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Land subsidence hotspots in Central Mexico: from Sentinel-1 InSAR evidence to risk maps

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The use of satellite Interferometric Synthetic Aperture Radar (InSAR) for land subsidence assessment is already a well established scientific research approach. Although several studies analyze subsidence patterns via integration of InSAR output maps with geospatial layers depicting hazard factors or elements at risk (e.g. surface and bedrock geology, cadastral and infrastructure maps), still limited is the body of literature attempting to generate value-added products. These not only have the potential to be used by stakeholders in urban planning, but also can be updated as new InSAR data are made available. With this scope in mind, this work presents the experience gained across Central Mexico, where land subsidence due to groundwater resource overexploitation is a pressing issue affecting many urban centers and expanding metropolises. Groundwater availability and aquifer storage changes provided by the National Water Commission are analyzed in relation to surface deformation data from wide-area surveys based on InSAR. The Parallel Small BAseline Subset (P-SBAS) method integrated in ESA's Geohazards Exploitation Platform (GEP) is used to process Sentinel-1 IW big data stacks over a region of 550,000 km^2 encompassing the whole Trans-Mexican Volcanic Belt (TMVB) and several major states, including Puebla, Federal District, México, Hidalgo, Querétaro, Guanajuato, Michoacán, Jalisco, San Luis Potosí, Aguascalientes and Zacatecas. A number of hotspots affected by present-day subsidence rates of several cm/year are identified across the TMVB, with extents ranging from localized bowls up to whole valleys or metropolitan areas spanning hundreds of square kilometers. Surface faulting hazard and induced risk on urban properties are assessed and discussed with a focus on: (i) Mexico City metropolitan area, one of the most populated and fastest sinking cities globally (up to −40 cm/year vertical, and ±5 cm/year E-W rates) [1]; (ii) the state of Aguascalientes, where a structurally-controlled fast subsidence process (−12 cm/year vertical, ±3 cm/year E-W) affects the namesake valley and capital city [2]; and (iii) the Metropolitan Area of Morelia, a rapidly expanding metropolis where population doubled over the last 30 years and a subsidence-creep-fault process has been identified (−9 cm/year vertical, ±1.7 cm/year E-W) [3]. InSAR results and the derived risk maps prove valuable not only to constrain the land deformation process at the hotspots, but also to quantify properties and population at risk, hence an essential knowledge-base for policy makers and regulators to optimize groundwater resource management, and accommodate existing and future water demands.

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