Measuring drought impacts using GNSS, InSAR, and GRACE

Grace Carlson[1,2], Susanna Werth[1], Manoochehr Shirzaei[1]
[1]Virginia Tech, Blacksburg, VA, USA
[2]University of California, Berkeley, Berkeley, CA, USA

Geodetic observations of the Earth's gravitational and deformational response to changes in terrestrial water storage (ΔTWS) have been essential measurements to characterize hydrological phenomena on a range of spatiotemporal scales. They have been especially useful to characterize and quantify the impact of hydrological hazards like droughts and floods. This knowledge has important implications for future water management in a world where these hazards are likely to become more frequent and intense. Because it is especially well instrumented and experiences dramatic fluctuations between wet and dry periods that are exaggerated by anthropogenic activity, California has been the focus of research of numerous hydro-geodetic studies. An ongoing question, however, is how to include hydrological processes over the extensive Central Valley aquifer system in a cohesive way at a sufficient spatial resolution. In this talk, I will present an approach to utilize observations from three geodetic sensors, Global Navigation Satellite System (GNSS) elastic vertical displacements, ΔTWS from the Gravity Recovery and Climate Experiment Satellites (GRACE and the follow-on mission, GRACE-FO) and Interferometric Synthetic Aperture Radar (InSAR) measurements of poroelastic aquifer deformation, to simultaneously assess ΔTWS and groundwater storage change (ΔGWS) across California. I will focus on water loss during water years 2020 and 2021, two of the driest on record and part of the most recent series of dry years of a two-decade-long mega-drought. I will show that this joint inversion framework yields a high-resolution and more realistic estimate of ΔTWS and ΔGWS within the Central Valley than GRACE-FO and GNSS provide, alone. This work reveals the potential of geodetic observations in hydro-hazards research and shows that by integrating multiple measurement systems, we can isolate notoriously challenging to measure storage components, like groundwater, providing insights into hydrologic and anthropogenic processes at a regional scale.