Mountainbuilding in the Eastern and Southern Alps - large earthquakes and active faults

- - - Project for the 2nd Phase of SPP2017: Mountain building processes in 4D - - -

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The main aim of research theme 2 of the 2nd SPP 4D-MB call is the distinction between the influences of deep seated processes (such as slab tearing and slab break-off) and surface processes on active tectonics and erosion patterns. Our proposal focuses on this aim at the transition zone between the Eastern and Southern Alps/Dinarides, partly covered by SWATH-D. This is the only region of the Alps that is still tectonically active as of today. Here, the strongest historical events of the Alpine region occurred with magnitudes exceeding M6.

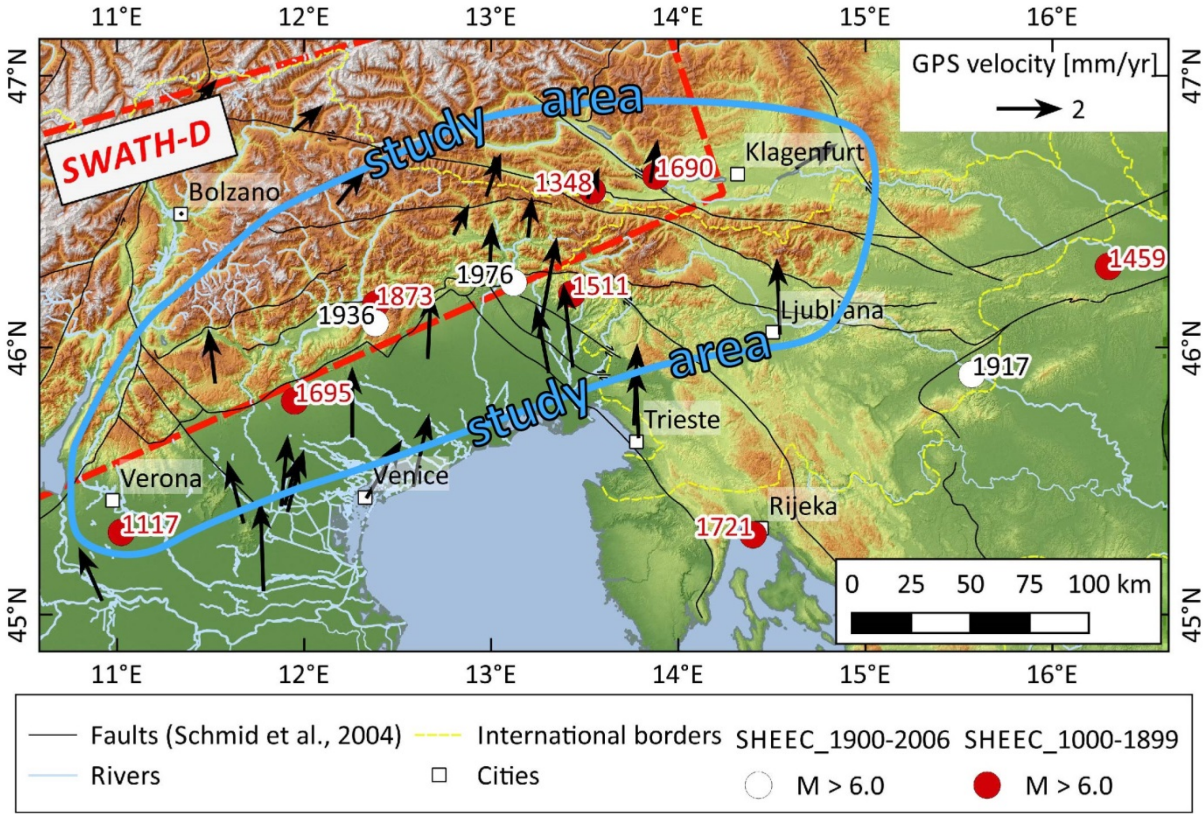

Figure 1: The proposed study area (blue) comprises roughly the triangle Verona-Ljubljana-Klagenfurt, where the strongest historical and instrumental earthquakes happened (AHEAD Working Group, 2019; Grünthal and Wahlström, 2012). Strong earthquakes (M>6) do not only concentrate along the southern Alpine front, but also occurred in the interior of the Alps. This area is covered by the SWATH-D experiment (red dashed line). GPS data show 2-4 mm/yr of ~northward motion of Adria with respect to stable Europe and a counter-clockwise rotation of the Adriatic plate around an Euler pole in the Western Alps (D'Agostino et al., 2008).

In our project "Mountainbuilding in the Eastern and Southern Alps - large earthquakes and active faults" we will analyse the geological and geomorphological record for evidence of strong earthquakes. Using tectonic geomorphology techniques we will analyse new high-resolution digital elevation models to detect post-glacial surface deformation. Near-surface geophysical data will allow imaging faulted strata in the shallow subsurface.

Paleoseismological trenching will be employed to investigate and to date surface-rupturing earthquakes. By working out the causative faults, the slip sense, magnitude, and recurrence intervals, we will extend the earthquake record to the Late Quaternary and we will address the question which major faults contribute to the present-day deformation of the Alps. We will also be able to shed light on the difference between events caused by glacial unloading and those that are triggered by the convergence of the Adriatic and European plates. Finally, we will compare our results to those from projects focussing on SWATH-D seismicity, geodetic measurements, erosion rates, and active fault studies on a Quaternary timescale to build a regional tectonic model covering multiple timescales. Integrating these datasets allows answering one of the most important questions related to the SWATH-D experiment: How representative is the short-term seismicity for active tectonics on larger timescales?

The open questions described above are of relevance for understanding the evolution of the Alps and the connection between deep-seated processes and their crustal expression. Thus, they directly address theme 2 of the 2nd SPP 4D-MB call. Our project proposal is part of Working Group C that deals with "Active tectonics at the Alps-Dinarides transition". This regional focus on the seismically most active area of the Alps allows for investigating both tectonic and other processes at work, and further makes use of the unprecedented seismicity data from the SWATH-D experiment. To our knowledge, our proposal is the only one to investigate individual strong earthquakes in the area covered by SWATH-D. It therefore closes the gap between studying recent (micro-) seismicity and research on crustal dynamics covering much longer timescales (millions of years). A recent study from Slovenia by Vičič et al. (2019) has shown that active faults may indeed produce significant micro-seismicity, despite the lack of large instrumental and historical events.

Because of the logarithmic magnitude scale, large earthquakes release the majority of the seismic moment in any seismically active area, that is, large events take up most of the overall deformation. Exploring the spatial and temporal distribution of strong earthquakes in the Alps during the Late Quaternary is necessary to understand the relative impact of the glacial cycles on seismicity. This then allows to project this knowledge into the past and to answer if the present-day picture is applicable to models that deal with the latest stages of Alpine evolution, especially at the transition between the Pliocene and the Pleistocene when the glacial cycles started. This knowledge is also necessary to calibrate models that link deep-seated processes like subduction switches or slab break-offs with deformation of the crust and the surface evolution of the Alps.

Our project is closely connected to the other proposals of Working Group C that will tackle the problem of the crustal expression of active tectonics by employing different techniques covering a wide range of time spans.

References

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