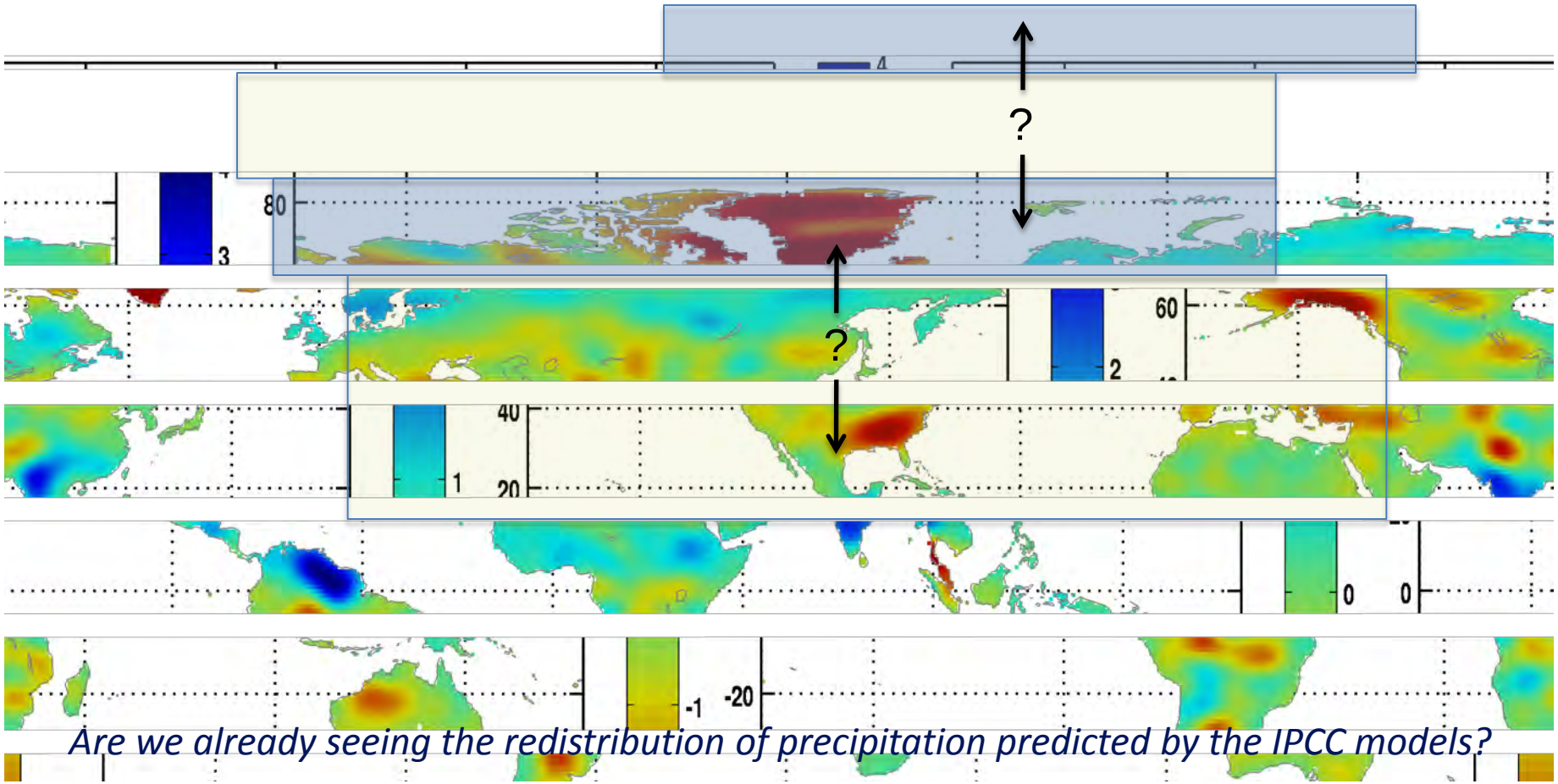
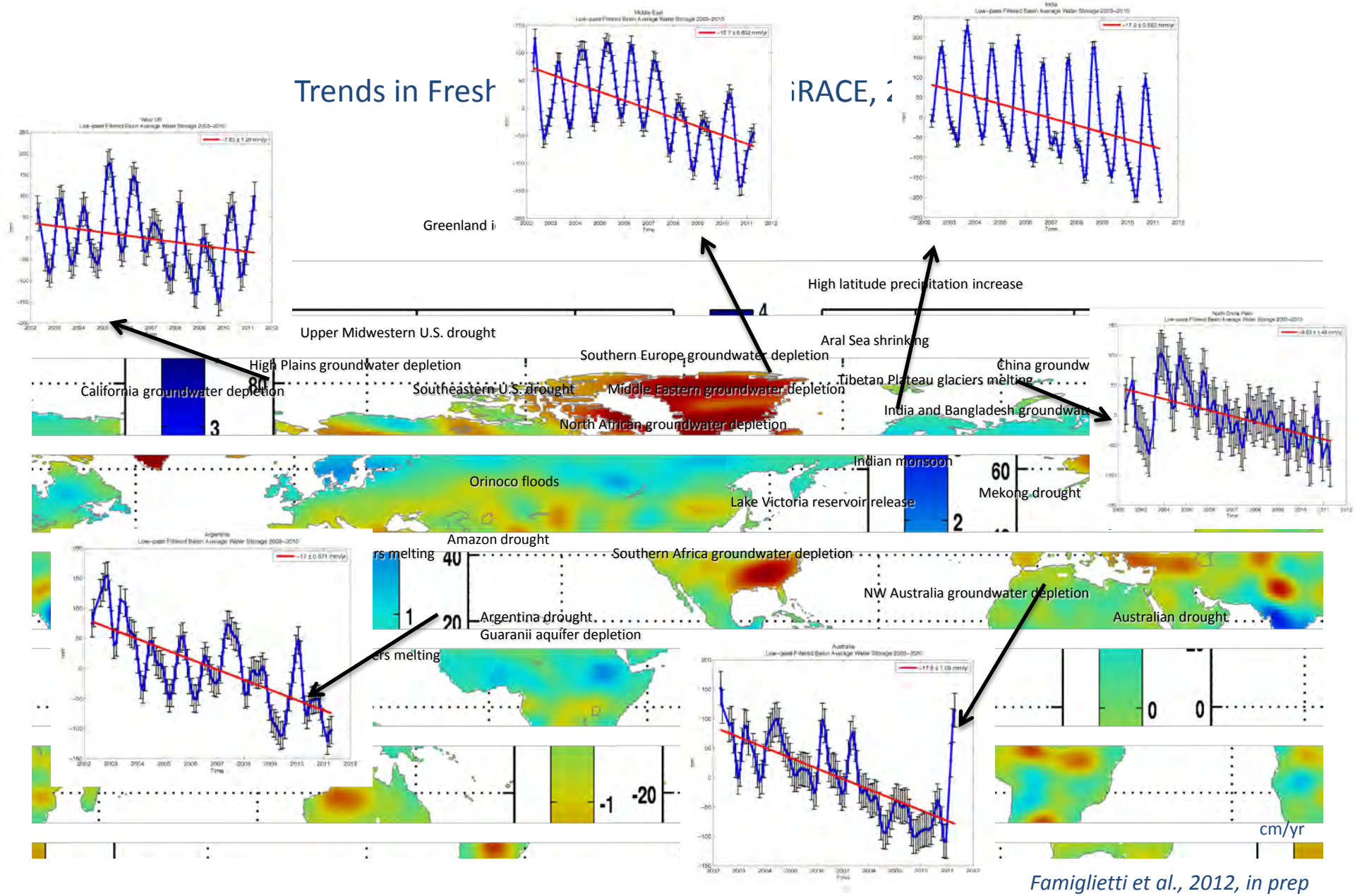
Trends in Freshwater Storage from GRACE, 2002-2010



