



Spaceborne Earth Observations and Climate Change

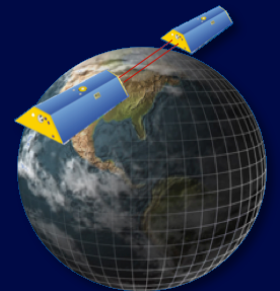
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Center for Space Research, University of Texas at Austin

2018 SEOGC Summer School 07/09-07/14, Shanghai, China



Traditional Methods

☐ **Ground (over the land)**

- ☐ Weather stations
- ☐ Water level and flow rate from river gauges
- ☐ Sea level from tide gauges
- ☐ ...

☐ **Ships (over the ocean)**

- ☐ Sea temperature
- ☐ Ocean current
- ☐ Sea water salinity (how salty sea water is)

☐ **Balloons/Airplanes (in the air)**

- ☐ Air temperature (at different levels)
- ☐ Wind speed and direction
- ☐ Humidity
- ☐ Other parameters of the air

Old Style (still in use in many parts of the world)



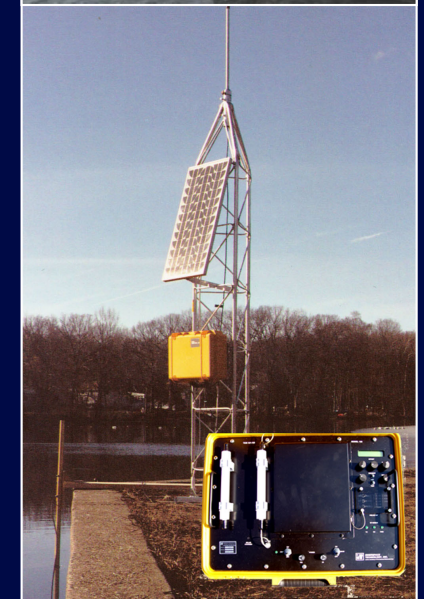
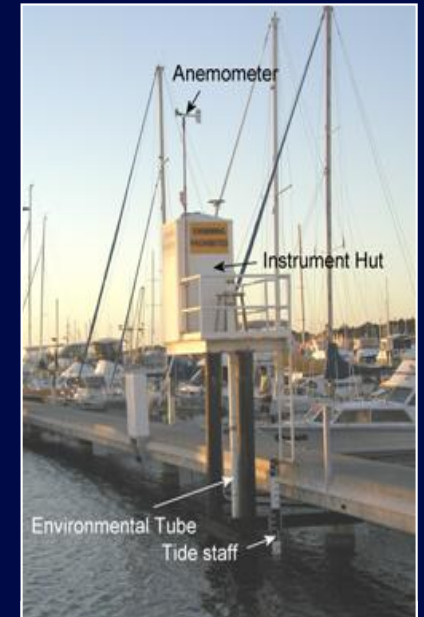
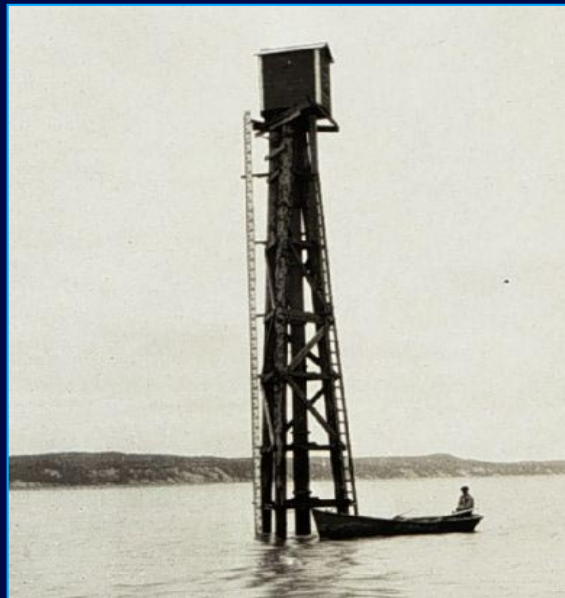
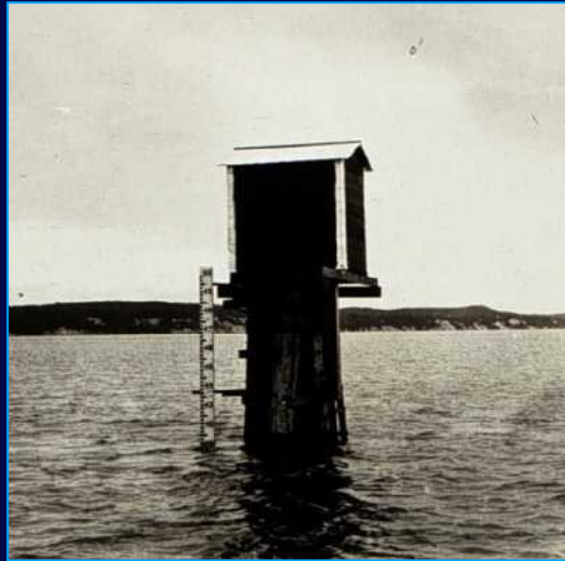
New Style (automated)



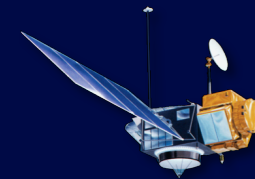
How to measure sea level? What is a tide gauge?



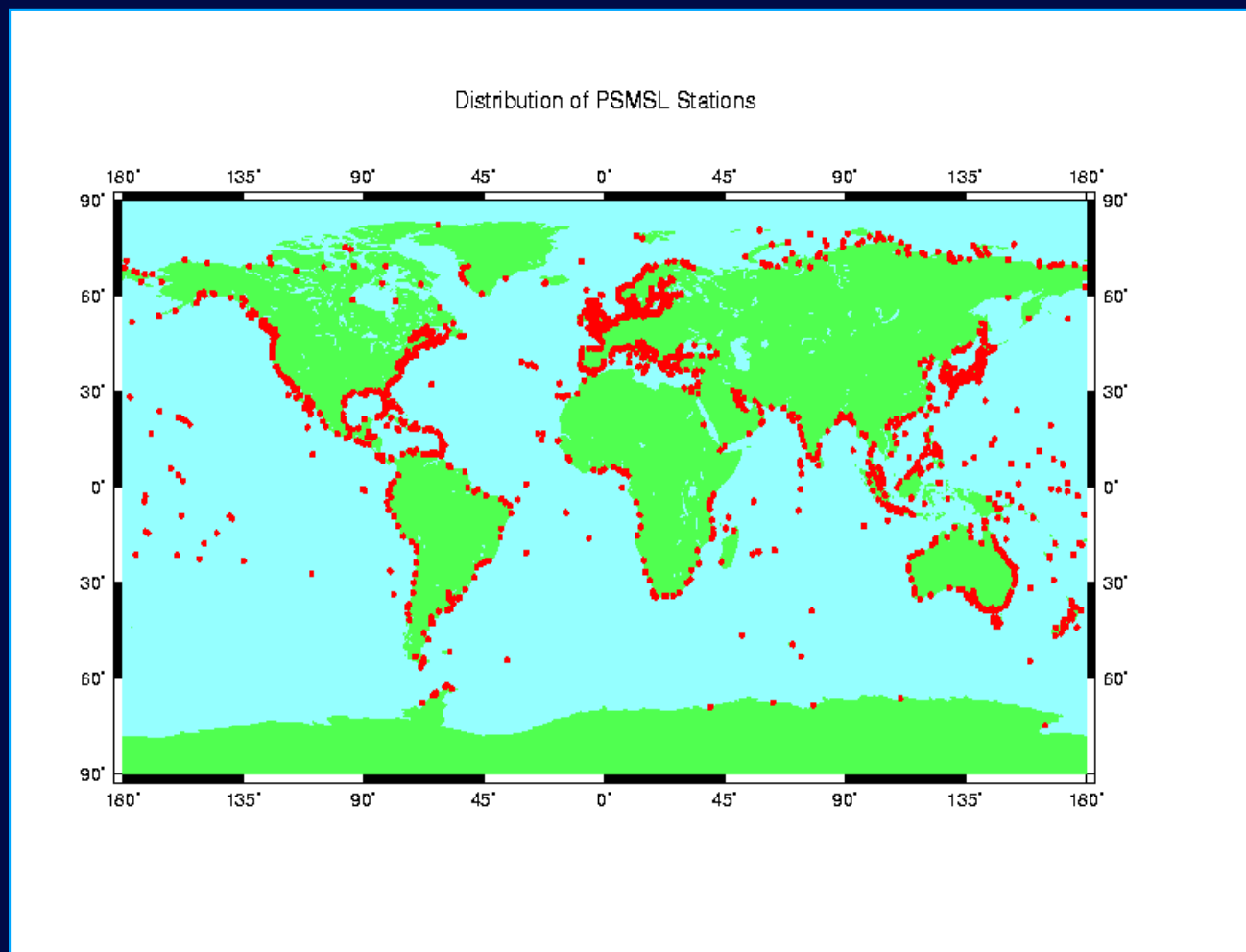
Historical Tide Gauges



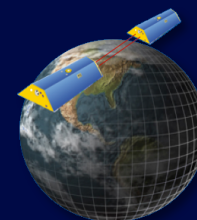
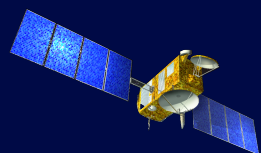
New Style (automated)

