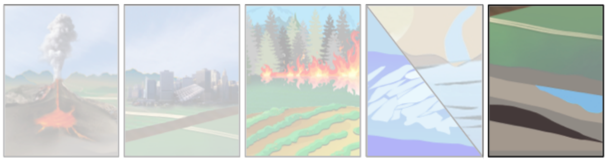
National Aeronautics and
Space Administration

NISAR: The NASA-ISRO SAR Mission



Drought and the Rapidly Changing Landscape

Droughts are accompanied by a host of troubles. The reduced surface water capture and supply results in more groundwater withdrawal, which in turn leads to ground subsidence that can impact infrastructure and even exacerbate future flooding in the very areas hardest hit by the drought.

Recent Drought in the United States

Drought is the consequence of abnormally low precipitation, reducing the surface water supply. In 2016 ~22% of the continental U.S. experienced moderate to extreme drought, and much of California was classified in the even more severe 'exceptional' drought category [U.S. Drought Monitor]. Although the western U.S. was hardest hit, droughts are by no means exclusive to the western states. The northeast, areas of the south, and parts of northern Georgia experienced the same exceptional drought in 2016 that plagued California. In fact, most of the southern states have experienced drought in recent years. Many areas, including the Georgia and California, have imposed water restrictions to safeguard dwindling water supply. Agriculture is often hard hit by drought, because supplying drinking water is the highest priority.

Photo: Ca. Dept. of Water Resources

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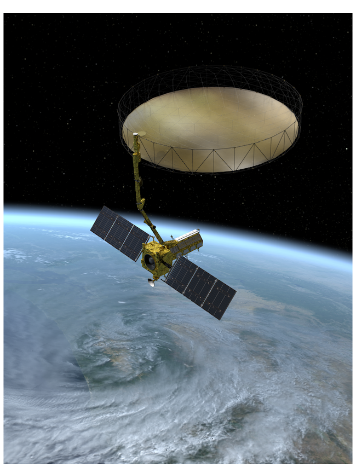
Photo: USGS

Photo: Va. Water Resources Research Center

Drought and Groundwater Withdrawal

During droughts, surface water flow declines, rivers run low, streams dry up, and reservoir inventories decline. Faced with little or no supply of water from runoff and snow melt, communities and businesses turn to an alternative source: aquifers, i.e., the underground reservoirs of water stored in water-bearing rock.



The NISAR Mission – Reliable, Consistent Observations

The NASA–ISRO Synthetic Aperture Radar (NISAR) mission, a collaboration between the National Aeronautics and Space Administration (NASA) and the Indian Space Research Organization (ISRO), will provide all-weather, day/night imaging of nearly the entire land and ice masses of the Earth repeated 4-6 times per month. NISAR's orbiting radars will image at resolutions of 5-10 meters to identify and track subtle movement of the Earth's land and its sea ice, and even provide information about what is happening below the surface. Its repeated set of high resolution images can inform resource management and be used to detect small-scale changes before they are visible to the eye. Products are expected to be available 1-2 days after observation, and within hours in response to disasters, providing actionable, timely data for many applications.

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The water in the aquifers, called groundwater, is an extremely valuable resource, like a water savings account that can be drawn on when times are hard. The water in the aquifers originally was precipitation that made its way down through the soil and rock via cracks and pores. All aquifers are not created equal: aquifers can hold small or vast amounts of water and recharge, or replenish, quickly or slowly depending upon the type of rock, both in and above the aquifer. For example, clays hold very little water and water transfers very slowly through them, so layers of clay will separate aquifers which have very different recharging rates. In fact, it is common for an area to have multiple aquifers at different depths. Shallow aquifers of saturated soil and rock in contact with the surface are called unconfined aquifers, and their water store depends upon recent activities, i.e., sources (e.g., rainfall) and sinks (e.g., pumping via wells, drainage to streams). Recharge is slow in deeper aquifers that are isolated from the surface by less permeable material. These confined aquifers collect water mainly around the edges of or through holes in the overlying rock. For these aquifers, recharge can take hundred to thousands of years.

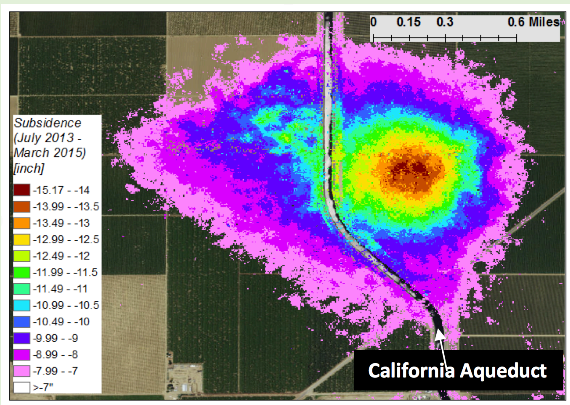
Groundwater is a valuable and renewable source of water that can be tapped through wells, rechargeable by rain and surface water runoff. However, pumping can have both immediate and long term impact. The pumping can cause ground subsidence that leads to cracks in roads and bridges, lower levee walls, and can even change the path of runoff, leaving the area at higher risk of flooding. Over-pumping can cause collapse of the aquifer pores, permanently reducing the water storage capacity. For slowly recharging aquifers, the effective water supply is reduced simply because it takes so long for surface water to reach the aquifer. In this case, restoration is possible, simply not on the scale that is needed for a practical water supply. Consequences can be a devastating loss of land viability for agricultural or habitation.

Sustainable, low impact groundwater extraction is possible, though, given information about the aquifer and the surface changes associated with pumping. This is where imaging by satellite radars capable of measuring changes in surface elevation, like NISAR, has immediate and practical value. NISAR will image global land areas on repeated orbits, providing a time series of the surface uplift and subsidence. This information shows both the long-term decline in surface elevation, which corresponds to unrecoverable loss or slow recharge of groundwater, and a seasonal cycle of uplift and subsidence that correlates to a sustainable balance between precipitation and withdrawals. Armed with this information, users can protect this valuable renewable water asset over the long term, avoiding the terrible consequences of permanent loss of water supply.

Unintended Consequences: Drought Impact to the California Aqueduct

The California Aqueduct supplies water originating in northern California and the central California mountain ranges to residents and businesses throughout much of central and southern California. The over 400-mile long water conveyance system is a cornerstone of California's water system, sustaining its populace and economy.

In 2014, as California entered the second year of extreme drought, groundwater pumping increased to replace the missing surface water. The figure to the right shows the cone of depression typical of new pumping from deep confined aquifers. In this case, the subsidence bowl extended across the California Aqueduct, which at its nearest is 0.5 mi from the center of the depression. The extensive subsidence caused the closest parts of the structure to sink more than 12".



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Radar-derived map of ground subsidence in the Central Valley, California, associated with groundwater pumping [Farr et al., 2015]. UAVSAR, an airborne prototype of the NISAR instrument, was used for the study.