Topic #4: Land Water Storage Variability

- **Topic: Land water storage variability as a function of human and natural controls**
- Datasets: GRACE water storage (equivalent water height over land), TRMM precipitation, GPM precipitation, AIRS near- surface temperature, ECMWF ERA5 near-surface temperature, GLDAS soil moisture (layer1), SMAP soil moisture
- Geographic foci: Global, Northern India, southwest US
- Questions:
  - Is there an apparent seasonality in GRACE water storage or GLDAS/SMAP soil moisture in heavily managed agricultural regions? How does that seasonality temporally align with seasonality in TRMM/GPM precipitation and AIRS near-surface temperature, and align with the agricultural seasons when soil water is used for irrigation?
  - Is there longer-term variability in GRACE time series that are not represented in TRMM/GPM precipitation, AIRS near-surface temperature or GLDAS/SMAP soil moisture (e.g. interannual & trend)?
  - From these datasets, what conclusions can we draw regarding the natural or anthropogenic drivers of water storage and soil moisture in this system at different time scales? Can these datasets be used to identify and quantify human influences on the water cycle?
- **Contact Scientists: JT Reager (John.Reager@jpl.nasa.gov)**

Hydrology is hard

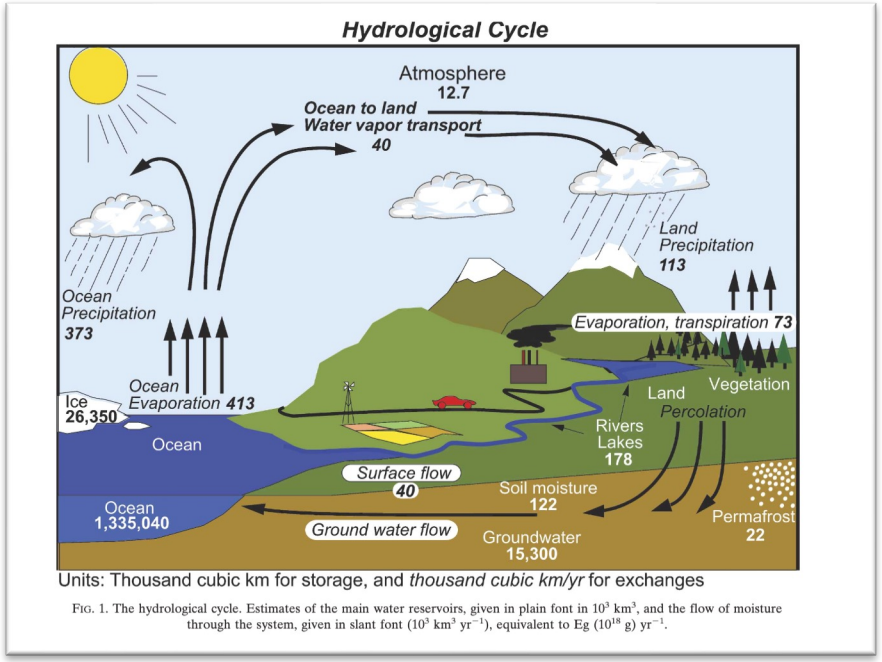
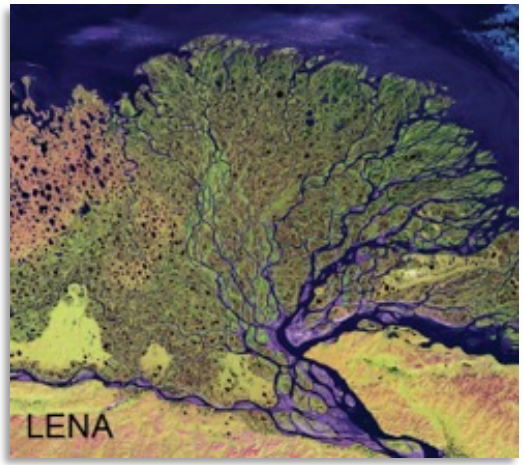


