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Nation-wide Detection and Measurement of Land Subsidence Induced by Groundwater Extraction in Iran

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Land subsidence associated with ground-water decline is recognized as a widespread problem in Iran.
In many parts of the country, agricultural, domestic, and municipal water needs are supplied primarily by groundwater pumping which results in rapid declines of groundwater. Many field evidences like cracks on the walls or fissures on the ground confirm the compaction of aquifer systems in different basins across the country. However, the exact spatial extent and temporal behavior of them are only known for a few of them. Several studies in the past investigated land subsidence in Iran. However, they were limited to a few major basins. Our main aim in this study is to investigate this issue in a country-scale and extend our understanding of it to all subsidence basins across the country. We benefit from broad coverage and regular data acquisition of Sentinel-1 to investigate both spatial and temporal behavior of subsidence basins in Iran.
Using Interferometric Synthetic Aperture Radar (InSAR), we estimate the location, extent, and magnitude of surface elevation change in a country scale. SAR images along each acquisition track are stitched to form extended SAR images across the country. Then, the images are resampled to a reference geometry. Using the stack of resampled images, a network of interferograms is generated by connecting each image to four images with shortest temporal intervals. The interferograms are spatially unwrapped, and then, the network of unwrapped interferograms is inverted using least-square adjustment approach. Finally, the average rate of displacement and time-series of movement are estimated. Large-scale errors induced by atmosphere or inaccuracies in coregistration are removed from the results by spatial filtering of unwrapped interferograms. To eliminate the localized displacements, which are not related to land subsidence, we produce the interferograms with a high multilook factor (5x25 in azimuth and range).
The SAR dataset used in this study includes more than 3500 images covering an area of ~6000 km2 spanning a three-year period between late 2014 and 2017. They are acquired by Sentinel-1 in 10 tracks. Each track of data covers an area of 250-km wide and 400-1400 km long. Using this extensive dataset, we produced a country-scale surface elevation map and identified more than 70 subsidence basins across the country with maximum subsidence between 5 and 30 cm/yr. The induced groundwater mainly affects agricultural areas, but in some parts, poses a hazard to urban areas as well. The linear trend of subsidence dominates the displacement time-series. However, in many basins, we observe a seasonal response to charge and discharge of reservoir. We investigate the long-term vs. seasonal displacement to characterize the recoverability of the observed subsidence. We also use groundwater level data, which is available for a few basins to understand the link between groundwater level and observed elevation change.