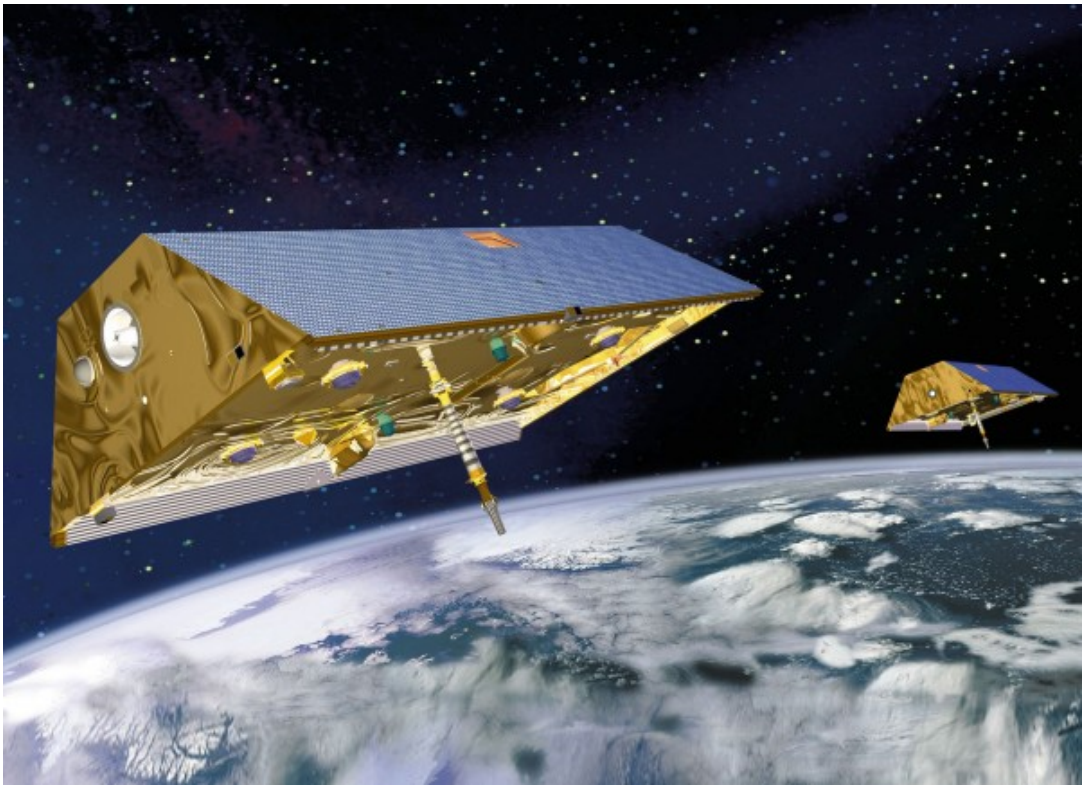
Epic California Drought and Groundwater: Where Do We Go From Here?

Jay Famiglietti of University of California, Irvine in Water Currents on February 4, 2014

Yesterday our team at the UC Center for Hydrologic Modeling released a report on the California drought. The report describes the birds-eye view of statewide water resources that we see from the NASA GRACE satellite mission.



We've been working since the mid-1990's, well before the mission was launched in 2002, to develop and test methods to help monitor groundwater depletion from space. We've applied them around the world — in California, across the U.S., in the Middle East, East Africa, in the Amazon River Basin and in India.

