

A 3D rendering of a satellite in orbit above Earth. The satellite is a yellowish-gold rectangular shape with solar panels and instruments. Two red laser beams extend from the satellite towards the Earth's surface. The Earth's horizon is visible in the background, with a bright sun or star in the upper right corner.

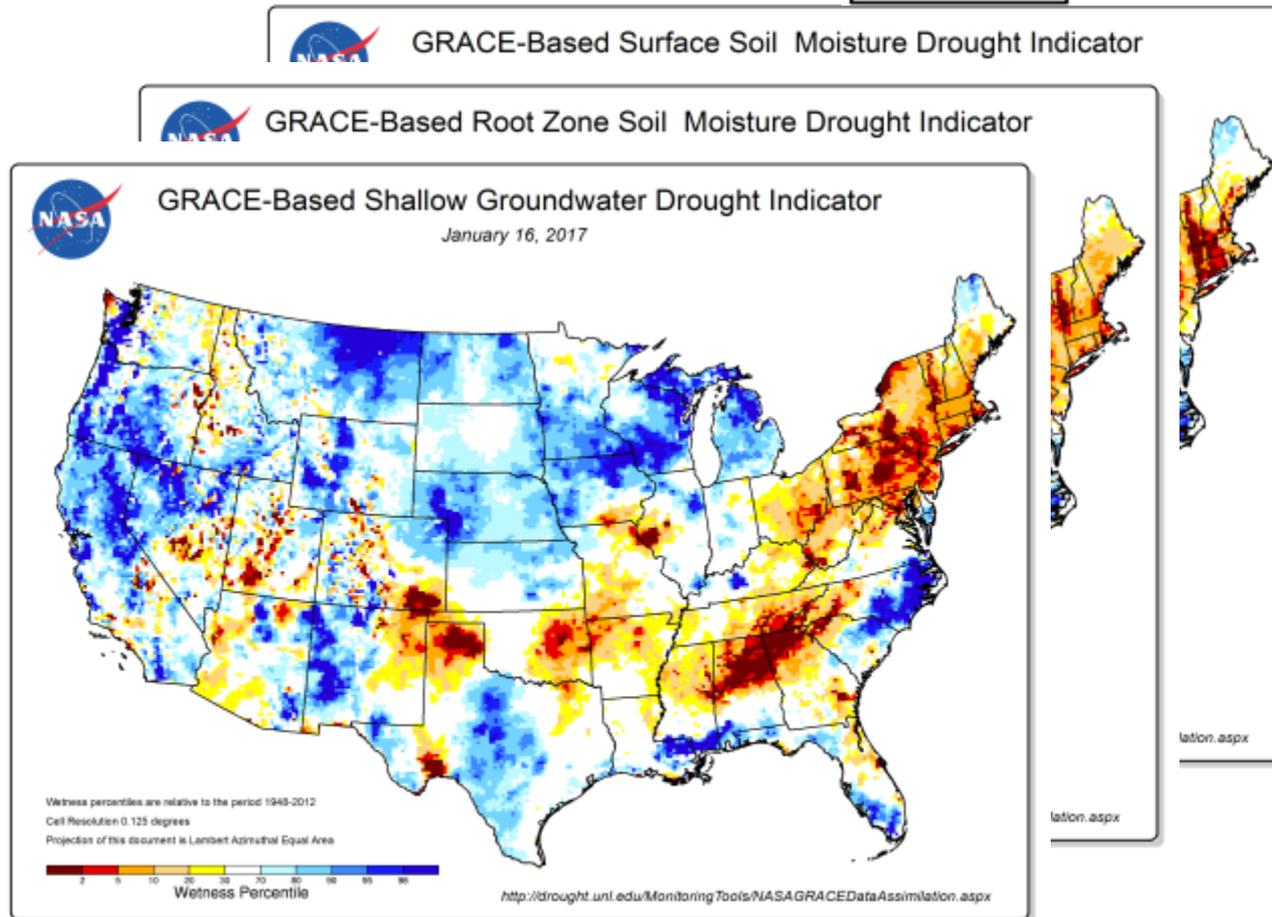
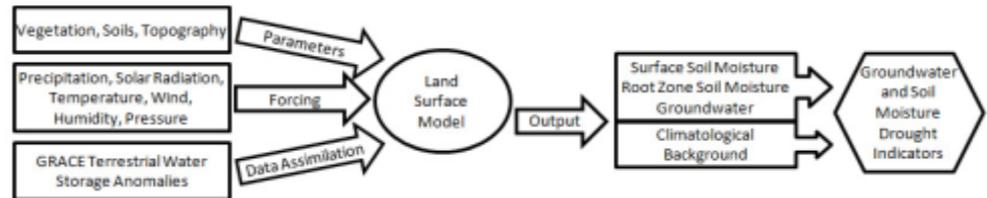
**Our changing view on Earth:  
New perspectives and chances through GRACE,  
GRACE-FO, and beyond**

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# National Drought Monitor



Weekly GRACE data assimilation for Soil Moisture and Groundwater Drought Indicators

