The imprint of glacial and periglacial erosion processes on fluvial landscape metrics

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Geodynamics.at ... understanding processes

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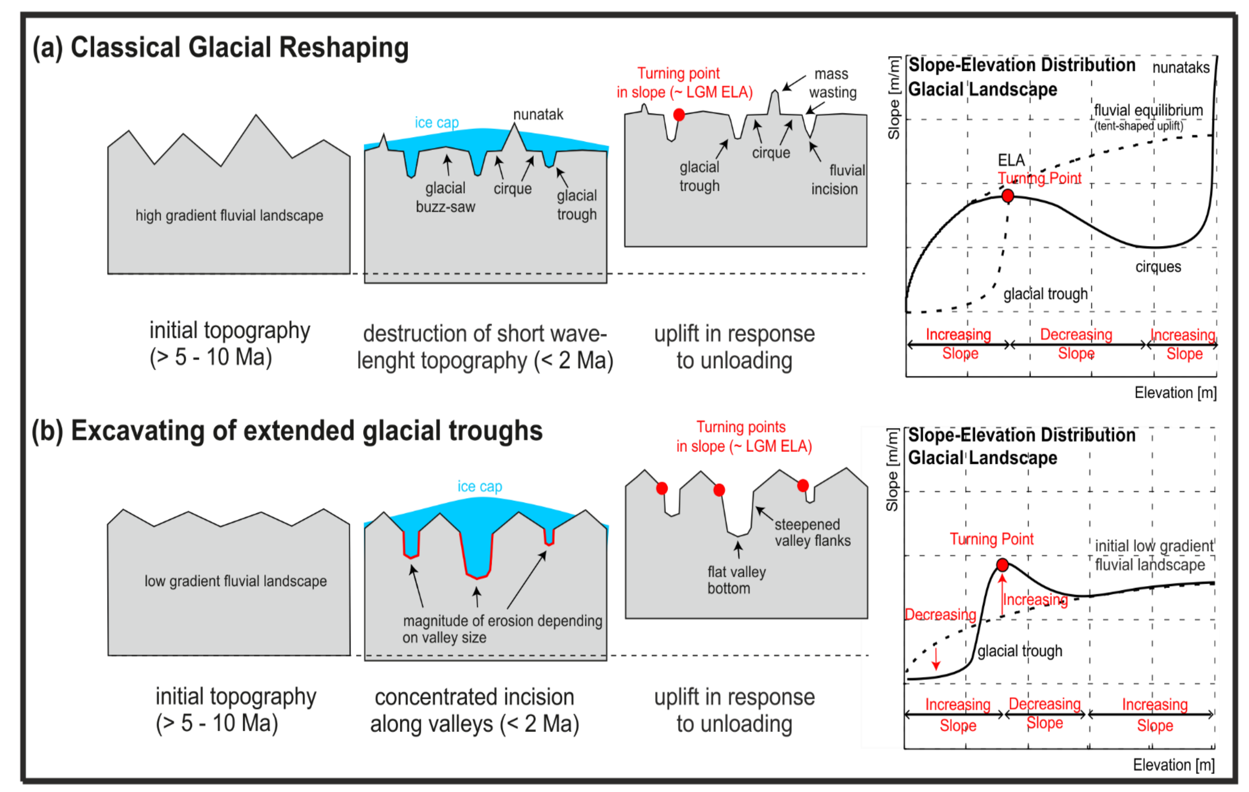
Motivation

It is still unclear:

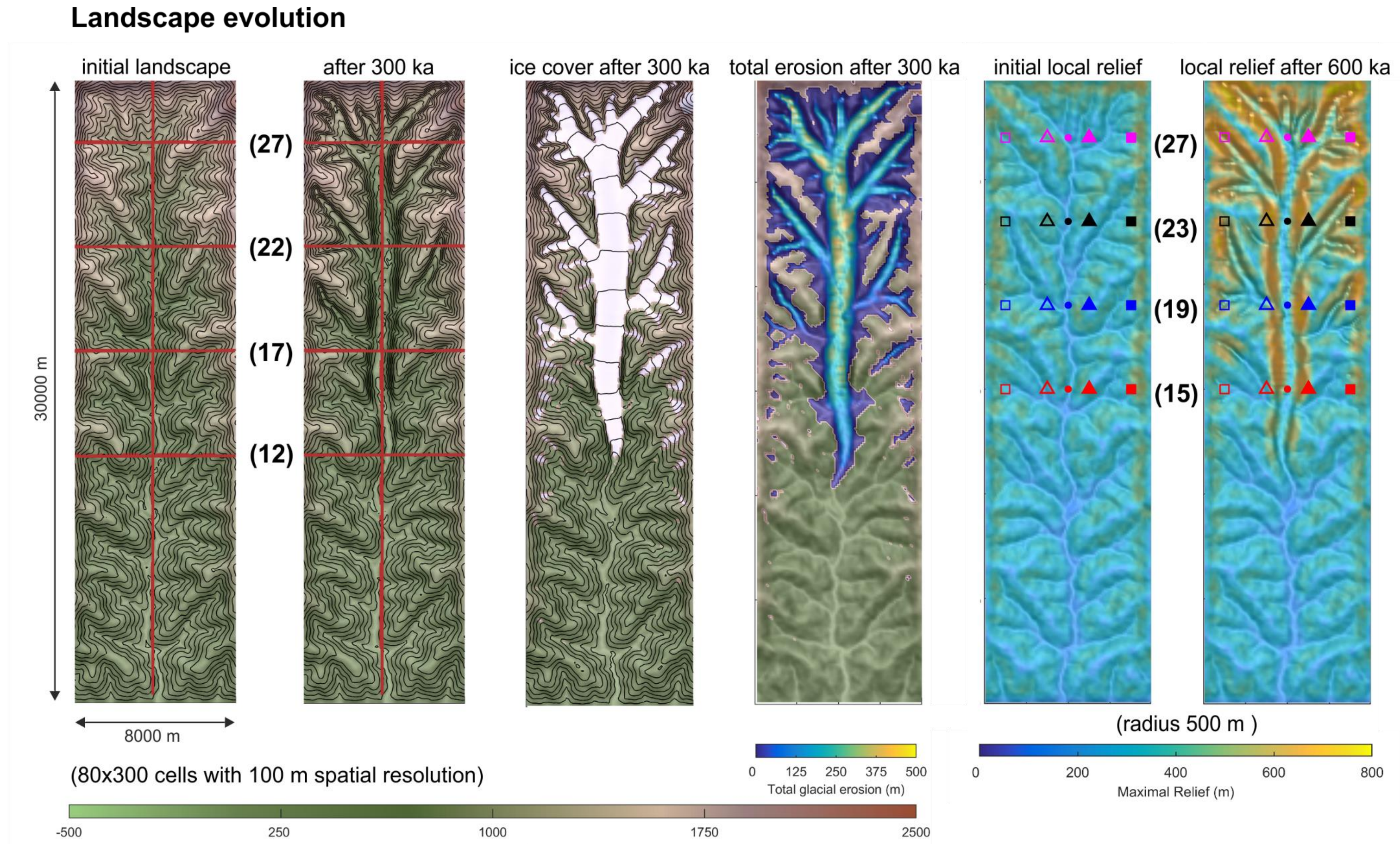
- how the formation of **cirques** above (including the potential destruction of peak relief) and the excavation of **glacial troughs** below the long-term snowline altered to the large-scale **topographic pattern** of mountain ranges originally conditioned by fluvial processes.
- how the **topographic feedbacks** influenced the (up to) million-year evolution of past and present glaciers.