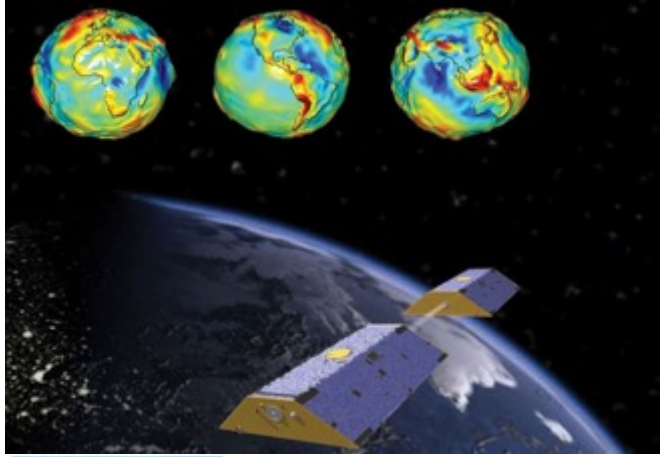
FIG. 1. The hydrological cycle. Estimates of the main water reservoirs, given in plain font in 10^3 km^3, and the flow of moisture through the system, given in slant font (10^3 km^3 yr^{-1}), equivalent to Eg (10^{18} g) yr^{-1}.

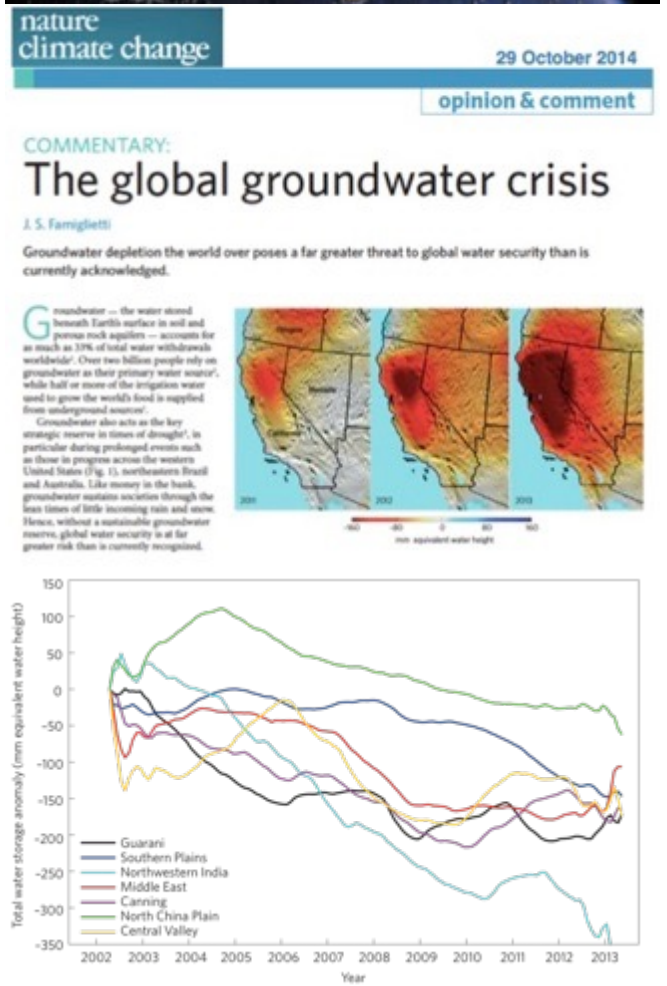


- Not many observations
- Highly variable in space and time
- Observational uncertainty affects model accuracy
- Our understanding of the global water cycle portrays a stable and unchanging system
- Remote sensing is the perfect tool

Gravity Recovery and Climate Experiment: **GRACE and GRACE-FO**

- First mission to see hydrology beneath the surface!
- Launched 2002: long record is critical for good science
- Still flying and returning data, with periodic outages to conserve power
- Measures total integrated water storage change beneath the satellites
- ~2-3 degree resolution
- GRACE-FO launch 2017