*Integral water storage provides insights into below-surface water reservoirs*



# California drought

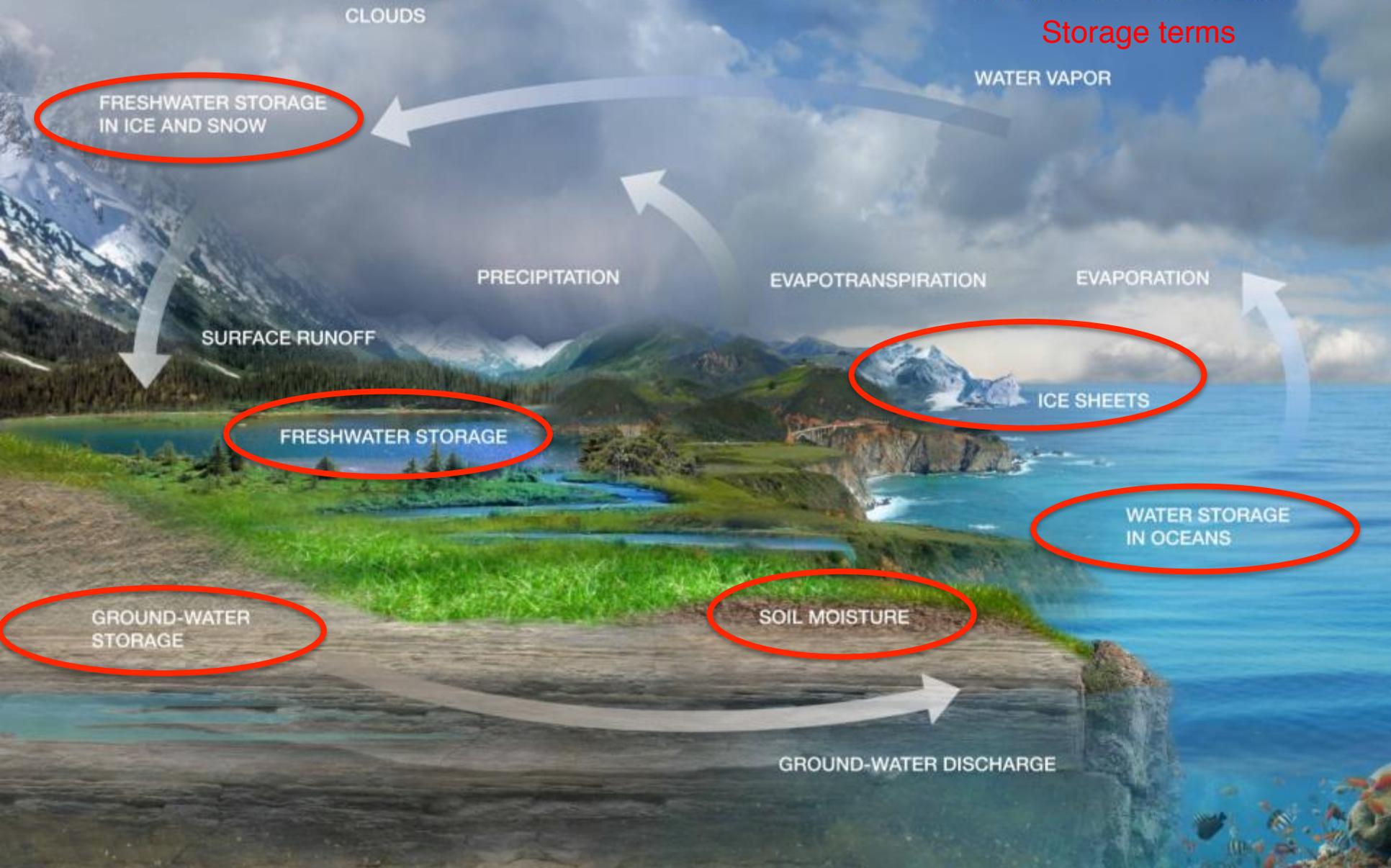
**GRACE captures  
duration and intensity of  
droughts**

