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Magnitude and extent of land subsidence in central Mexico revealed by regional InSAR ALOS time-series survey

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The societal impacts of land subsidence are colossal, both in terms of decrease in water resources and in threat to human life due to buildings damages and increase in flood risk from rivers. Most subsidence surveys in Mexico focus on Mexico City, known to subside since the 1950s, while a few studies have documented the occurrence of land subsidence in other medium to large-seized cities of central Mexico. However, because most works target one single city, they fail to reveal the bigger picture. Here we use Interferometric Synthetic Aperture Radar (InSAR) time-series analysis of ALOS L-band SAR data to resolve land subsidence in an area of 200,000 km2 in central Mexico. We processed over 600 SAR images acquired between 2007-2011 and produced over 3000 interferograms.

The data reveal significant subsidence in seventeen cities, including sixteen with over 100, 000 inhabitants and allow mapping of subsidence with high spatial and temporal resolutions. Land subsidence is detected, from east to west, in Puebla (population of 2.5 million), Mexico city (population of 21 million), Toluca de Lerdo (population of 427K), Queretaro (population of 825K), San Luis de la Paz (population of 101K), Celaya (population of 266K), San Luis Potosi (population of 936K), Morelia (population of 537K), Salamanca (population of 144K), Irapuato (population of 317K), Silao (population of 147K), Leon (population of 1.4 million), Aguascalientes (population of 735K), Zamora de Hidalgo (population of 186K), Guadalajara (population of 3.8 million), Ahuacatlan (population of 6.5K), and Tepic (population of 261K). We additionally identify subsidence in 3 agricultural areas outside major urban centers: 20 km southwest of the city of San Luis de la Paz, south of Villa de Reyes (40 km south of San Luis Potosi), and west of villa de Arista (50 km north of San Luis Potosi).

The time-series suggest nearly constant rates of subsidence at most the locations over the 2-years period spanned by the SAR acquisitions. Subsidence rates of 30 cm/yr are observed in Mexico city, in agreement with previous surveys, while in the other locations typical rates of 5-10 cm/yr are observed. We additionally compare our results with GPS data to address the temporal and spatial variability of land subsidence and we correlate subsidence with surface geology, faults distribution, and land use to evaluate the importance of each of these parameters in the distribution of land subsidence.