Are we already seeing the redistribution of precipitation predicted by the IPCC models?

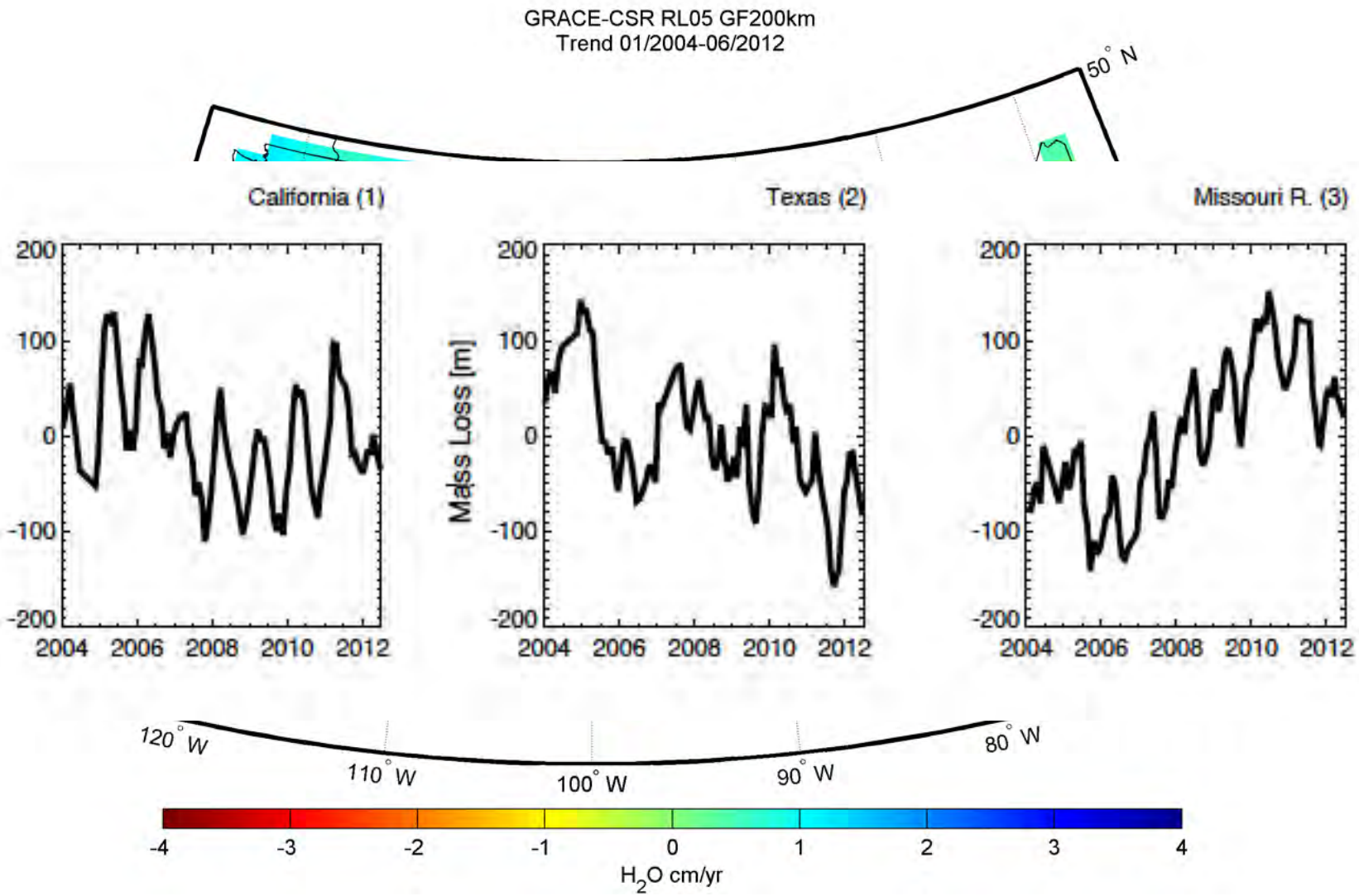
Famiglietti et al., 2012, in prep

Trends in Fresh … GRACE, 2…