*Continuous  
measurements identify  
groundwater loss vs.  
surface storage*



# WATER CYCLE

Storage terms

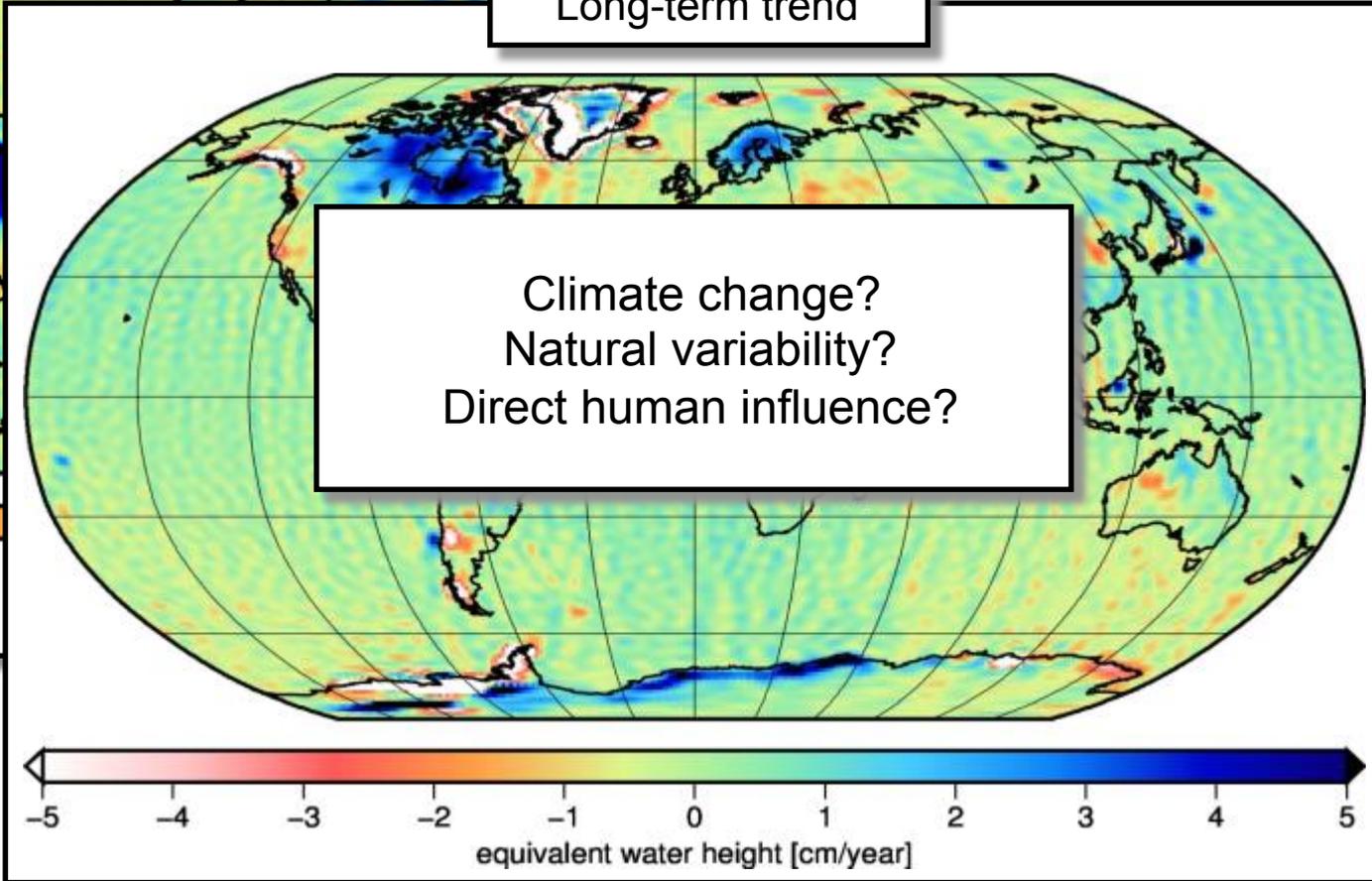
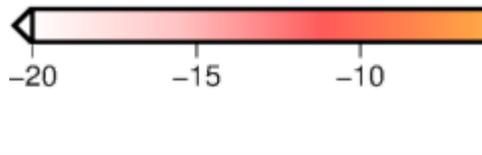


