A MAP OF THE FUTURE OF WATER

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Overview

Defining water security
What are satellites telling us about water security?
What are some implications and emerging policy needs for water, food and human security?
What are we going to do about it?
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GRACE (2002-2017)
GRACE-FO (2018-)
Functions like a ‘scale in the sky’
Measures changes in total water storage
Timescales > monthly
Regions >150,000 km²
Accuracy 1.5 cm equivalent water height

Updated from Voss et al., 2013
Changing freshwater availability from GRACE (2002-2016)
Rodell, Famiglietti et al., 2018, Nature, Emerging Trends in Global Freshwater Availability
Changing freshwater availability in North America from GRACE (2002-2016)

Rodell, Famiglietti et al., 2018, Nature, Emerging Trends in Global Freshwater Availability
Groundwater

The water stored under the ground in aquifers
Primary water source for over 2 billion people
Provides nearly half of the water for irrigation
In many cases is non-renewable
How do we estimate groundwater storage changes with GRACE?

Rodell and Famiglietti, 2002, J. Hydrology

\[ \Delta S_{\text{LAND}} = \Delta S_{\text{SNOW}} + \Delta S_{\text{SW}} + \Delta S_{\text{SM}} + \Delta S_{\text{GW}} \]

\[ \Delta S_{\text{GW}} = \Delta S_{\text{LAND}} - \Delta S_{\text{SNOW}} - \Delta S_{\text{SW}} - \Delta S_{\text{SM}} \]

Remove this (\(\Delta S_{\text{SNOW}} + \Delta S_{\text{SW}} + \Delta S_{\text{SM}}\)) from \(\Delta S_{\text{LAND}}\)

To isolate this (\(\Delta S_{\text{GW}}\))
Future prospects for estimating groundwater storage changes from space

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


SWOT (2022)  SMAP (2015)
Groundwater Depletion is Detected From Space

By FELICITY BARRINGER

Science Times
TUESDAY, MAY 31, 2011

Sensing Groundwater
Hydrologists have used a pair of gravity-sensing satellites known as GRACE to detect a large-scale decline in groundwater levels in California. The data, which show that groundwater levels have fallen by about 15 inches since the beginning of the decade, have been used to predict future changes in California's water supply.

Cumulative Groundwater Loss

- USGS-CVHM
- GRACE
- Dry - Wet

Variable to dry
Variable to wet

NASA
JPL

Changing freshwater availability from GRACE (2002-2016)
Rodell, Famiglietti et al., 2018, Nature, Emerging Trends in Global Freshwater Availability
Figure 2 from The global groundwater crisis, J. S. Famiglietti, Nature Climate Change 4, 945–948 (2014) doi:10.1038/nclimate2425 Published online 29 October 2014. Water storage declines (mm equivalent water height) in several of the world’s major aquifers in Earth’s arid and semi-arid mid-latitudes, derived from the NASA GRACE satellite mission. The monthly storage changes are shown as anomalies for the period April 2002–May 2013, with 24-month smoothing. Image: J. S. Famiglietti and J. T. Reager, NASA Jet Propulsion Laboratory, California Institute of Technology; and University of California, Irvine, USA.
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The human fingerprint on the freshwater landscape - through climate change, ice melt, changing extremes, and water management - is a dominant force that is dramatically changing patterns of water availability. This change – and with it, major threats to water and food security -- is happening far more rapidly than most people realize.
Most are in a state of chronic water scarcity
There are many ‘solutions’ for metropolitan regions but fewer for agriculture
Will we need to move water to the major food producing regions?
Food-related water problems are national and international problems

Implications for food producing regions
Implications for socioeconomics, policy

Society is not prepared for the water, food and energy future that confronts us

Distinct classes of water ‘haves and have nots’ are emerging

Violent conflict and water/climate refugees will increase

Revisions to water law and new transboundary policies required
Implications for groundwater management

Recognize and accept that we use more water than we have available.

Hydrogeological exploration of the world's major aquifers.

Measuring, monitoring, reporting of groundwater quantity and quality data, and sharing across political boundaries.

Conjunctive surface and groundwater use.

Recognize groundwater as a critical element of national and international water supplies.

COMMENTARY:

The global groundwater crisis

J. S. Famiglietti

Groundwater depletion the world over poses a far greater threat to global water security than is currently acknowledged.

Groundwater — the water stored beneath Earth's surface in soil and porous rock aquifers — accounts for as much as 33% of total water withdrawals worldwide. Over two billion people rely on groundwater as their primary water source, while half or more of the irrigation water used to grow the world's food is supplied from underground sources.

Groundwater also acts as the key strategic reserve in times of drought, in particular during prolonged events such as those in progress across the Western United States (Fig. 1), northeastern Brazil and Australia. Like money in the bank, groundwater sustains societies through the lean times of little incoming rain and snow. Hence, without a sustainable groundwater reserve, global water security is at far greater risk than is currently recognized.
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Some perspective

There is an urgent need for regional and global science, engineering and water policy innovations

Academics need to engage with policy makers, planners, stakeholder and the public to discuss adaptation strategies and science and policy needs

• Engage deeply and co-develop key questions
• Do the highest quality work
• Communicate to stakeholders, resource managers, elected officials and the public

We need to integrate across disciplines and institutions
The world’s wet regions are getting wetter and its dry areas are getting drier much more quickly than previously thought, changes that threaten the availability of fresh water and create new risks to people’s health, the food supply, and the environment.
More Information

Trend, Future of Water issue
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