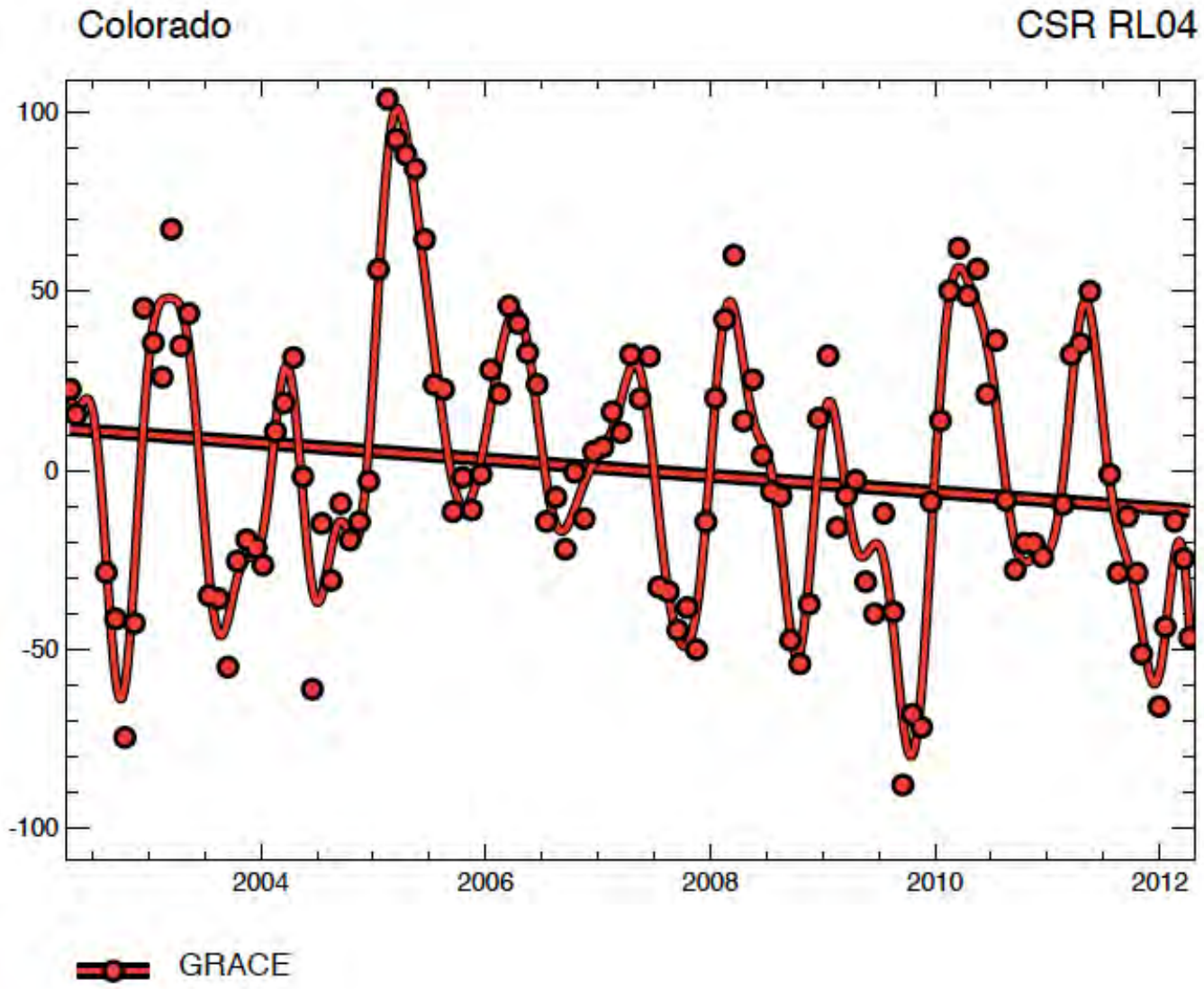


Famiglietti et al., 2012, in prep

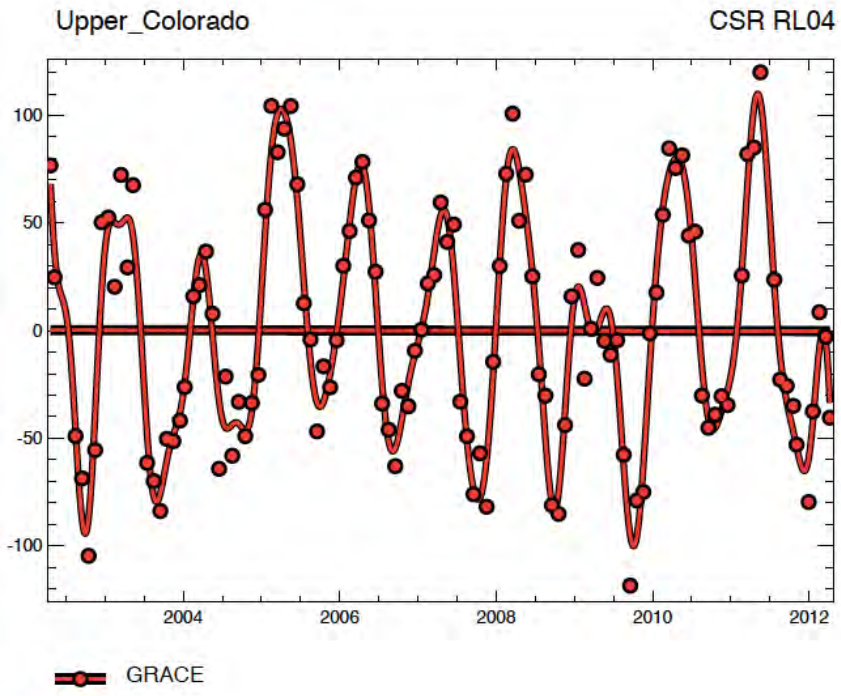
Trends in Freshwater Storage from GRACE, 2004-2012

