



Groundwater Depletion

Observing changes in groundwater storage



Jet Propulsion Laboratory
California Institute of Technology

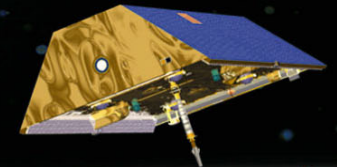
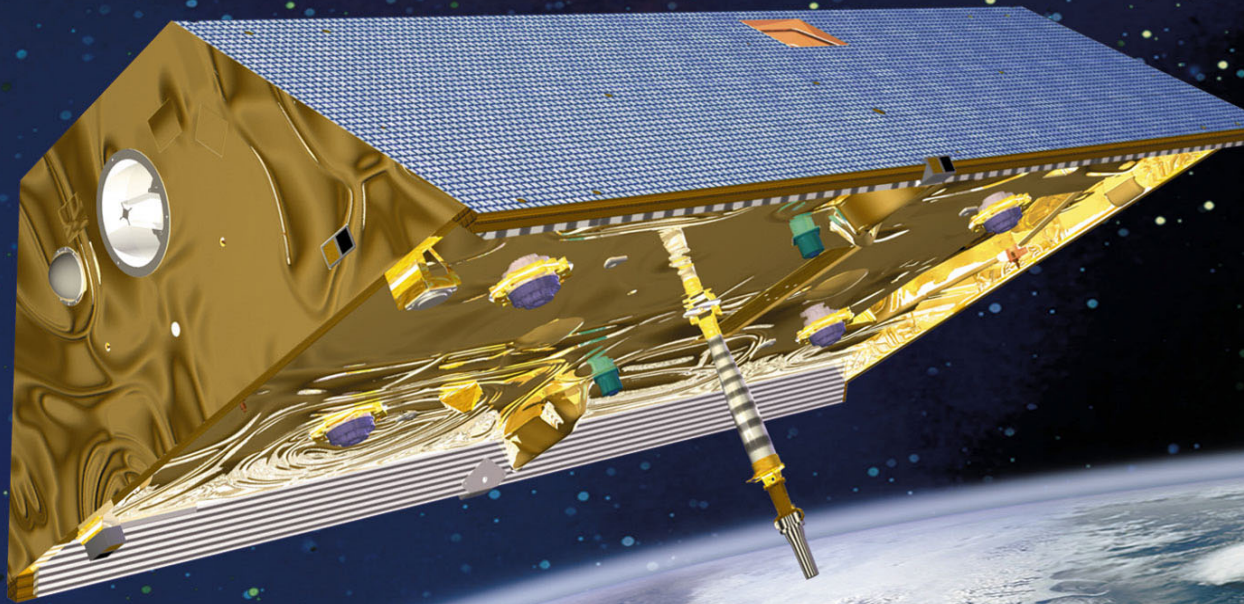
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Outline of discussion

- GRACE satellites
- Global groundwater stress
- Site-specific examples
 - Central Valley, California, USA
 - East Africa
 - Colorado River Basin, USA
- Uncertainty in global groundwater storage

NASA Gravity Recovery and Climate Experiment (GRACE)

- Launched in 2002
- Functions like a 'scale in the sky' that can weigh the monthly increase or decrease in water storage in a large ($>150,000 \text{ km}^2$) region with an accuracy of 1.5 cm



Title

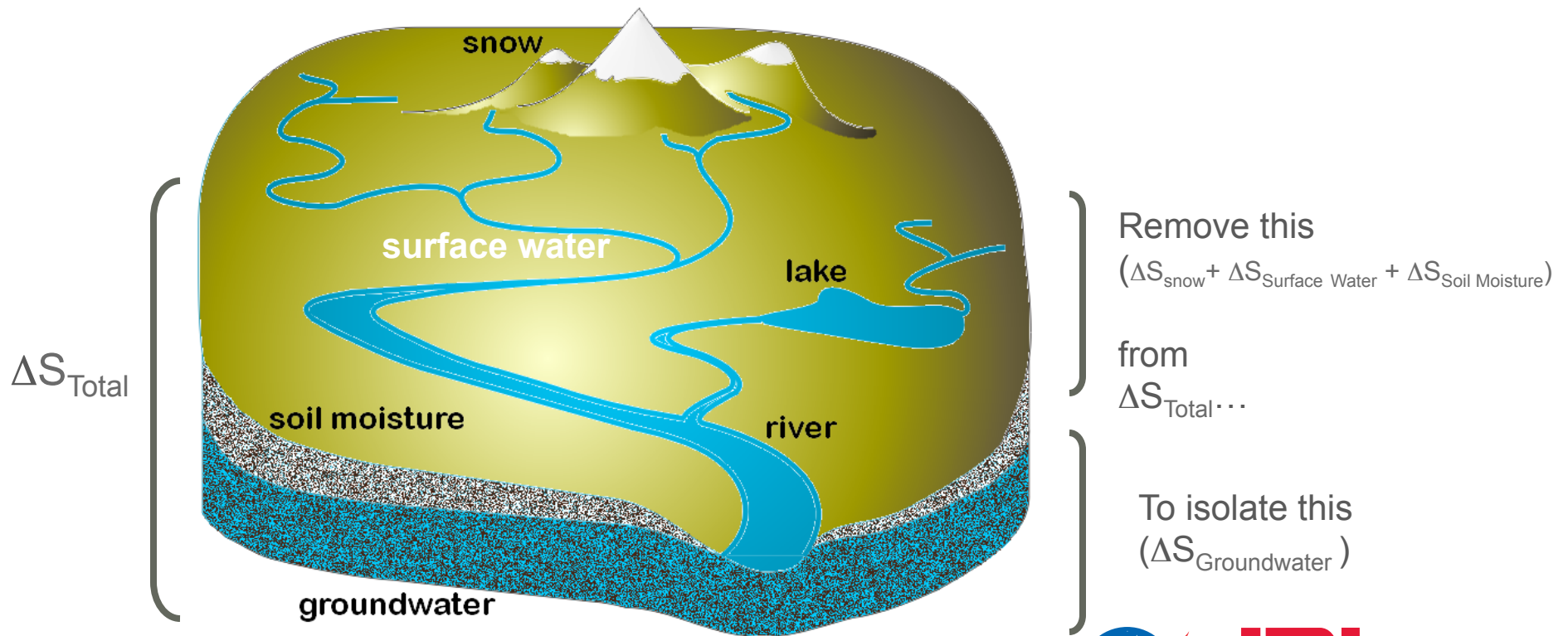




Groundwater depletion: Colorado River Basin

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

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







Global Groundwater Depletion

Limitations of GRACE

- **Scale**
>150,000 km²
- **Salt water intrusion/water quality**
- **3-dimensional changes**
No information of groundwater flow
- **Confined vs. Unconfined**

Global Groundwater Stress

Definition of “Groundwater Use”

- Renewable Groundwater Stress (RGS)