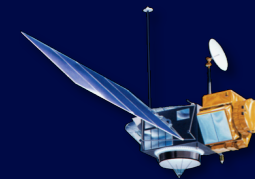


Global Distribution of PSMSL Tide Gauge Stations

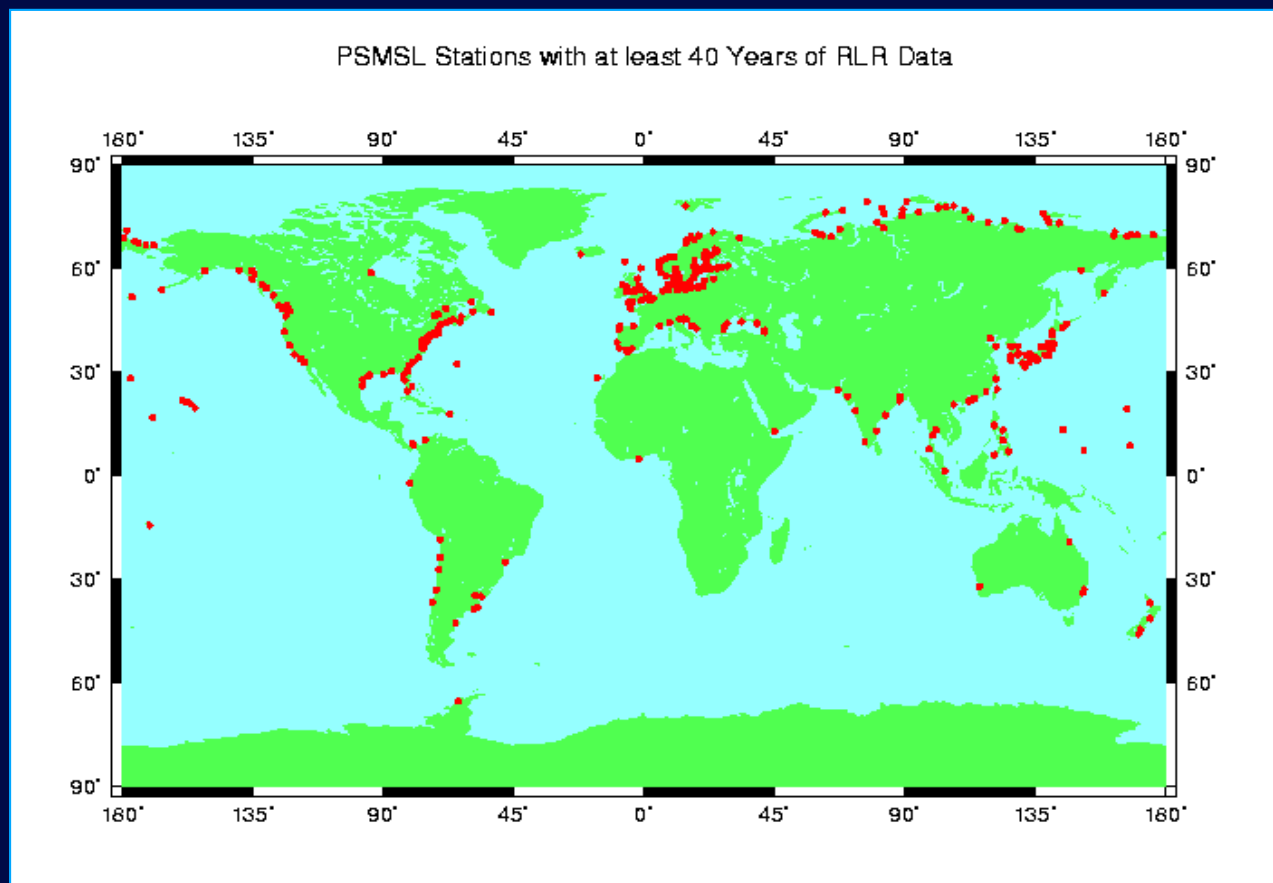


Courtesy of PSMSL



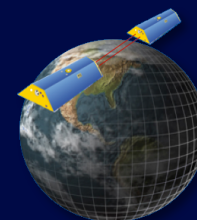
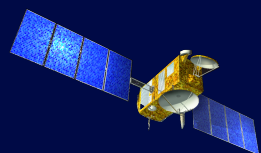


PSMSL Tide Gauge Stations (with at least 40 years of data)



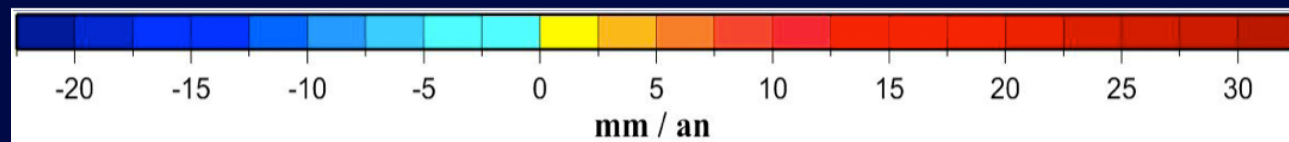
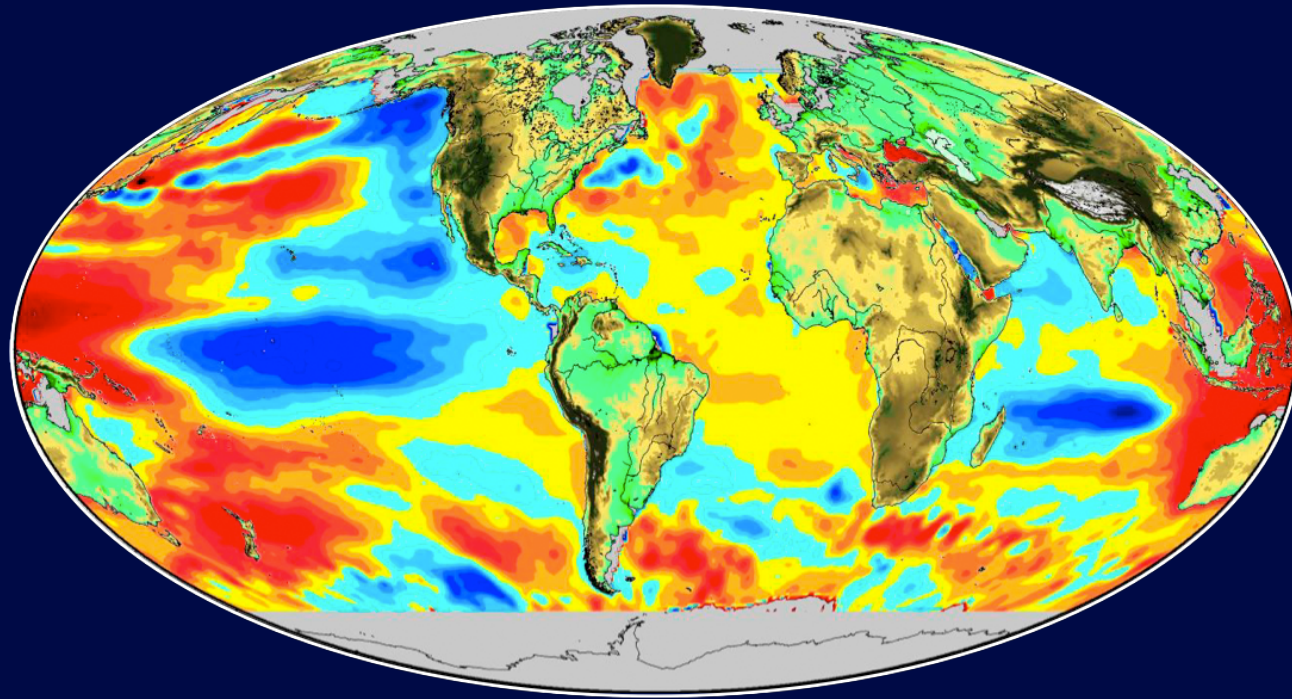
Courtesy of PSMSL

**Will these many stations be good enough to monitor
the global sea level change?**



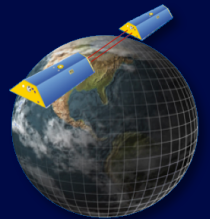
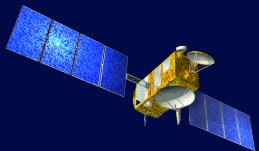
Global Sea Level Change Rates

Satellite Measurements



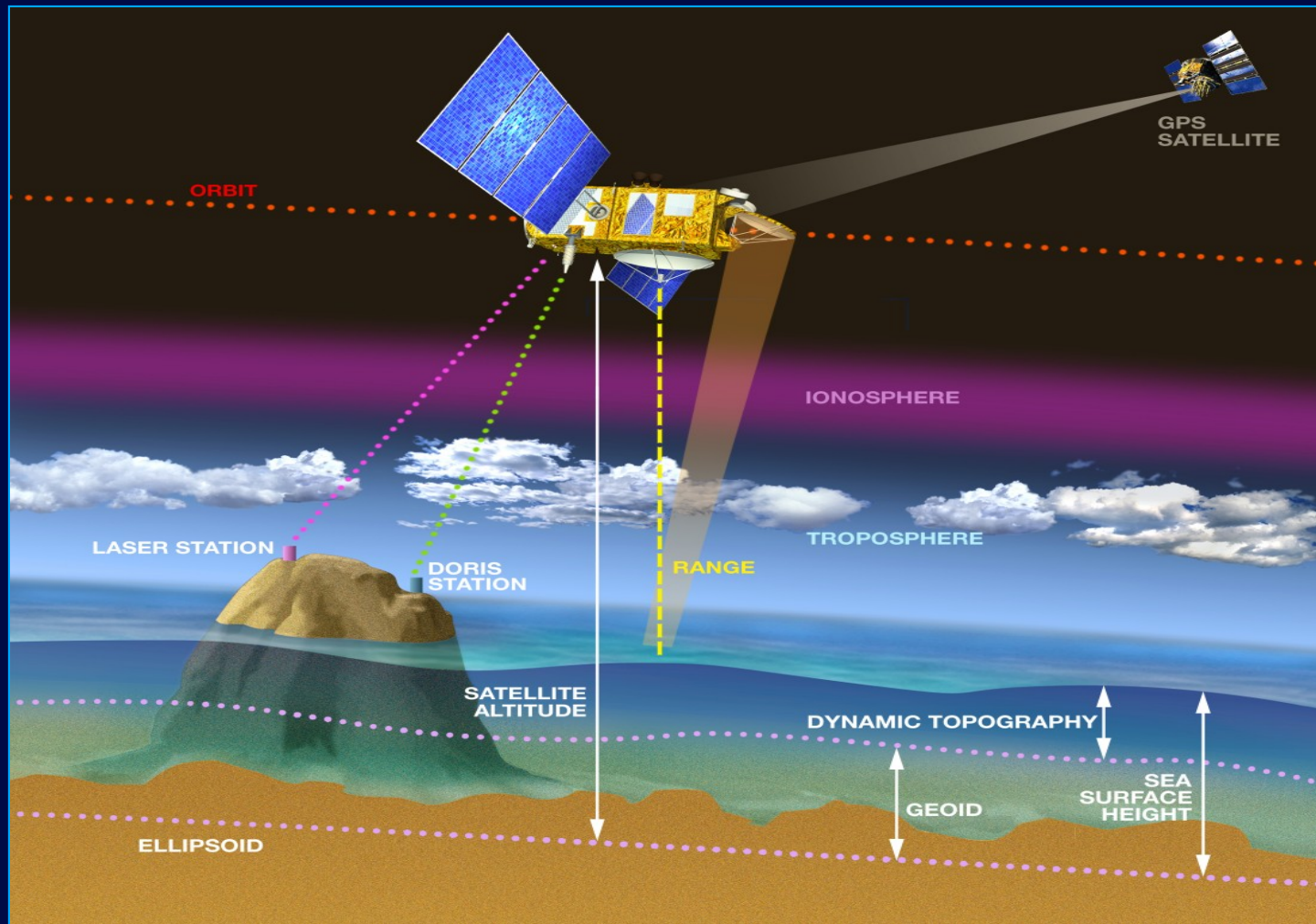
So, will tide gauge data
be good enough to
monitor the global sea
level change?

