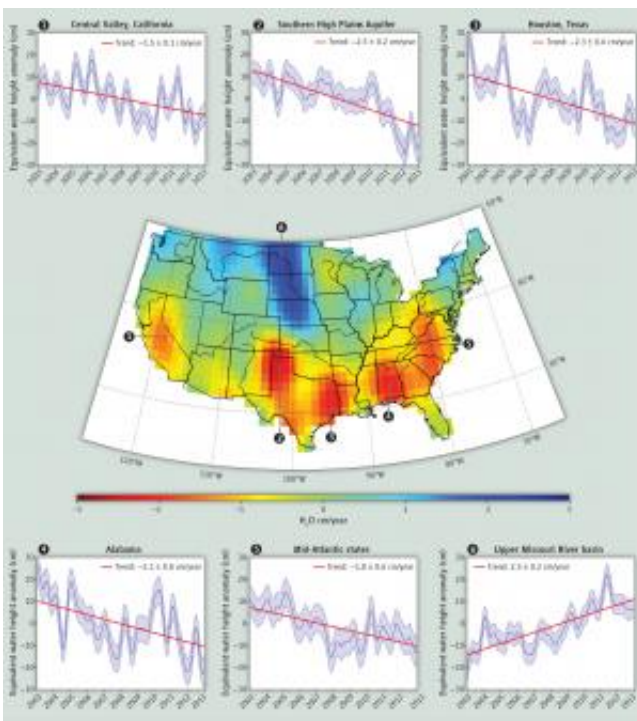


# Satellite data will be essential to future of groundwater, flood and drought management

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Groundwater storage trends around the United States as measured by the NASA/German Aerospace Center Gravity Recovery and Climate Experiment (GRACE) satellites between 2003 and 2012. GRACE data show water losses in major US agricultural regions such as (1) California’s Central Valley ( $-1.5 \pm 0.1$  centimeters, or  $-0.59 \pm 0.04$  inches, per year) and (2) the Southern High Plains Aquifer ( $-2.5 \pm 0.2$  centimeters, or  $-0.98 \pm 0.08$  inches, per year), caused by over-reliance on groundwater to supply irrigation water. Regions where groundwater is being depleted as a result of prolonged drought include (3) Houston ( $-2.3 \pm 0.6$  centimeters, or  $-0.9$  inches, per year), (4) Alabama ( $-2.1 \pm 0.8$  centimeters, or  $-0.83$  inches, per year) and (5) the Mid-Atlantic ( $-1.8 \pm 0.6$  centimeters, or  $-0.71$  inches, per year). Water storage is increasing in (6), the flood-prone Upper

Missouri River basin ( $2.5 \pm 0.2$  centimeters, or 0.98 inches, per year). The graphs surrounding the main image are monthly time series of GRACE-derived anomalies of total water storage (in centimeter-equivalent water height) for the points annotated (1) -- (6). Monthly data are displayed as darker blue lines. Trend lines (in centimeters per year), in red, have been added to each time series plot. Monthly errors are shown as light blue shading.. Data from University of Texas CSR Release-05 and prepared by Caroline de Linage, UC Irvine. Credit: J. S. Famiglietti and M. Rodell, Water in the Balance, *Science*, 340, 1300 (2013). Figure appears as Figure S1 in Supplementary Online Materials, [www.sciencemag.org/cgi/content/full/science.1236460/DC1](http://www.sciencemag.org/cgi/content/full/science.1236460/DC1). Prepared by Caroline de Linage, UC Irvine and Preston Huey, *Science Magazine*.

New satellite imagery reveals that several areas across the United States are all but certain to suffer water-related catastrophes, including extreme flooding, drought and groundwater depletion.

The paper, to be published in *Science* this Friday, June 14, underscores the urgent need to address these current and rapidly emerging water issues at the national scale.

"We don't recognize the dire water situation that we face here in the United States," said lead author Jay Famiglietti, a professor of [Earth System Science](#) at the University of California, Irvine, and Director of the UC Center for Hydrologic Modeling (UCCHM). Since its launch in 2002, Famiglietti and co-author Matt Rodell, Chief of the Hydrological Sciences Laboratory at NASA's Goddard Space Flight Center, have been using data from the NASA Gravity Recovery and [Climate Experiment](#) (GRACE) [satellite mission](#) to track changing freshwater availability all over the world.

"Worldwide, [groundwater supplies](#) about half of all drinking water, and it is also hugely important for agriculture, yet without GRACE we would

have no routine, [global measurements](#) of changes in groundwater availability," said Rodell. "Other satellites can't do it, and ground-based monitoring is inadequate."

The report, entitled *Water in the Balance*, draws attention to water management as a national, rather than just a regional or statewide problem. The [GRACE mission](#) is able to monitor monthly water storage changes within [river basins](#) and aquifers that are 200,000 km<sup>2</sup> or larger in area, and, according to Famiglietti and Rodell, can contribute to water management at regional and national scales, and to international policy discussions as well.

Using GRACE data, the researchers were able to identify several water 'hotspots' in the United States, including its key food producing regions in 1) California's Central Valley, and 2) the southern High Plains aquifer; a broad swath of the southeastern U. S. that has been plagued by persistent drought, including 3) Houston, Texas, 4) Alabama, and 5) the Mid-Atlantic region; and 6) the flood-prone upper Missouri River basin. They also noted that since 2003, the wetter, northern half of the U.S. has become wetter, while the drier, southern half has become drier.

According to Famiglietti and Rodell, without coordinated and proactive management, the aquifers supplying the Central Valley and the southern High Plains with water for irrigation will deplete their groundwater reserves, perhaps within decades, putting the nation's food supply at considerable risk. Meanwhile, if sufficient measures are not taken, the upper Missouri River basin will experience extensive flood damage. The authors state that using GRACE, groundwater supplies can now be better managed, while the lead-time for flood and drought predictions could be substantially increased, potentially saving hundreds of millions of dollars and countless lives in the process.

"GRACE data provide new insights into regions in the U.S. and around

the world where water issues have already approached the crisis stage. Their potential for game-changing contributions to regional water management is just beginning to be realized," says Famiglietti, who believes that maps like his and Rodell's make a strong case for immediate action, and ultimately, for a comprehensive, national water policy in the United States.

The authors argue for greater investment to speed current GRACE data processing to ensure its availability for seasonal flood and drought forecasting, and for future gravity missions that can help water management even more than at present.

"A future mission that could monitor [water](#) storage changes every week or two, rather than on a monthly basis, and for river basins and aquifers that are tens of thousands of square kilometers, rather than hundreds, would be ideal," notes Rodell.

According to *USA Today*, in 2012 flood damage from Hurricane Sandy and the Midwest/Great Plains drought cost the U.S. \$100 billion. The U.S. Geological Survey recently reported that since the beginning of the 20th century, enough groundwater has been depleted in the [United States](#) to fill Lake Erie twice.

**More information:** "Water in the Balance," by J.S. Famiglietti et al. *Science*, 2013.

Provided by University of California, Irvine

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