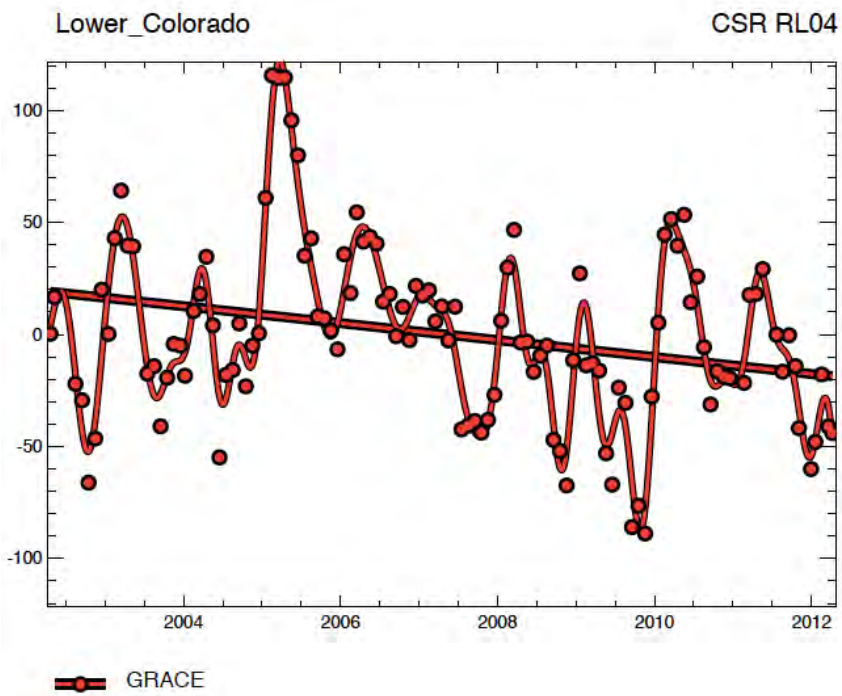


Water Storage Changes in the Colorado River Basin from GRACE



Water Storage Changes in the Colorado River Basin from GRACE

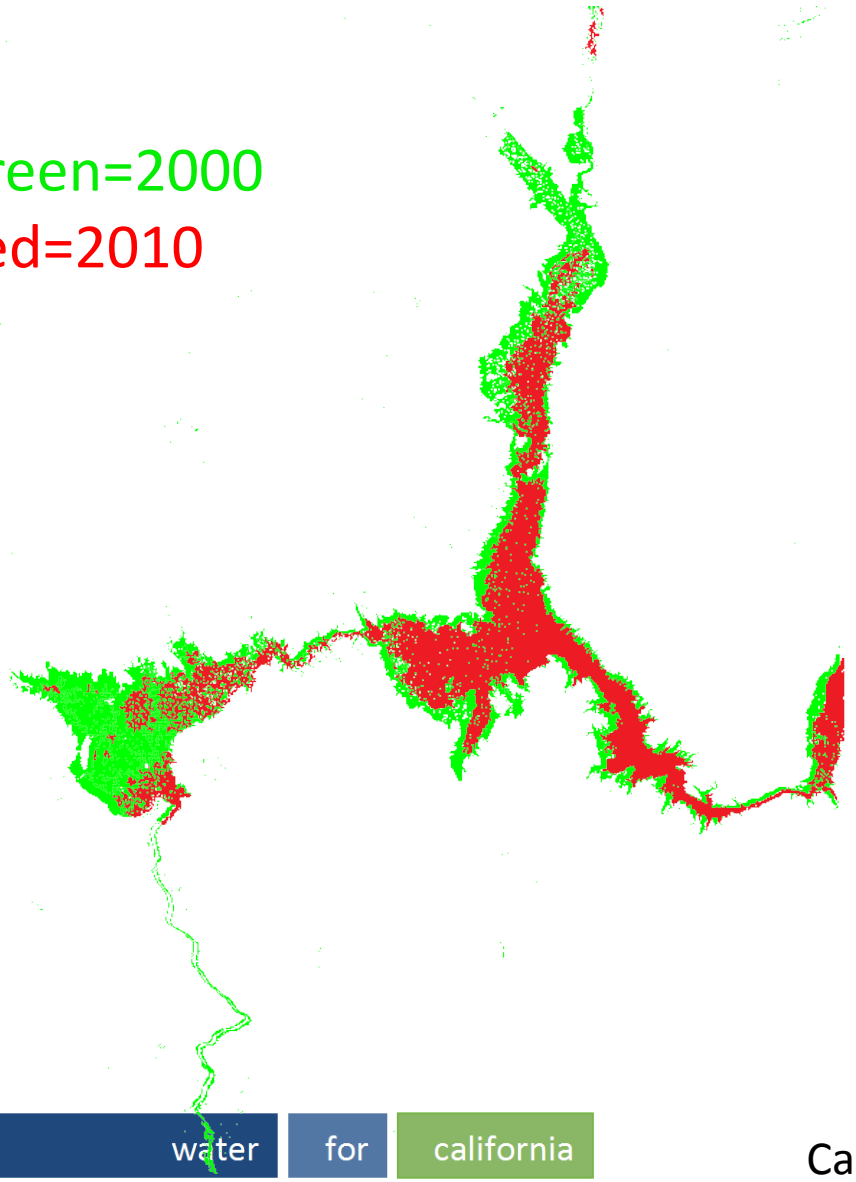


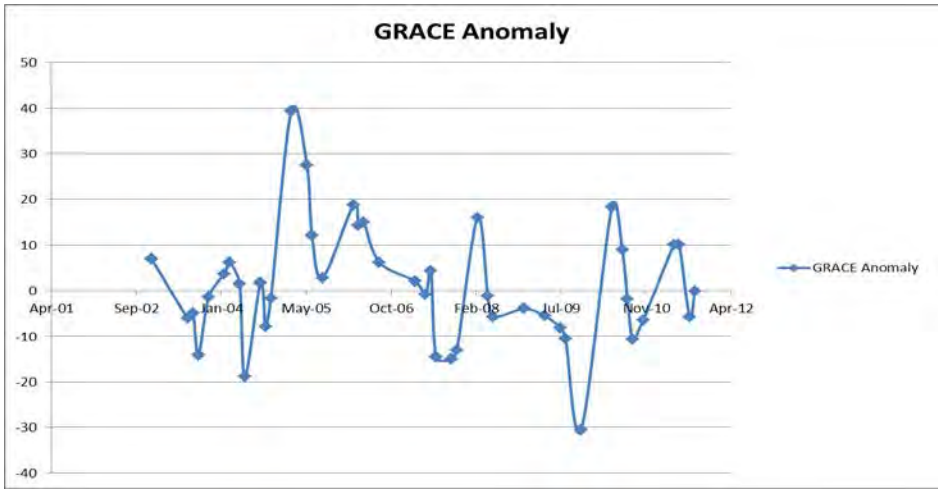


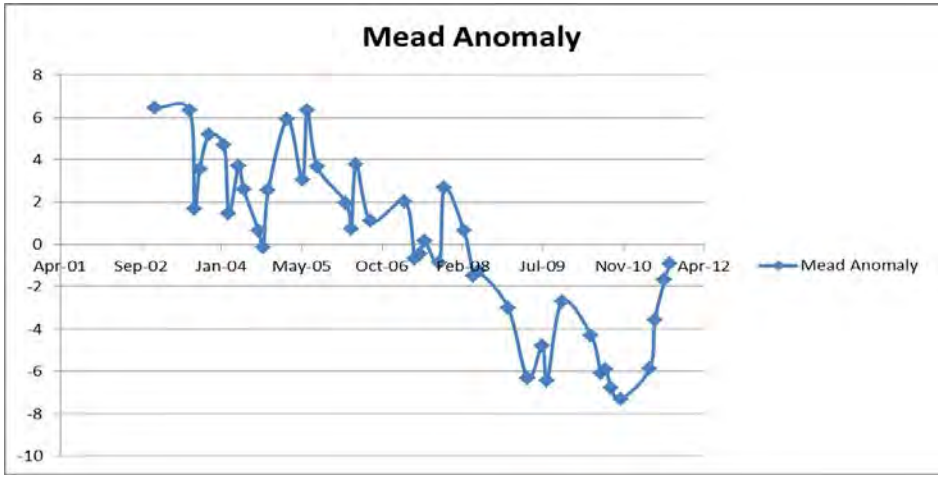
Mead Storage 2000 versus 2010

Green=2000

Red=2010







water for california

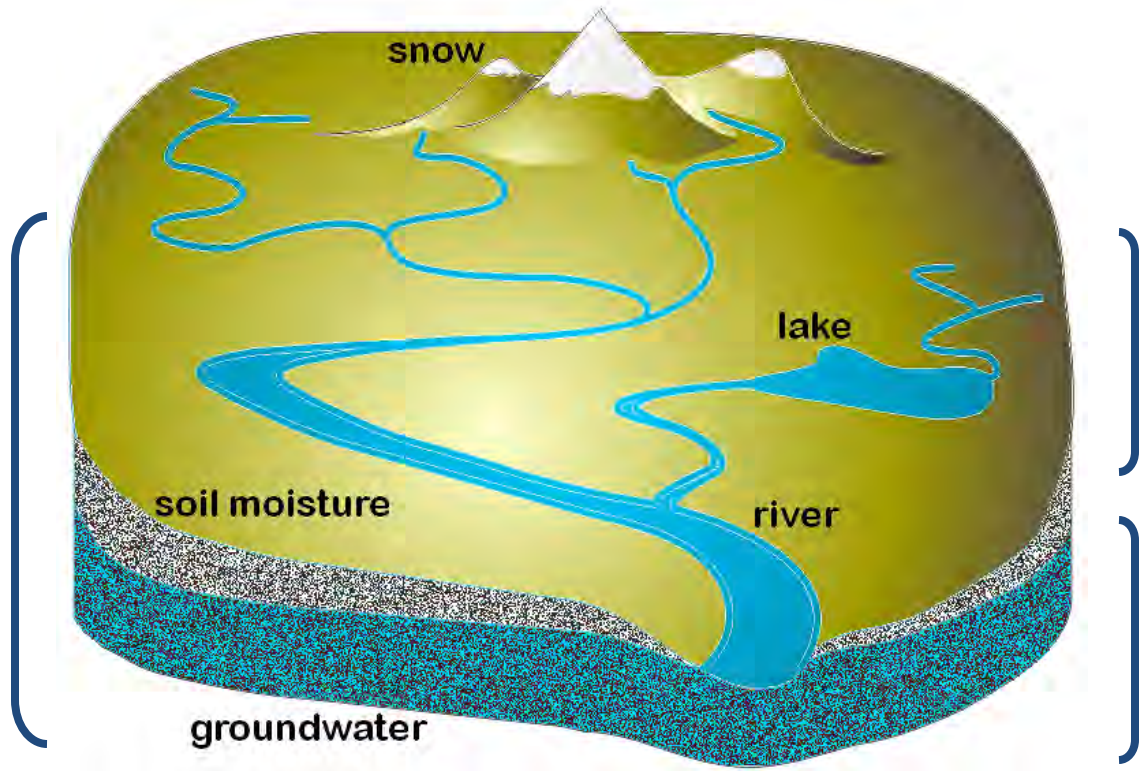
Castle et al., 2012

Estimating groundwater storage changes with GRACE

$$\Delta S_{LAND} = \Delta S_{SNOW} + \Delta S_{SW} + \Delta S_{SM} + \Delta S_{GW}$$

$$\Delta S_{GW} = \Delta S_{LAND} - \Delta S_{SNOW} - \Delta S_{SW} - \Delta S_{SM}$$

