

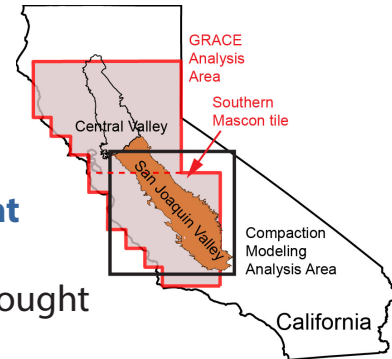
Remote sensing of groundwater storage change - past, present and future

Susanna Werth, Manoochehr Shirzaei, Chandrakanta Ojha & Grace Carlson

Objective: How can we remotely detect groundwater storage changes in deep confined aquifers at management scale and consistent with large scale observations from GRACE?

Methods: Poroelastic modeling of aquifer compaction to estimate aquifer storage depletion during drought

Data: Vertical land motion from GPS (or InSAR), well levels, GRACE water storage variations



Introduction: The quantification of **groundwater storage changes (GWSC)** in large aquifers, e.g. the Central Valley California, is of high importance to sustainable water management. Traditional methods to quantify GWSC either use the water balance equation (result for Central Valley shown by blue line in the figure below) or hydrological models (purple line) driven by well observations and storativity properties of the aquifer. Since 2002, satellite gravimetry has delivered first estimate of GWSC, however, this has high uncertainties in signal amplitude (red, gray and black line from different estimates based on GRACE). In recent studies, we have utilized vertical land motion from InSAR and GPS in a 1D-poroelastic model to quantify GWSC in the California's Central Valley Aquifer (overview map at the top right) for the 2007-2009 (Ojha et al., 2018) and in the southern San Joaquin Valley for the 2012-2015 (Ojha et al., 2019) drought. The results for the latter are shown in the figure below, which are based on analysis of GPS vertical land motion and are consistent with traditional and GRACE-based estimates. Based on these results, we summarize our perspective for the past, present and future of remote sensing of GWSC and its applications below.

Past accomplishments in the scientific community:

- Quantification of groundwater storage changes from satellite gravimetry with limited spatial resolution and high uncertainties
- Integration of GRACE-GWSC into hydrological models & drought indicators
- Remote sensing products mostly not applicable for management purposes

Present scientific developments:

- Poroelastic modeling of GWSC using vertical land motion observations from GPS and InSAR
- Quantification of aquifer storage parameter using a combination of well level measurements with vertical land motion suitable to groundwater management

Future expected developments:

- Combined inversion of gravity and vertical land motion to estimate GWSC
- Integration of poroelastic model results and combined inversion products into groundwater routines of hydrological models
- Remotely sensed GWSC applicable for management purposes

