Present-day kinematics of the Southern Eastern Alps

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The European Alps exhibit extremely low (<2 mm/yr) horizontal deformation rates caused by the anticlockwise rotation of the Adriatic lithosphere. Uplift peaks in the Central Alps at 2-3 mm/yr due to post-glacial isostatic rebound, slab tearing and erosion. The subducted Adriatic plate causes N-S shortening on ~E-W trending frontal thrust faults separating the Southern-Eastern (SE) Alps from the densely-populated foreland. Regional seismicity is abundant and includes M6+ earthquakes such as the 1975 M_w6.5 Friuli event. Further north the Eastern Alps extrude towards the Pannonian basin at sub-millimeter rates.

Global Navigation Satellite System (GNSS) rates provide a first-order constraint on plate locking, a vital component in seismic hazard assessment. But the geometry of the active faults remains unclear. I present recent deformation rate maps of the SE-Alps in unprecedented resolution (~400 m, 6 days). The rate maps were derived from interferometric (InSAR) small-baseline (SBAS) time-series collected by the European Sentinel-1 radar satellite mission since 2017. Each of the assembled eight 240-km-wide radar tiles contains 300+ acquisition images, resulting in 2000+ interferograms (per tile), which were automatically generated, phase-unwrapped, and corrected for atmospheric and topographic signal contributions. I used the LiCSBAS time-series analysis software that applies a small-baseline (SBAS) approach, accounting for spatio-temporal coherence and seasonality. After tying the individual rates maps into a Eurasian reference frame defined by published GNSS rates I decomposed the rates originally observed in two look directions into east and vertical components. Field surveys, originally scheduled to densify the GNSS network in Slovenia were unfortunately canceled due to the pandemic.

The rate maps provide insight on the InSAR signal-detection limit of a challenging region like the heavily vegetated and snow-covered SE-Alps, overprinting subtle deformation signals along N-S, to which radar antennas are least sensitive: The vertical rates reflect a mixture of isostatic, and anthropogenic processes, overlaid by significant soil-moisture bias (Figure 1). The long-wavelength tectonic signal, remained below the detection threshold of the east rates. In comparison, considering only persistent scatterers (PS) produces more significant InSAR signals (cf. Areggi et al., 2023).

Based on recently updated GNSS rates (Pintori et al., 2022) I designed a kinematic model of the most active faults of the SE-Alps. I embedded an inter-connected chain of five dislocations in an elastic half-space and activated them in back-slip mode with no constraints on geometry or slip. Using simulated annealing I first scanned the parameter space randomly (Monte-Carlo) then gradually preferred parameter sets with a promising data fit. Such a multi-parameter model would add valuable new information on the unknown geometry of the active faults, also, because accurate earthquake locations of other 4D-MB projects (e.g., Najafabadi et al., 2020; Hofmann et al., 2023) provide ambiguous information on the fault dip. My tests resulted in unstable solutions, suggesting that geometric constraints (cf. Serpelloni et al. 2016) are compulsory in this particular case.

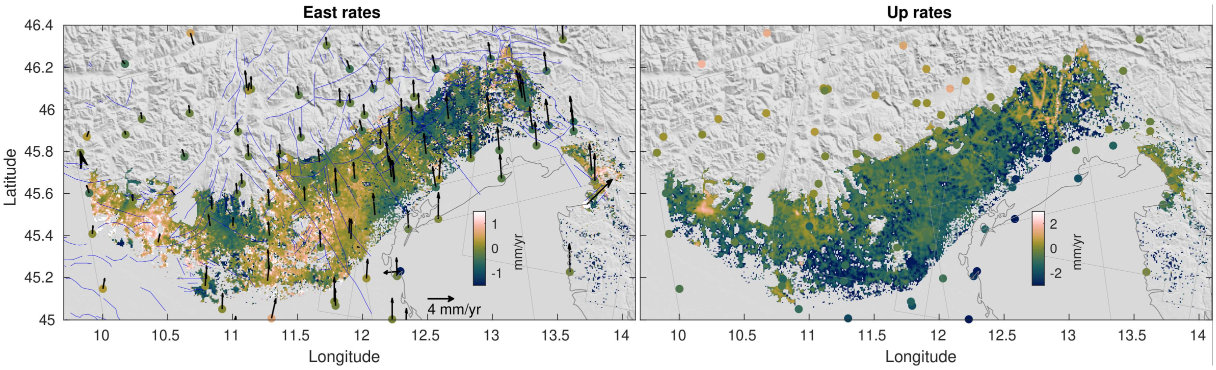

Figure 1: InSAR rate maps, masked, tied to the Eurasia-stable GNSS reference frame, and decomposed into east (left) and vertical (right) rates.

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