

Spaceborne Earth Observations and Climate Change

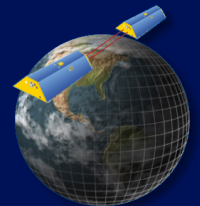
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上海天文台天文空间技术应用及全球变化实验室



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)



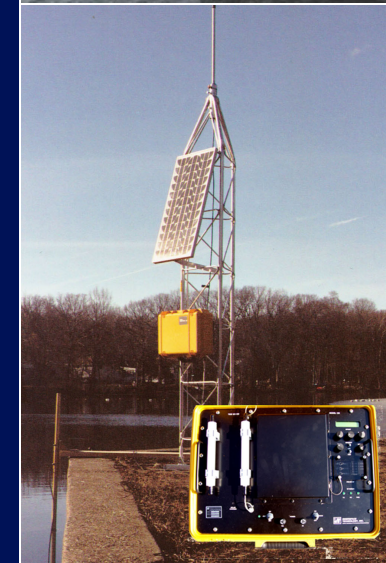
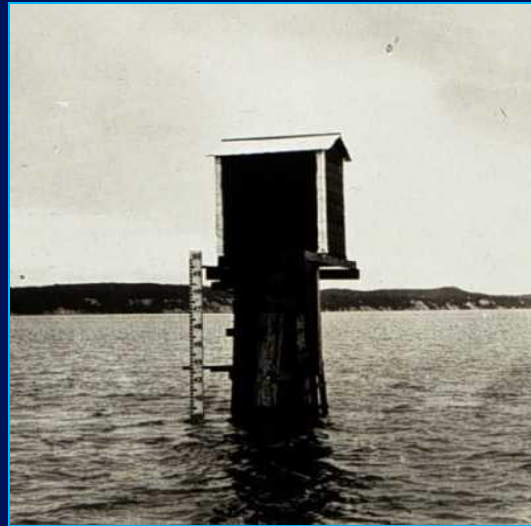
New Style (automated)