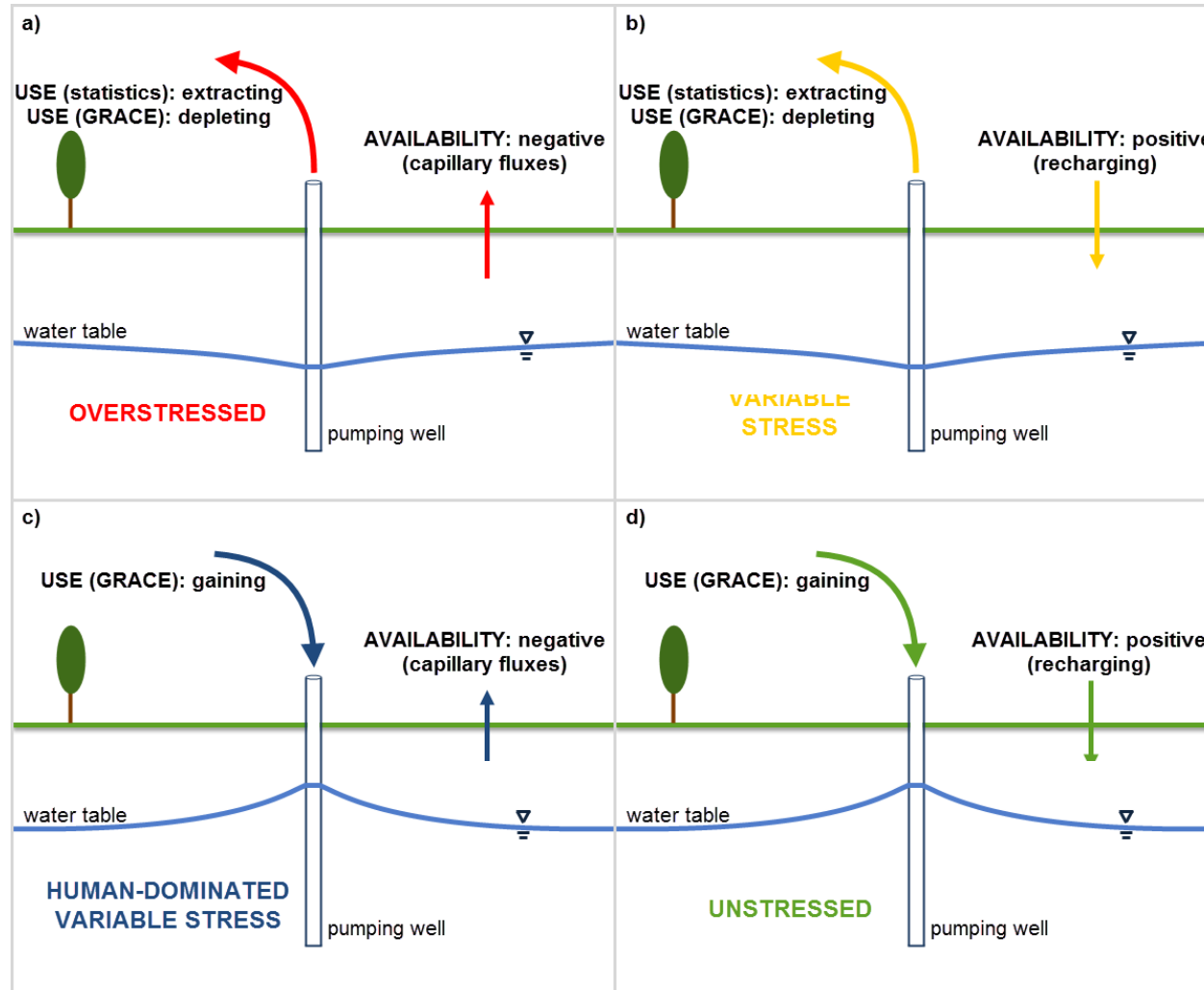
$$RGS = \frac{use}{availability}$$

use: withdrawal statistics or GRACE

availability: simulated aquifer recharge

Global Groundwater Stress

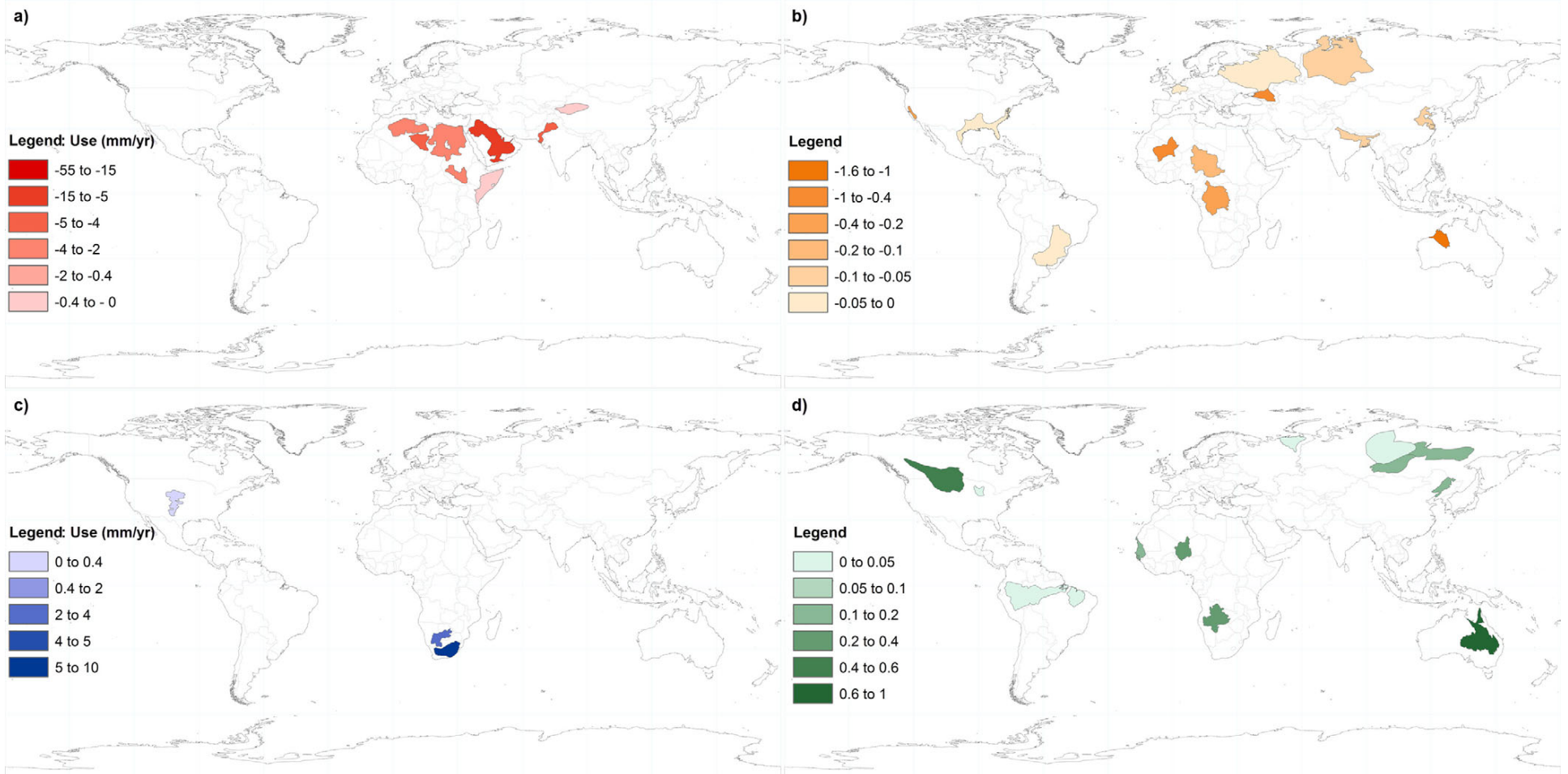
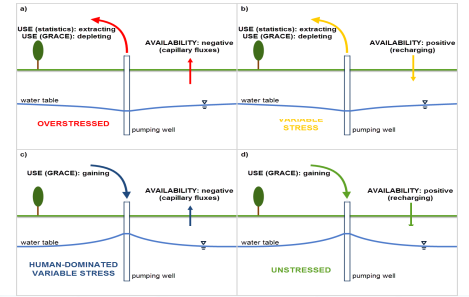
Definition of "Groundwater Use"



