# Drought Induced Groundwater Loss in and Around Great Salt Lake, Utah, Inferred from 3D GPS Displacements

**Zachary Young[1], Corné Kreemer[1], Geoffrey Blewitt[1]**

[1]Nevada Geodetic Laboratory, Nevada Bureau of Mines and Geology, University of Nevada, Reno, Reno, Nevada, USA

The American Southwest experienced a massive drought between 2011 and 2016 with significant impacts to regional water storage. During this period, the Great Salt Lake (GSL), Utah, lost 1.84 meters of water and Global Positioning System (GPS) data show significant changes in nearby station positions during the same time. Although the GPS data show expected uplift and extension localized on the GSL, preliminary analysis suggests that the observed GSL unloading alone cannot fit the GPS displacements and contributions from groundwater loss surrounding the GSL are likely. This study applies a damped least squares inversion to determine the amount and distribution of groundwater removal consistent with the observed deformation. We test a large number of load distributions over a range of radial load rings and compare both the predicted vertical and horizontal displacements to the data. We estimate the loading coefficients of load belts using the code of D'Urso and Marmo (2013). Three dimensional inversion provides the most realistic distributions, compared to horizontal and vertical only solutions, and yield GSL unloading comparable with the observed water loss (i.e., a volume of 7.70 km3). The best model implies a radially decreasing mass loss up to 84 km from the edge of the lake at a volume of 54.54 km3, nearly three times the estimated volume of the entire GSL. The maximum localized unloading is on the lake itself; however, the contribution of exterior groundwater loss is substantial and greatly improves the fit to the data. In conclusion, we find that there is groundwater loss up to 84 km away from the lake and that the total amount of water loss surrounding the lake is ~7 times that for the lake itself.

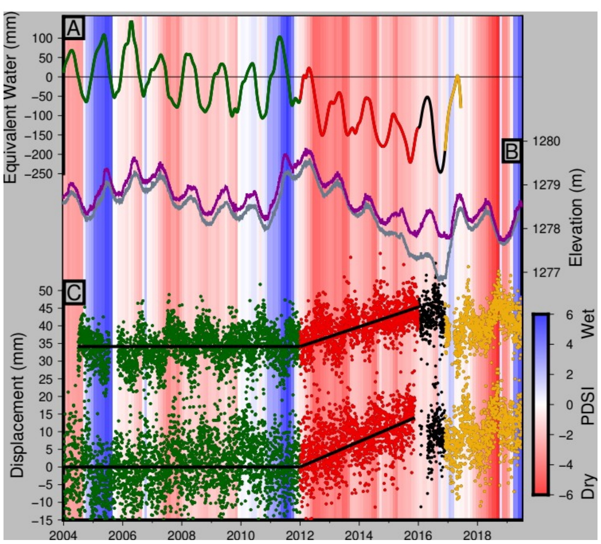


**Figure 1:** Comparison of GPS, GRACE, PDSI, and GSL surface elevation data. Background shading indicates the Palmer Drought Severity Index for Utah (NOAA, 2019). **A.)** Averaged GRACE data of four grid points centered nearest the GSL. Detrended relative to 2004-2012 (Landerer and Swenson, 2019). **B.)** GSL lake surface elevations for two monitoring sites separated by the railroad causeway. Station 10010100 is located on the northern side of the lake (gray), and Station 10010000 is located on the southern side (magenta). The mean difference between north and south is ~20 cm prior to 2012 (USGS, 2016). **C.)** Detrended GPS timeseries for stations P122 (top, north side of GSL) and COON (bottom, south side of GSL, Blewitt et al., 2018). Trend lines are added to distinguish the change in velocity through the drought period.

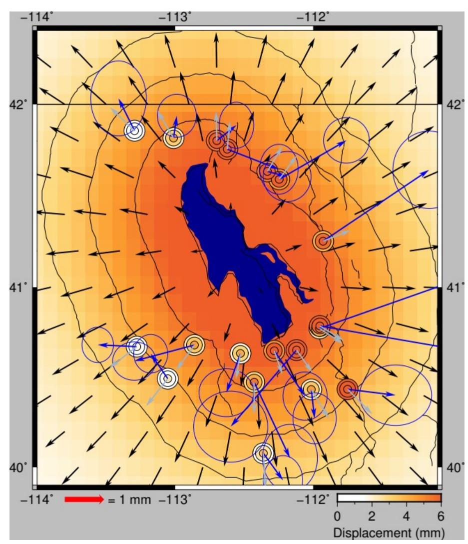


**Figure 2:** Displacements calculated for the most realistic load distribution. Observed GPS horizontal displacements are shown by blue arrows with 95% confidence ellipses. Observed vertical displacements are the central circles with inner and outer circles representing one sigma deviation. Modeled horizontal displacements are shown at GPS sites as gray arrows and on a grid as black arrows.