ΔS_{LAND}



Remove this ($\Delta S_{SNOW} + \Delta S_{SW} + \Delta S_{SM}$) from ΔS_{LAND}…

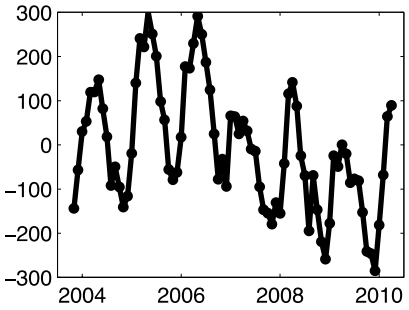
To isolate this (ΔS_{GW})

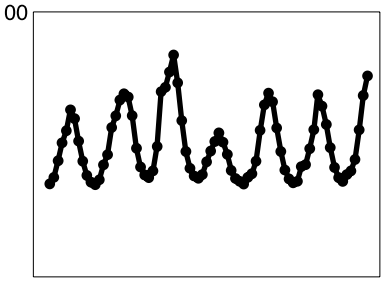
Groundwater depletion in California's Central Valley, October, 2003-March, 2009

- Since GRACE 'sees' all the water storage changes on land, in order to estimate the groundwater storage change signal, the snow, surface water and soil moisture mass changes must be estimated and removed

$$\Delta S_{Groundwater} = \Delta S_{Total} - \Delta S_{Snow} - \Delta S_{Surface\ Water} - \Delta S_{Soil\ Moisture}$$