# Changes in water mass

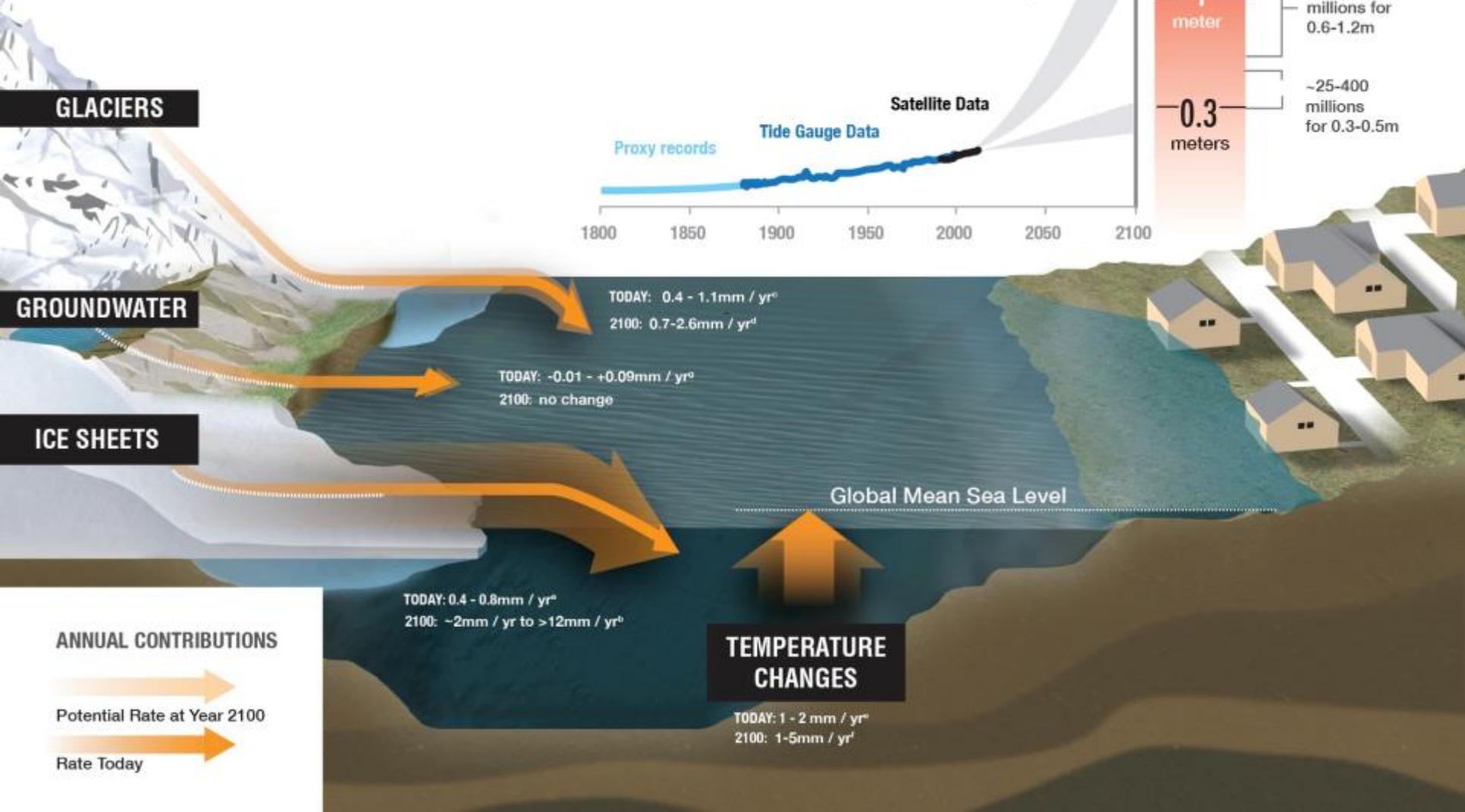
Annual cycle, July

Long-term trend

Climate change?  
Natural variability?  
Direct human influence?



# SEA LEVEL RISE CONTRIBUTIONS & IMPACTS



**GLACIERS**

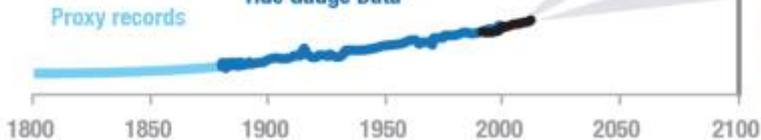
**GROUNDWATER**

**ICE SHEETS**

**ANNUAL CONTRIBUTIONS**

Potential Rate at Year 2100

Rate Today



**2 meters**

People impacted by flooding per year if not mitigated

**1 meter**

~50-575 millions for 0.6-1.2m

**0.3 meters**

~25-400 millions for 0.3-0.5m

TODAY: 0.4 - 1.1mm / yr<sup>a</sup>  