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

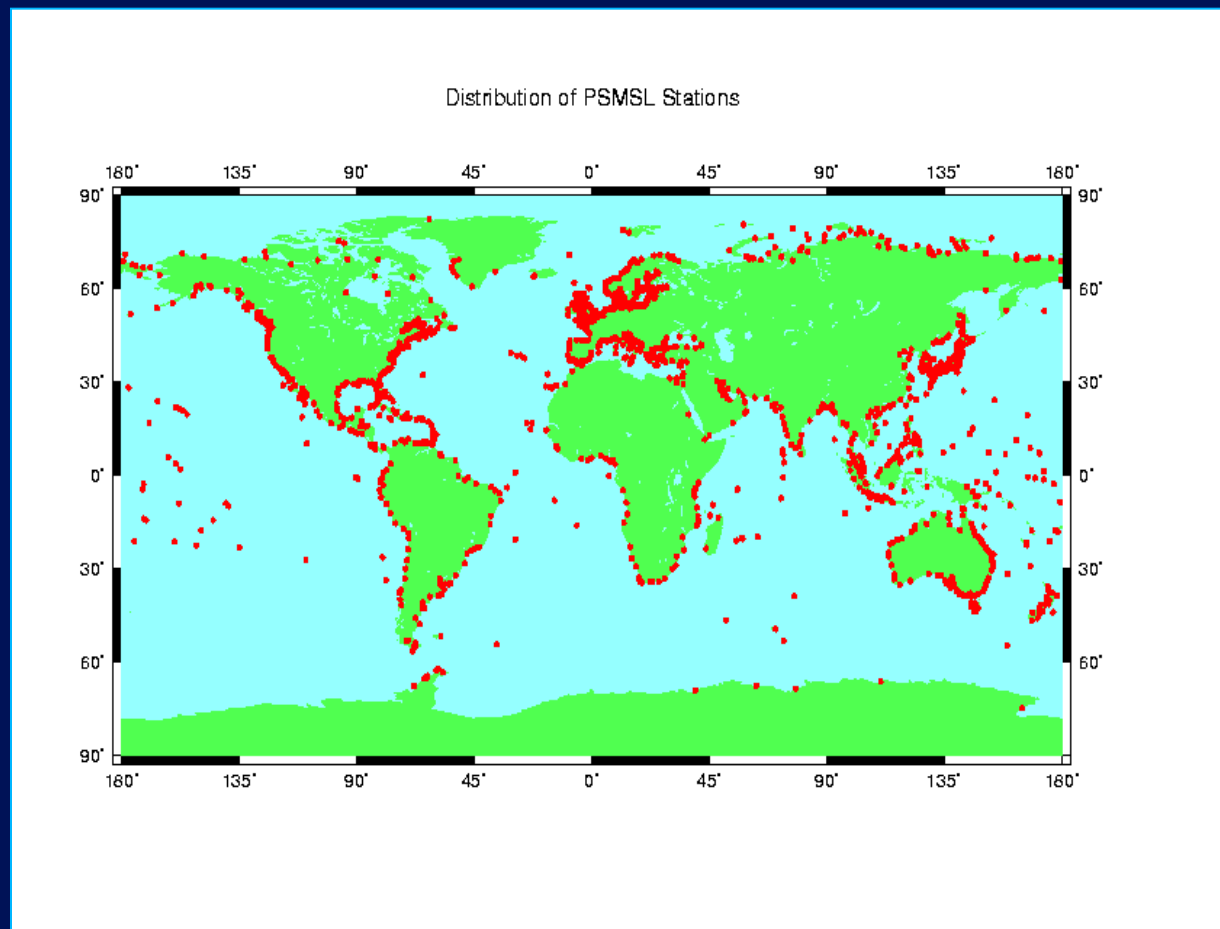


Historical Tide Gauges

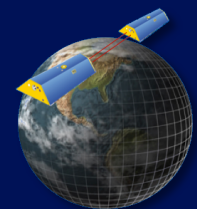
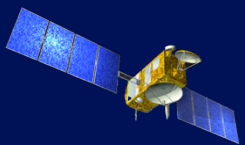
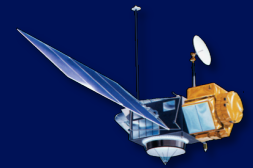


New Style (automated)