Richey et al (2015)

Global Groundwater Stress

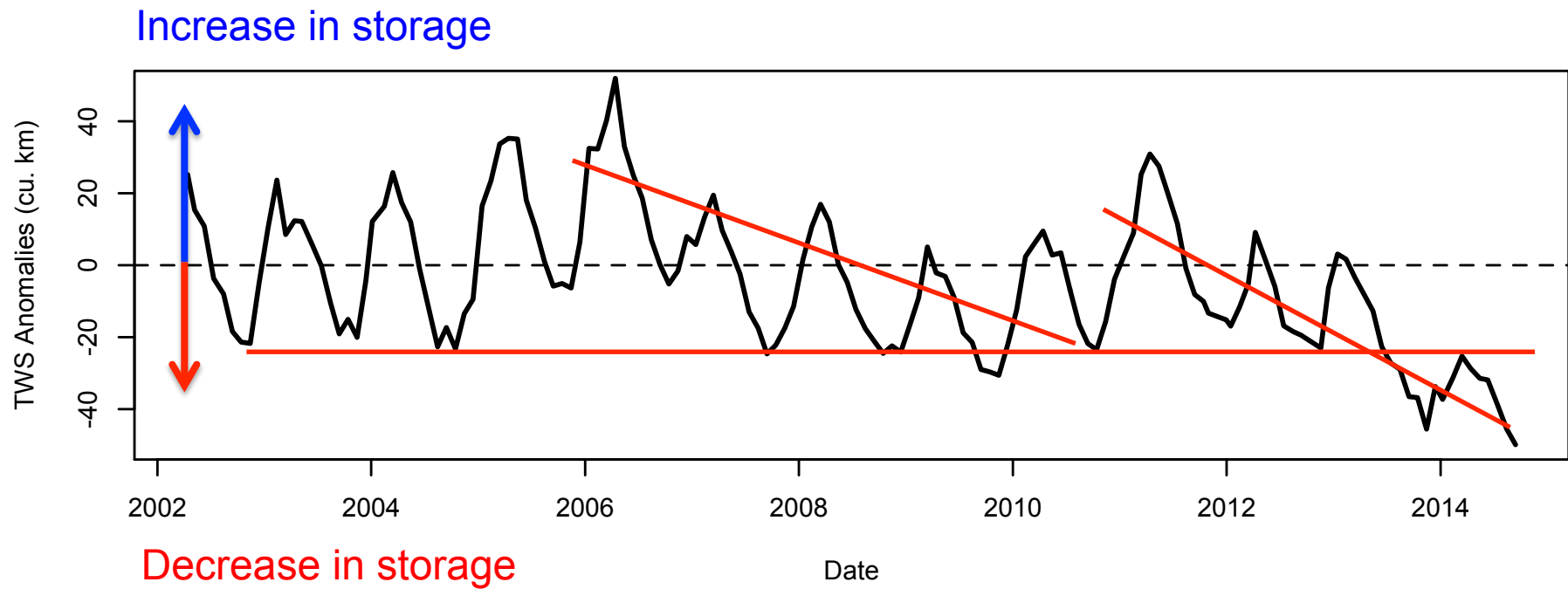
Definition of "Groundwater Use"



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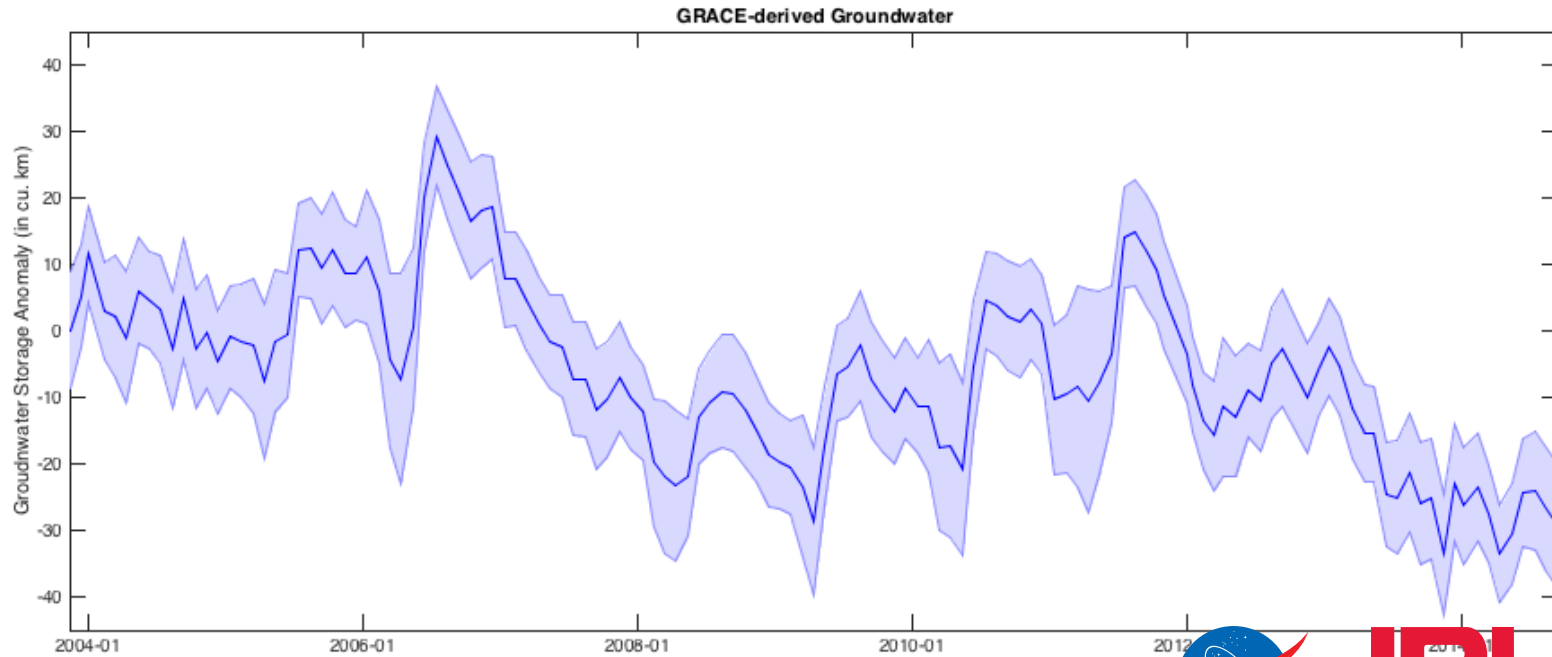
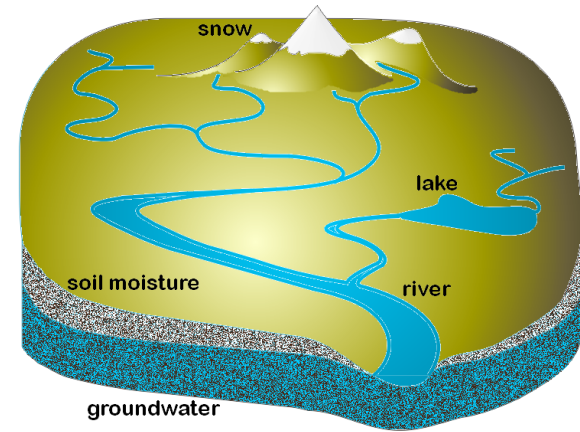
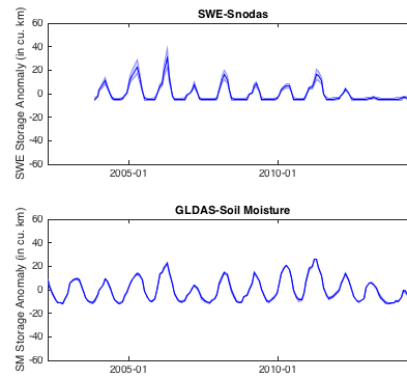
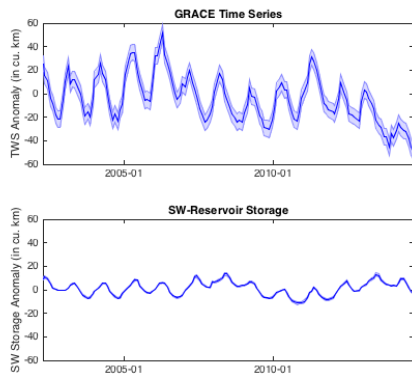
Regional Groundwater Studies