2100: 0.7-2.6mm / yr<sup>d</sup>

TODAY: -0.01 - +0.09mm / yr<sup>a</sup>  
2100: no change

TODAY: 0.4 - 0.8mm / yr<sup>a</sup>  
2100: ~2mm / yr to >12mm / yr<sup>d</sup>

**TEMPERATURE CHANGES**

TODAY: 1 - 2 mm / yr<sup>a</sup>  
2100: 1-5mm / yr<sup>d</sup>

Global Mean Sea Level



# Causes and Observations of Sea Level Change

Jason series measures sea surface height changes since 1992

Sea Level Change

GRACE measures water mass changes since 2002

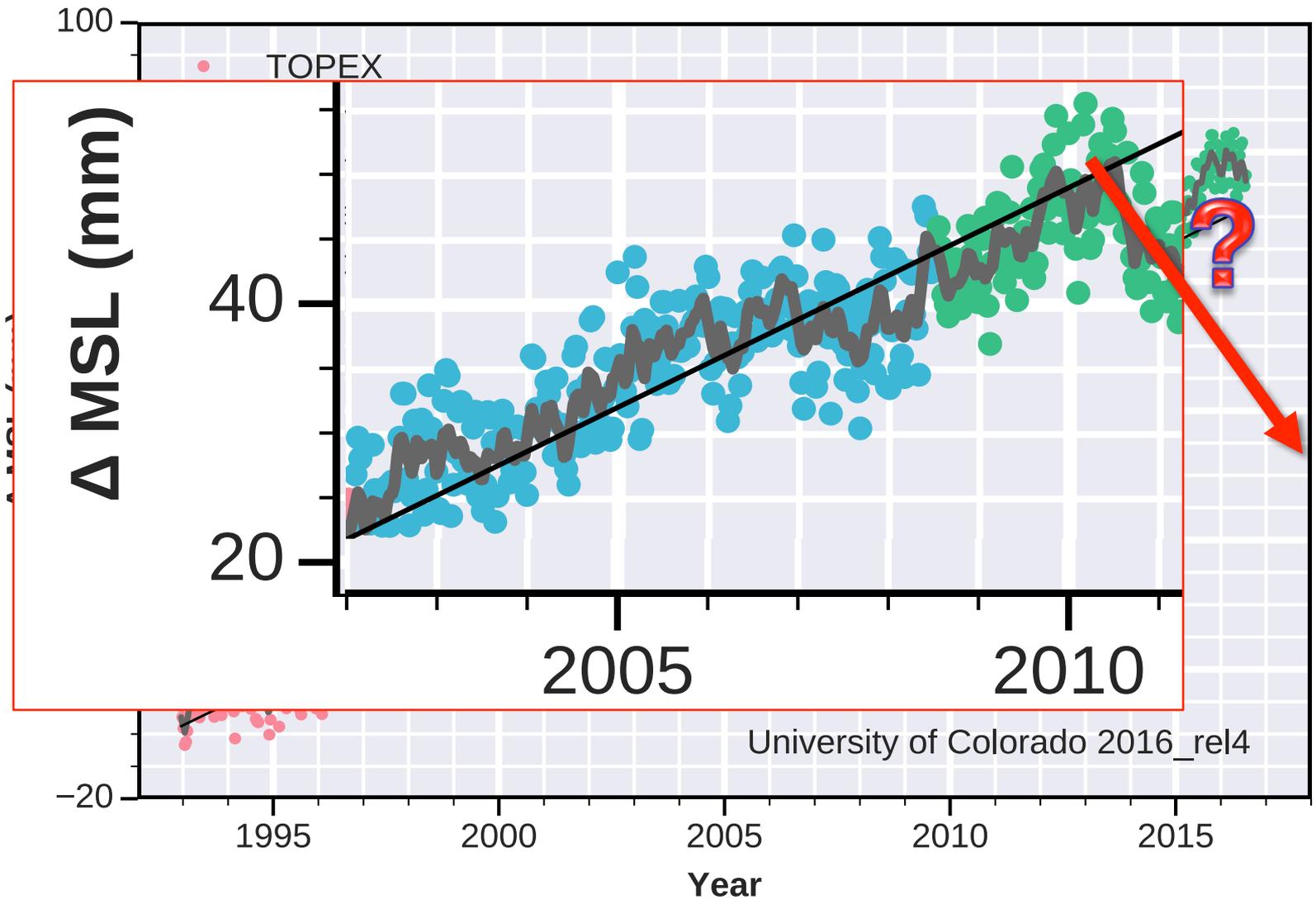
$$h_{\text{total}} = h_{\text{mass}} + h_{\text{density}}$$