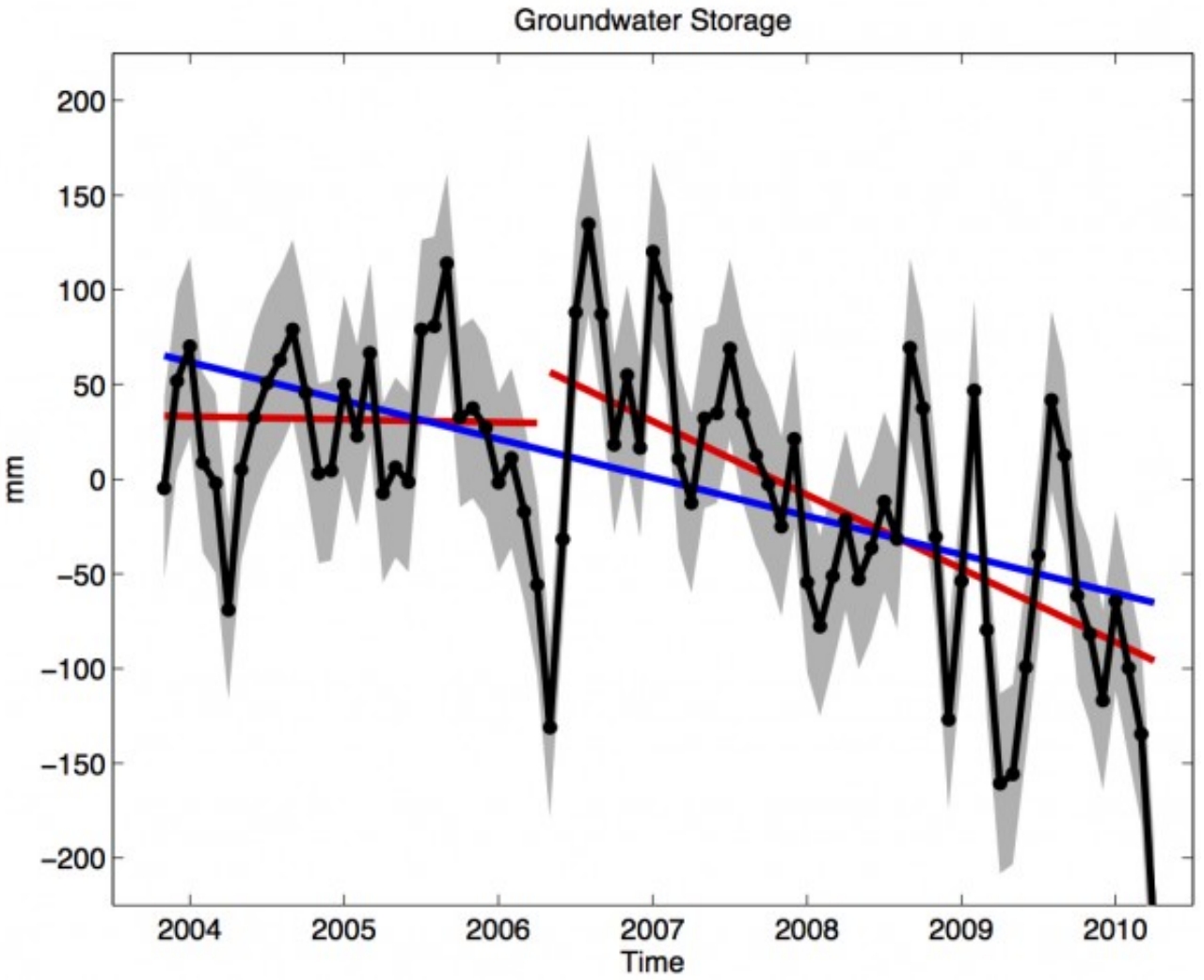
Our endgame is simple. We want to use GRACE and other satellites, combined with invaluable measurements on the ground, to help quantify how regional and global freshwater availability is changing.

The good news is that the methods work great. The GRACE mission functions like a giant 'scale in the sky,' weighing how various regions around the world are gaining and losing water each month. We can see the ups and downs of 'total' water storage – all of the snow, surface water, soil moisture, and groundwater – like never before.

The bad news is that we are running out of groundwater.

In particular, this is happening in the places that we need it most — the dry parts of the planet where we love to live, precisely because it does not rain. Out of necessity, our reliance on groundwater in these parts of the world is much greater than elsewhere.

Our team and several others around the globe are showing that most of the major aquifers in the world's arid and semi-arid regions are being depleted at a rapid pace, and one that is most likely unsustainable in the long term. Groundwater is a finite resource after all.



