1980.

This study demonstrates the capability of historical terrestrial images to enhance the reconstruction of vegetation development in context with morphodynamics in high alpine environments within the context of climate change. However, it is important to note that long-term mapping of vegetation development through digital monoplotting has limitations, contingent on the accessibility and quality of historical terrestrial images, as well as the challenges posed by shadows in high alpine regions. Despite these limitations, this long-term approach offers fundamental data on vegetation development for future modelling efforts.