Runoff from land hydrology adds ocean mass

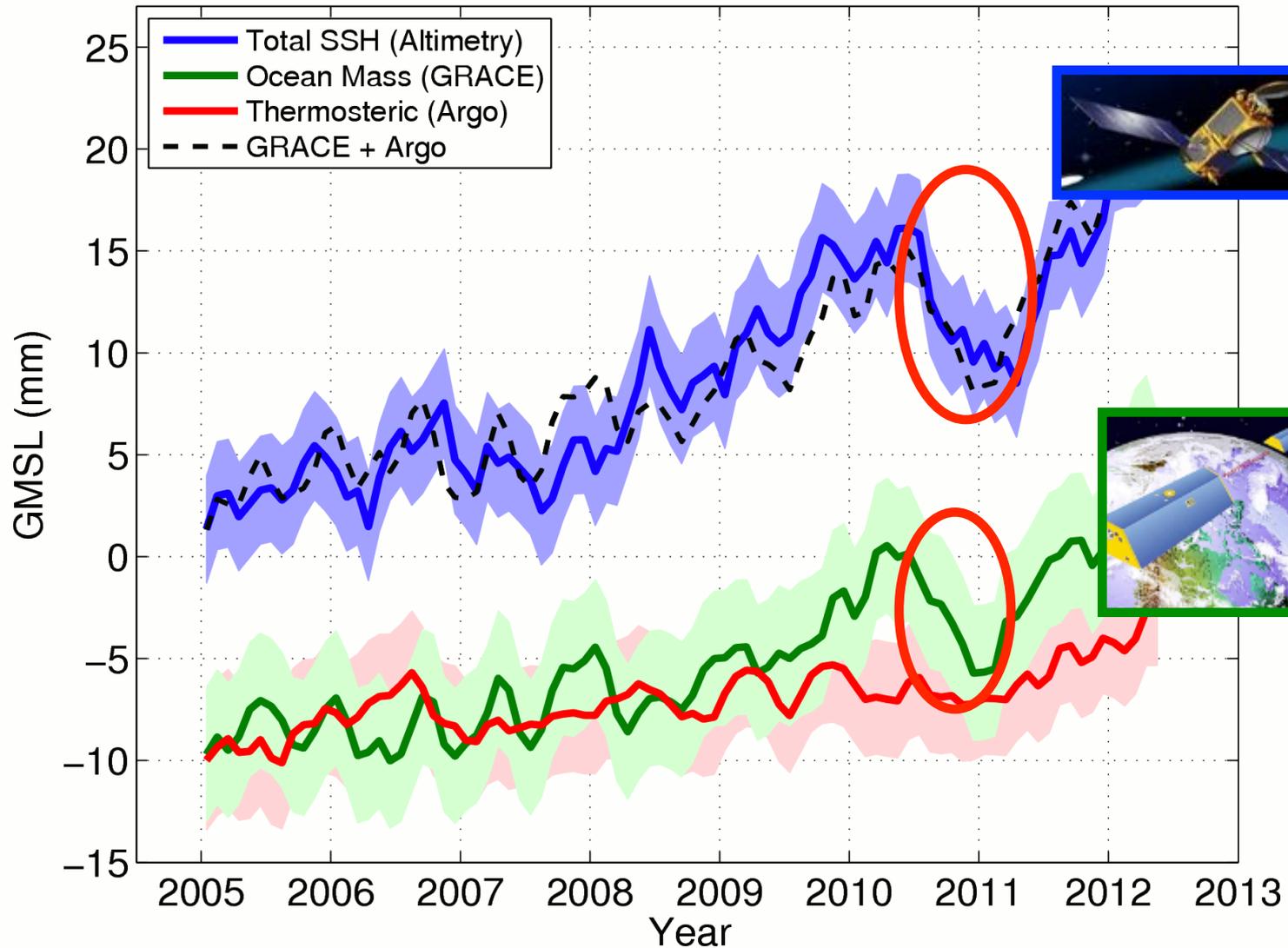
Warming water leads to (thermal) expansion