Groundwater storage changes in California from 2003-2010. From the GRL paper by Famiglietti et al, 2011. Blue line shows overall decreasing trend, about 3 cubic kilometers per year. Red line shows piecewise trends, and that most of the depletion occurred during the drought of 2006-2010.

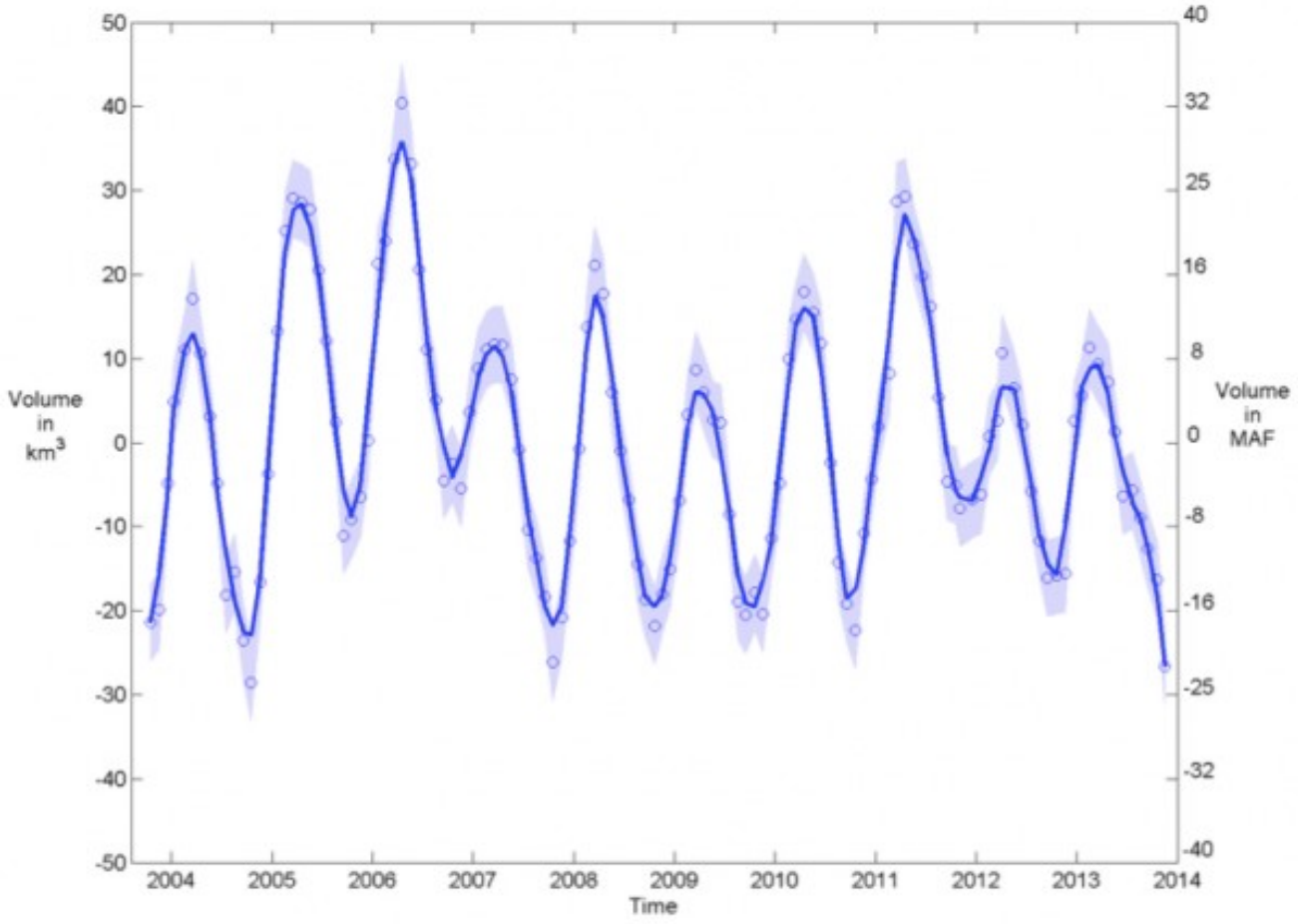
What has GRACE shown us about California?

