Fluctuations in Subsurface Water in Oregon and Washington Inferred from Global Positioning System

Dain Kim (Boston University), Donald F. Argus (NASA Jet Propulsion Laboratory)

The Global Positioning System (GPS) measures solid earth elastic deformation with high accuracy, providing an effective means to infer changes in water thickness and total terrestrial water storage from vertical signals. The high spatial resolution of GPS allows estimation of water storage change over small-scale regions and mitigates the limitations of geodetic satellites with a coarse resolution. In this study, we quantify anomalies in terrestrial water storage for Washington and Oregon, investigating the total, subsurface, and groundwater storage using GPS observations and hydrologic products. The GPS vertical displacement data from NASA Jet Propulsion Laboratory, assimilated snow water equivalent from SNODAS, and assimilated soil moisture from NLDAS-Noah were utilized to compute the change in total, subsurface, and groundwater storage. For our area of focus, Northern and Middle Cascades, the mean seasonal oscillation in total water from 2006-2021 came out to approximately 30 km^3 (0.36 m), ~22% of the 137 km^3 mean yearly cumulative precipitation. The mean seasonal oscillation in subsurface water was about 28 km^3, ~20% of cumulative annual precipitation. There were significant fluctuations in the mountain groundwater in our study region, and the time of peak mountain groundwater lagged the time of maximum snow by two months. These findings can be related to the hydrologic water balance equation, where the change in water storage is inferred by subtracting evapotranspiration and river discharge from precipitation. Our results also provide insights into identifying the moment magnitude and duration of slow slip earthquakes more accurately in Oregon and Washington.