Melting ice adds to ocean mass

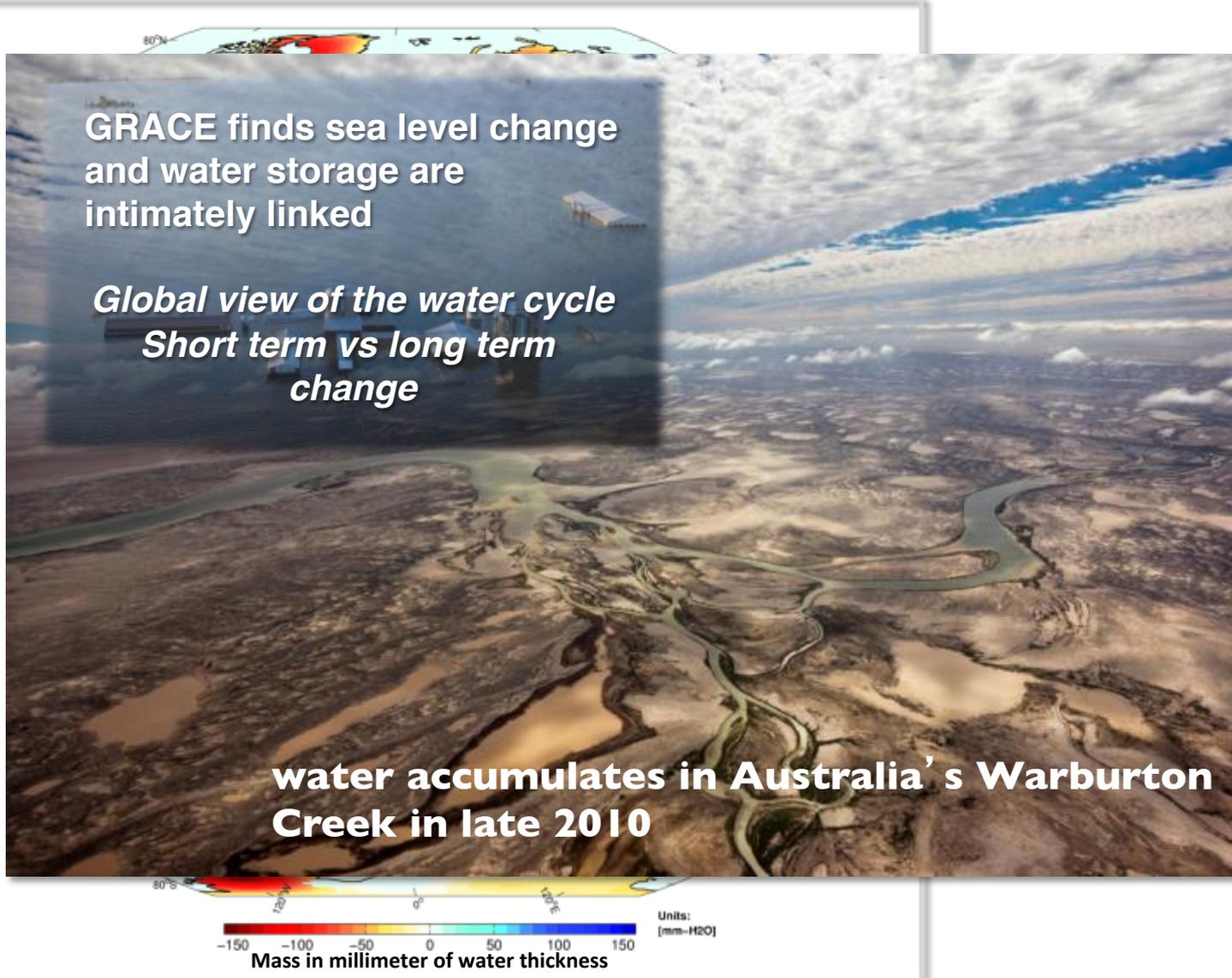
# Records of sea level change since 1992



# Using Multiple Satellites to “Track” Water



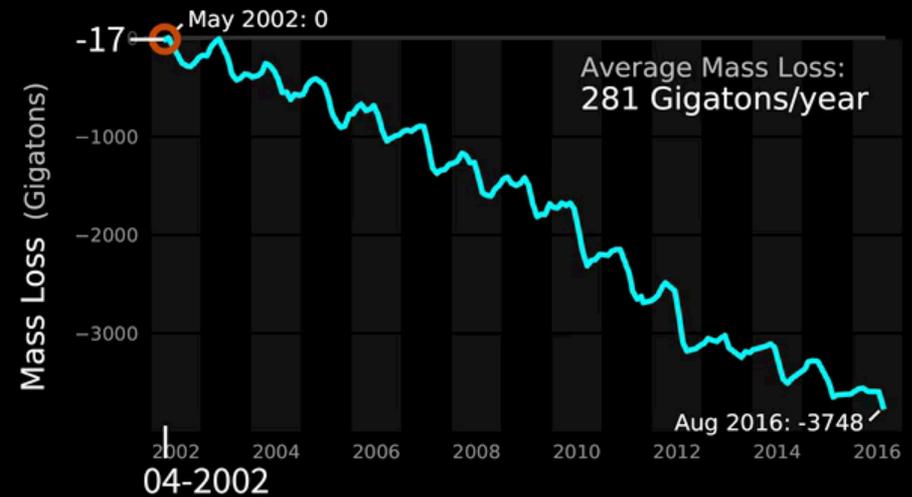
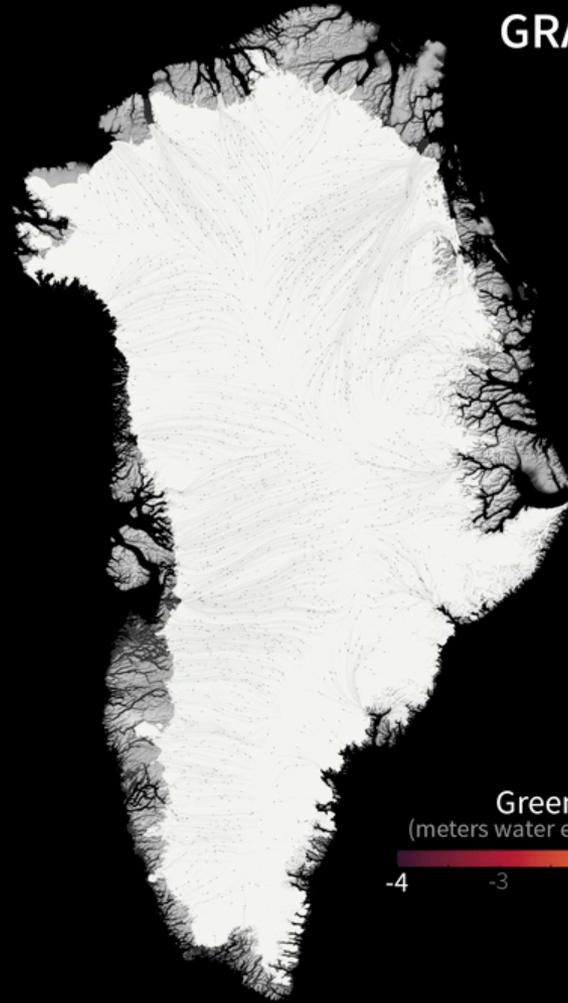
# Terrestrial Water Storage in 2010 and 2011



