Sentinel-1 InSAR survey to constrain subsidence-induced surface faulting and quantify its induced risk in major cities of central Mexico

Francesca Cigna and Deodato Tapete
Italian Space Agency (ASI), Via del Politecnico s.n.c., 00133 Rome, Italy

Several major cities in central Mexico suffer from aquifer depletion and land subsidence driven by overexploitation of groundwater resources to address increasing water demands for domestic, industrial and agricultural use. Ground settlement often combines with surface faulting, fracturing and cracking, causing damage to urban infrastructure, including private properties and public buildings, as well as transport infrastructure and utility networks. These impacts are very common and induce significant economic loss, thus representing a key topic of concern for inhabitants, authorities and stakeholders. This work provides an Interferometric Synthetic Aperture Radar (InSAR) 2014-2020 survey based on parallel processing of Sentinel-1 IW big data stacks within ESA's Geohazards Exploitation Platform (GEP), using hosted on-demand services based on multi-temporal InSAR methods including Small BAseline Subset (SBAS) and Persistent Scatterers Interferometry (PSI). Surface faulting hazard is constrained based on differential settlement observations and the estimation of angular distortions that are produced on urban structures. The assessment of the E-W deformation field and computation of horizontal strain also allows the identification of hogging (tensile strain or extension) and sagging (compression) zones, where building cracks are more likely to develop at the highest and lowest elevations, respectively. Sentinel-1 observations agree with in-situ observations, static GPS surveying and continuous GNSS monitoring data. The distribution of field surveyed faults and fissures compared with maps of angular distortions and strain also enables the identification of areas with potentially yet-unmapped and incipient ground discontinuities. A methodology to embed such information into the process of surface faulting risk assessment for urban infrastructure is proposed and demonstrated for the Metropolitan Area of Mexico City [1], one of the fastest sinking cities globally (up to 40 cm/year subsidence rates), and the state of Aguascalientes [2], where a structurally-controlled fast subsidence process (over 10 cm/year rates) affects the namesake valley and capital city. The value of this research lies in the demonstration that InSAR data and their derived parameters are not only essential to constrain the deformation processes, but can also serve as a direct input into risk assessment to quantify (at least, as a lower bound) the percentage of properties and population at risk, and monitor how this percentage may change as land subsidence evolves.