Improved InSAR SBAS Inversion for Groundwater Observation:
Tropospheric Noise Separation and Bayesian Uncertainty Quantification

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Interferometric Synthetic Aperture Radar (InSAR) is used to infer groundwater movement within aquifers by observing the surface expression of sub-surface poroelastic deformation and permanent compaction. However, any small, temporally smooth signal, such as from typical poroelastic expression of groundwater movement, is overwhelmed by the much larger tropospheric noise present in the InSAR interferograms and requires the production of excellent timeseries of deformation to observe. The Small-Baseline Subset (SBAS) family of inversion algorithms generates a timeseries of Line-of-Sight (LOS) ground displacement motions in decorrelating regions from a network of temporally and spatially small-baseline interferograms. In this work, we describe a novel Bayesian SBAS algorithm distinguished by its incorporation of separation of tropospheric delay noise from true surface deformation. We treat the pixel-by-pixel timeseries of the turbulent component of the tropospheric delay as temporally uncorrelated, while considering the hydrologic displacement signal to be temporally smooth. We incorporate these assumptions into the joint prior covariance matrix and use a simple linear Least-Squares inversion to separate the two signals with high fidelity. Furthermore, as a Bayesian inversion, this method provides a built-in uncertainty quantification. We show results from a network of Sentinel-1 interferograms located within the San Joaquin Valley in California's southern Central Valley to observe poroelastic rebound associated with groundwater recharge. We demonstrate the ability of this method to cleanly distinguish between tropospheric and non-tropospheric signals using a synthetic interferogram stack.

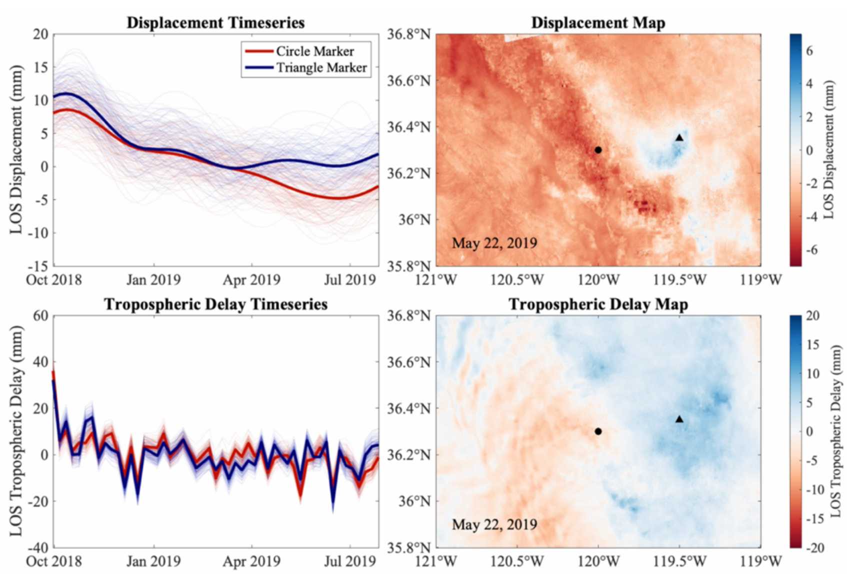

Figure 1. *Results from our Bayesian SBAS inversion applied to a network of 138 Sentinel-1 interferograms in the San Joaquin Valley from October 2018 to July 2019.*