Global Distribution of PSMSL Tide Gauge Stations

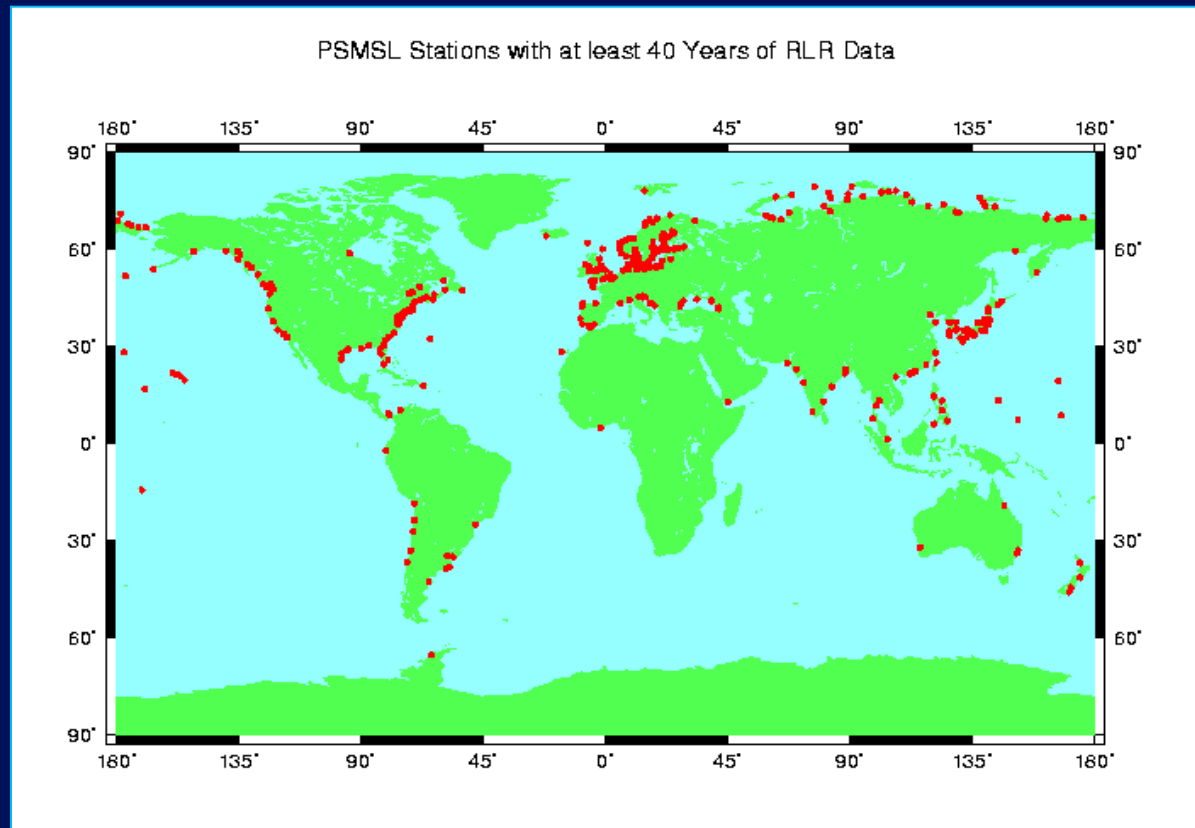


Courtesy of PSMSL



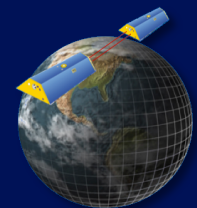
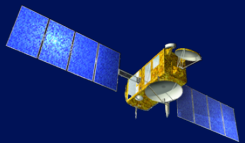


PSMSL Tide Gauge Stations (with at least 40 years of data)



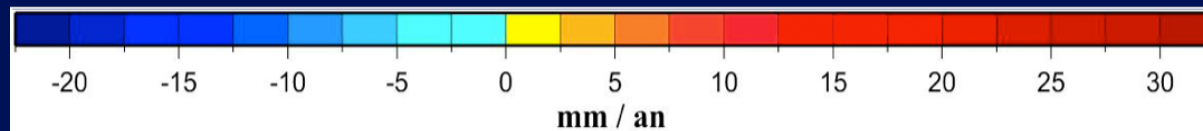
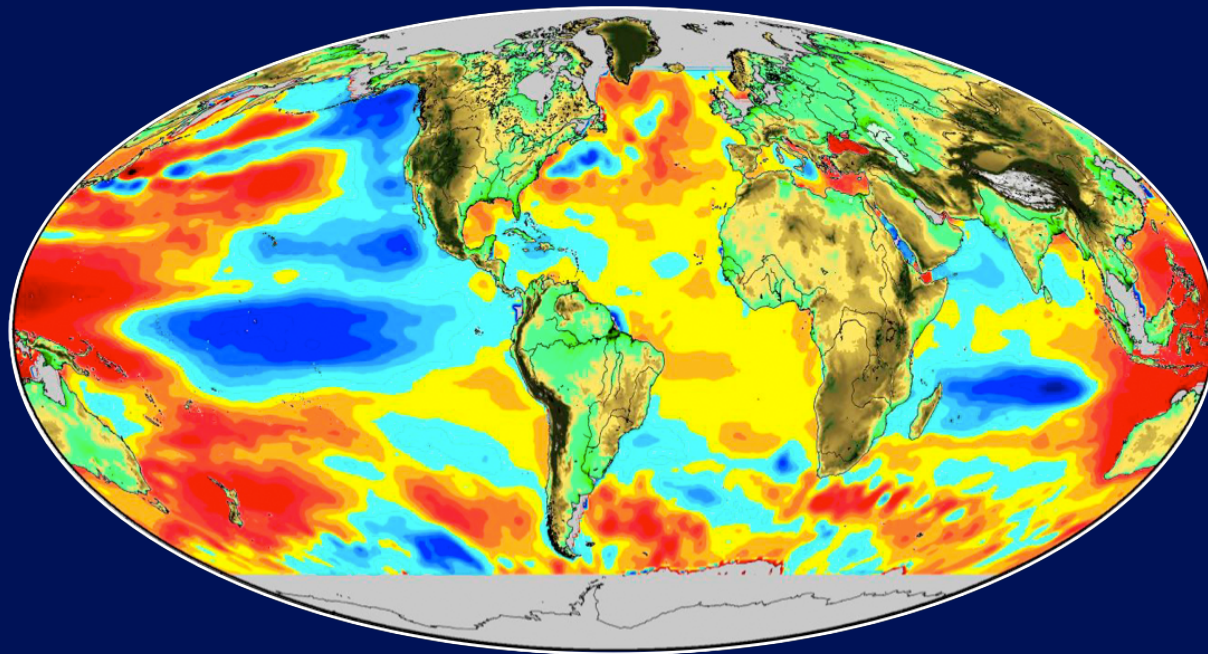
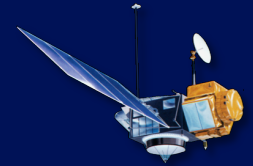
Courtesy of PSMSL