The answer is
simply 'No'.



Satellite Observations

A New Era of Climate Change Study



TOPEX/Poseidon Satellite Altimeter



The Amazing And Most Successful Satellite Altimeter Mission

(1992.09 - 2006.01)

(originally designed for 3 - 5 years)

Jason-1/2 (TOPEX/Poseidon Follow On)



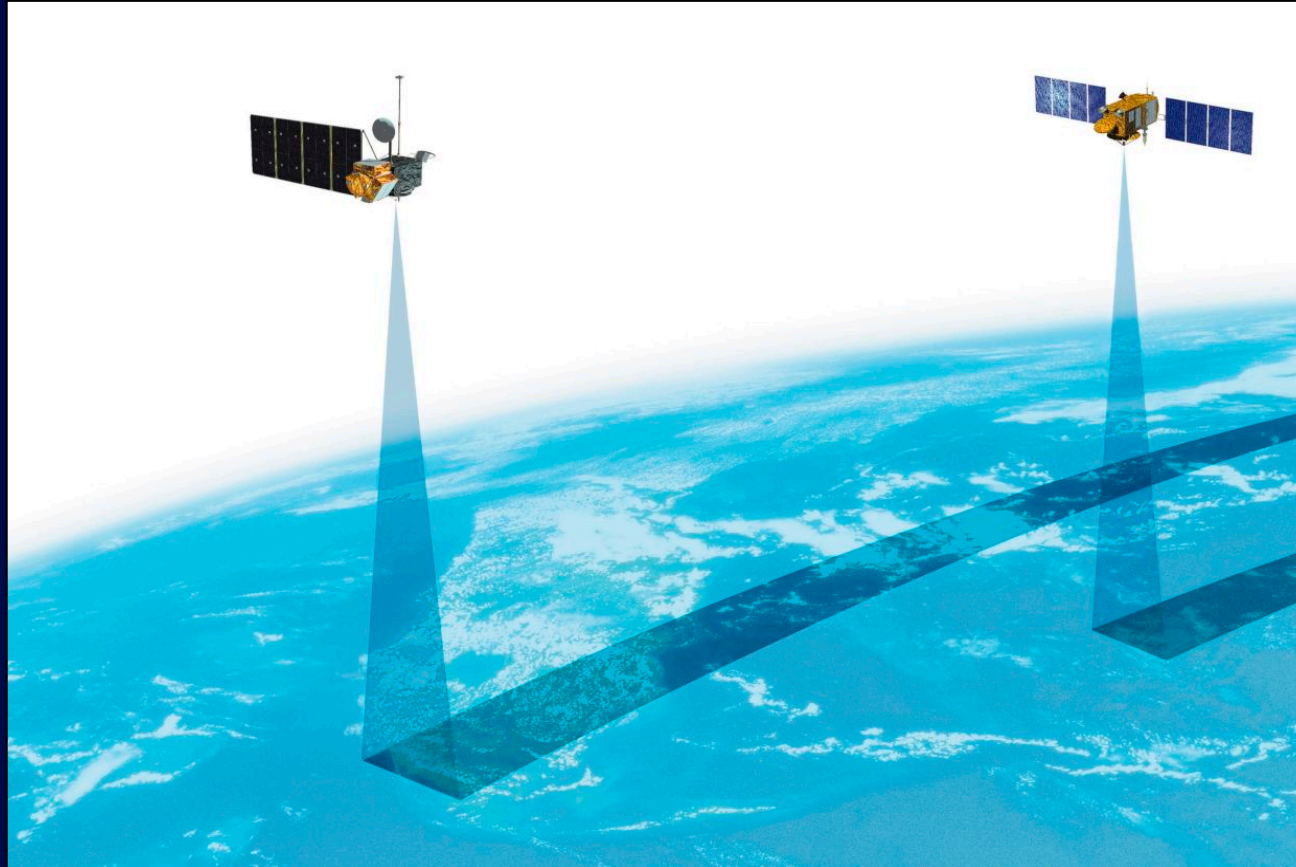
**Much More Compact - 5 Times Lighter Than TOPEX/Poseidon
(Launched in December, 2001)**

An Ocean Odyssey



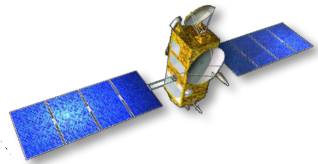
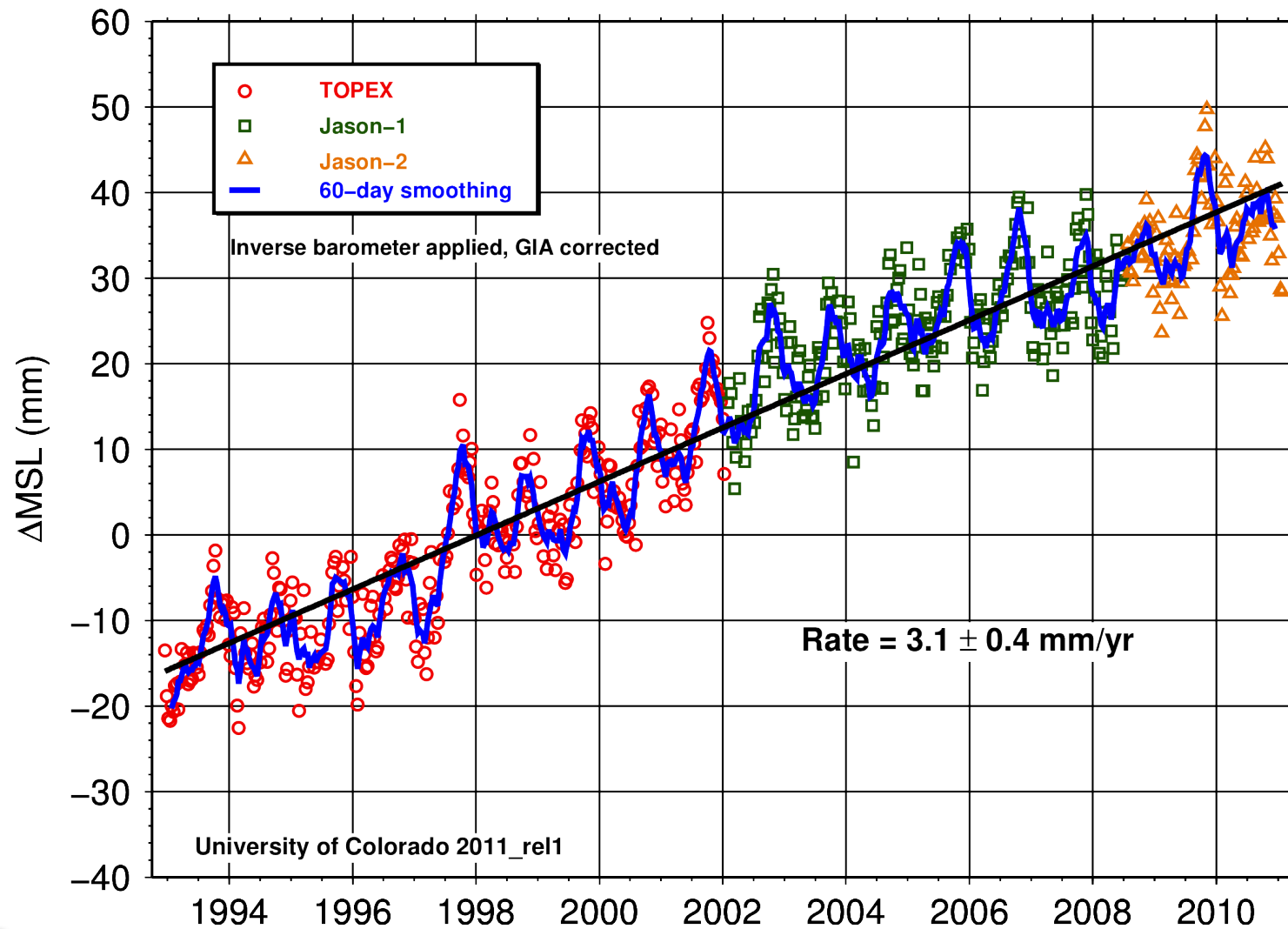
**TOPEX/Poseidon & Jason-1 had been jointly flying
in the orbit for over 4 years (2001.12 - 2006.01).**

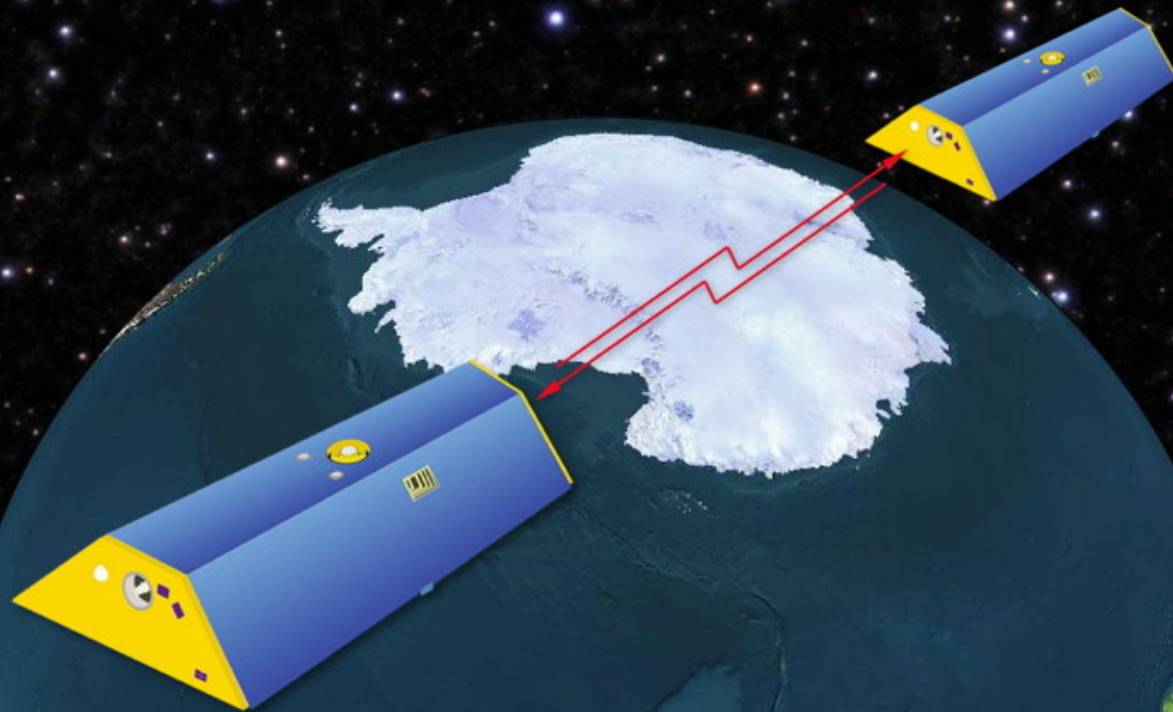
The Tandem Mission



The over 4 years (2001.12 - 2006.01) overlapping period is so important for validating measurements from both satellites.