Groundwater…

…accounts for 96% of unfrozen freshwater globally

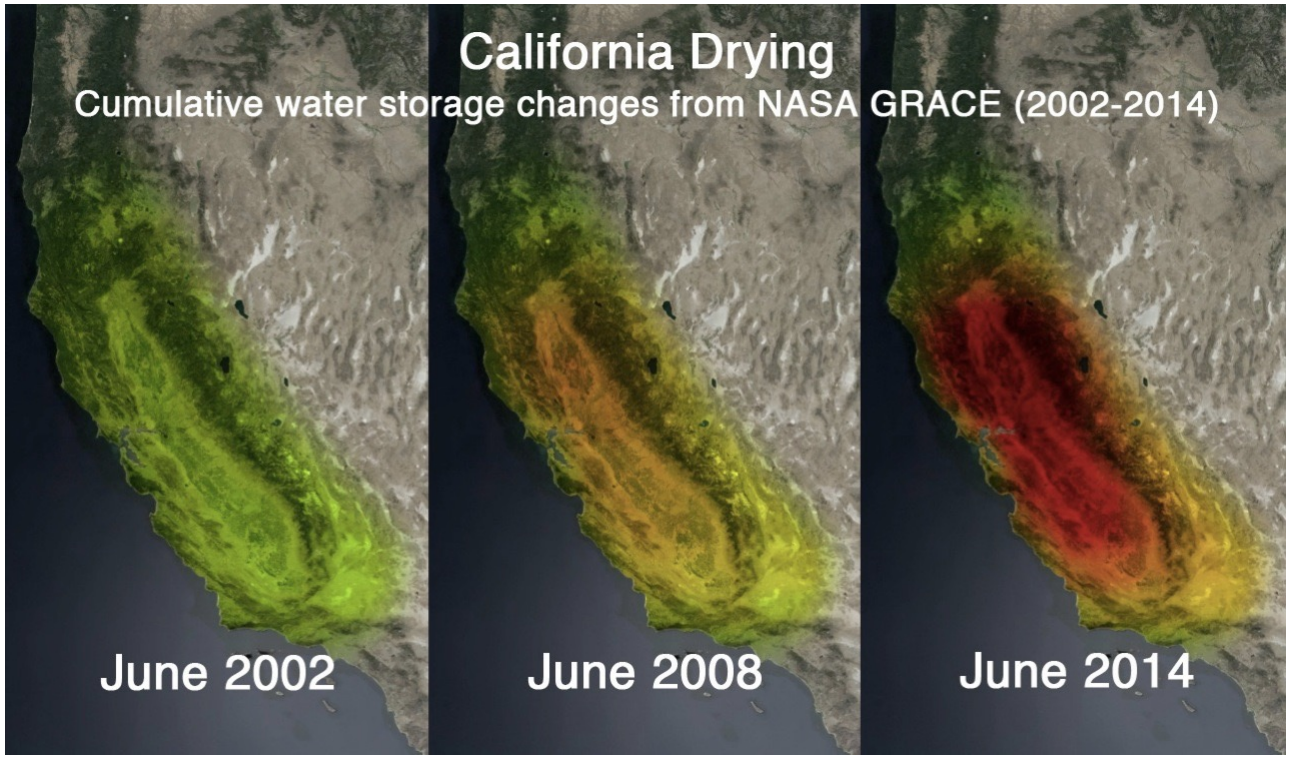
…is the major source of water for over 2 billion people globally
…supplies roughly 45% of water for irrigation globally