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



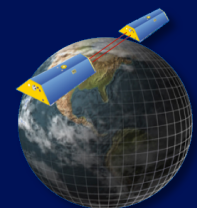
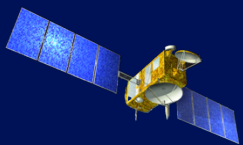
Global Sea Level Change Rates

Satellite Measurements



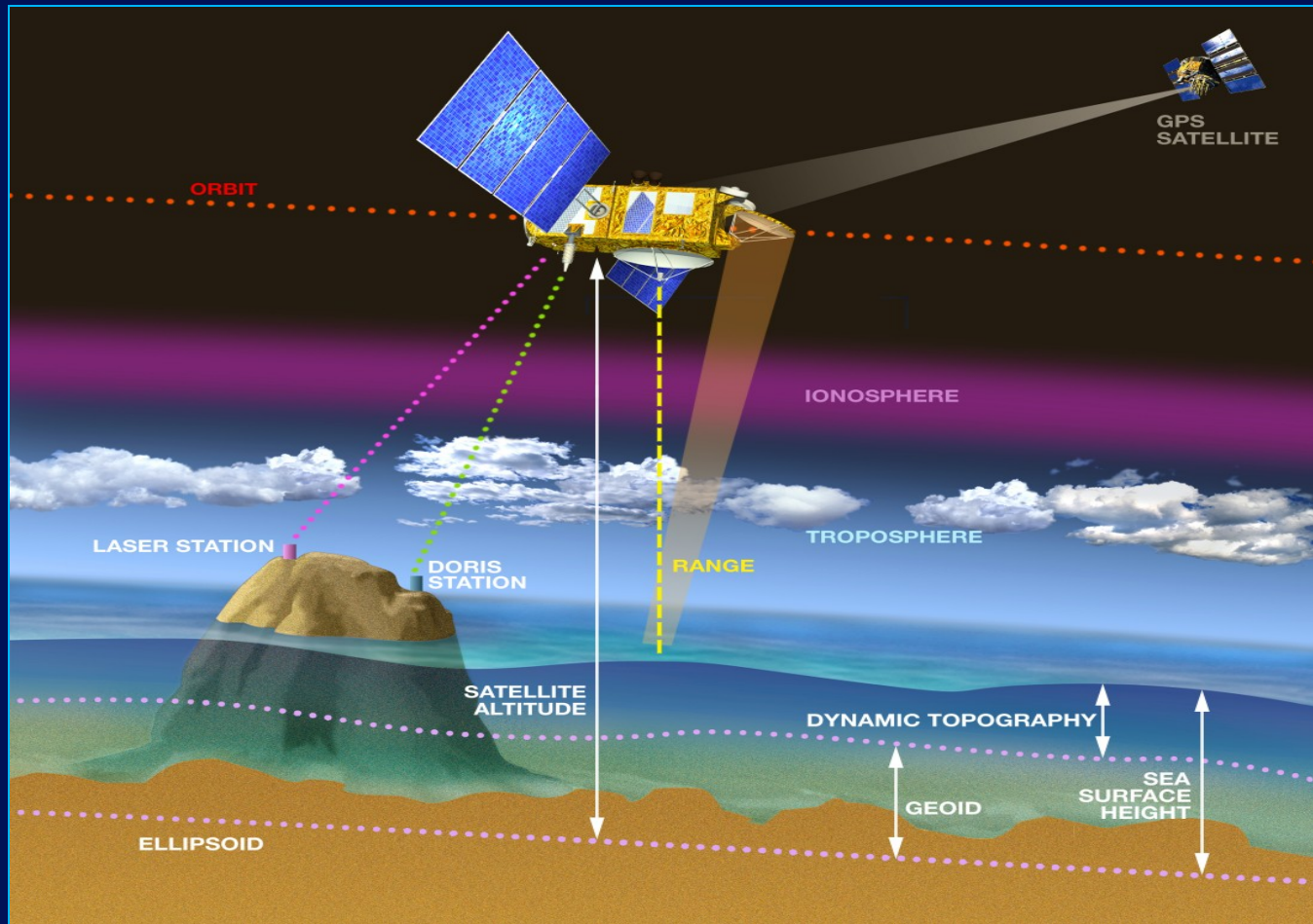
So, will tide gauge data
be good enough to
monitor the global sea
level change?

The answer is
simply 'Not'.