Global Mean Sea Level Change From Satellite Altimeters



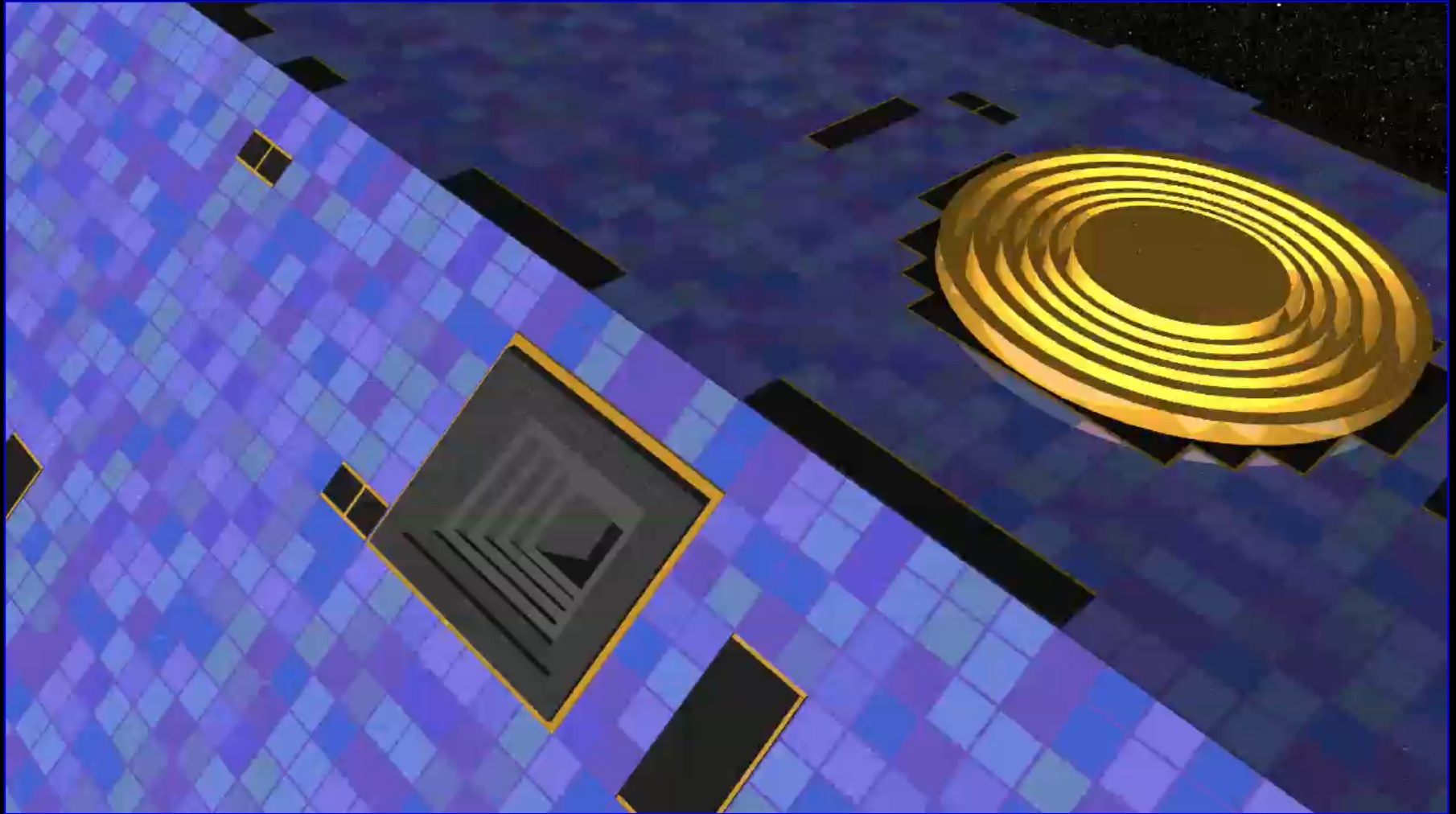


GRACE

Gravity Recovery And Climate Experiment

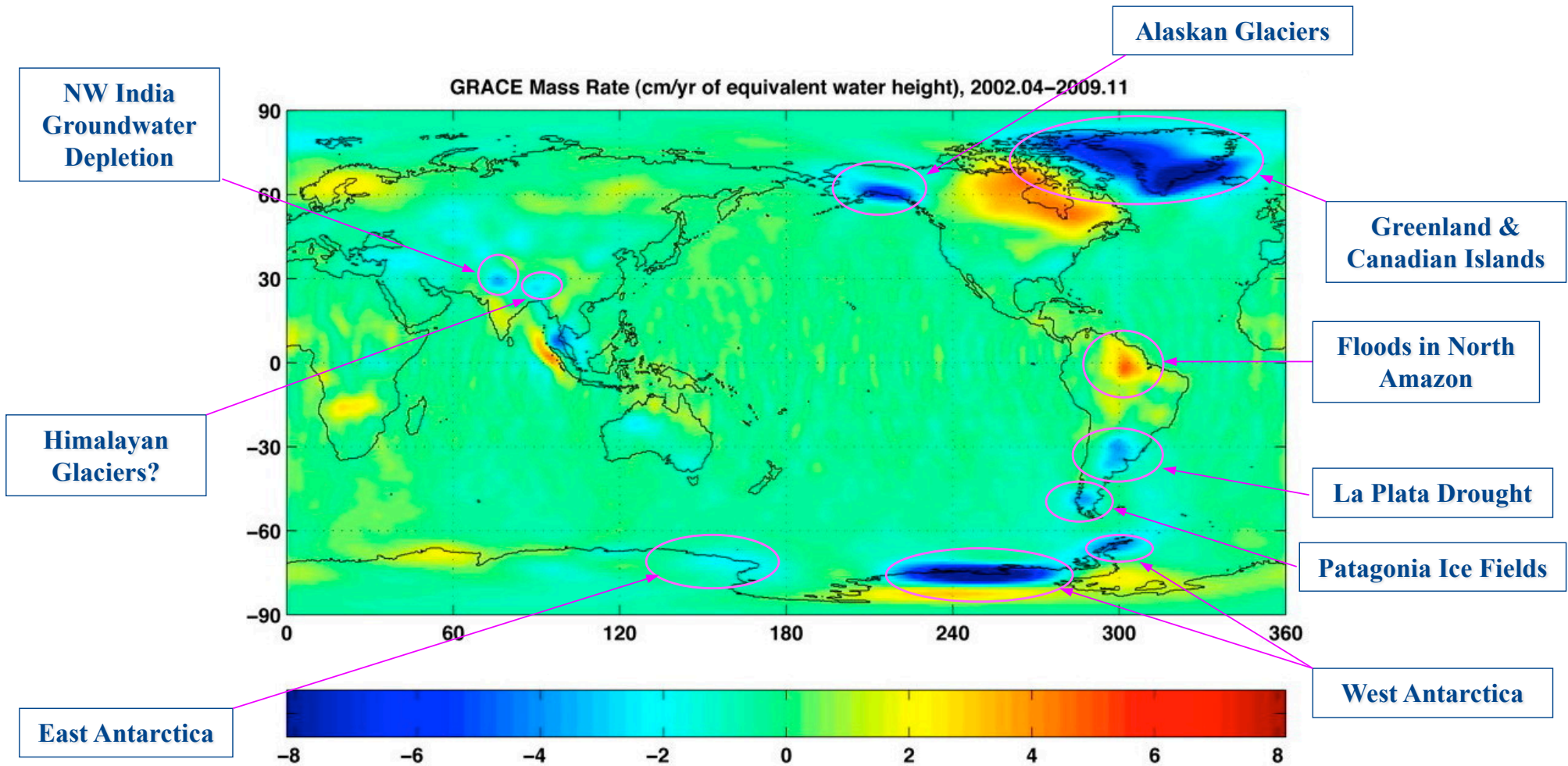
GRACE Mission

(Gravity Recovery and Climate Experiment)



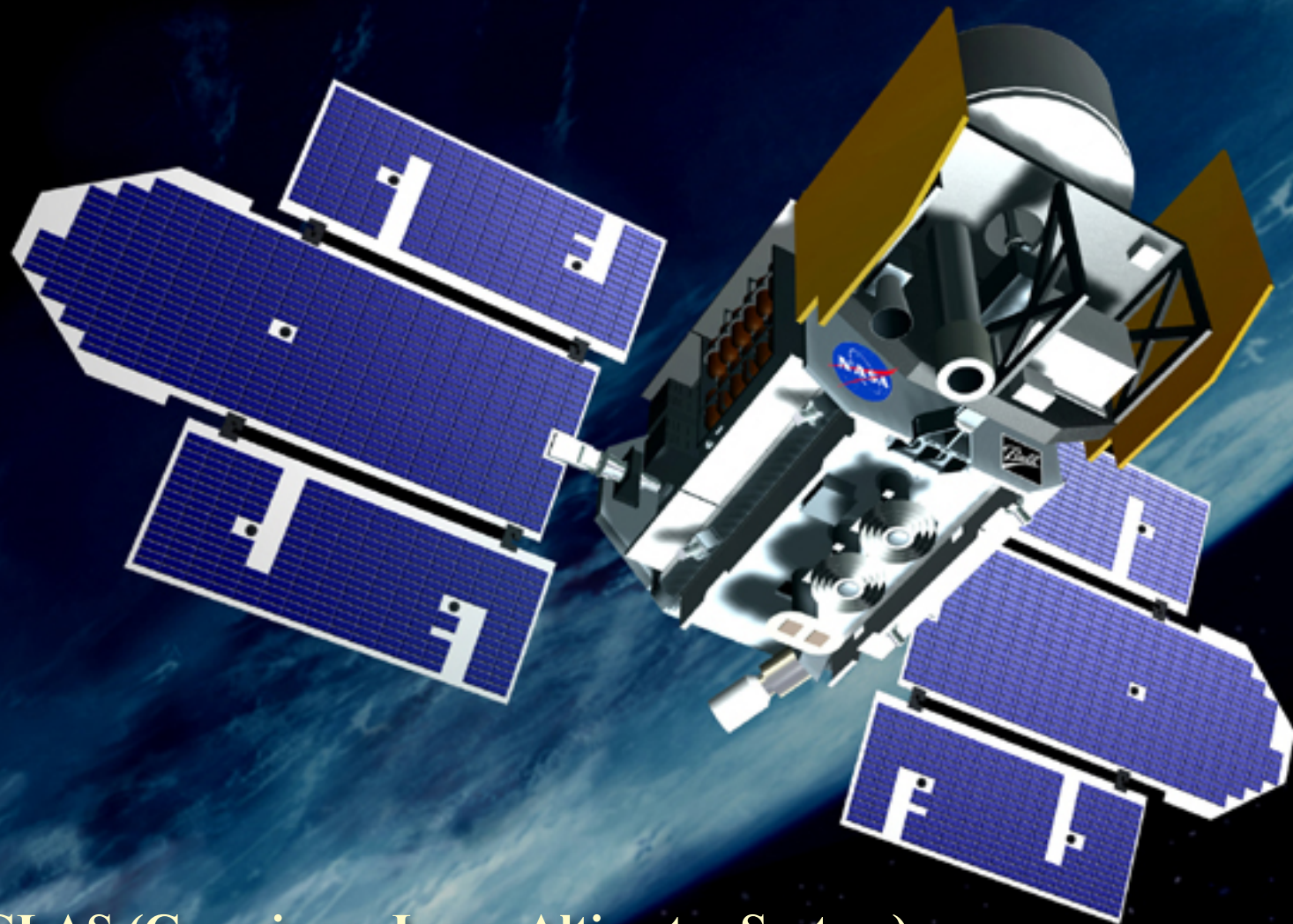
To measure water and snow/ice change on the Earth surface.