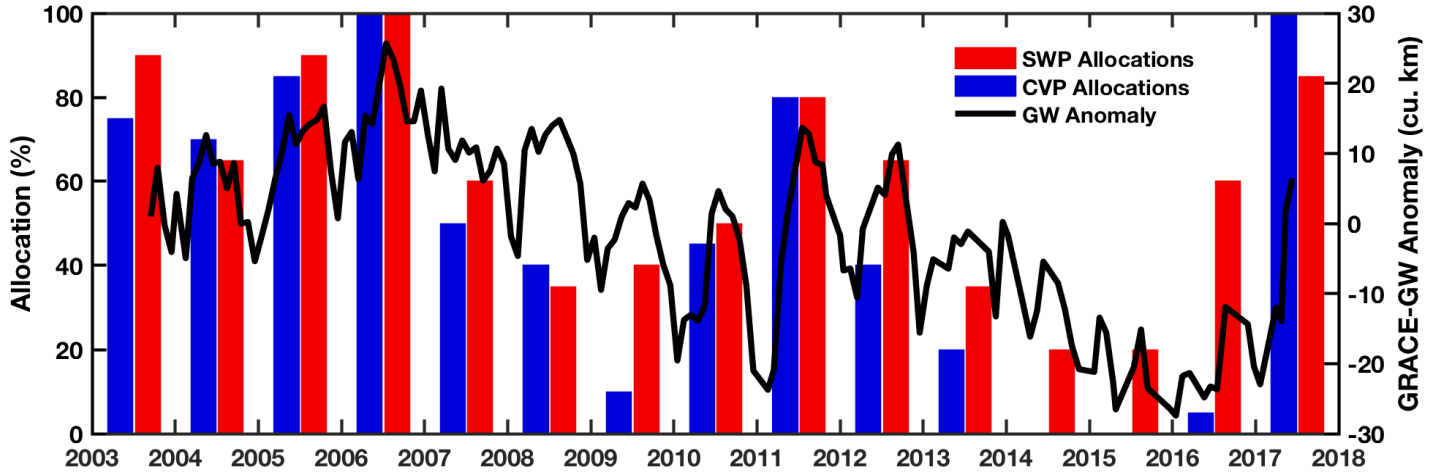
…supplies over half of the drinking water in the United States
…supplies over 60% of the water used for irrigation in the United States

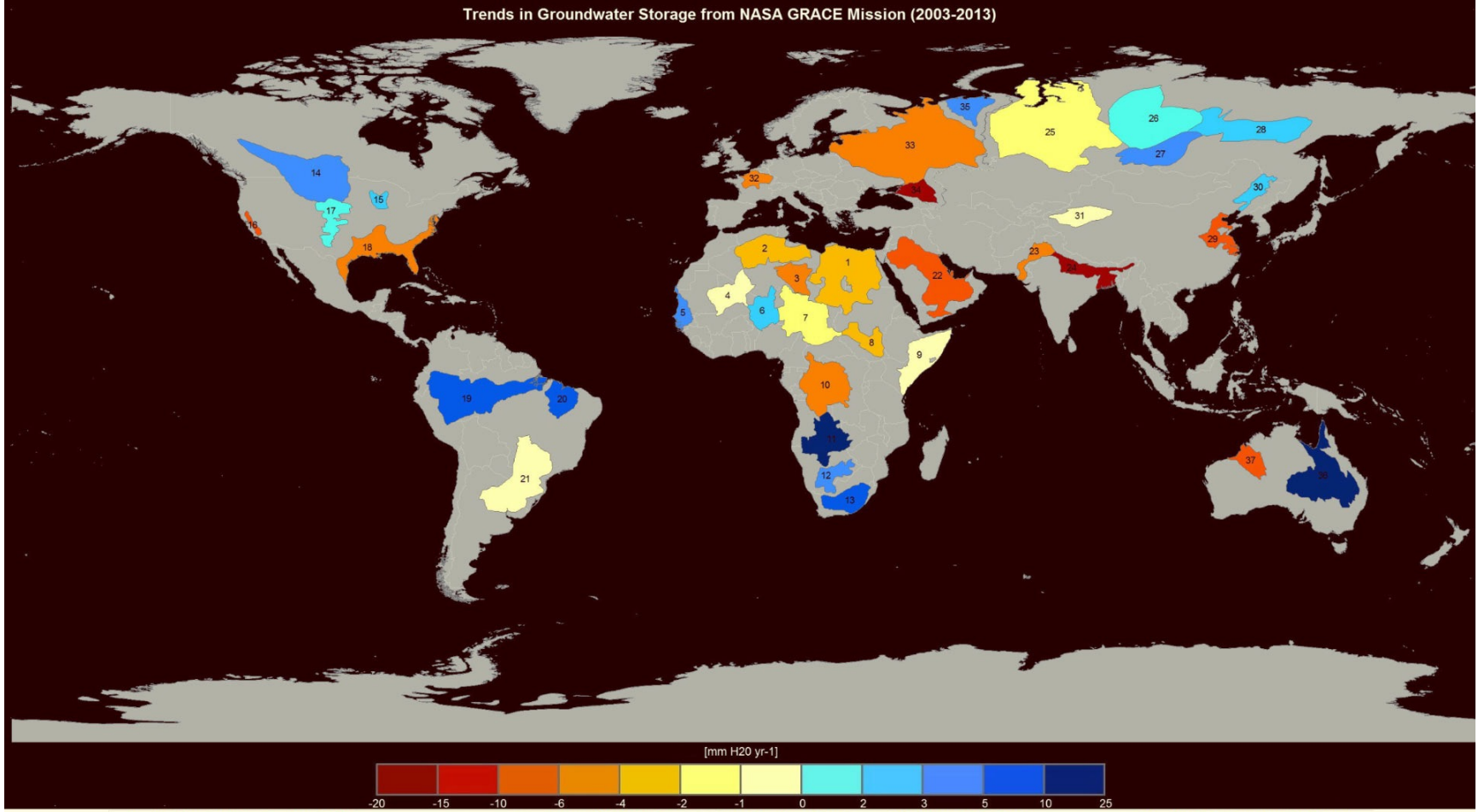
…is THE strategic water reserve in times of extreme drought

