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A New Technique for Modeling Land Subsidence Facilitates Better Groundwater Management

Overview

Land subsidence – the sudden sinking or gradual settling of Earth's surface – can occur naturally or be triggered by human activity. One of the most common human-affected factors is groundwater pumping, a practice that has been steadily increasing due to prolonged periods of drought. Groundwater pumping is so prevalent in some areas that it is severely compromising the quantity and quality of the groundwater as well as the physical structure of the land and aquifer capacity beneath it. Large-scale initiatives for putting water back into the ground, or groundwater recharge, are being implemented in some regions. However, groundwater resource managers still need better information to determine where the land is at greatest risk of subsidence as well as where recharge efforts would be the most effective. Integrating two reliable data gathering sources – helicopter-deployed systems (airborne electromagnetic or AEM technology) that measure electromagnetic fields and satellite-deployed systems (interferometric synthetic aperture radar or InSAR) to measure deformations – offers groundwater managers an improved method for more accurately modeling changes in the land surface related to the pumping and recharge of groundwater. Additionally, the ability to more precisely detect subsidence may offer an early warning system for declining groundwater levels.

Problem Statement

A single data-gathering method that provides a reliable and complete picture of the conditions above and below the surface of the land is currently unavailable. Not having this information creates challenges for developing accurate, predictive subsidence models which resource managers need to make optimal decisions for groundwater management to prevent further disturbance of the land and underground aquifers.

The Facts

In the United States, the U.S. Geological Survey (USGS) estimates that more than 17,000 square miles of land across 45 states have been directly affected by subsidence. It's particularly problematic throughout the Central Valley of California, where years of severe drought combined with heavy agricultural extraction of groundwater have resulted in areas marked by up to 28 feet of subsidence. Effects of subsidence include: the loss of groundwater storage; damage to levees and other infrastructure; and potential water contamination due to the drainage of clays and the resulting concentrations of naturally occurring chemicals like arsenic.

In an effort to avoid further aggravating existing issues of subsidence, water agencies and farmers are already exploring novel ways to capture water run-off and put it back into the groundwater system. However, the required infrastructure is often costly, so having access to accurate prediction models on the impact of recharge efforts in specific locations would help administrators better manage their water resources and optimize their investments.

To date, decision-makers have largely relied upon data gathered from three sources: monitored water wells that only assess a portion of the aquifer; GPS which is labor intensive and can be subject to error; or the satellite data that measure surface changes. By developing a new and accurate model that accounts for deformation of the subsurface layers through the combination of two consistent, yet distinct, measuring techniques, a more comprehensive understanding of actual subsurface conditions can be formed and a predictive capability developed.