Our earlier study showed that between October 2003 and March 2010, the Sacramento and San Joaquin River Basins lost about 30 cubic kilometers of freshwater, nearly the equivalent of the full volume of Lake Mead. Of this, we determined that about two-thirds was due to groundwater depletion in the Central Valley.

During the drought of 2006-2010, state and federal surface water allocations were drastically reduced, forcing farmers to tap groundwater reserves far more heavily than in 'normal,' wetter years. The resulting volume of depleted groundwater was so great that it was registered by a satellite 'scale' that orbits about 400 km above Earth's surface.

Our new report is an update to this previous work, and it points to one critical question for California.

One of the key numbers to emerge from the report is that the combined Sacramento and San Joaquin River Basins have already lost 10 cubic kilometers of freshwater each year in 2012 and 2013.



Anomalies of total water storage (deviations from mean) in the Sacramento and San Joaquin River Basins from GRACE, 2003-2013. November 2013 marks the low point in nearly a decade. From the UCCHM Water Advisory #1. GRACE data processed by Sean Swenson, National Center for Atmospheric Research

To put that number in perspective, it is roughly the amount of water used by the entire population of California, for household, municipal, and industrial use (that is, for nearly everything else besides agriculture and environment). It is also the steepest decline in total water availability that our team has witnessed in the 12 years that we have been monitoring California water resources with the GRACE mission.

A second contribution of the report is that it further exposes the unsustainable pattern of groundwater use in the Central Valley. While there is some replenishment of groundwater during wet years, groundwater levels decline precipitously during drought, when farmers have no choice but to rely far more heavily on groundwater to meet their irrigation water needs.

This is shown quite clearly in the image below, created by combing USGS data from 1962 to 2003 (courtesy of Claudia Faunt, USGS) with GRACE data from 2003-2013.

What do we see? A little up, a lot down, a little increase, a big plunge. The downs are way bigger than the ups, which means that groundwater levels are on a one-way journey to the very bottom of the Central Valley.

