GPS as an independent measurement to estimate terrestrial water storage variations in California, Oregon and Washington

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Abstract:

The vertical loading deformation in the Pacific mountain system is observed with GPS to be large. The mountains subside up to more than 1 cm in the fall and winter due to the load of snow and rain, and then rise during the spring and summer when the snow melts, rainwater runs off, and soil moisture evaporates. In this study, we invert such GPS measurements of loading deformation for surface water variations in Equivalent Water Thickness (EWT), and study seasonal, interannual and long-term trend water storage variations in Washington, Oregon and California.

The resulting GPS determination of the total water thickness change is compared with GRACE and hydrology results [Fu et al., 2015]. The GPS inversed seasonal mass variation mimics different physiographic provinces of western U.S. The inferred seasonal change in water thickness from April to October is large (up to a half meter in EWT) in the Cascade, Klamath, and Sierra Nevada Mountains. Seasonal water storage decreases sharply east into the Great Basin and Columbia Plateau and west toward the Pacific coast.

With GPS monthly time series, we infer surface water variation at higher temporal (monthly) interval. The current California drought since 2011 is precisely quantified with GPS inversed surface water change. In the Sierra Nevada Mountains, our GPS results indicate ~14 Gigaton/year water loss between 2011 to 2014, and this rate is much larger than that of the previous drought event (~9 Gigaton/year) between 2006 to 2009. Our results inferred from GPS show that rapid near-surface water decrease is occurring in Sierra Nevada Mountain, Klamath Mountain. In the Cascade Range of Washington and Oregon, there is no significant water loss there.

We [Fu et al., 2015] demonstrate that GPS-determined water storage variations can fill gaps in the current GRACE mission, also in the transition period from the current GRACE to the future GRACE Follow-on missions. In addition, GPS-inferred water storage variations can determine and verify local scaling factors for GRACE measurements. Because the GPS network in the western U.S. is dense enough and GPS position solutions can be derived very quickly, we conclude that GPS provides an independent determination of water storage in the Pacific mountains system at high spatial resolution in near real time.