- The snow, surface water and soil moisture signals were estimated using best available observed and modeled data sets





Famiglietti et al., 2011

Groundwater dep
• New method to a
suggest El Niño

From the company that brought you
An Inconvenient Truth, Food,Inc. and **Waiting for "Superman"**

LAST CALL AT THE OASIS

TURN IT AROUND

ATO PICTURES and PARTICIPANT MEDIA present a film by JESSICA YU

A FILM IN PHOTOGRAPHY JON ELSE MUSIC BY JEFF BEAL MUSIC SUPERVISOR MARGARET YEN BASED ON THE BOOK "THE BOTTLED TRUTH" BY ALEX PRUD'HOMME EDITOR KIM ROBERTS, ACE

EXECUTIVE PRODUCERS JEFF SKOLL DIANE WEYERMANN CAROL BAUM DAVID HELPERN PRODUCED BY ELISE PEARLSTEIN PRODUCED, WRITTEN AND DIRECTED BY JESSICA YU

participant media

MAY 2012

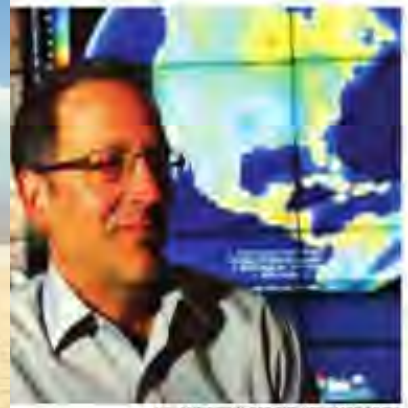
ART TAKES OVER

LEARN MORE ABOUT YOUR WATER : TAKEPART.COM/LASTCALL #KNOWYOURWATER LASTCALLATTHEOASIS.COM

k Times

imes TUESDAY, MAY 31, 2011

Depletion
m Space



...ANN JOHANSSON FOR THE NEW YORK TIMES

...f the University of California Center for Hydrologic ...ctober 2007 to March 2010, aquifers under the state's ...lown by 25 million acre-feet.

...in arid re-
...groundwa-
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... said Dr.
...was blown
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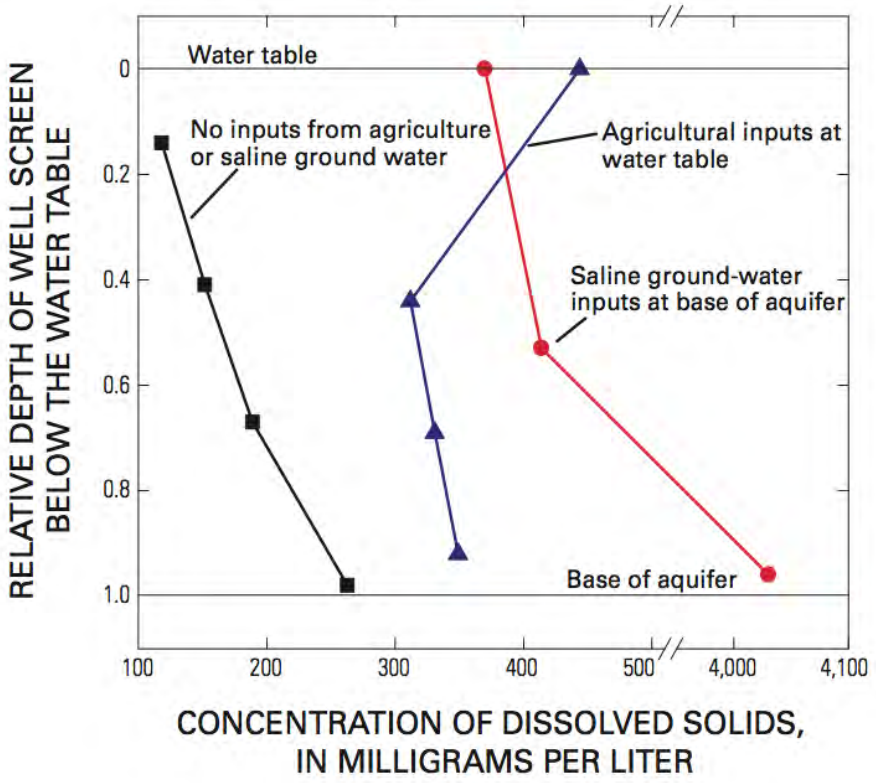
...is is amaz-
...!"

Gravity's tug on a pair of satellites helps pull in precise data.

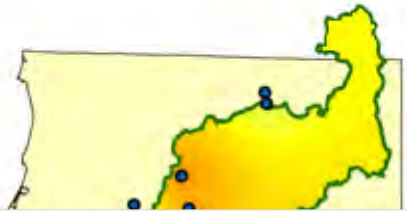
Back then the Grace experiment was still waiting in a queue of NASA projects. But he and Matt Rodell, a Ph.D. candidate under his supervision, threw themselves into investigating whether Grace would work, a so-called "proof of concept" exercise that turned out to show that Grace data was reliable and could support groundwater studies.