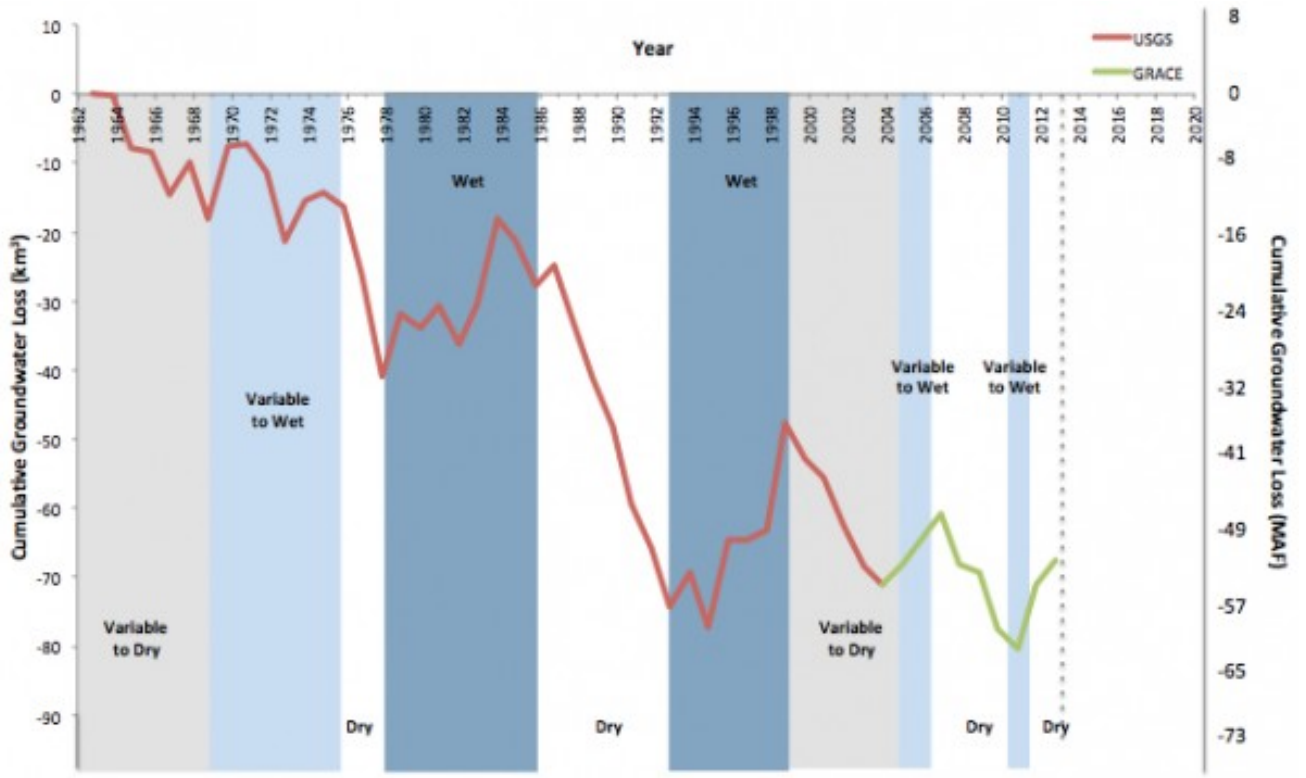


Figure from UCCHM Water Advisory #1. Cumulative groundwater losses (cubic km and million acre-ft) in California's Central Valley since 1962. The red line shows data from USGS calibrated groundwater model simulations from 1962-2003. The green line shows satellite-based estimates of groundwater storage losses produced by the UCCHM at UC Irvine. Background colors represent periods of drought (white), of variable to dry conditions (grey), of variable to wet conditions (light blue) and wet conditions (blue). Groundwater depletion mostly occurs during drought; and progressive droughts are lowering groundwater storage to unsustainable levels. After Figure B9 from USGS Professional Paper 1766. USGS data courtesy of Claudia Faunt. Satellite data courtesy of NASA and the National Center for Atmospheric Research.

So, that critical question: Where do we go from here?

Governor Brown declared a statewide drought emergency for California on January 17th. Historical observations point to this drought being among the worst ever. Levels of rainfall, snowpack, reservoirs, and streamflow are all at record lows. Exactly one week later, on January 24th, officials for the State Water Project announced that surface water allocations would be 0…as in zero.

In practical terms this means that 25,000,000 California residents just had their water supply slashed, while 750,000 acres of Central Valley agriculture are now at risk. Allocations from the federal Central Valley Project will be announced later this month. Most likely, the news will be equally disturbing.

While such management decisions are extremely difficult, and the cuts may be necessary, the implication can only be that in the Central Valley and around the state, we are poised for our next great epoch of groundwater depletion. Though using less via conservation and increased efficiencies is essential, there is really not much of a choice if we still want to eat and drink.

The problem with that is the pattern shown in the figure above practically defines the term ‘unsustainable.’ Not only is this vast strategic water reserve disappearing rapidly, a host of depletion-related impacts will inevitably kick in: continued land subsidence, progressively worsening water quality, increasing groundwater pumping costs to lift the water over greater distances, the need to dig deeper and deeper wells, increasing food costs, depletion of overlying streams, other ecological damage…you get the picture.

We need a plan to manage groundwater as a reliable resource for the foreseeable future, and we need it right now.

Thankfully Governor Brown understands this and is taking steps to secure groundwater and other critical components of the state’s water future. Last week I presented this report to the California State Water Resources Control Board. Late last year I did the same before the California State Board of Food and Agriculture. Prior to that, Governor Brown’s Office of Planning and Research has reached out to our team and to our university and research colleagues on several occasions. This is all a very positive development. However, I remain extremely concerned, because when I look at the figure above, I see a state that is standing on the edge of a cliff. This current drought, if it continues, will be like none other in recent times. The stress on groundwater will be far greater than ever before. Without an effective groundwater management plan, we’ll be in Trouble. If we jump off that cliff, there may be no safety net to break the fall.