Global Long-Term Climate Change Signatures from GRACE



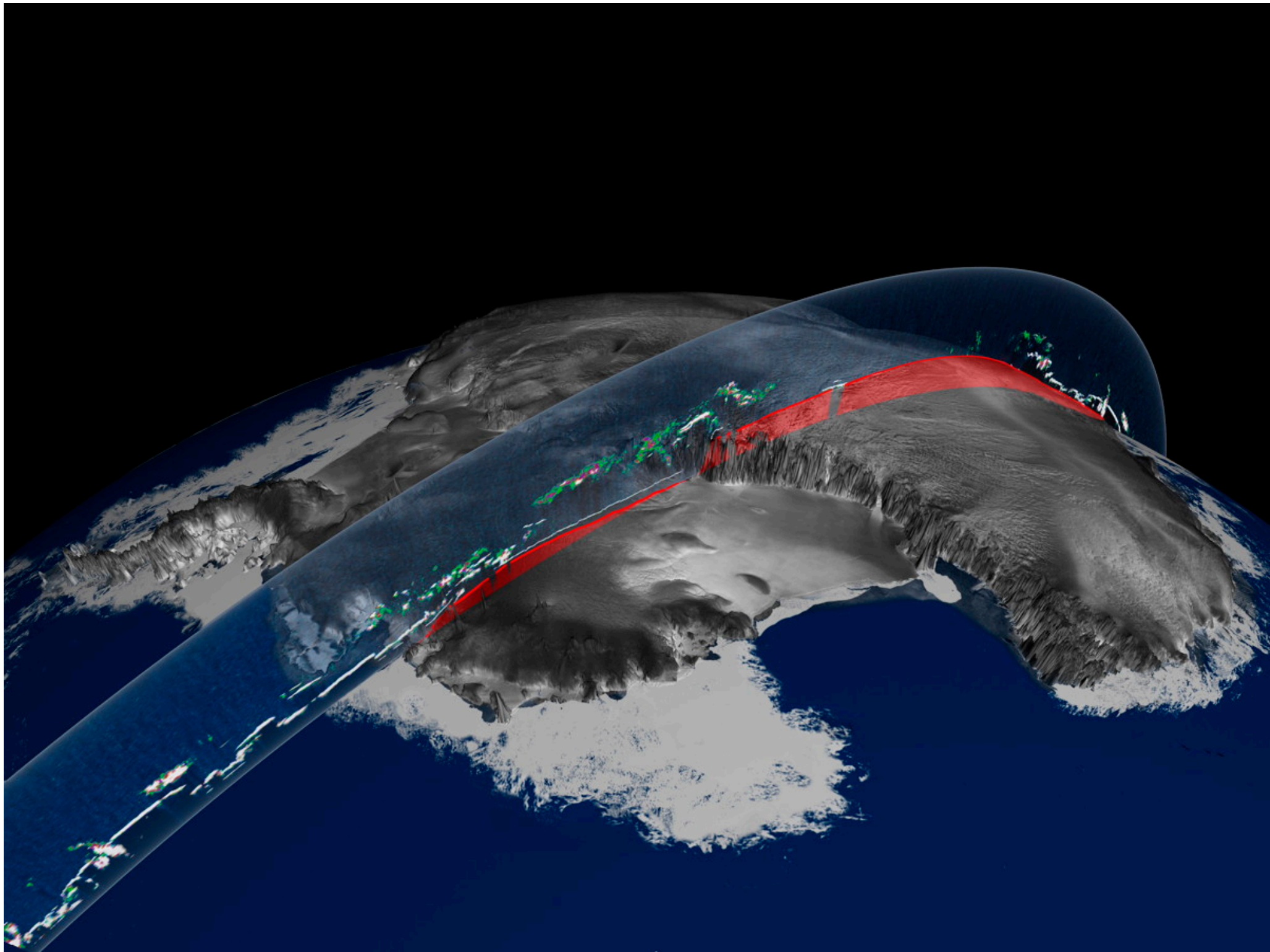
ICESat

(Ice, Cloud, and land Elevation Satellite)

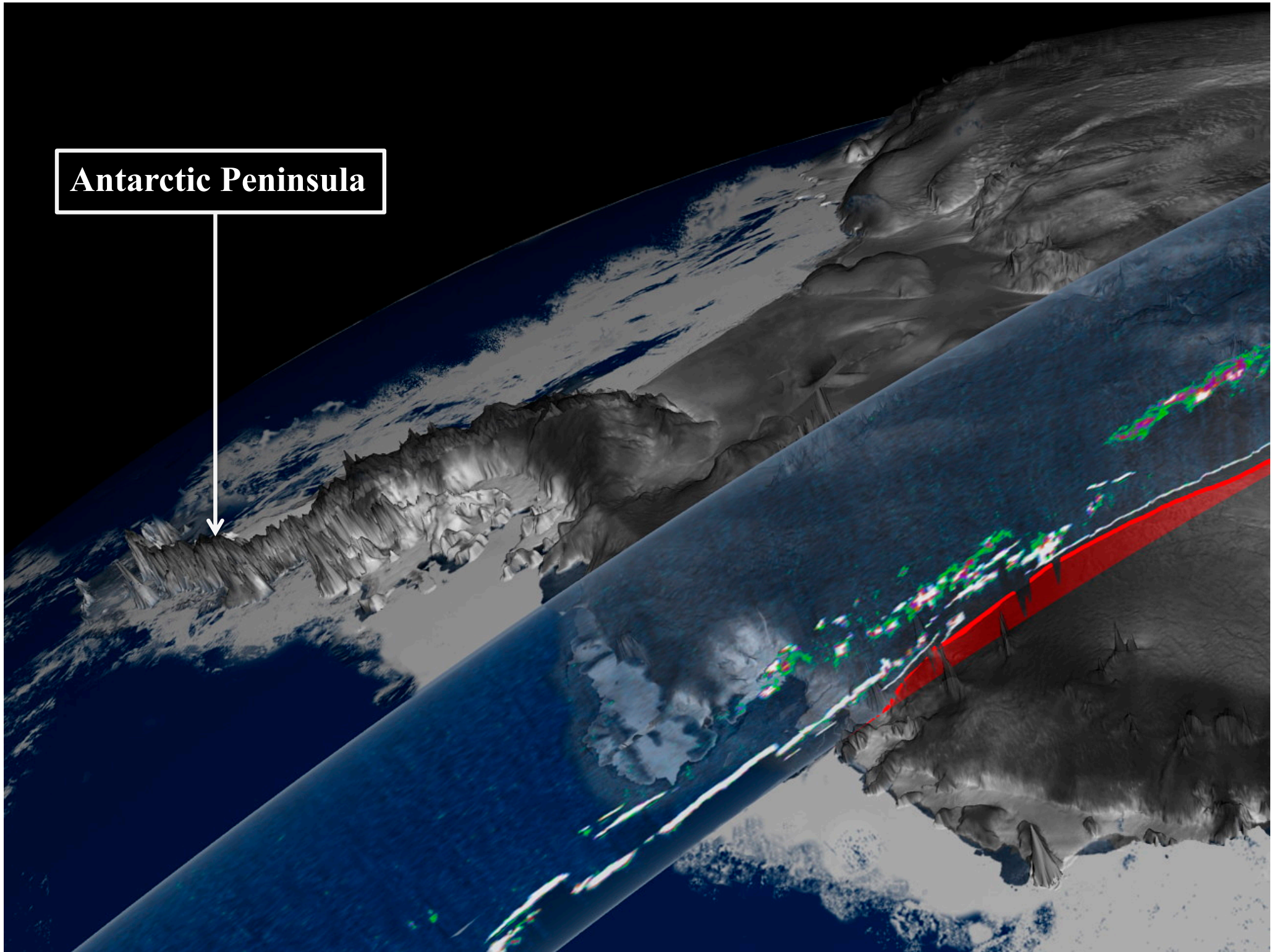


GLAS (Geoscience Laser Altimeter System)

