Characterizing Groundwater Response Time to Droughts Across the United States

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The global importance of groundwater as a resilient water supply has increased in recent years as groundwater is the major water supply for over 2 billion people worldwide. Global population growth and expansion of irrigated agriculture have caused groundwater depletion particularly in semi-arid and arid regions, and efforts are underway to achieve groundwater sustainability in these areas. As groundwater flow is slow, and most aquifers have very long residence times, time horizons of 50-100 years are often suggested for setting up groundwater sustainability goals. However, aquifer response time to various stressors is site specific and depends on aquifer properties, climatic conditions, and frequency and intensity of droughts. Here, we utilize daily groundwater observations from unconfined aquifers across the conterminous United States to quantify groundwater recovery time to meteorological droughts during 1981-2017 period. We consider two metrics to quantify groundwater recovery time: 1) the “time-lag” between the end of the precipitation drought and the termination of groundwater storage loss, and 2) the “time of rise”, the time that it takes until the aquifer storage reaches the pre-drought conditions. Our results indicate that the average time lag of aquifer response time to drought is 15 months, and the time lag can increase up to 15 years for some aquifers. Analysis across 634 wells reveal that depth to water table is the primary factor that determines whether aquifer physical properties or precipitation characteristics control this time lag to droughts. In regions with shallow water tables, aquifer physical properties determine lag time while in aquifers with deep groundwater tables precipitation properties are more important. The average recovery time of a shallow water table aquifer is about 3 years, and the recovery time is longer during severe droughts. It is expected that with projected increases in intensity and frequency of droughts in the future, the buffering capacity of aquifers will decrease, increasing the need for developing groundwater sustainability plans that consider conjunctive water use.