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)



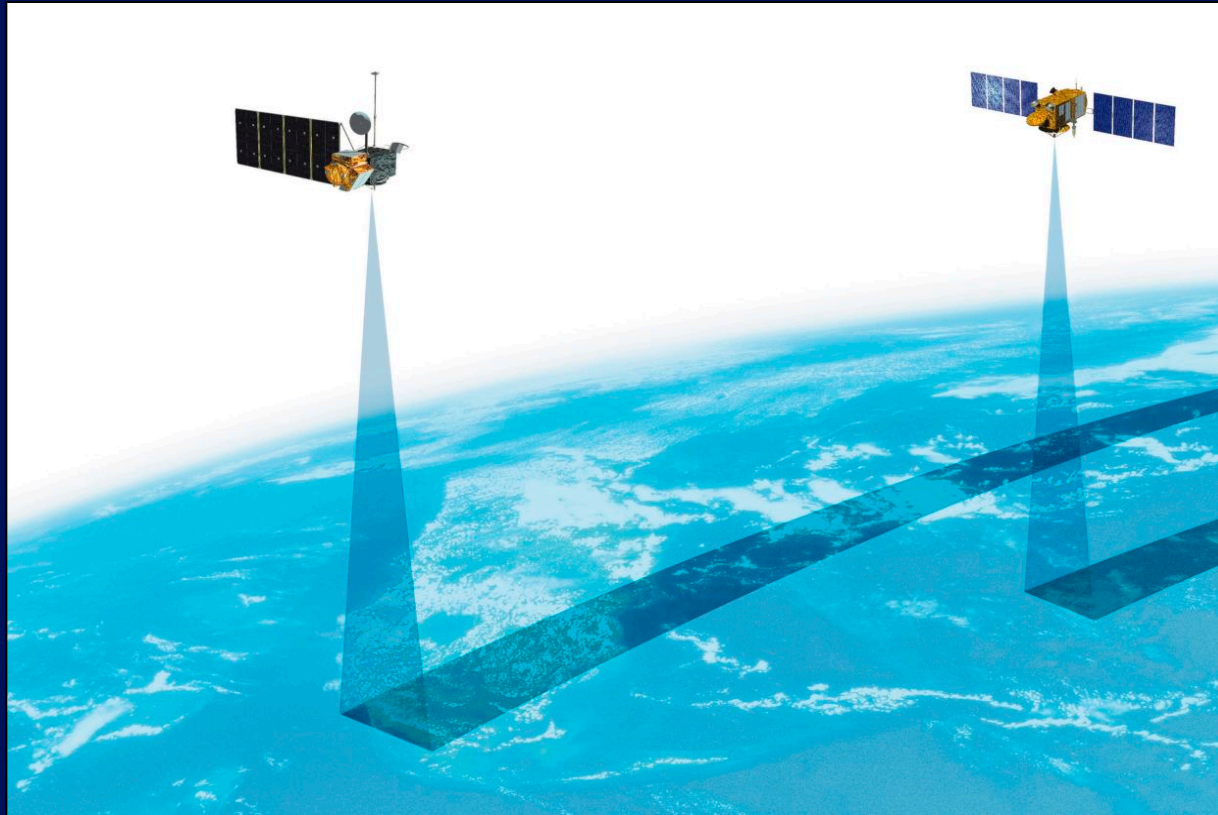
Much More Compact - 5 Times Lighter Than TOPEX/Poseidon