GRACE time series



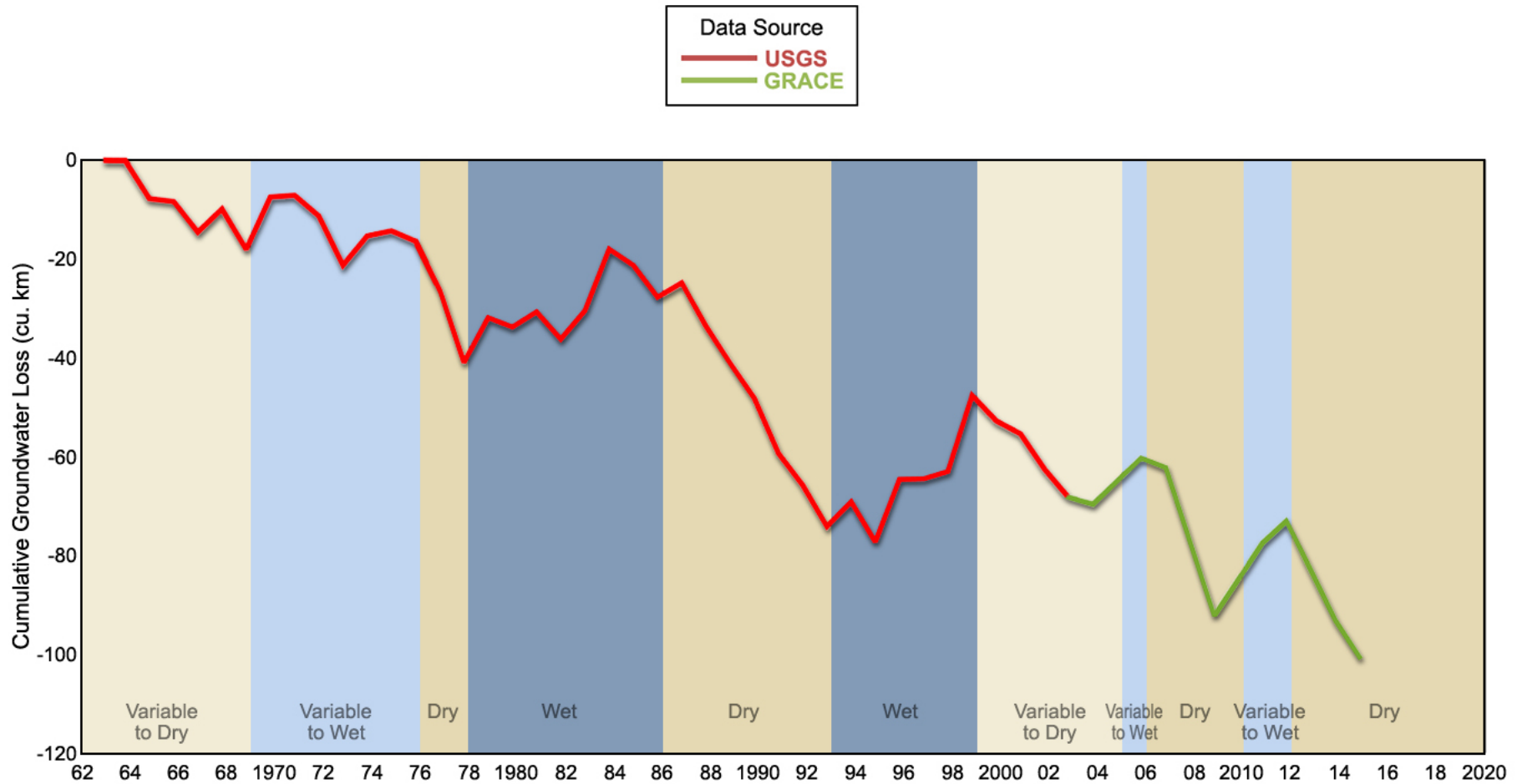
Regional Groundwater Studies

California Central Valley



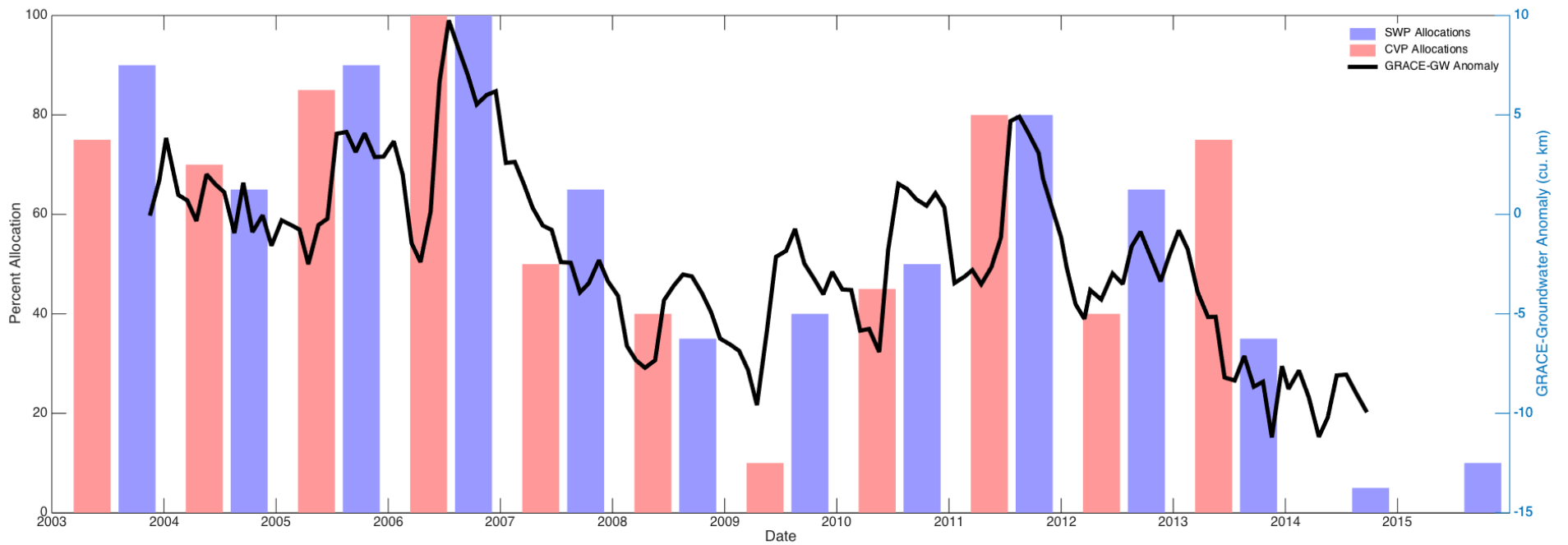
Regional Groundwater Studies

California Central Valley



Regional Groundwater Studies