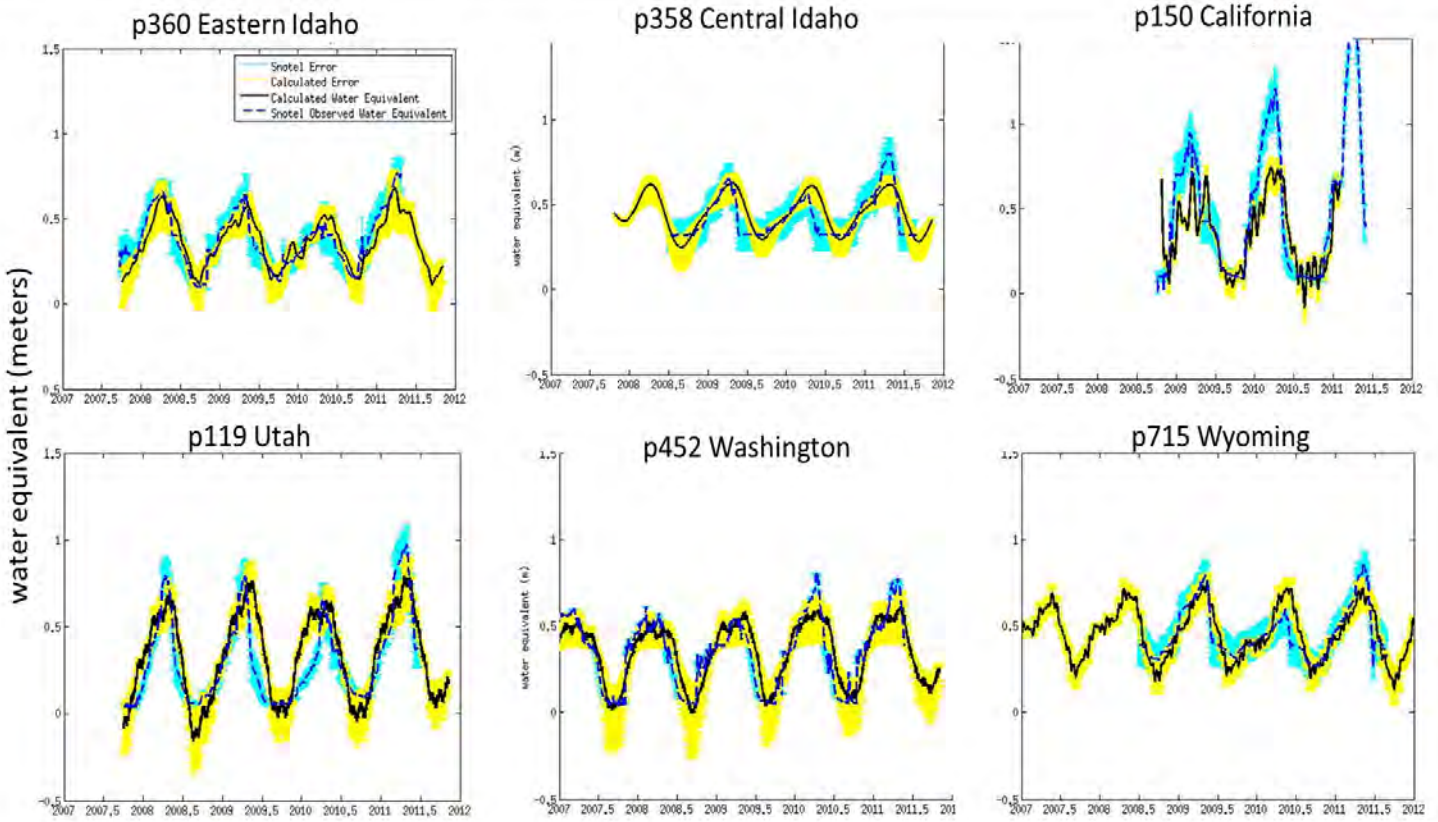
"It was a wide-open field we came into," said Dr. Rodell, now a researcher at NASA's Goddard Space Flight Center. "We were like kids in a candy store. There was so much to be done."

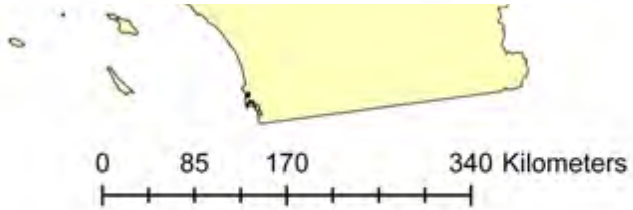
When Grace was conceived by a group of scientists led by Byrnn D. Tapley, the



From McMahon et al, 2007
Gibbons et al, 2012







Ouellette et al, 2012

Where do we go from here?

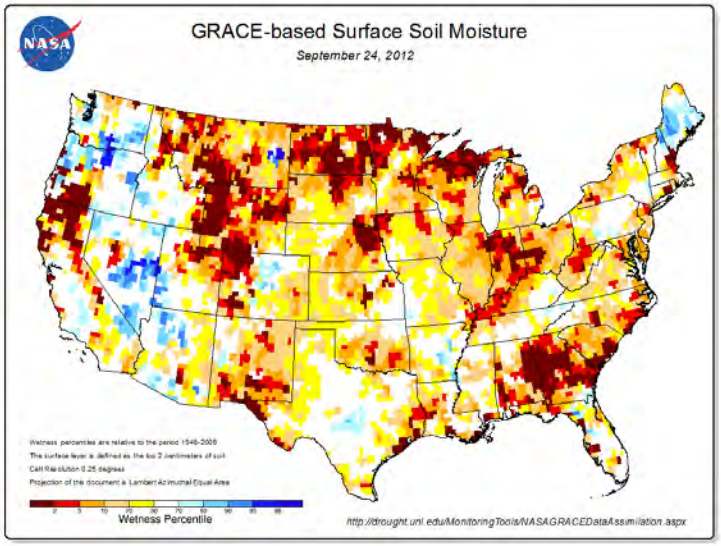
Essential to provide water managers, environmental decision makers and elected officials best available science. Need to know

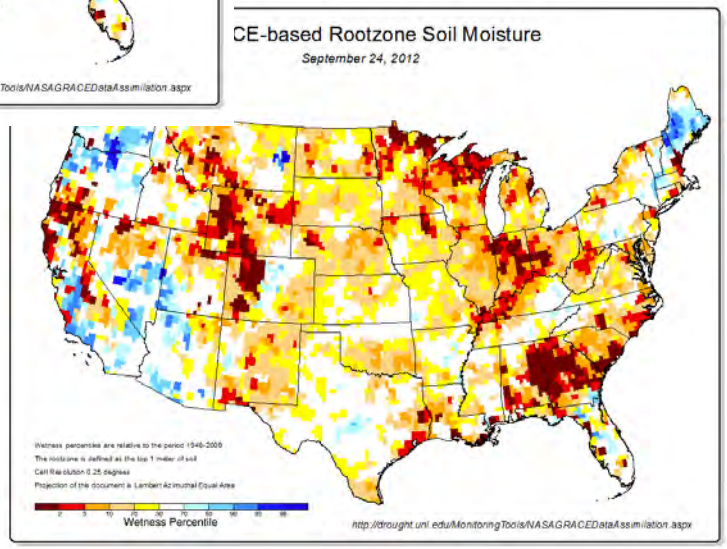
- How much water do we have?
- How much do we need?
- How will these change in the future?