An Ocean Odyssey



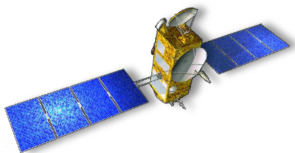
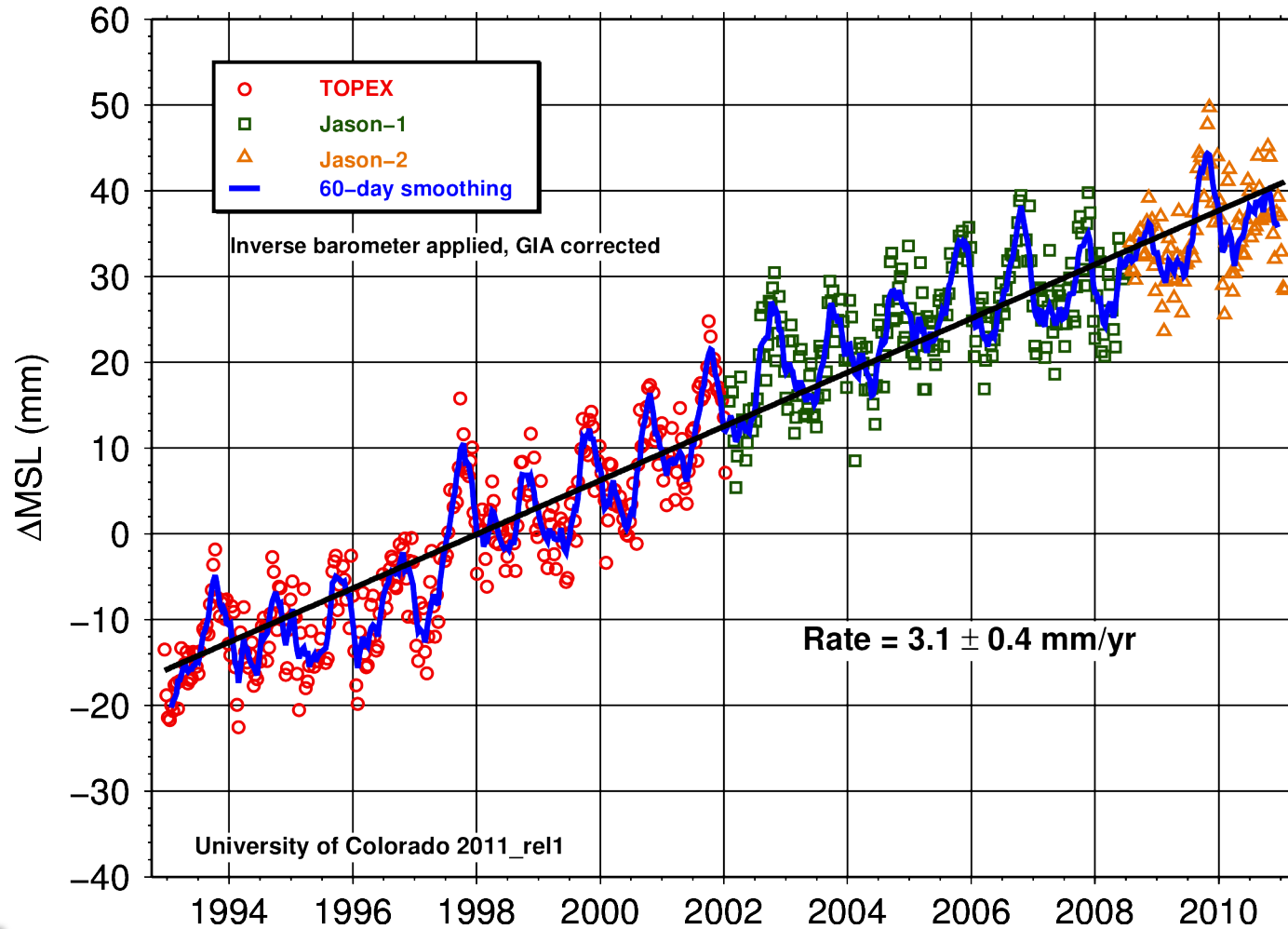
**TOPEX/Poseidon & Jason-1 had been jointly flying
in the orbit for over 4 years (2001.12 - 2006.01).**