However, groundwater withdrawals go unmonitored and unmanaged in most places around the world, including most states in the United States, and the lack of management is becoming apparent. This poses a considerable threat to our nation's water security


Which is the heaviest neutrino? p. 1555
Changing goals of nature conservation pp. 1558
Epigenetic roles in immune cell development pp. 1578, 1528, & 1580
Science
$10
26 SEPTEMBER 2014
AAAS
The drought you can't see
Geophysical methods detect changes in water storage pp. 1543 & 1587


California Drying
Cumulative water storage changes from NASA GRACE (2002-2014)
June 2002
June 2008
June 2014


SWP Allocations
CVP Allocations
GW Anomaly
Allocation (%)
GRACE-GW Anomaly (cu. km)
0
20
40
60
80
100
-30
-20
-10
0
10
20
30
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018



1	Nubian Aquifer System (NAS)	11	Upper Kalahari-Cuvelai-Upper Zambezi Basin	20	Maranhao Basin	29	North China Aquifer System
2	Northwestern Sahara Aquifer System (NWSAS)	12	Lower Kalahari-Stampriet Basin	21	Guarani Aquifer System	30	Song-Liao Basin
3	Murzuk-Djado Basin	13	Karoo Basin	22	Arabian Aquifer System	31	Tarim Basin
4	Taoudeni-Tanezrouft Basin	14	Northern Great Plains Aquifer	23	Indus Basin	32	Paris Basin
5	Senegalo-Mauritanian Basin	15	Cambro-Ordovician Aquifer System	24	Ganges-Brahmaputra Basin	33	Russian Platform Basins
6	Iullemeden-Irhazer Aquifer System	16	Californian Central Valley Aquifer System	25	West Siberian Basin	34	North Caucasus Basin
7	Lake Chad Basin	17	Ogallala Aquifer (High Plains)	26	Tunguss Basin	35	Pechora Basin
8	Sudd Basin (Umm Ruwaba Aquifer)	18	Atlantic and Gulf Coastal Plains Aquifer	27	Angara-Lena Basin	36	Great Artesian Basin
9	Ogaden-Juba Basin	19	Amazon Basin	28	Yakut Basin	37	Canning Basin
10	Congo Basin						

Richey et al., 2014

37 largest aquifers
21 are declining
13 are being rapidly depleted