California’s Epic Drought as Viewed from Space

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Photo by Allen Schaben for the Los Angeles Times
Geodetic sensors measure Earth’s shape and gravity field
Key results reported today

- New ‘Total Water Storage Deficit’ drought analysis using NASA GRACE mission can now quantify beginning, end and magnitude of drought
  - Peak Total Water Storage Deficit in California drought is 42 km$^3$ in 2014, nearly 1.5 times the volume of Lake Mead

- NASA’s Airborne Snow Observatory (ASO) is providing first high-resolution snowpack measurements in mountainous regions
  - Shows previous measurements of snowpack are off by a factor of 2 in California’s Sierra Nevada range

- Integrating NASA GRACE data into U.S. Drought Monitor provides new information on groundwater storage during drought
  - reveals that groundwater levels across the southwestern U.S. rank in lowest 1% -10% since 1949.
NASA Gravity Recovery and Climate Experiment (GRACE) Mission
Change in total water storage in the Sacramento-San Joaquin River basins from GRACE 2002-2014

Jay Famiglietti, NASA JPL

NASA JPL
Characterizing California drought with GRACE

Actual monthly water storage variations

‘Normal’ range of monthly water storage variations

Differences from ‘normal’ dry conditions

Jay Famiglietti, NASA JPL

peak Total Water Storage Deficit is 42 km$^3$ in 2014
GRACE observations of Terrestrial Water Storage changes in California

2002 05 09

GRACE animation Jay Famiglietti, NASA JPL and NASA GSFC
Central Valley groundwater depletion from GRACE (2003-2013)
Surface water allocations and groundwater use are closely connected
Central Valley groundwater depletion from GRACE (2003-2013)

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Jay Famiglietti, NASA JPL

California’s system of aqueducts for surface water redistribution
Cumulative groundwater depletion in California’s Central Valley from USGS and GRACE

Data Source
- USGS
- GRACE

Cumulative Groundwater Loss (cu. km)

Jay Famiglietti, NASA JPL
Sierra Snowpack in 2014 Drought
Observations by Airborne Snow Observatory
Snow Water Equivalents
(inches)

Data for: 01-May-2014
Provided by the California Cooperative Snow Surveys

Tom Painter, NASA JPL
Less Accumulation ➔ Less Extent, More Warming

Tom Painter, NASA JPL
Mapping the Snow Water Equivalent with ASO

AIRBORNE SNOW OBSERVATORY

Snow Water Equivalent
2014
NASA ASO Shows Less Snow Than Thought

Tuolumne River Basin
Snow Water Equivalent errors
20 April 2014
Integration of GRACE and other data

Solar Radiation (W/m²)

Precipitation (mm/month)

GRACE Water Storage Anomaly (cm)

Other land surface properties and meteorological variables

Numerical model of land surface hydrology

Matt Rodell, NASA GSFC
Integration of GRACE and other data

Drought indicators from GRACE data assimilation
December 1, 2014

Surface Soil Moisture
Root Zone Soil Moisture
Groundwater

 Integration of GRACE and other data (wetness percentiles relative to the period 1948-present)


Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought
Indicators of drought based on GRACE data assimilation

Monitoring Drought from Space

Root Zone Soil Moisture

Shallow Groundwater

Wetness Percentile

Date

2003 01 06
Indicators of drought based on GRACE data assimilation

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Date

Matt Rodell, NASA GSFC