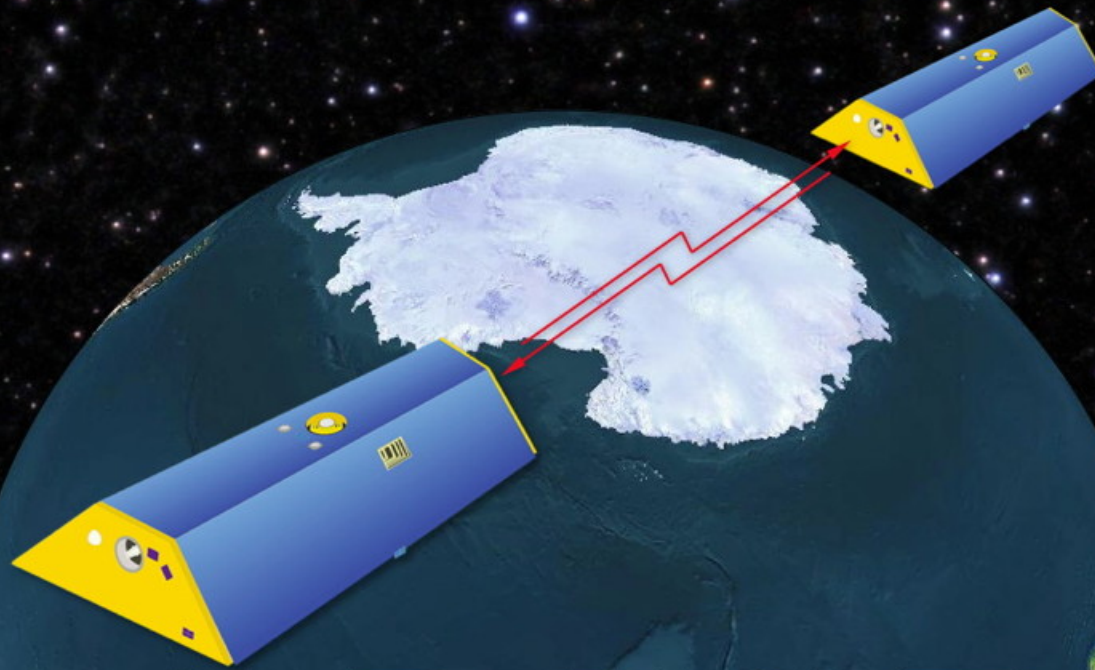
The Tandem Mission



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





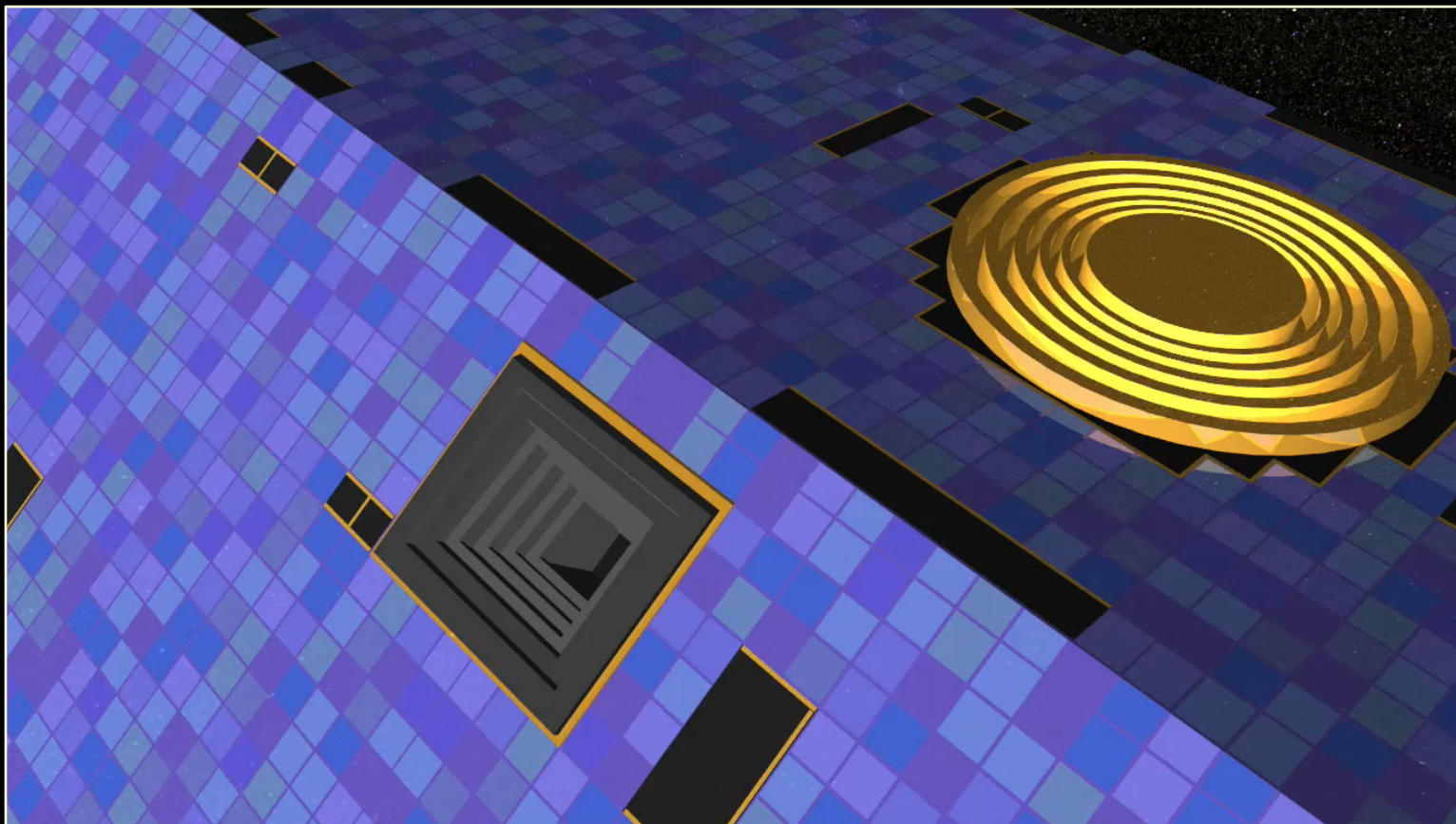
