GPS Imaging of Crustal Uplift in the High Plains Aquifer, Central United States

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A recently-developed technique known as "GPS Imaging" uses robust trends in time series of GPS positions to create a velocity field that can reveal rates and patterns of vertical motions that would be otherwise difficult to detect. We use GPS data from 350 stations to construct an image of vertical velocities in the Great Plains region of the United States. These results are based on the recent reprocessing of the entire GPS data archive at the Nevada Geodetic Laboratory using JPL's GipsyX 1.0 software, JPL's final orbit and clock products, with IGS14-consistent models and standards. Improved precision is achieved by using the VMF1 mapping function with gridded data from numerical weather models.

In the Southern Great Plains region, we have discovered a signal of crustal uplift of approximately 1 mm/year. The uplifting signal is in contrast with much of the Central United States where, e.g., to the north there is subsidence due to forebulge collapse from Glacial Isostatic Adjustment. The uplift signal overlaps Colorado, Kansas, Oklahoma, New Mexico, and Texas, covering an area approximately 700 km long and 250 km wide, roughly corresponding to the location of the High Plains aquifer. This aquifer is one of the largest groundwater systems in the United States, comprising an area of roughly 451,000 km^2 beneath eight states. Groundwater withdrawal rates from 1900-2015 show that water levels are declining overall, by over 45 m in some areas. Previous studies in other areas have shown that hydrological effects can impact region vertical crustal motions, both seasonally and over longer periods of time. Aquifer depletion can cause subsidence through compaction in addition to uplift attributable to surface mass unloading. The areas of largest groundwater decline in the High Plains aquifer experience broad uplift only, suggesting that unloading is the dominant mechanism driving uplift.

In this presentation we will document the magnitude of the uplift signal, resolution, and uncertainties of the GPS Imaging result. To test the hypothesis that groundwater decline drives uplift we will examine seasonal and multiannual changes in the uplift rates, and compare them to the distribution of aquifer depletion.

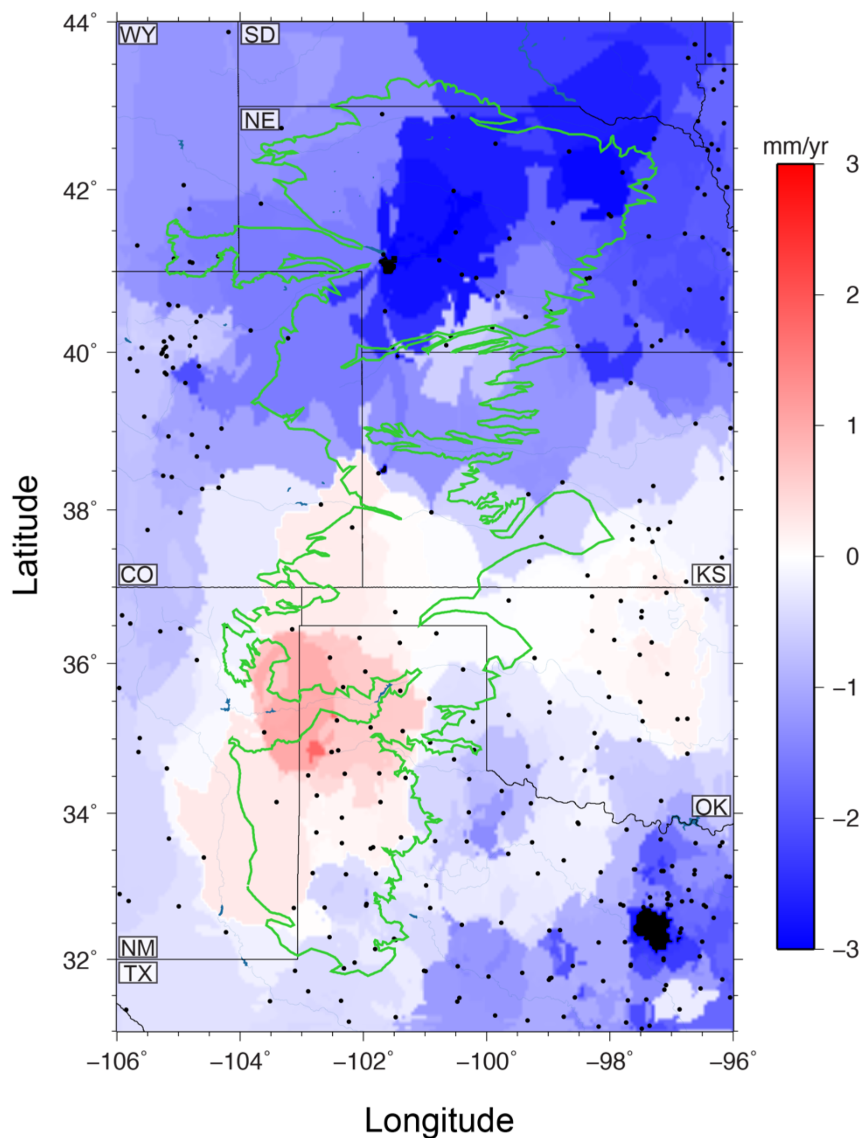

Figure 1: GPS Imaging results of vertical velocity field in Central United States. Signals that are similar between stations may be ascribed to the spatially coherent movement of the solid Earth. The swath of uplifting signal extends through much of the southern portion of the High Plains aquifer (green polygon). Black dots represent station locations.