Modelling cold surface processes

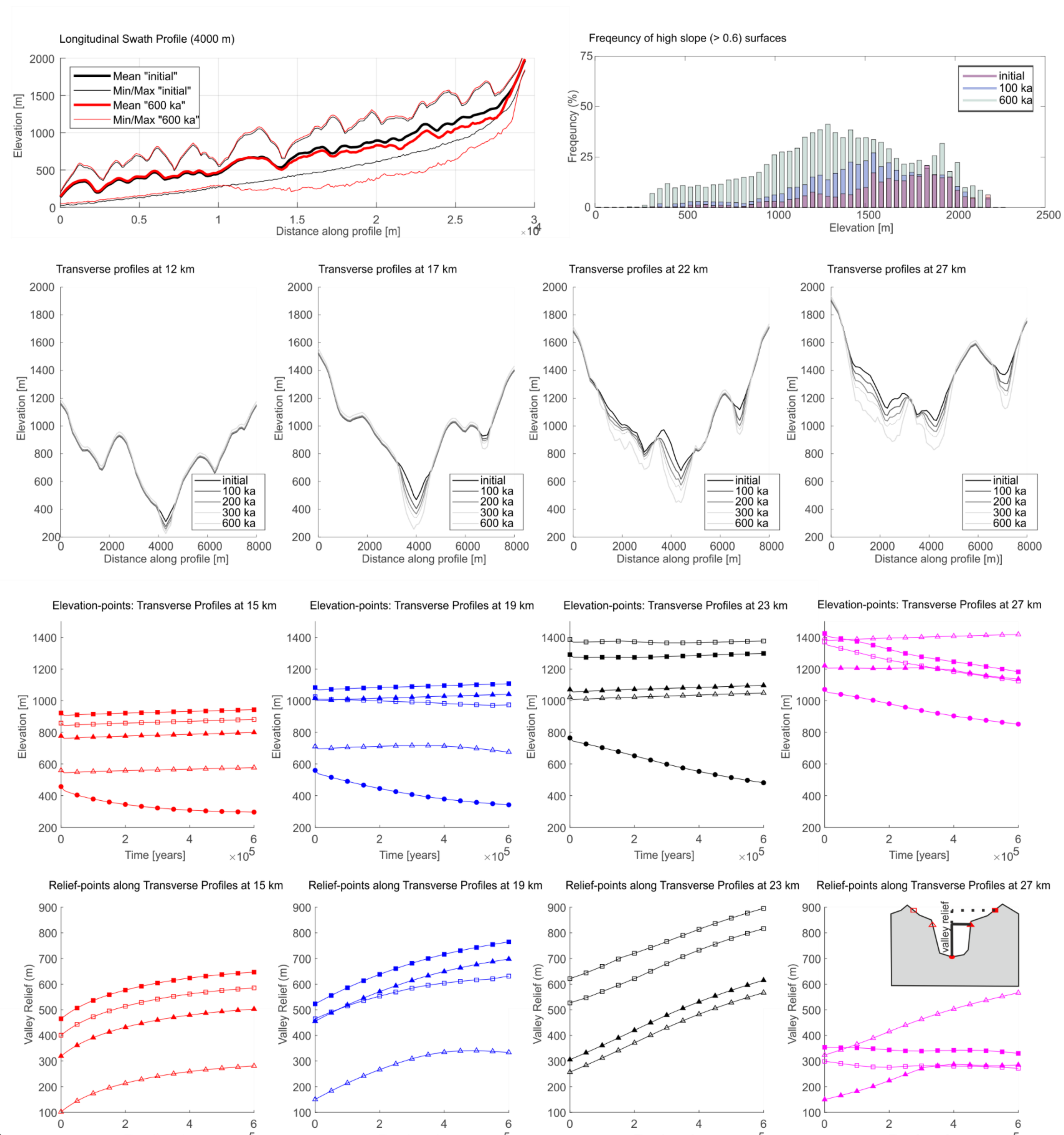
to integrate ice dynamics, climate, and erosion over million-year time scales. This might help us to understand how ice contributed to the shaping of Earth's surface. We investigate the evolution of the landscape's morphometry with the intention of discriminating the efficiency of glacial erosion at different spatial positions.

Landscape evolution



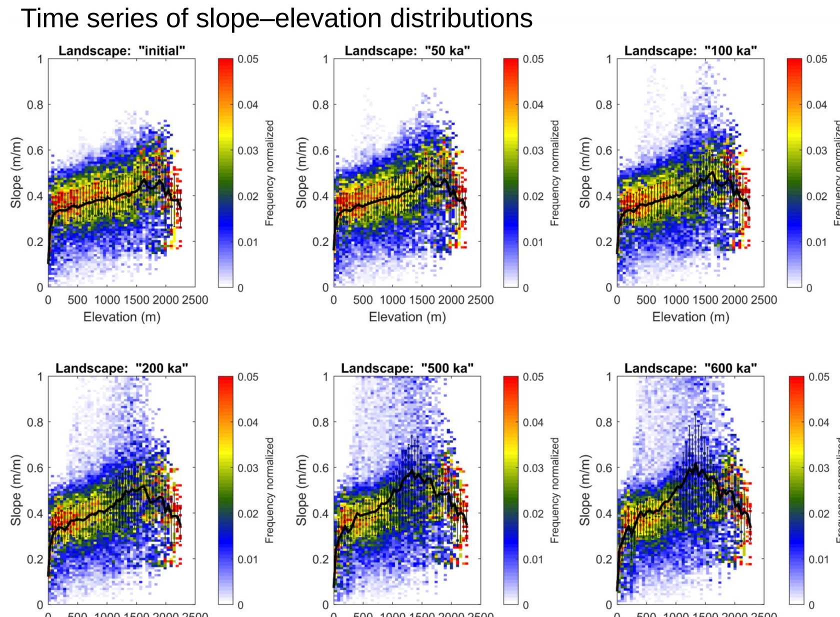
Even though the signatures of **glacial erosion processes**, such as U-shaped valleys, hanging valleys, overdeepened bedrock basins and glacial cirques, highlight **significant differences** from the morphology of **fluvial systems**, the **objective quantification** of glacial erosion patterns on topography is **still difficult**.