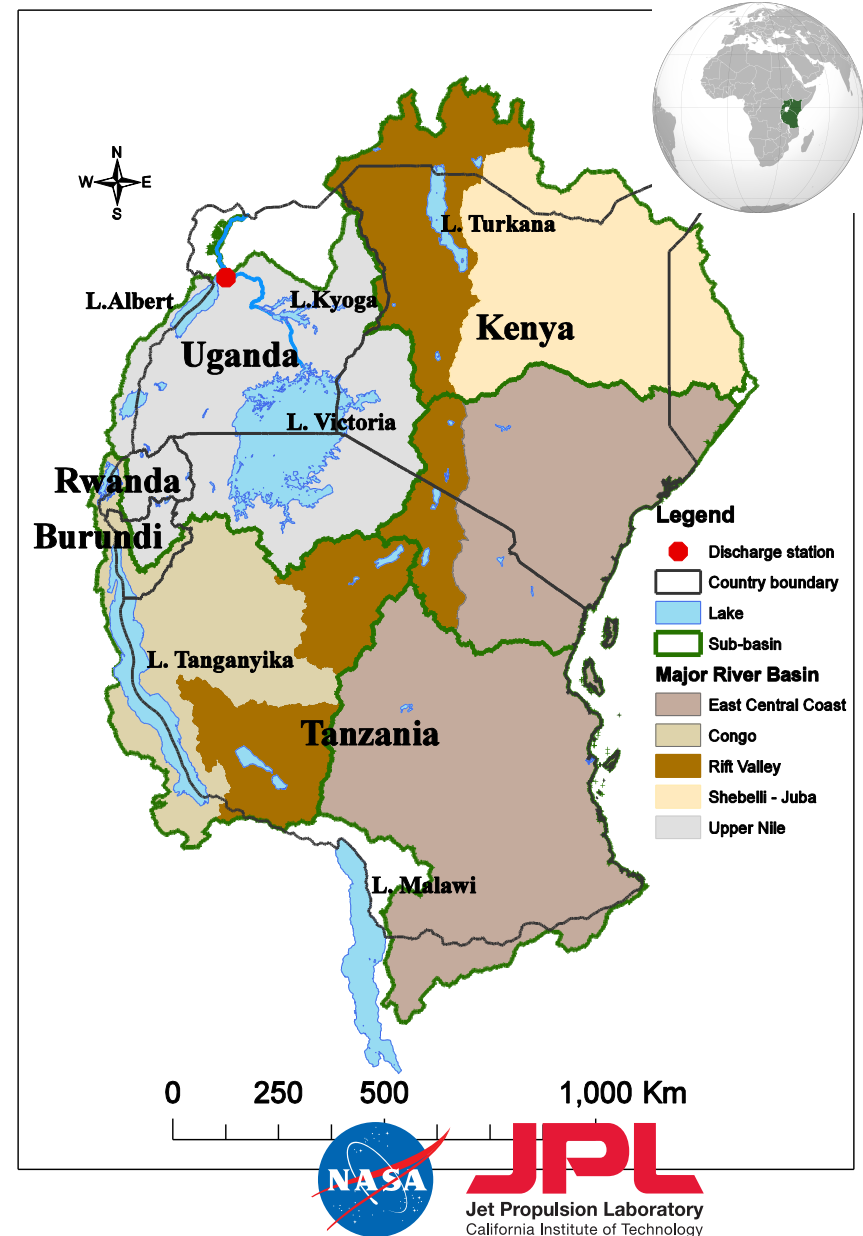
California Central Valley



Regional Groundwater Studies

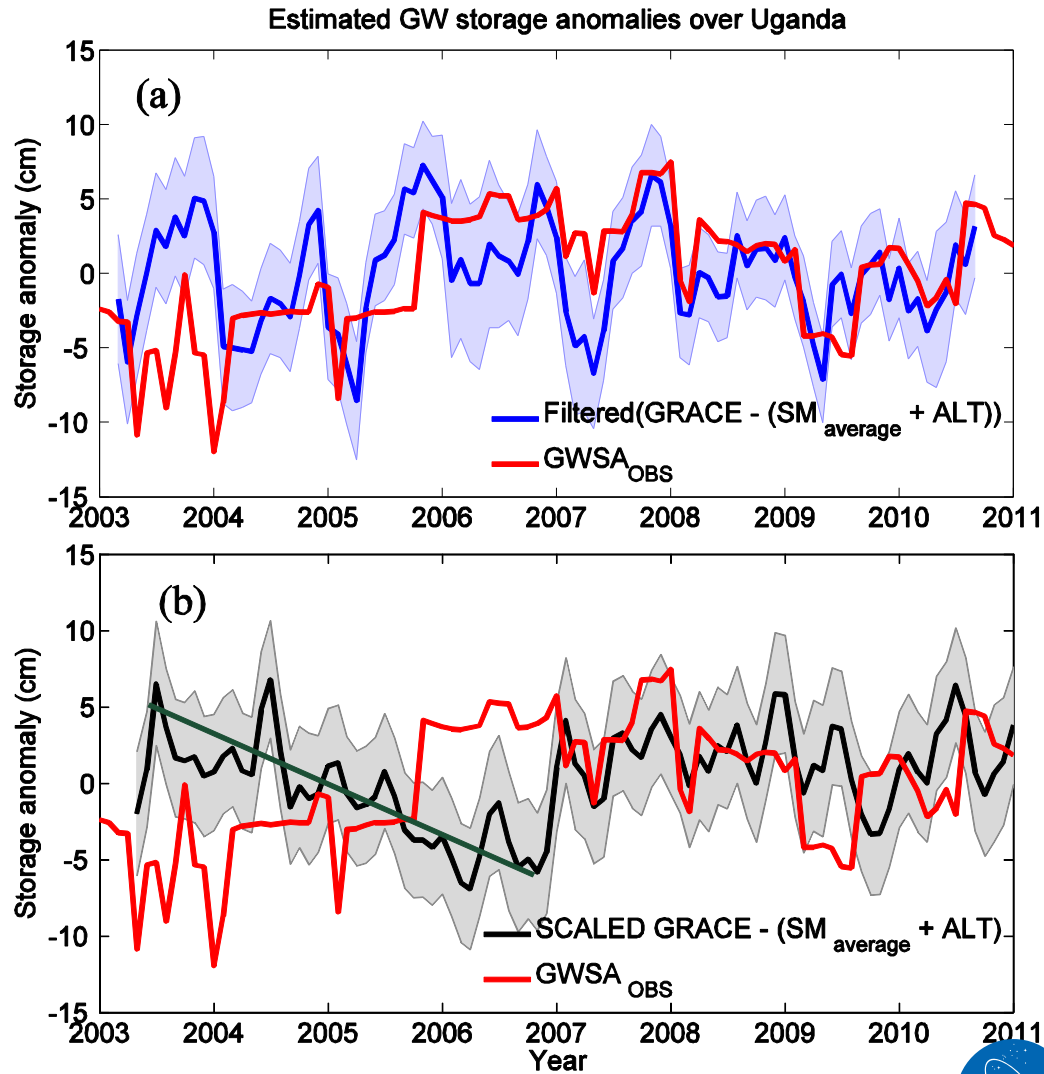
East Africa

- ~80% of population relies on groundwater
- Records impeded by limited funding and regional conflicts



