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# Quantifying Ground Deformation for depleted aquifers across Iran: lessons learned from two decades of InSAR survey

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Iran is located in a semi-arid to arid environment, and in many parts of it, groundwater is the primary or sole resource of water for domestic, industrial, and agricultural purposes. Over-exploitation of groundwater in the past few decades has caused widespread land subsidence and increased sinkhole occurrence in the country. Ground-water related subsidence on the one hand poses a significant hazard to infrastructure and urban areas and on the other hand reduces the storage capability of aquifers and threatens long-term developments of the country. In a few studies, researches have investigated groundwater depletion and its associated land subsidence for some of the important aquifers across the country. However, in many areas, information on land subsidence is still missing.

In the past two decades, the abundance of SAR data provided by missions like Envisat and ALOS helped boost development of InSAR methods and their applications for land subsidence studies. Although regular data acquisition from those satellites was rare, their archive still helps to study the long term behavior of land subsidence in many areas where SAR data is available. The launch of the Sentinel-1 mission in 2014 revolutionized the availability of SAR data, providing a unique opportunity for near-real time data mining in order to extract homogeneous information over large areas up to country-scale.

In this study, we present the results of our InSAR survey to study land subsidence in Iran. All Sentine-1 SAR images acquired in descending frames between 2014 and 2017 (3500 images) are analyzed across the country to determine for the first time the exact extent and number of areas affected by land subsidence. Existing information of groundwater levels as well as results from previous surveys using older SAR sensors are then used to examine both inelastic and elastic behavior of the aquifers.

Our nation-wide subsidence map that we present here provides the first complete picture of the extent of water problem in Iran that we can achieve thanks to recent advancement in satellite remote sensing . We detect approximately 90 subsidence areas, some of them show significant inelastic deformation with the ratio between elastic and inelastic deformation $< 0.4$. Our analysis shows that land subsidence mostly happens in agricultural areas where groundwater extraction in more severe. It appears to be in qualitative agreement with previous estimations that agricultural section consumes 90% of the existing water resources in the country. Such information can help decision makers, local authorities, and communities to increase awareness of the problem and prepare measures to mitigate the effects of land subsidence.