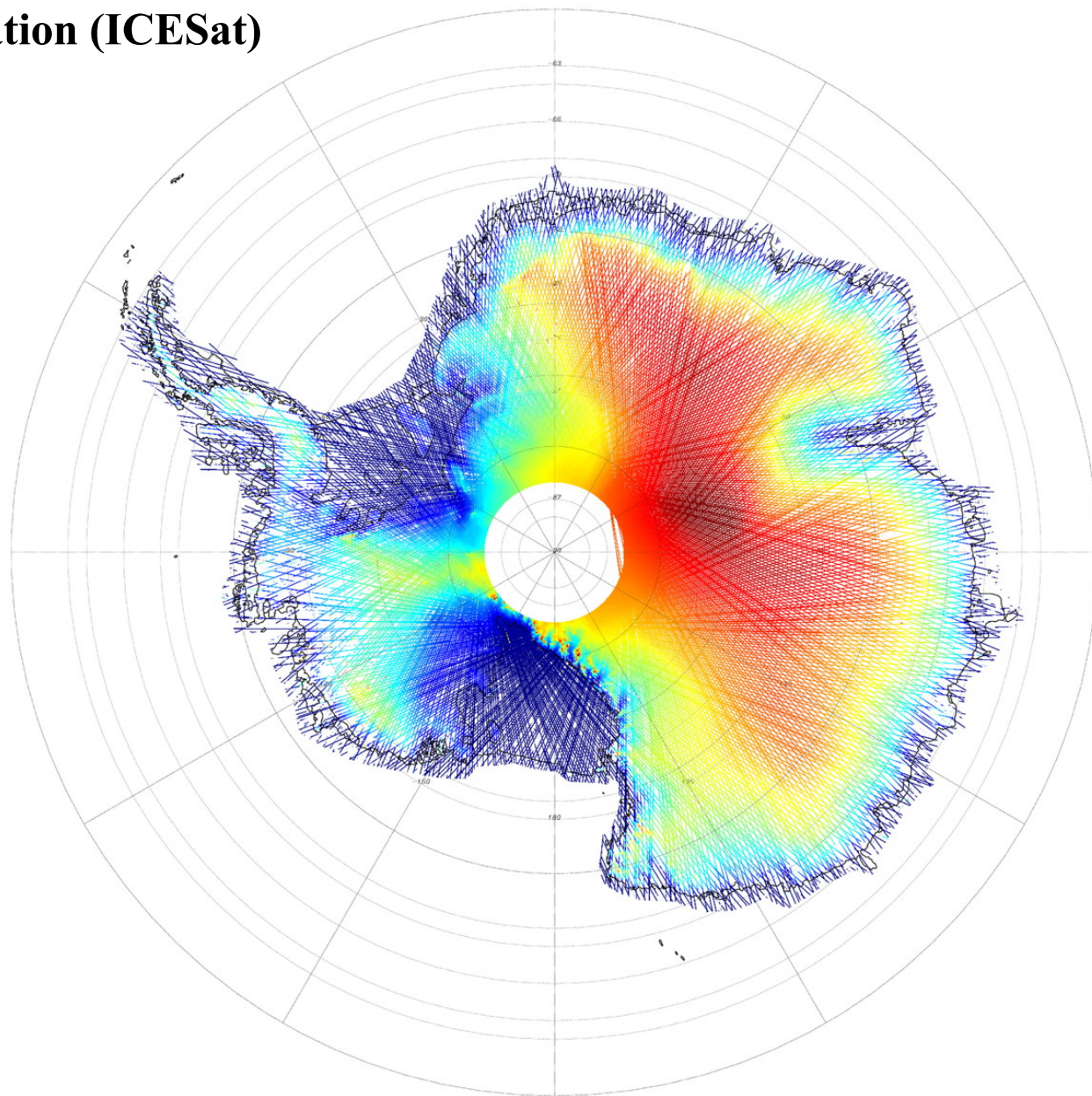




Antarctic Peninsula



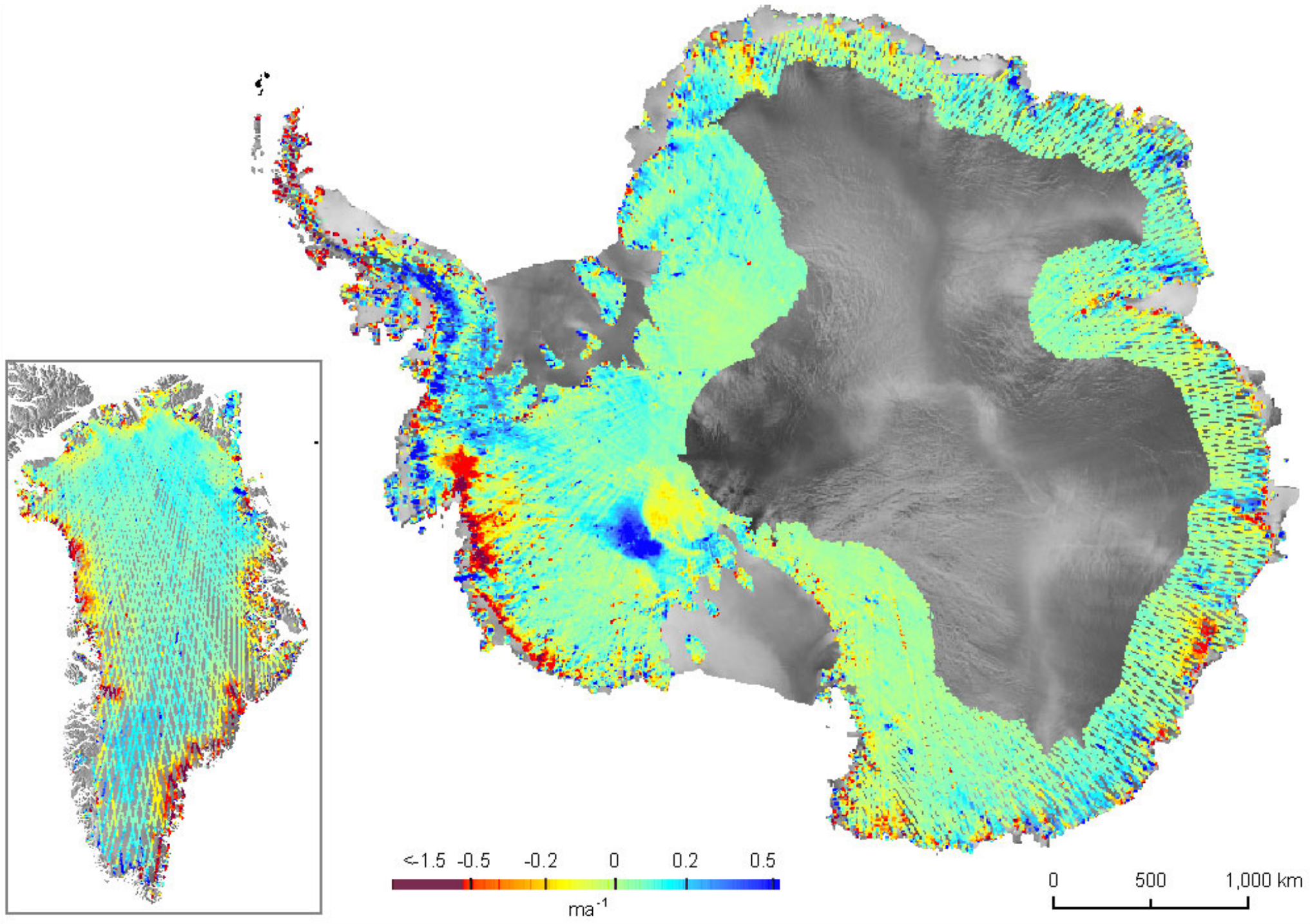
Antarctic Elevation (ICESat)



Elevation (m)



Polar Ice Sheets Thinning from ICESat (2003 – 2007) (*Pritchard et al., 2009*)

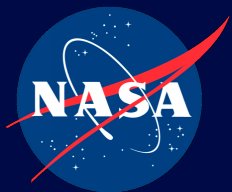
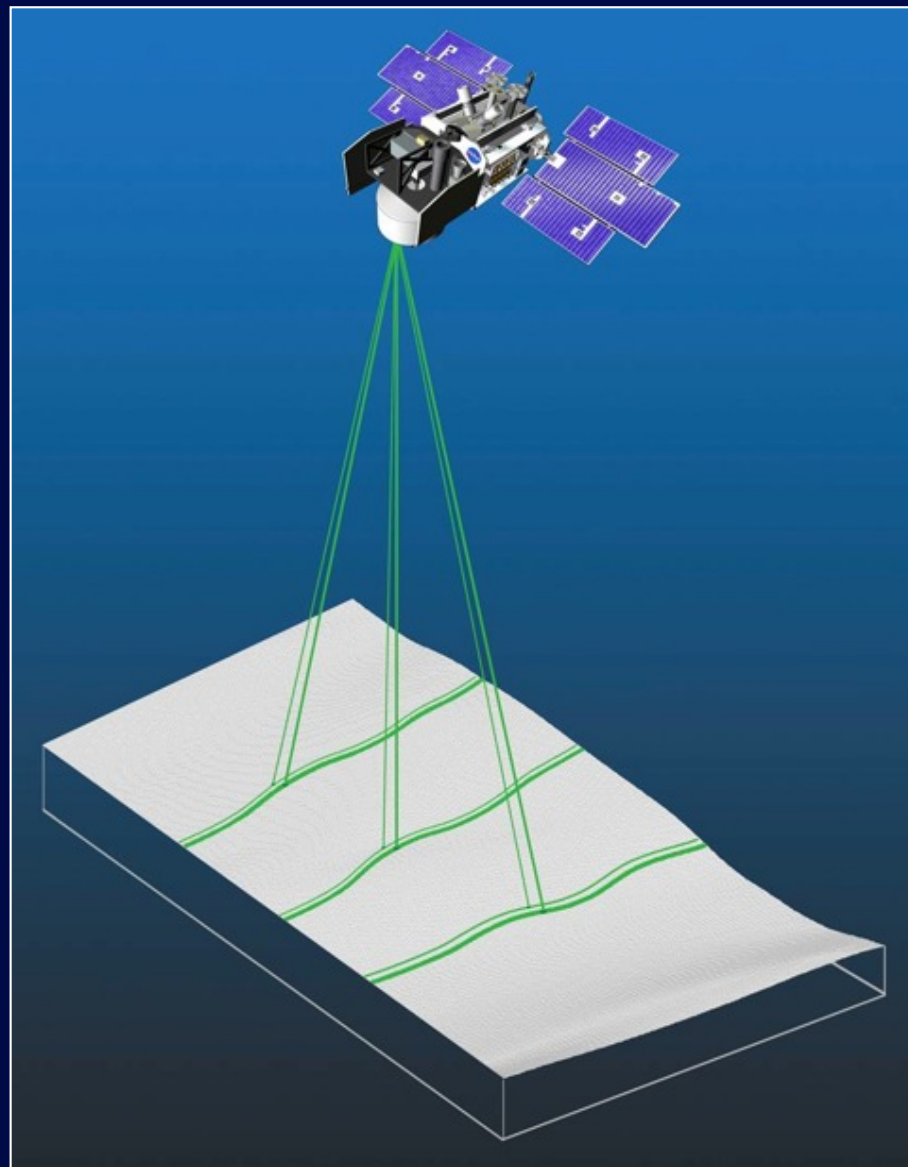


ICESat-2

(Scheduled for launch in early 2016)

In contrast to the ICESat design, ICESat-2 will use a micro-pulse multi-beam approach. This provides dense cross-track sampling to resolve surface slope on an orbit basis.

This concept has advantages over ICESat of improved elevation estimates over high slope areas and very rough areas and improved lead detection for sea ice freeboard estimates.

