

Multi-Mission PSInSAR Assessment of Long-Term Ground Deformation Processes in Belgium

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Abstract: Ground deformation linked to land subsidence and post-mining uplift represents a growing environmental and geotechnical concern in Belgium. Using Persistent Scatterer Interferometric Synthetic Aperture Radar (PSInSAR) analyses based on more than thousand SAR images from ERS-1/2, ENVISAT, TerraSAR-X and Sentinel-1A satellites, this study investigates the spatial and temporal evolution of ground movements over the past three decades. Results highlight several main regions affected by measurable vertical ground motion. The Scheldt estuary and harbour area of Antwerp exhibit subsidence rates up to 3.4 mm/year, mainly driven by the compaction of Holocene alluvial sediments and heavy industrial loading. In West Flanders, a 45 × 25 km subsidence bowl shows average velocities between −1 and −2.9 mm/year, caused by overexploitation of the Landenian and Cambrian aquifers. Around Merchtem, 20 km north-west of Brussels, PSInSAR time series reveal alternating phases of subsidence and uplift related to groundwater extraction and subsequent aquifer recharge in the Cambro-Silurian formations exploited by local industries. In contrast, former coal mining basins in Limburg (Campine) and Hainaut demonstrate progressive uplift following mine closure and flooding of underground workings. Velocities reach up to +18 mm/year in Limburg, reflecting rapid hydrostatic rebound, while lower values in Hainaut correspond to slower post-closure recovery. These observations emphasize the dual anthropogenic origin of land deformation in Belgium—subsidence from groundwater withdrawal and compaction, and uplift from mine water rebound. The study confirms the efficiency of PSInSAR for long-term, low-amplitude deformation monitoring in a temperate, densely urbanized environment. It provides critical insights for urban planning, groundwater management, and risk mitigation associated with geotechnical and hydrogeological processes.