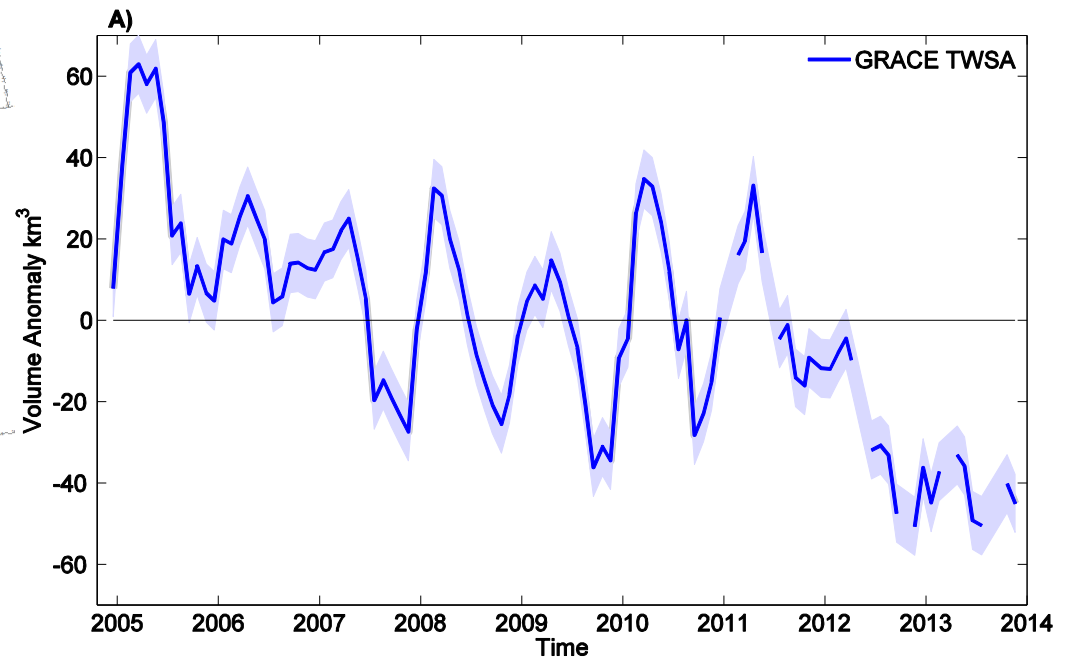
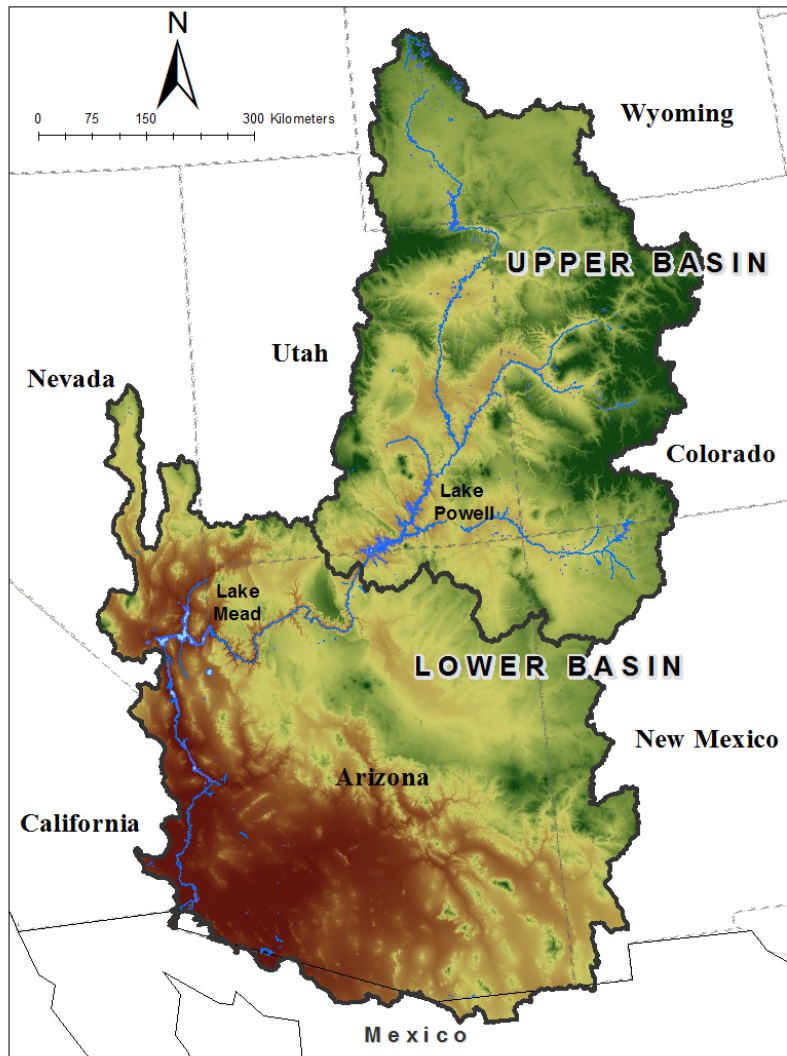
Regional Groundwater Studies

