Hydrological signature in the current surface deformation of the eastern Adriatic by InSAR and GNSS

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Résumé

Advancements in measurement accuracy and spatio-temporal resolution of space-borne remote sensing have enabled the emergence of hydrogeodesy, which investigates hydrological phenomena through their effects on Earth's shape and gravity field (e.g. LaRochelle et al. 2022). This approach is particularly relevant in the eastern Adriatic, where water-induced displacements constitute significant background noise in tectonic studies within this seismically active region. Moreover, understanding hydrological processes is essential for water resource management and risk mitigation in the Mediterranean basin (e.g. Tarantino et al. 2024).
In this study, we perform a parametric decomposition of Sentinel-1 InSAR time series processed via the CNES-FormaTerre FLATSIM service over the eastern Adriatic (Thollard et al. 2021). The analysis separates linear trends, coseismic steps, and annual seasonal variations (Meridi et al., 2025). Large-scale displacement maps, once referenced to a null-deformation polynomial surface, reveal correlations with hydrological features. The seasonal displacement amplitude varies from zero to several centimeters, with maxima in marly-clay basins, suggesting a swelling-removal behavior. Phase analysis identifies two groups: one with maximum motion toward the satellite in spring (post-rainy season), and another in fall, which could reflect two distinct mechanisms of elastic crustal deformation. The first group predominantly appears in Quaternary basins and karst areas, likely reflecting poroelastic strain, while the second is observed in coastal zones and alluvial plains, consistent with elastic loading. Focusing on the Zagreb city area and the Velebit karstic massif, both exhibiting strong seasonal signals, we compare local hydrological data with detrended displacement time series. These comparisons confirm the parameterization results and reveal a 0-3 week lag between hydrological forcing and surface displacement.

The surface motion predicted by elastic loading calculations, based on the hydrological model GLDAS (Aliedocs service, Barneoud et al. 2023), are well consistent with the displacements measured in regions dominated by elastic response. Nonetheless, some discrepancies persist

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in timing and underpredicted amplitudes. Lastly, areas showing significant vertical displacements combined with large seasonal amplitudes are identified as prime candidates for exploring non-elastic, hydrologically induced deformation mechanisms.

Mots-Clés: Hydrogeodesie, Hydrologie, InSAR, Karst, Aquifers, Balkans, Croatie