Land Subsidence Over Densely Vegetated Aquifers in Texas and the Central Valley, CA Derived from Spaceborne Radar Data

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In this study, we measure the extent and magnitude of land subsidence signals over the Carrizo-Wilcox aquifer in Texas and the Central Valley in California using spaceborne Interferometric Synthetic Aperture Radar (InSAR) techniques. Here the subsidence signals are associated with withdrawal of fluids from the subsurface, either from oil and gas production or confined aquifer pumping. We processed 110 C-band Sentinel-1 SAR images from 2017-2021 over a ~100 x 200 km region near San Antonio, TX and 122 C-band Sentinel-1 SAR images over the southern Central Valley, CA. These InSAR datasets suffer from severe decorrelation artifacts due to the presence of dense vegetation. To overcome this limitation, we employ the cosine phase similarity algorithm [1] to choose high-quality, Persistent Scatterers (PS) pixels that suffer from minimal decorrelation noise. In areas with very low PS density, we interpolate phase measurements between the final set of PS pixels [2] to restore the InSAR phase continuity in space. We select the PS-interpolated interferograms with minimal phase unwrapping errors and compute the cumulative line of sight (LOS) deformation over our study regions based on a linear deformation model. The Texas cumulative LOS deformation map derived from the repaired interferograms shows a region over 100 km long of up to 10 cm of LOS subsidence overlaying the Eagle Ford shale, the location of ongoing, extensive hydraulic fracturing. In the Central Valley, preliminary results show a subsidence region up to 90 cm LOS. For both datasets, the InSAR measurements match the GPS data at all available stations with sub-centimeter error. Future work includes analysis with in-situ well data to further explore the deformation due to pumping and groundwater withdrawal and subsequent aquifer compaction. Subsidence mapping over the large- scale, complex aquifers will help transform our understanding of groundwater resources and their sustainable management.

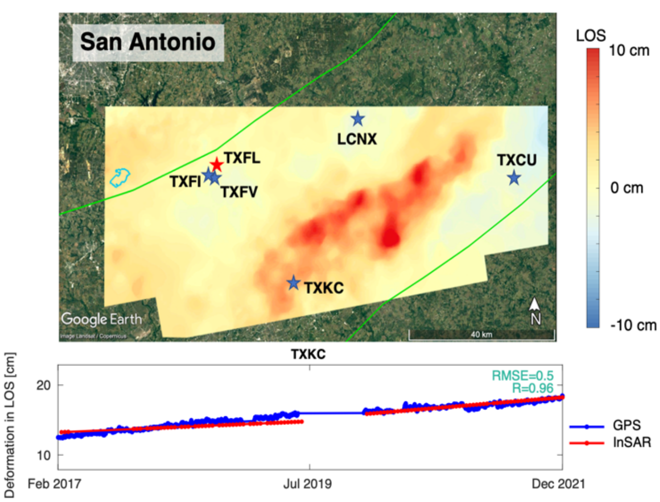

Figure 1: (top) The cumulative LOS deformation map over the Eagle Ford shale from February 2017 – December 2021 derived from PS interpolated interferograms, showing available GPS stations (stars). (bottom) GPS and PS InSAR time series comparison at GPS

References:

[1] K. Wang and J. Chen, "Accurate Persistent Scatterer Identification Based on Phase Similarity of Radar Pixels," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 60, pp. 1-13, 2022, Art no. 5118513, doi: 10.1109/TGRS.2022.3210868.

[2] Chen, J., Zebker, H. A., and Knight, R. (2015), A persistent scatterer interpolation for retrieving accurate ground deformation over InSAR-decorrelated agricultural fields, *Geophys. Res. Lett.*, 42, 9294– 9301, doi:10.1002/2015GL065031.