East Africa



Regional Groundwater Studies

Colorado River Basin

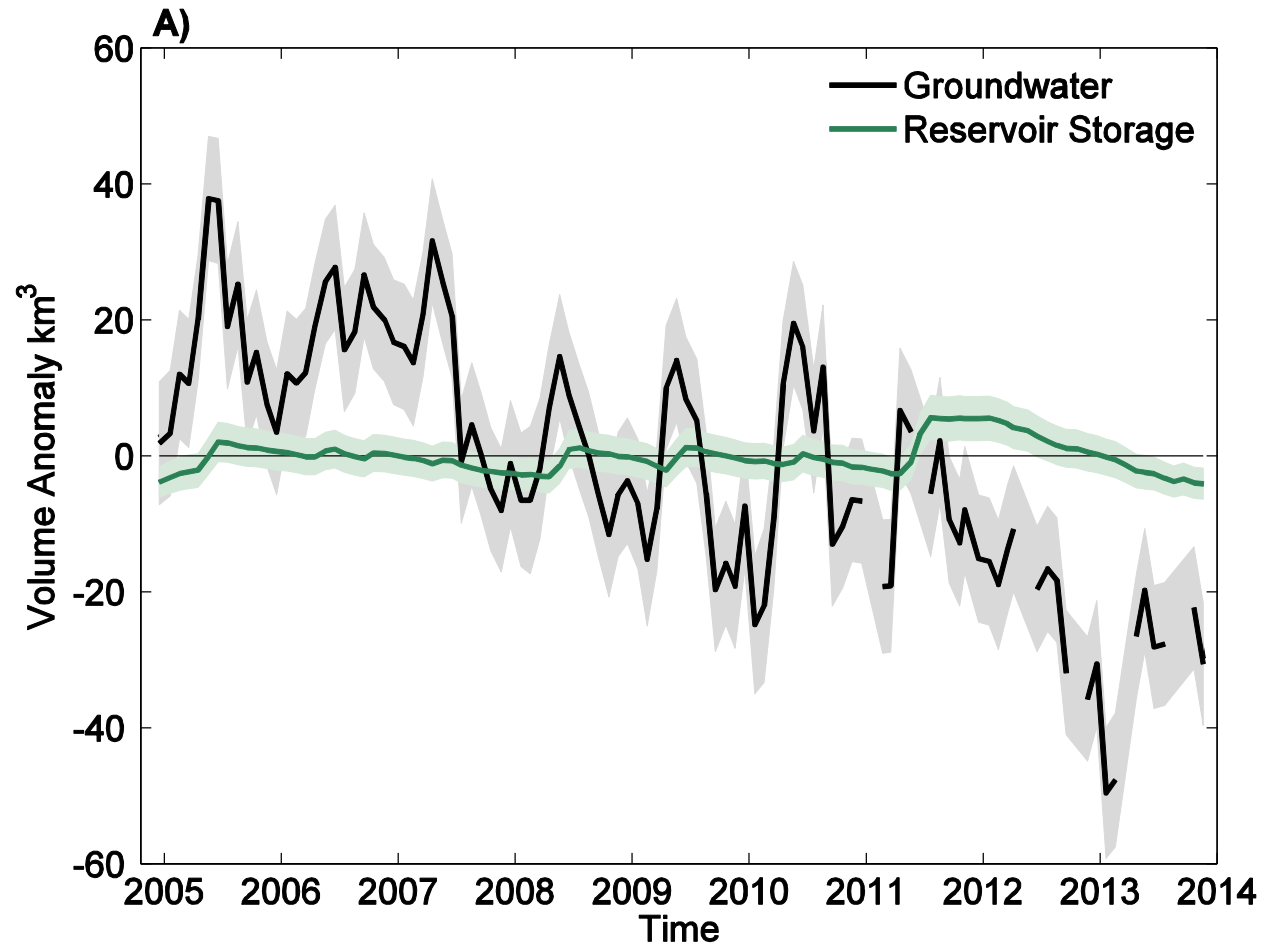


Castle et al., 2014

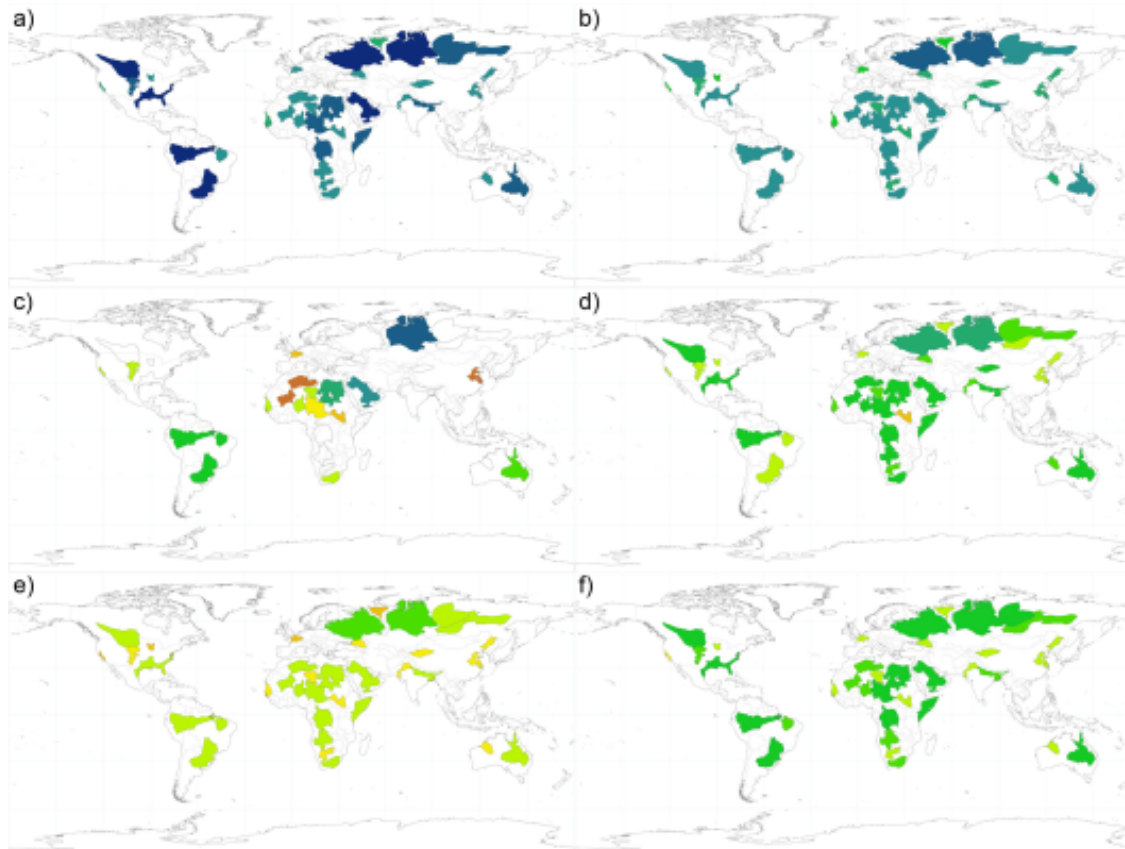


Regional Groundwater Studies

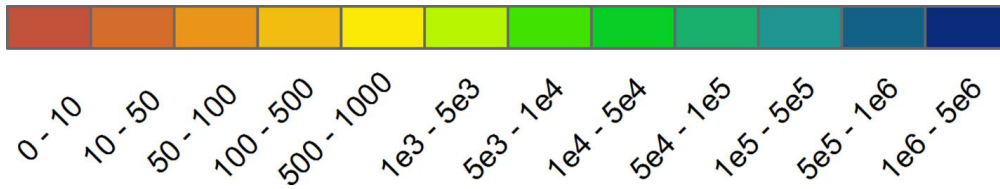
Colorado River Basin



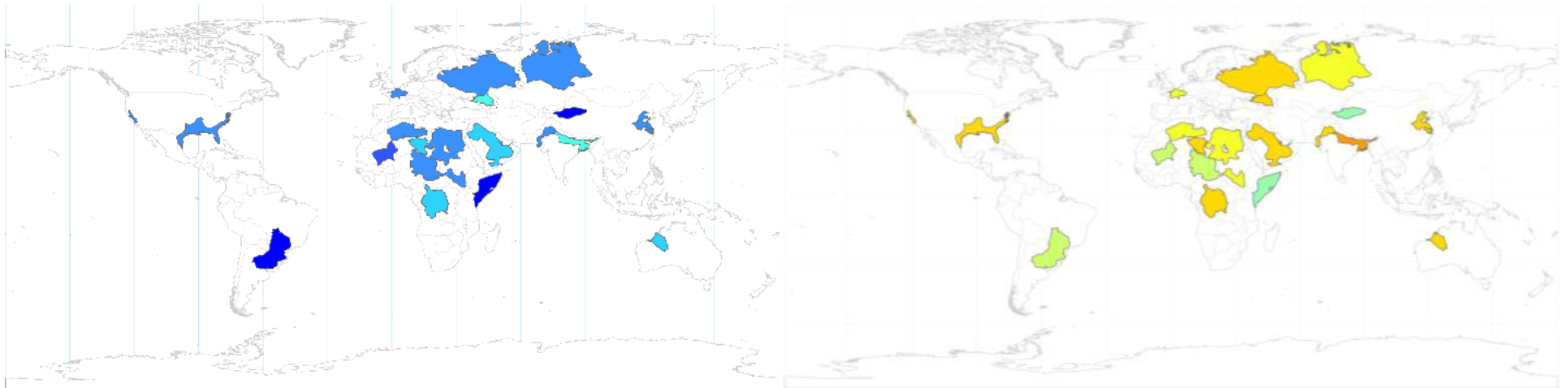
Uncertainty in Global Groundwater Storage