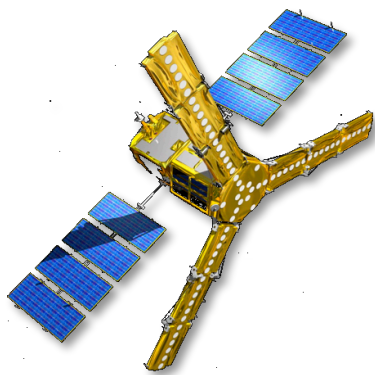


European Space Agency



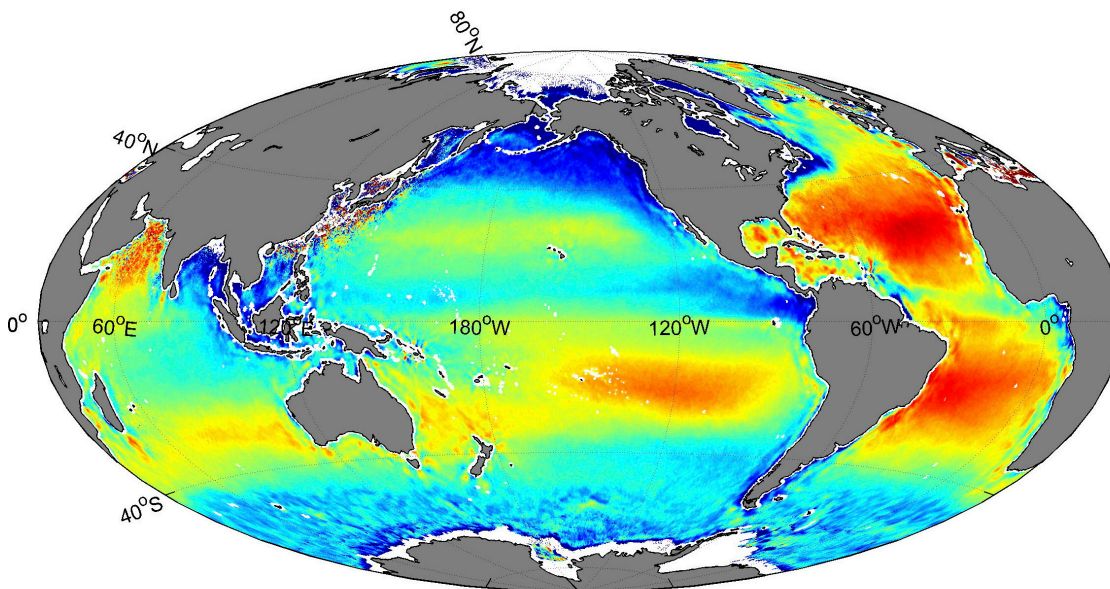
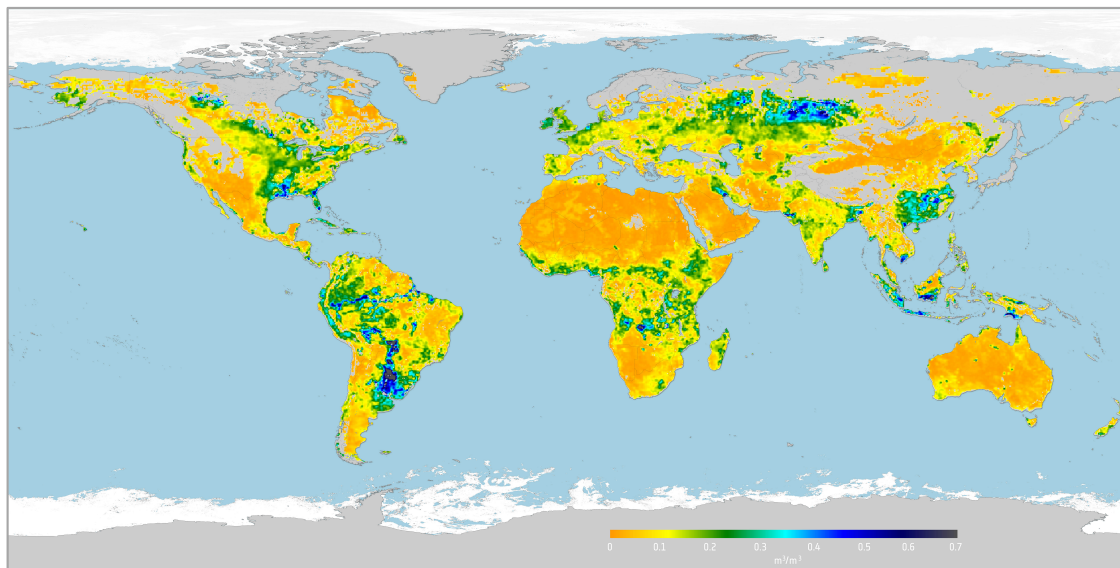
ESA's SMOS Mission **(Soil Moisture and Ocean Salinity)**

Launched on 2 November 2009



SMOS

ROOT-ZONE SOIL MOISTURE MAY 2016



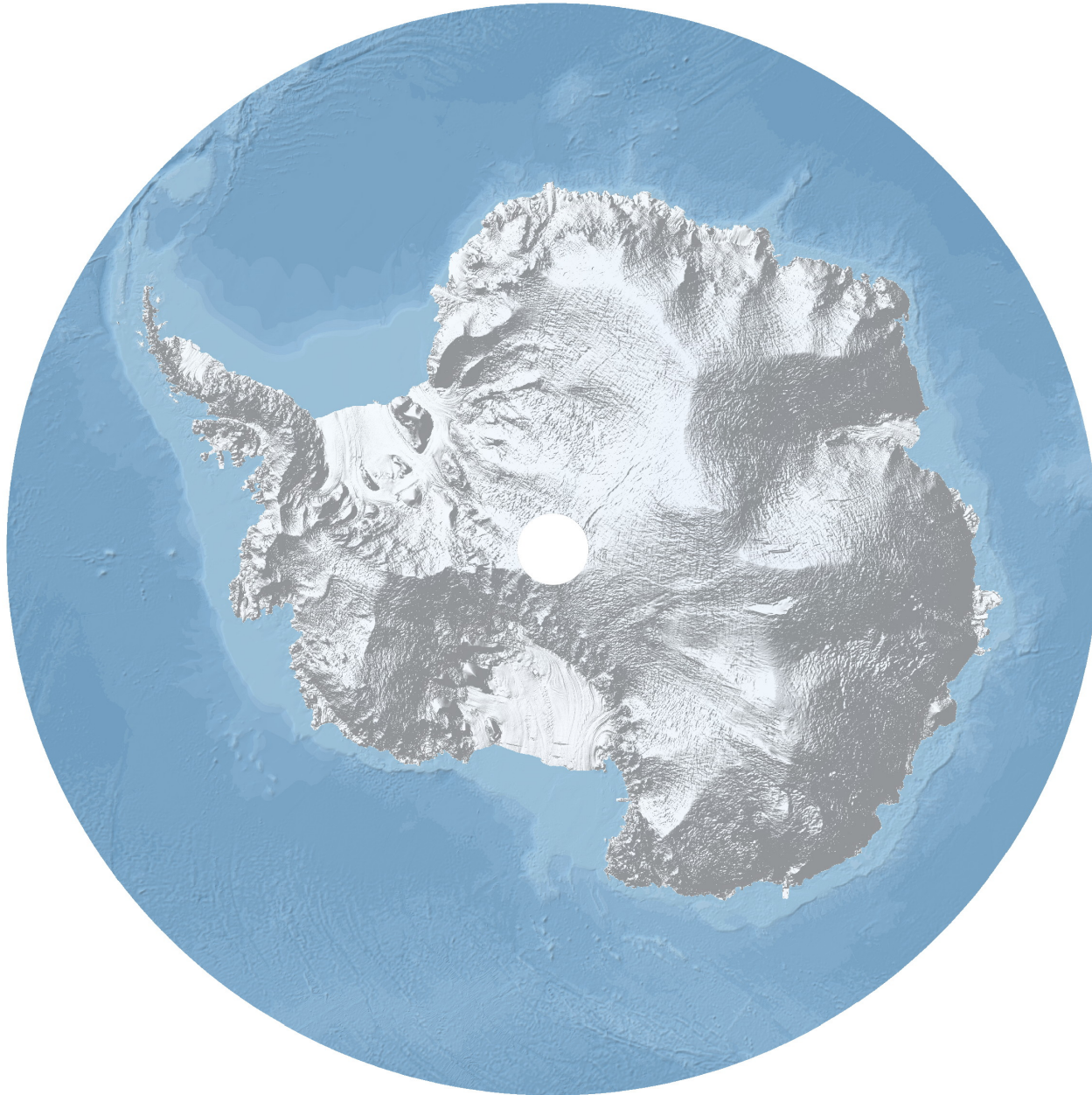
SMOS



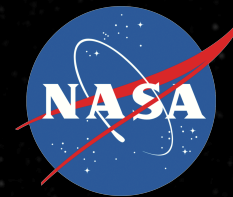
CryoSat-2 - Cryosphere Satellite

(To measure snow and ice thickness change)