Putting numbers on topography



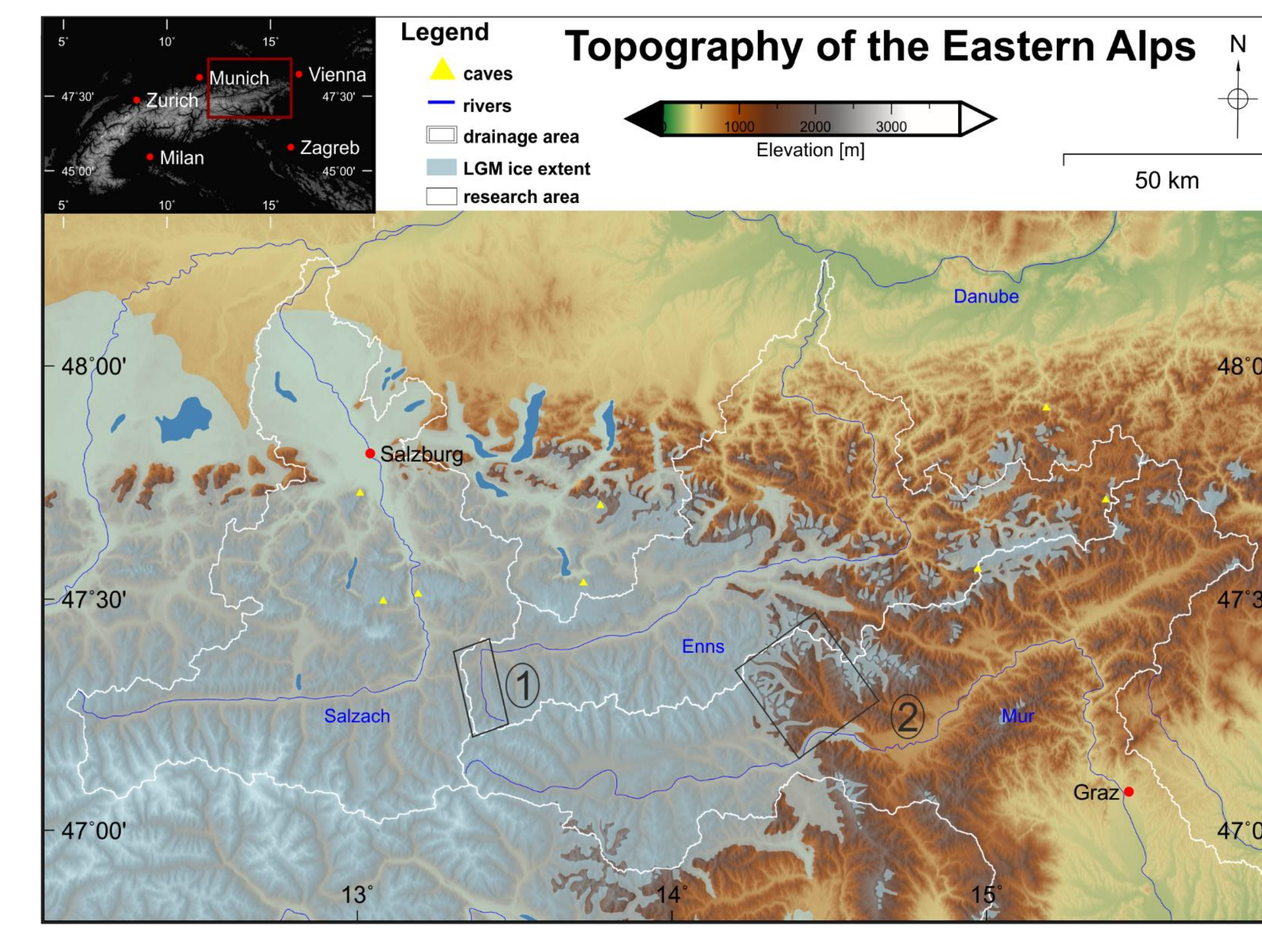
- The comparison of the initial and final swath profile after 600 ka glacial occupation along the trunk valley emphasize the remarkable amount of **erosion predicted in the downstream part of the profile.**
- Major valleys are excavated faster and deeper than tributaries and surrounding topography.
- The maximum effect of glacial erosion is located around the **ELA (1250 m)** displayed by the strongest rise of slopes on average and variance.

