EGU2020-12302, updated on 17 Oct 2021
https://doi.org/10.5194/egusphere-egu2020-12302
EGU General Assembly 2020

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

Susanna Werth[1,2], Manoochehr Shirzaei[1], Grace Carlson[1], and Chandrakanta Ojha[1]
[1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA (swerth@asu.edu)
[2]School of Geographical Sciences & Urban Planning, Arizona State University, Tempe, AZ, USA

Groundwater remains one of the least comprehensively monitored storage components in the hydrological cycle, because it's flow and storage processes are strongly linked to geology of the underground and because direct observations from well sites provide only point observations of complex and partly deep aquifer systems.

In recent years, geodetic methods have become increasingly available to complement ground-based observations and to expand investigations of the impact of climate extremes or human water use on groundwater storage variability. Satellite gravimetry from the Gravity Recovery And Climate Experiment (GRACE/FO) has been shown to be sensitive to groundwater depletion at large spatial scales (> 300km) and relatively high temporal resolution (monthly). These data provide a valuable boundary condition for regional studies, and they have been applied widely to improve parameter and structure of hydrological models.

Moreover, changes in groundwater stocks cause surface deformation associated with regional elastic loading of the Earth’s crust and localized poroelastic compaction of the aquifer skeleton, which are detectable by GPS and InSAR. The loading signal is typically much smaller than the land subsidence due to poroelastic compaction and thus masks out the loading signal adjacent to the aquifer system. However, the poroelastic signal can be used to estimate groundwater volume change in confined aquifer units and provides insight into the mechanical properties of the aquifer system. Also, the deformation sensors provide spatial resolutions of tens of meters (e.g., InSAR) to several kilometers (e.g., GPS) that can be used to solve for the volume of fluid removed from the aquifer system.

In this presentation, we demonstrate and discuss the applicability of poroelastic modeling, by applying GPS and InSAR based observations of vertical land motion, to quantify groundwater storage changes. Using the Central Valley in California as an example, we will show when this approach is applicable and when it is not, depending on the type of aquifer and observed deformation compared to water level changes. Using a 1-D poroelastic calculation based on deformation data, we find a groundwater loss of 21.3±7.2 km^3 for the entire Central Valley during 2007-2010 and of 29.3±8.7 km^3 for the San Joaquin Valley during 2012-2015. These loss estimates during drought are consistent with that of GRACE-based estimates considering uncertainty ranges.

Finally, we will discuss the increased availability of high-resolution radar data from Sentinel 1A/B as well as the upcoming radar mission NASA-ISRO SAR Mission (NISAR), to be launched in 2022, and how this will allow for high-resolution monitoring of vertical land motion and with that of compaction in confined aquifers around the world. The availability of these datasets increases the capability of geodetic methods for groundwater monitoring at higher spatial resolution than GRACE data, hence, providing the potential to apply these datasets to further improve parameterization and formulation of groundwater routines in regional to large-scale hydrological models.