Launched on 8 April 2010



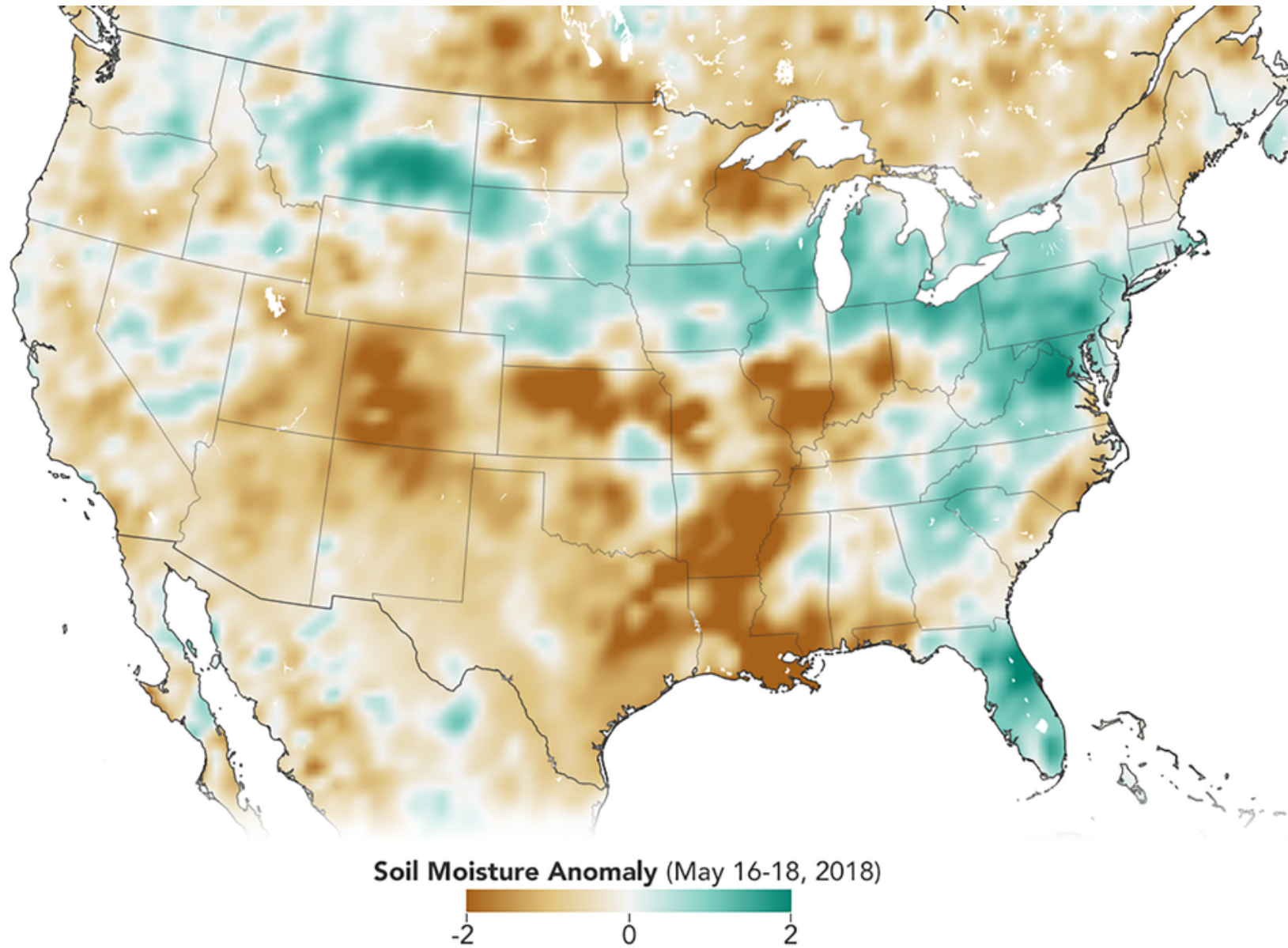
CryoSat-2 provides the most accurate 3D view ever of the Antarctic Ice Sheet



SMAP (Soil Moisture Active Passive) Mission

(Launched in January, 2015)

NASA SMAP Soil Moisture Data Advances Global Crop Forecasts



Global Positioning System (GPS)



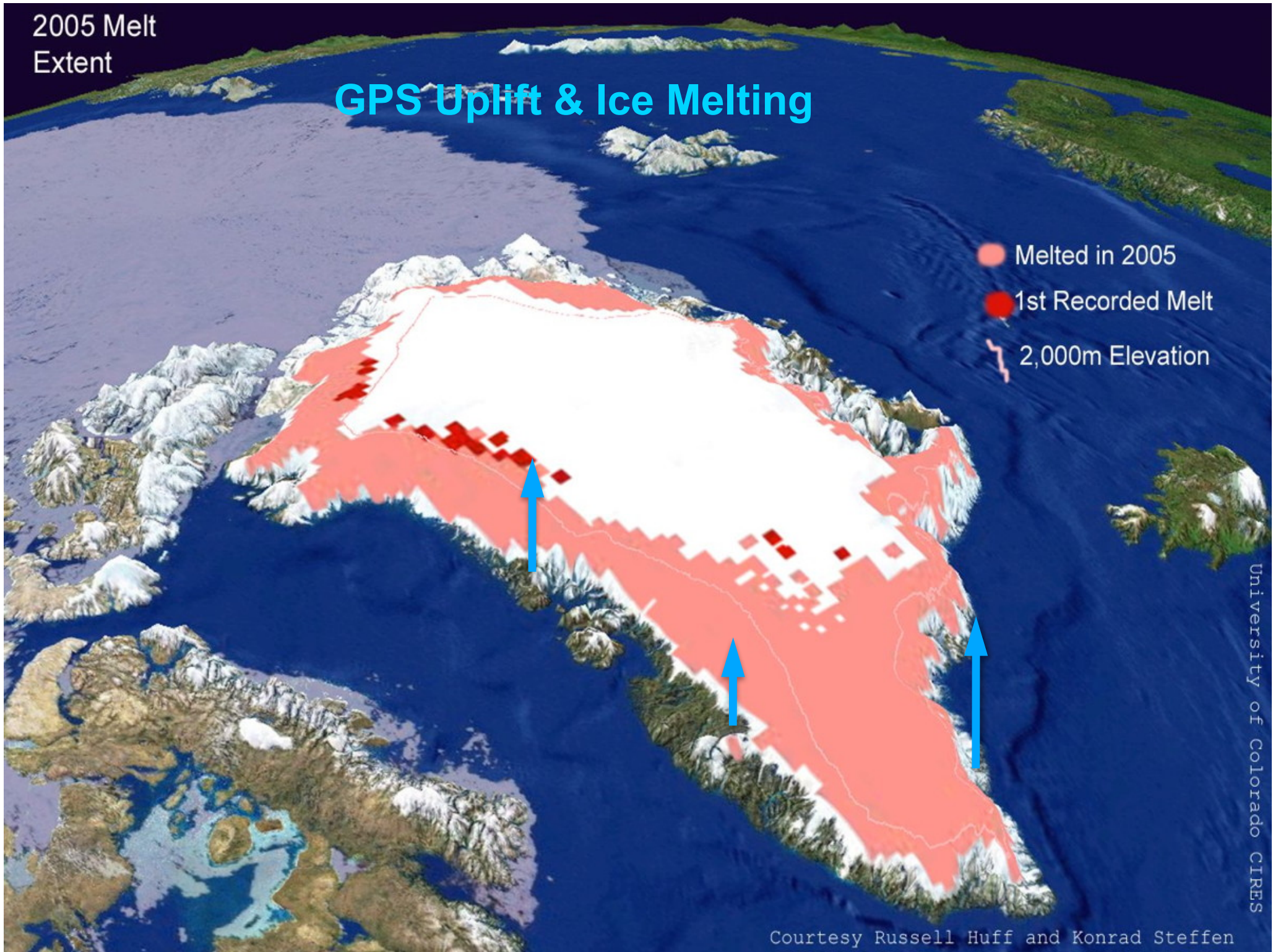
2005 Melt
Extent

GPS Uplift & Ice Melting

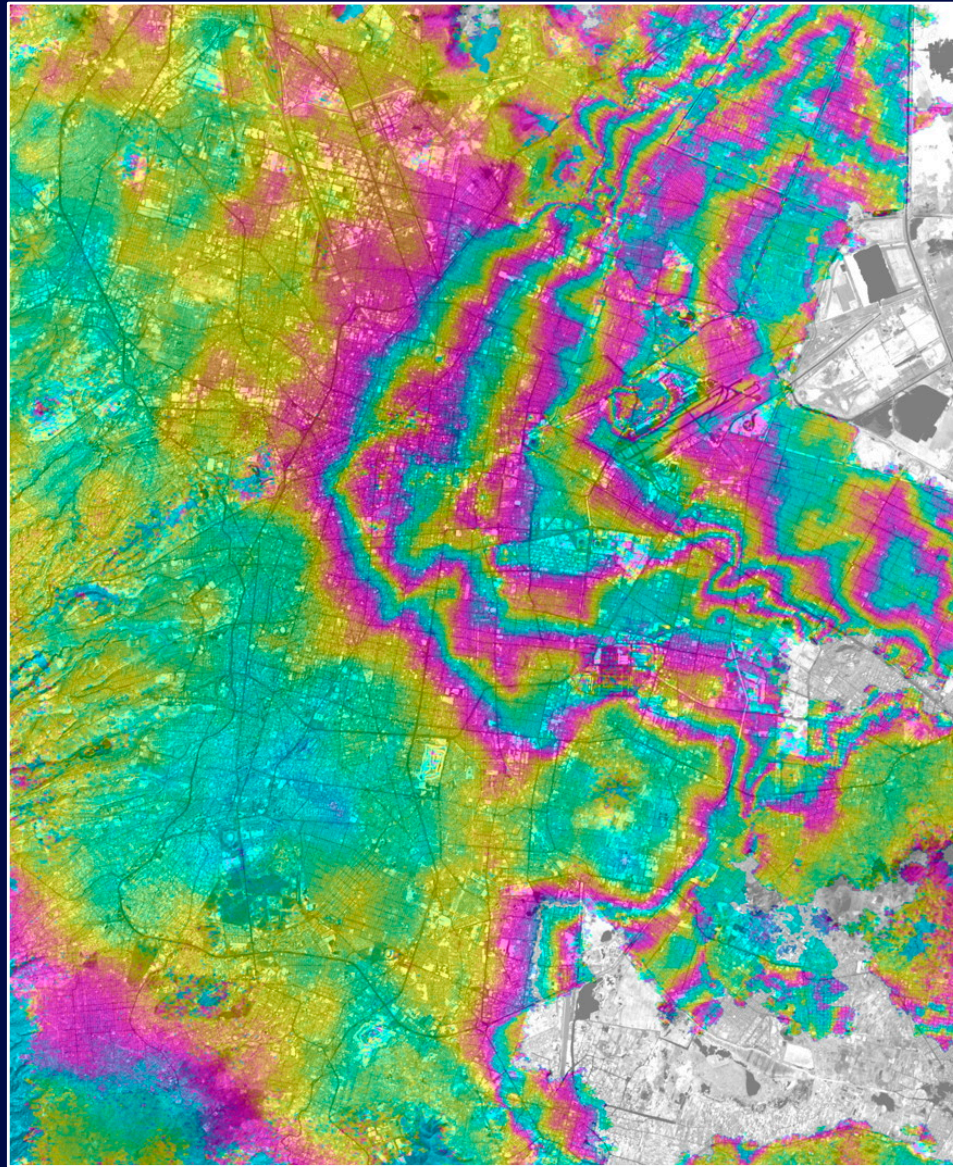
- Melted in 2005
- 1st Recorded Melt
- 2,000m Elevation

University of Colorado CIRES

Courtesy Russell Huff and Konrad Steffen



InSAR measurements indicate land subsidence in Mexico City.



The Three 'Pillars' of Geodesy:

- ❑ Earth's Shape (Deformation)
- ❑ Earth's Gravity Field
- ❑ Earth Rotation



A composite image of Earth from space, showing the Americas. Three satellites are depicted in orbit: one in the upper left with two long blue solar panels, one in the upper right with a large blue solar panel and an orange body, and one in the lower left with two blue solar panels. The word "Thanks!" is written in a large, bold, orange, italicized font across the center of the Earth.

Thanks!

The Magic Blue Marble