GRACE water storage data from 2010 indicates more water in Australia and South America.

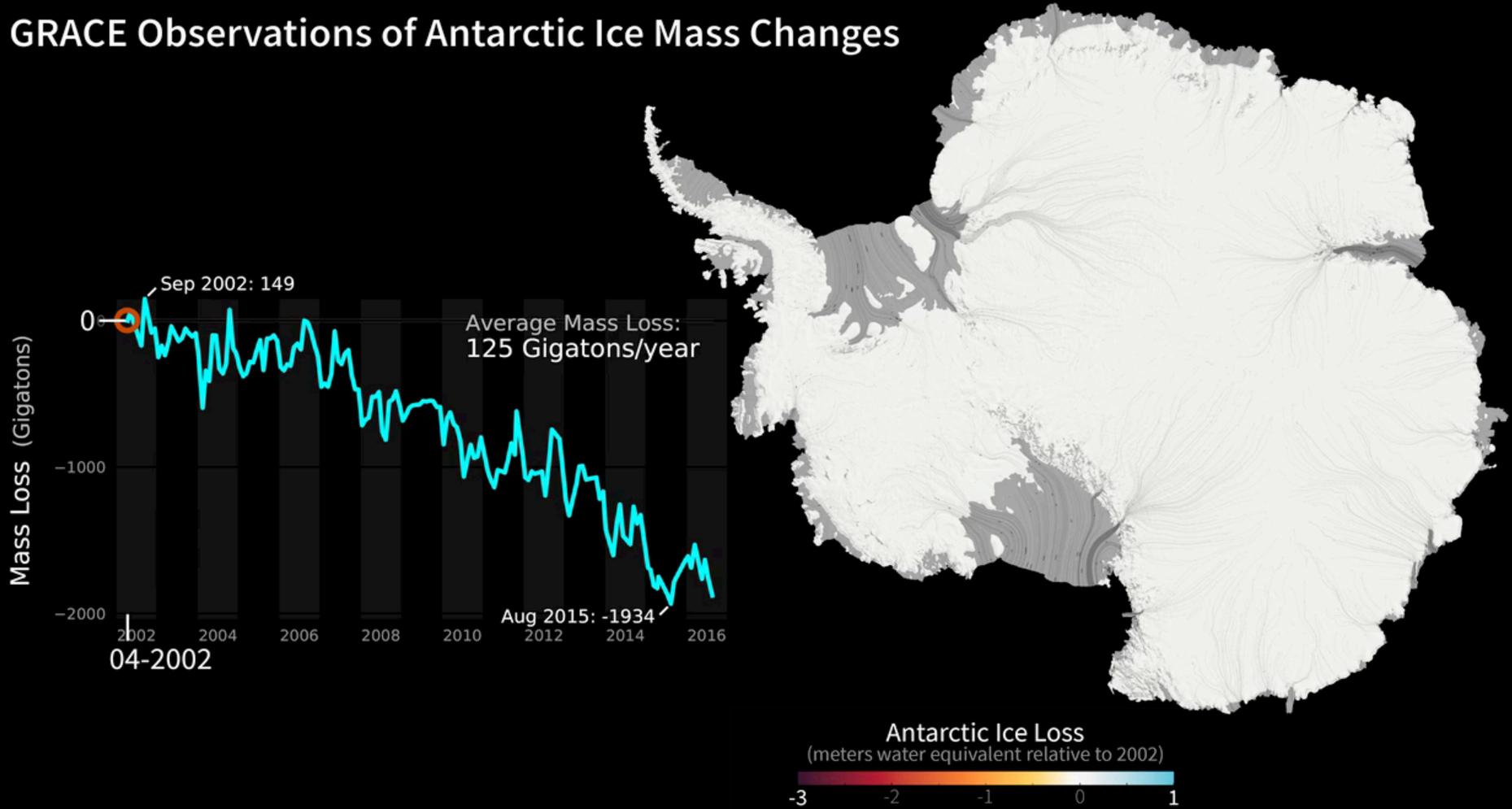
# Ice Sheet Loss affecting sea level

## GRACE Observations of Greenland Ice Mass Changes



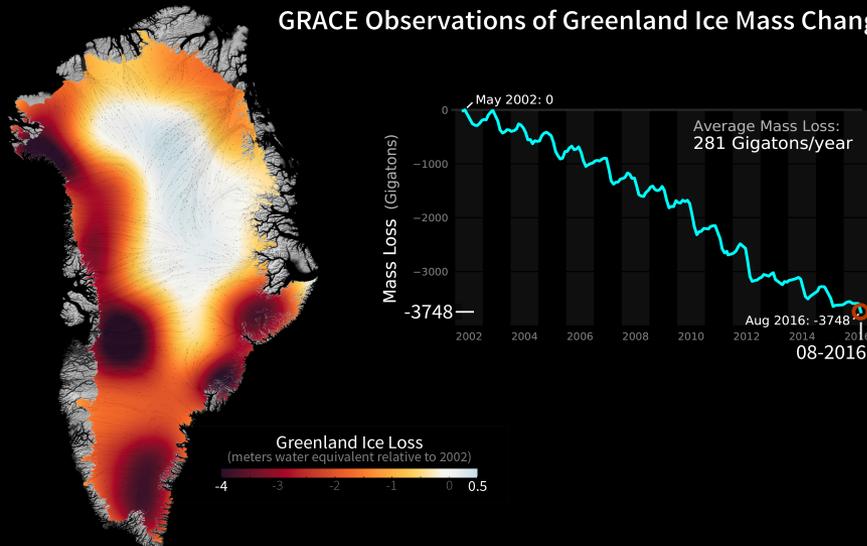
# Ice Sheet Loss affecting sea level

## GRACE Observations of Antarctic Ice Mass Changes



# Ice Sheet Loss affecting sea level

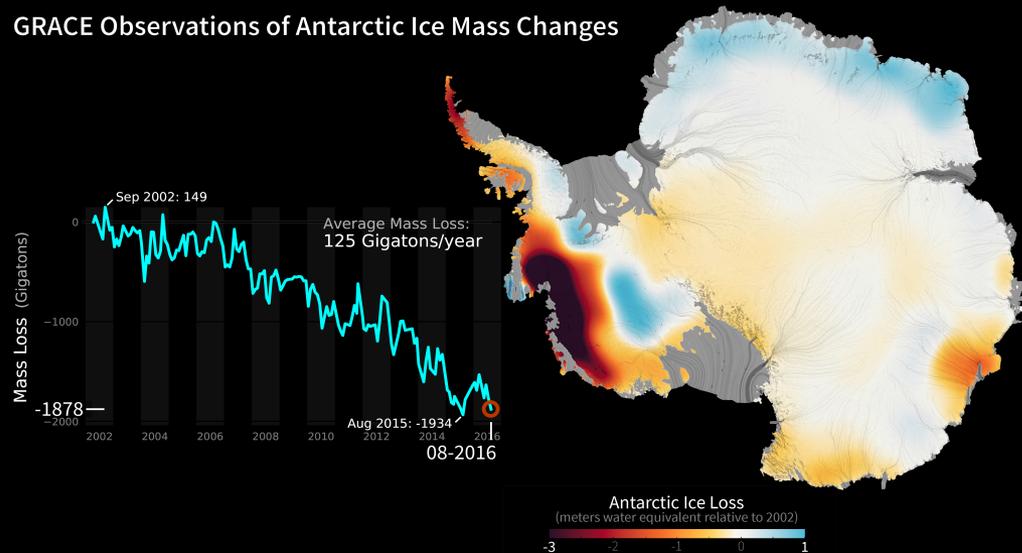
GRACE Observations of Greenland Ice Mass Changes



**Greenland: ~7 m sea level eqv.  
Antarctica: ~60 m sea level eqv.**

***GRACE weighs the ice sheets and identifies loss and gain on regional level***

GRACE Observations of Antarctic Ice Mass Changes



**Continuous measurements ensure we identify regional change and long term vs short term variations which ensures an “early warning system”**

- *Demonstrated to be essential to providing reliable estimates of climate variability and global change*
- *Key climate continuity observation*
  - *Water cycle*
  - *Sea level rise*
  - *Ocean heat content and circulation*
  - *Ice sheets*
- *Demonstrated to be essential for near real time use for water resource management*
  - *National Drought Monitor*
- *Requires extension of the time series as well as increased spatial and temporal resolution*
  - *30+ year record (extension of the existing 15 yr record)*
  - *2 pairs allow for better spatial and temporal coverage*

## Salient Features

- Implemented under US-German partnership
- Tech-Demo Laser Ranging Interferometer is Class D
- Follow-on to original GRACE Mission launched 2002
- Launch: **December 2017 on SpaceX Falcon 9**
- Orbit: Near-circular Polar Orbit, 495 km altitude, 89° inclination

## Science

- Will **continue and expand** upon the measurements initiated by the pathfinder GRACE Mission
- Will provide estimates of the **global high-resolution models of the Earth's gravity field for a period of up to five years** at a precision and temporal sampling equivalent to that achieved with GRACE.
- Will provide **QuickLook (<24h) products for enhanced operational use** for water resource management.
- Will demonstrate satellite-to-satellite interferometry in low Earth orbit for future gravity missions