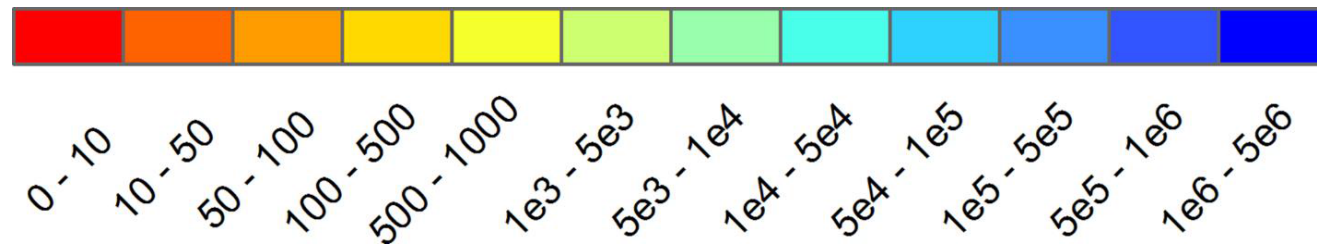
Estimated groundwater storage (in cu. km)



Uncertainty in Global Groundwater Storage



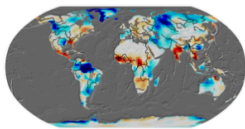
Time to 90% depletion (in years)



GRACE Data

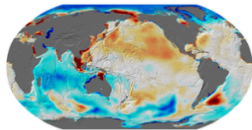
<http://grace.jpl.nasa.gov/data/get-data/>

Get Data



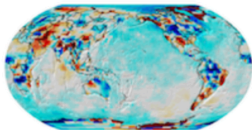
GRACE Monthly Mass Grids - Land

Land water storage from GRACE is updated monthly, and is provided on 1-degree global grids.



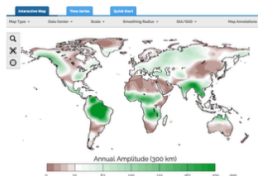
GRACE Monthly Mass Grids - Ocean

Ocean bottom pressure from GRACE is updated monthly, and is provided on 1-degree global grids.



GRACE Monthly Mass Grids - JPL Global Mascons

Global surface mass (land + ocean) from GRACE is updated monthly, and is provided on 0.5-degree global grids.



Interactive GRACE Data Browsers

These links to data browser allow the interactive retrieval of GRACE Land data over river basins, as well as the evaluation of long-term trends and mean seasonal amplitudes.

Data News & Updates

Please check [Data News and Updates](#) for announcements and important information.

Featured Resources



[GRACE global gravity animation](#)



[GRACE data over the United States, 2003-2012](#)



[Scale in the Sky](#)

[› more resources](#)



GRACE Data

Monthly GRACE Grids

- Terrestrial TWSA and Scaling Factors
- Time series error must be calculated
- netCDF or ascii format
- 1-degree global grid

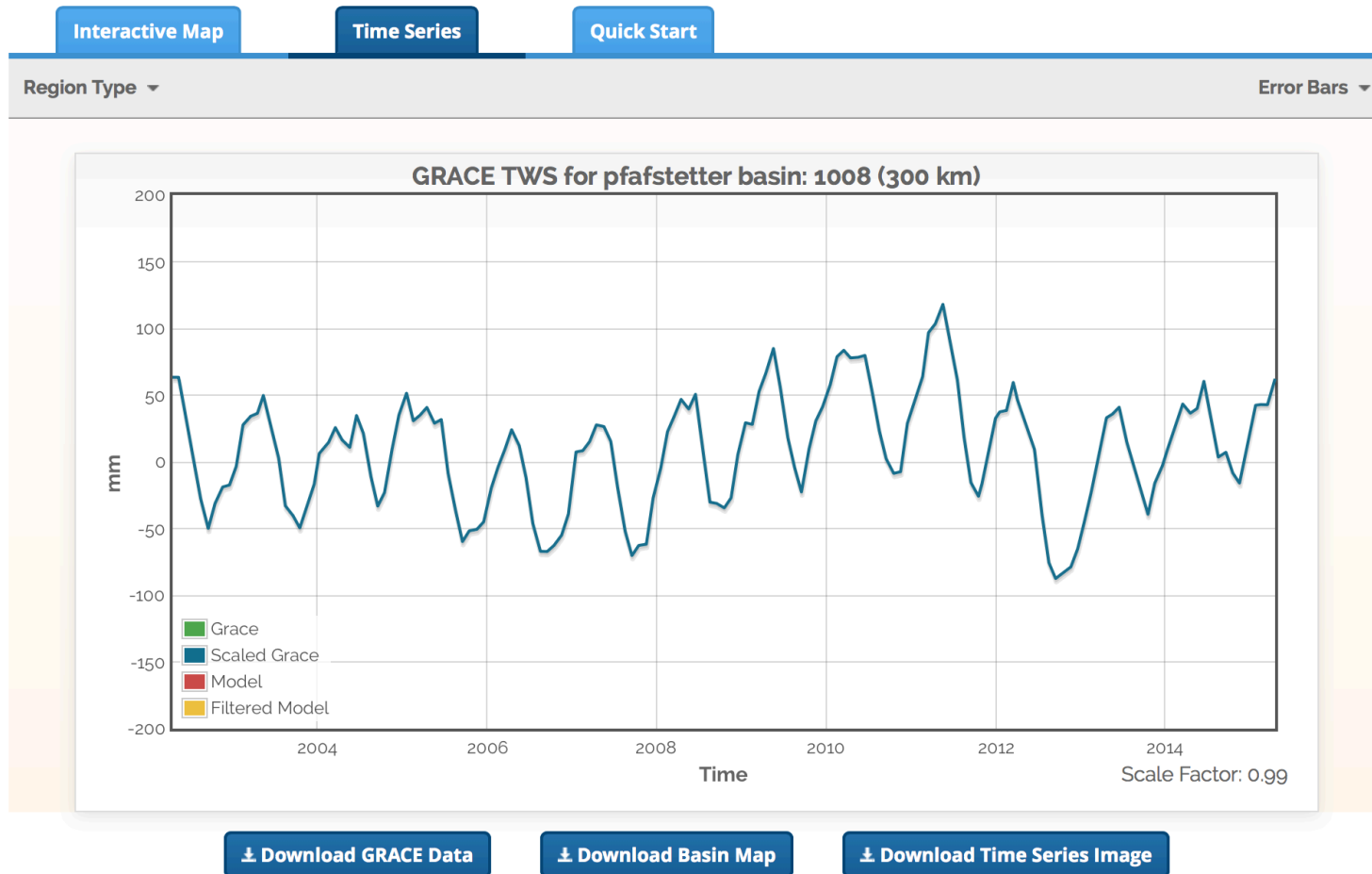
GRACE Data

TWSA Mascons

- Mass Concentration Blocks (mascons)
- Avoids spherical harmonics calcs
- Available at 0.5-degree grid, but recognize original 3-degree resolution
- Gain factors are used for hydrology-based analysis

GRACE Data

CU GRACE Data Portal



Questions?



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