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Aquifer Deformation in the Virgin River Valley, Nevada: GPS Sensitivity to Deformation Over Various Time and Distance Scales

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As reported in this session [Warner et al., 2003], we have used GPS to quantify aquifer storage in the Virgin River Valley, Nevada during a three-month period of controlled pumping. Here we assess the use of GPS as a tool for aquifer deformation research, including experiment design, logistical considerations, data processing strategy, the quality of the station displacement time series, and the fitness of these time series to detect and quantify transient deformations over a variety of spatial and temporal scales. The physics of the aquifer deformation model being tested drove the network design. As time from the onset of pumping increases, the model predicts that the location of maximum surface strain propagates away from the pump head; so the surface deformation pattern scales spatially with time. In order to broaden the bandwidth of signal sensitivity with respect to time, GPS stations were situated along an approximate straight line leading away from the pump head, with an ever-increasing spacing between stations. We investigate how sensitivity to the deformation pattern depends on the characteristic distance and temporal scales that are unique to aquifer deformation problems. Distances between the GPS stations and the pump head ranged from 200 -- 2,000 meters. As distance increases, one might expect the GPS relative displacement errors to increase due to decorrelation of tropospheric and ionospheric delay. In the absence of ionospheric errors, simultaneous processing L1 and L2 carrier phase data can improve relative positioning by a factor of 3 as compared to processing the standard ionosphere-free linear combination of L1 and L2, due to improved signal to noise (including multipath suppression). We assess such signal-to-noise characteristics using the observed deformation data from our aquifer deformation experiment, and draw conclusions on optimal network design and parameter estimation strategy.

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