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PLANET EARTH

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on Mon, 10 Nov 2014

From 310 Miles Above the Earth, Satellites Weigh Groundwater Lost to Irrigation (http://dx.doi.org/10.1002/2014GL061213)

Picture a shimmering cube of water three miles high. In the past decade, that much water—nearly the volume of Nevada's Lake Tahoe—was lost from aquifers under the American High Plains.

That figure doesn't come from measurements of the water level in wells. Rather, it's drawn from orbit, in a new study that uses data from NASA's Gravity Recovery and Climate Experiment (GRACE) spacecraft. GRACE has been weighing groundwater from on high since the late 1990s. But previous GRACE models have overlooked ways in which humans impact aquifers, says study lead author Jose Agustin Brena-Narañjo. "Which, in this case, is irrigation."

Center-pivot irrigation systems near Sublette, Kansas, draw from the High Plains Aquifer.

His team's new technique, tested on the High Plains Aquifer, uses irrigation records to improve space-based estimates of the water left underground. It could eventually help track dwindling aquifers in places like India's Indus Plains or the Tigris-Euphrates region.

GRACE doesn't take pictures from space to map groundwater. Instead, it feels along the contours of Earth's dimpled gravity like a hand reading Braille. It works like this: the two GRACE spacecraft fly over Earth one behind the other. If the first satellite flies above a continent, for example, it's accelerated away from the trailing satellite—gravity is subtly stronger over the continents, which are heavier than the oceans. By measuring tiny changes between the GRACE satellites as they pass one after the other over an area, scientists map bumps in the planet's mass. It's even possible to tease apart the weight added by underground water. Yet existing GRACE studies of aquifers have elided the very factor that places so many aquifers at risk: watering crops.

The challenge is to subtract the weight of wet soil from the total water mass known from GRACE, leaving behind just the water in the aquifer. Soil moisture is usually estimated from complex models of climate and geology. But Brena-Narañjo and his collaborators argue that records of irrigation can better predict soil moisture, at least in heavily irrigated areas. With many well measurements to check against, the High Plains Aquifer offers a perfect test case.

The High Plains aquifer sprawls across eight U.S. states, from Wyoming to Texas. Since the 1950s, the aquifer has been pumped relentlessly, in part to water crops, and has fallen over 14 feet, on average. Rising concerns about water use have made the High Plains system among the planet's most studied.

In the north, the High Plains system is in decent health, according to Orrin Feril, who manages Big Bend, the fifth of five Groundwater Management Districts in Kansas. "Our water table recovers nicely" after drought, he writes in an email. Down in Texas, though, the situation is dire.

"Bottom line is we're pumping six times as much out of the aquifer as we think is coming back in," says Robert Mace, deputy executive administrator at the Texas Water Development Board. "If you run your checking account that way, every month you're going to see less in the bank," says Mace. "That's what we're seeing."

Compared to the usual GRACE method, Brena-Narañjo found, the combo of gravity data and irrigation records is a closer match to actual measurements from High Plains wells. The harsh drought between 2010 and 2013, unseen by the traditional GRACE analysis, came across clear. Brena-Narañjo's technique also suggests that the water lost from the High Plains Aquifer in the last decade alone is between a fourth and a third of the total amount lost since the 1950s.

An expert source who reviewed the research raised questions in an email, pointing out that Brena-Narañjo's team "tuned" their model "using the same data (observed groundwater) that they used for evaluation." Anthony Kendall, a co-author on the study, admits this weakness, which he hopes further work will address. "The fact that all the wiggles match really well provides you with some degree of confidence, even though you'd like more," he says.

For his part, Mace told me this work dispels some doubts he's had about past GRACE groundwater studies. "The trends they show on [water] storage changes look reasonable," he says.

Texas' slice of the High Plains Aquifer, benighted as it is by drought, is already pinpricked with enough wells to make space-based measurements unnecessary. Which is why, after this first test, Brena-Narañjo hopes to apply his model elsewhere, in places like South Africa, India, and the Middle East where GRACE can fill in gaps of data on the ground. "When you go to any region of the world where you have irrigation fields," he says, "it's very likely you're going to have these problems."

To learn more about other Earth-observing satellites, watch "Earth From Space."

Image credit: NASA