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An integrated application of SAR interferometry and GRACE solution to land subsidence in a rapidly urbanizing groundwater dependent basin in Pakistan

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Land subsidence and crustal deformation associated with groundwater abstraction is a gradually instigating phenomenon. The exploitation of Interferometric Synthetic Aperture Radar (InSAR) for land subsidence velocity and the Gravity Recovery and Climate Experiment (GRACE) for change in groundwater storage have great potential besides other applications to address this problem. In this paper we used an integrated approach to combine InSAR and GRACE solutions to show that land subsidence velocity in a rapidly urbanizing and groundwater dependent basin in Pakistan is largely attributed to over exploitation of groundwater aquifer. We analyzed a total of 28 Sentinel-1 based interferograms generated for the period October 2014 to November 2016 to quantify the level of land subsidence in the study area. To increase the accuracy of our interferometry results we then applied a filter of Amplitude Dispersion Index (ADI) to confine the spatial extent of land subsidence to persistently scattering pixels. For the GRACE experiment we take the average of change in Total Water Storage (TWS) solutions provided by the Center for Space Research (CSR), the German Research Centre for Geosciences (GFZ), and the Jet Propulsion Laboratory (JPL) and validate this mean TWS for the study area using a network of observed time series groundwater levels. The validation result of GRACE TWS field shows that although the GRACE foot print is spatially larger than the extent of the study area but significant change in water storage can contribute to the overall trend of declining water storage. Finally we compared our results of InSAR land subsidence velocities and GRACE TWS change field. A strong dependence of the land subsidence on the temporal change in TWS suggests that most of the land subsidence could be attributed to the unchecked exploitation of groundwater aquifer.