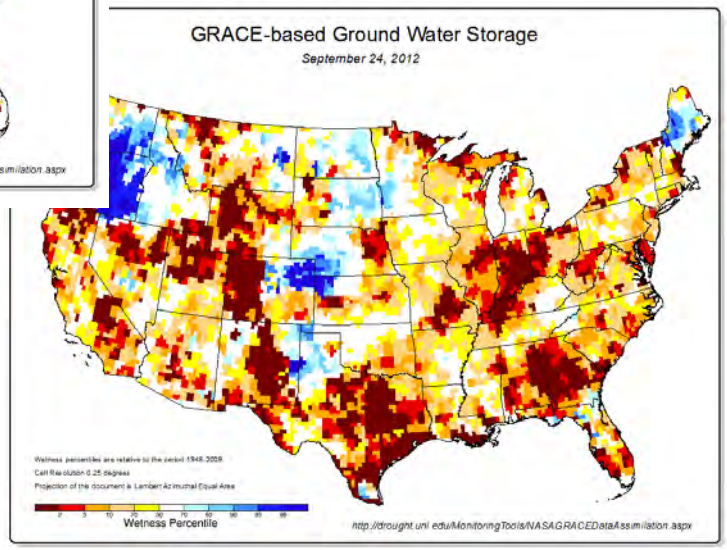
A key step is to integrate remote sensing data like GRACE, SMAP, SWOT, MODIS, etc into the decision making stream, **and**, into our computer models. Remote sensing is providing too much good, realistic information on what our water landscape looks like to be ignored

Models themselves need a huge acceleration in development, to integrate all of snow and ice, surface waters, soil moisture, groundwater and the basics of human water management like conveyances, groundwater pumping and irrigation, in ways that can be integrated into climate models

Example of GRACE integrated into US Drought Monitor





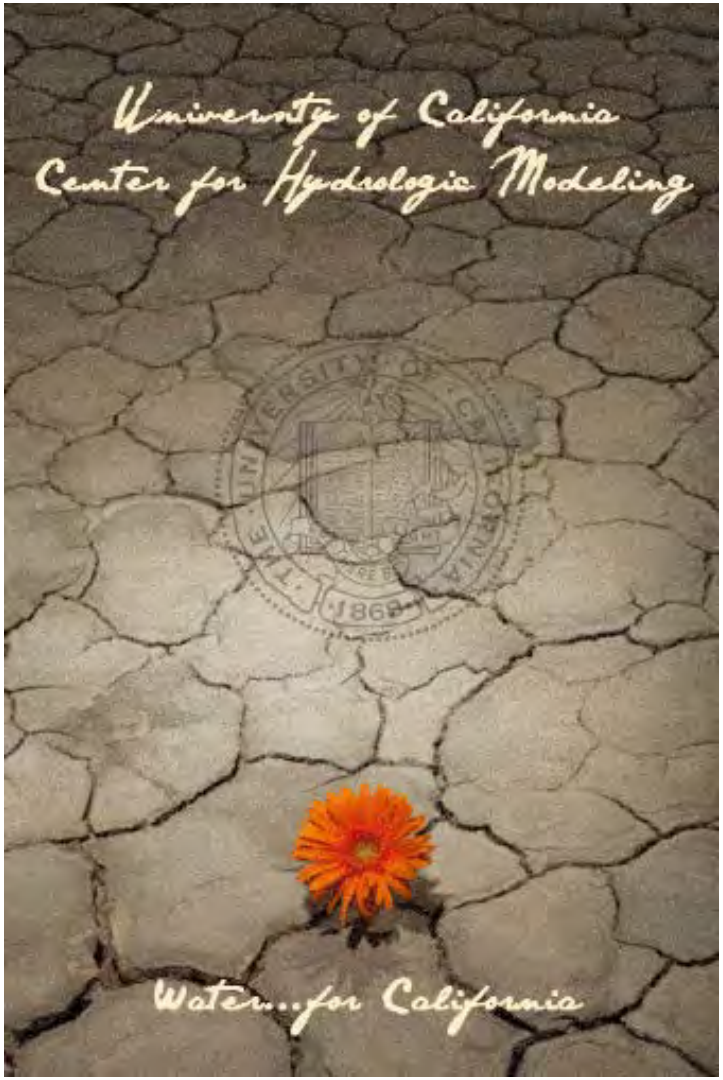


UC Center for Hydrologic Modeling

Mission

Harnessing the power of UC hydrology to develop state-of-the-art models, data products and data management to support system-wide research and sustainable water management for California and the west

- Coordinated model development, distribution and support
- Best available data products
- Data management and information system
- HPC computer access
- Informing state and regional water management abd environmental decision making
- Water education and outreach



UC Center for Hydrologic Modeling

Vision

Sustainable water resources management informed by systemwide, state-of-the-science input

Modeling Progress

Based on Community Hydrologic Modeling Platform (CHyMP)
Famiglietti et al., 2008a,b, 2009, 2011, Arrigo et al., 2011

- High resolution (1-km)
- Integrated water cycle (snow, surface water, soil moisture, groundwater) with interchangable components
- Major features of water management (aqueducts/canals, reservoirs, groundwater pumping, irrigation)
- Explicit representation of watersheds, rivers, aquifers, lakes, reservoirs, etc.
- NASA mission assimilation friendly (SWOT, SMAP, GRACE…)
- In situ observation assimilation friendly
- Ability to link to other model types (climate, weather, ecological, biogeochemical, energy, agricultural, economic…)
- Ability to simulate or link model types across scales (e.g. linking land surface models with floodplain models)
- User-friendly platform with distribution, support, HPC access

Groundwater Depletion in the Central Valley

We call this ‘THE MOONSHOT”

We can do it, but we need partners and your help

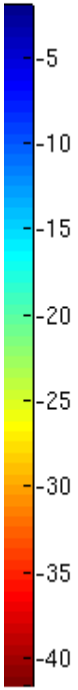
We need to hear from the water managers and what they need

We need to partner with the California Water Foundation

We need help making the connections to state and federal funding sources, and to keep the pressure on the state and federal agencies

We need to, together, keep beating the drum on the need for more and better observations, for data transparency, and for accelerated model development

We need to elevate our critical water issues to the level of everyday understanding




Groundwater
Replenishment System
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