Time series of slope–elevation distributions

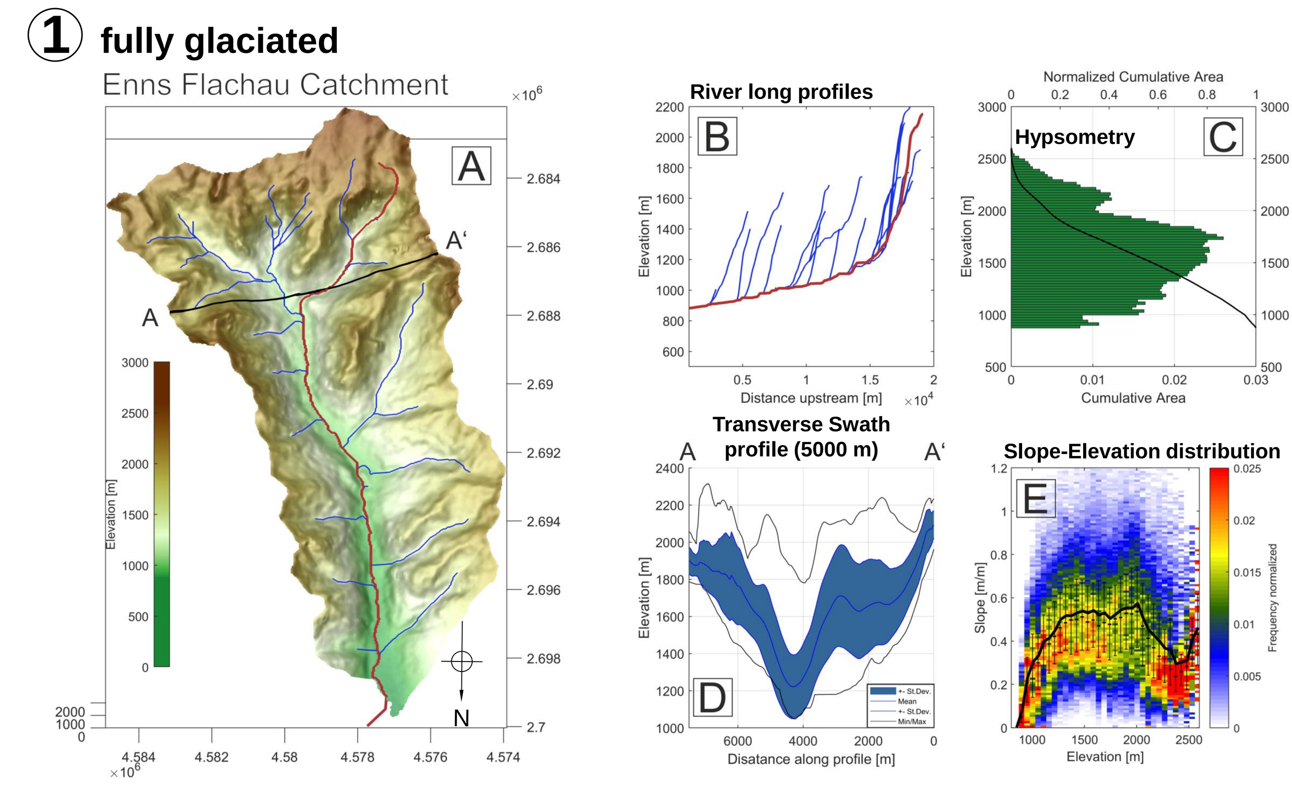


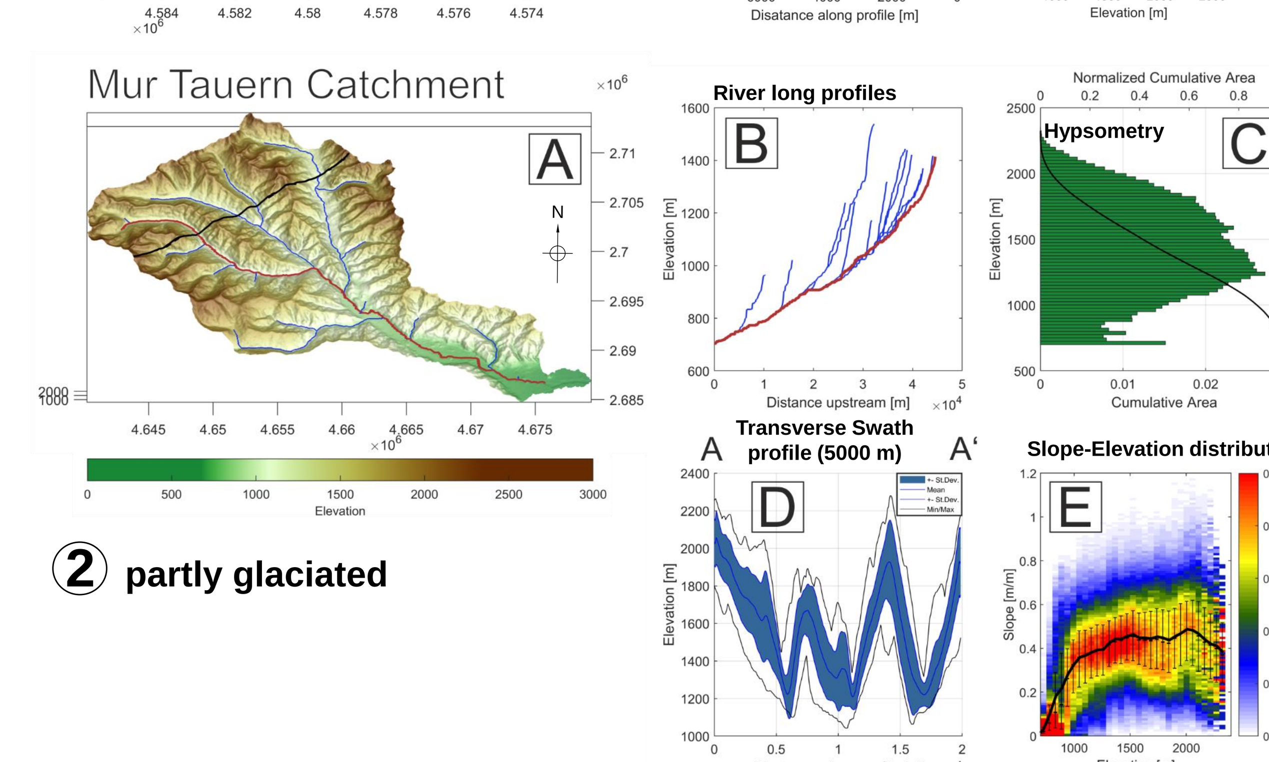
European Eastern Alps as a natural labortory

to proof a glacial signal on topography, there both glaciated and never/sparse-glaciated regions exist in direct spatial proximity and the two different key areas feature a similar lithological and structural inventory.



① fully glaciated





② partly glaciated

By transferring the outcomes of our computational experiments to the morphometric signature of catchments in the Alps, we aim to obtain possible explanations if the large-scale topographic pattern of former glaciated mountain ranges, such as the European Eastern Alps, results from glacial reshaping.

Conclusion

- In the evolving glacial landscape flattened longitudinal valley segments are emerging. These are leading up to headwalls and indications of cirque basins are observable.
- Above the snow line, **bimodality** vanishes and mean slope is similar to the initial fluvial topography. Interestingly, in the European Eastern Alps, we explore a similar pattern where the **transition from increasing to decreasing slope** with elevation is located at about 1800-2000 m, which is roughly at the position of the last glacial maximum (LGM) snowline of this region.
- Our experiments illustrate the characteristics of alpine glacial erosion to cut deep in order **to produce relief rather than destroy it.**

Outlook

- Explore the pattern of cold climate erosional processes on a **mountain range scale** landscape, which incorporates several catchments with glaciers varying in size.
- Investigate the sensitivity of temperature (ipso facto the **position of the snowline altitude**) on spatial patterns of long-term glacial erosion.

References
Egholm, D. L., Knudsen, M. F., Clark, C. D., & Lesemann, J. E. (2011). Modeling the flow of glaciers in steep terrains: The integrated second-order shallow ice approximation (iSOSIA). Journal of Geophysical Research: Earth Surface, 116(F2).