GRACE

Gravity Recovery And Climate Experiment



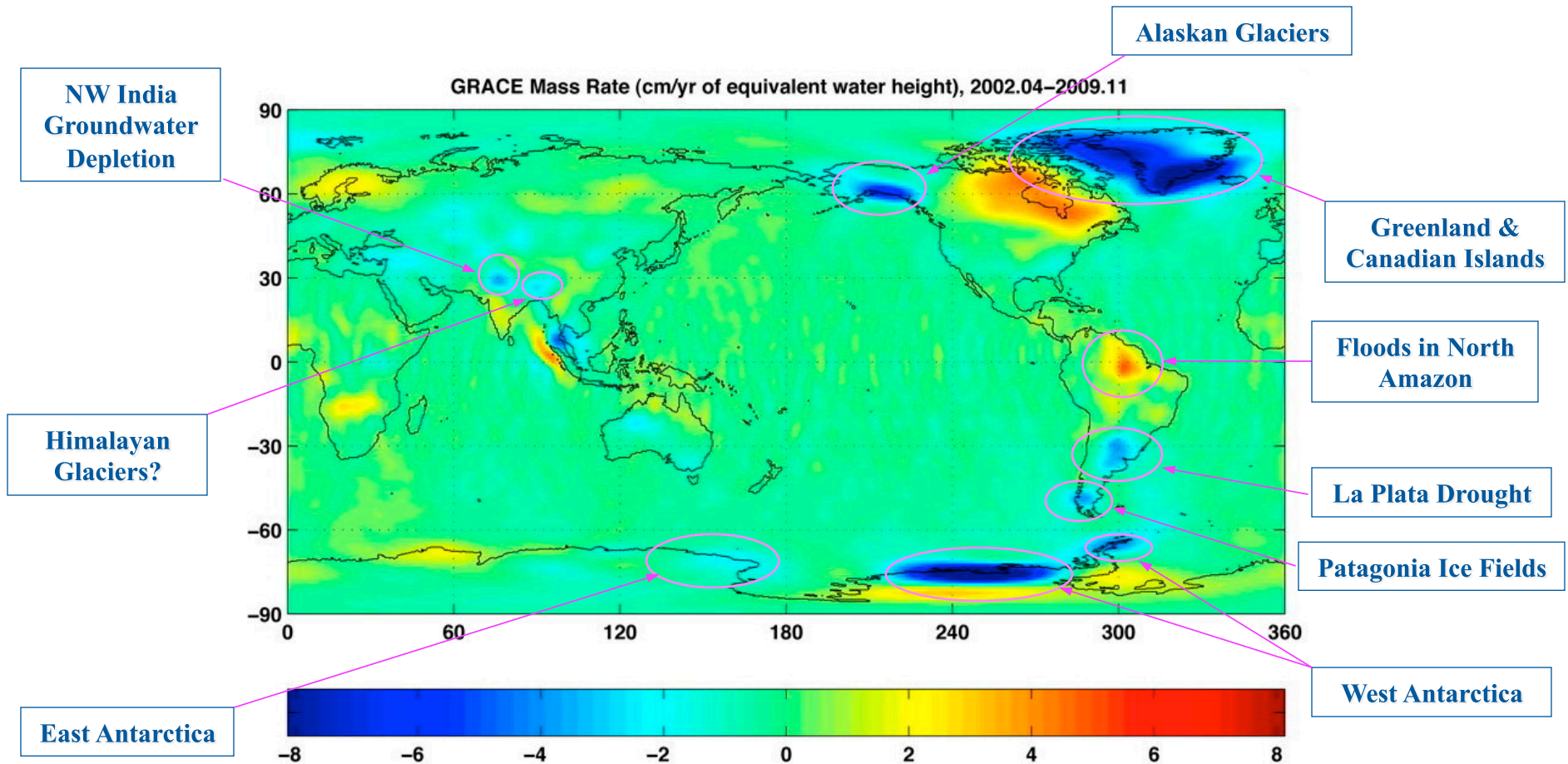
GRACE Mission

(Gravity Recovery and Climate Experiment)



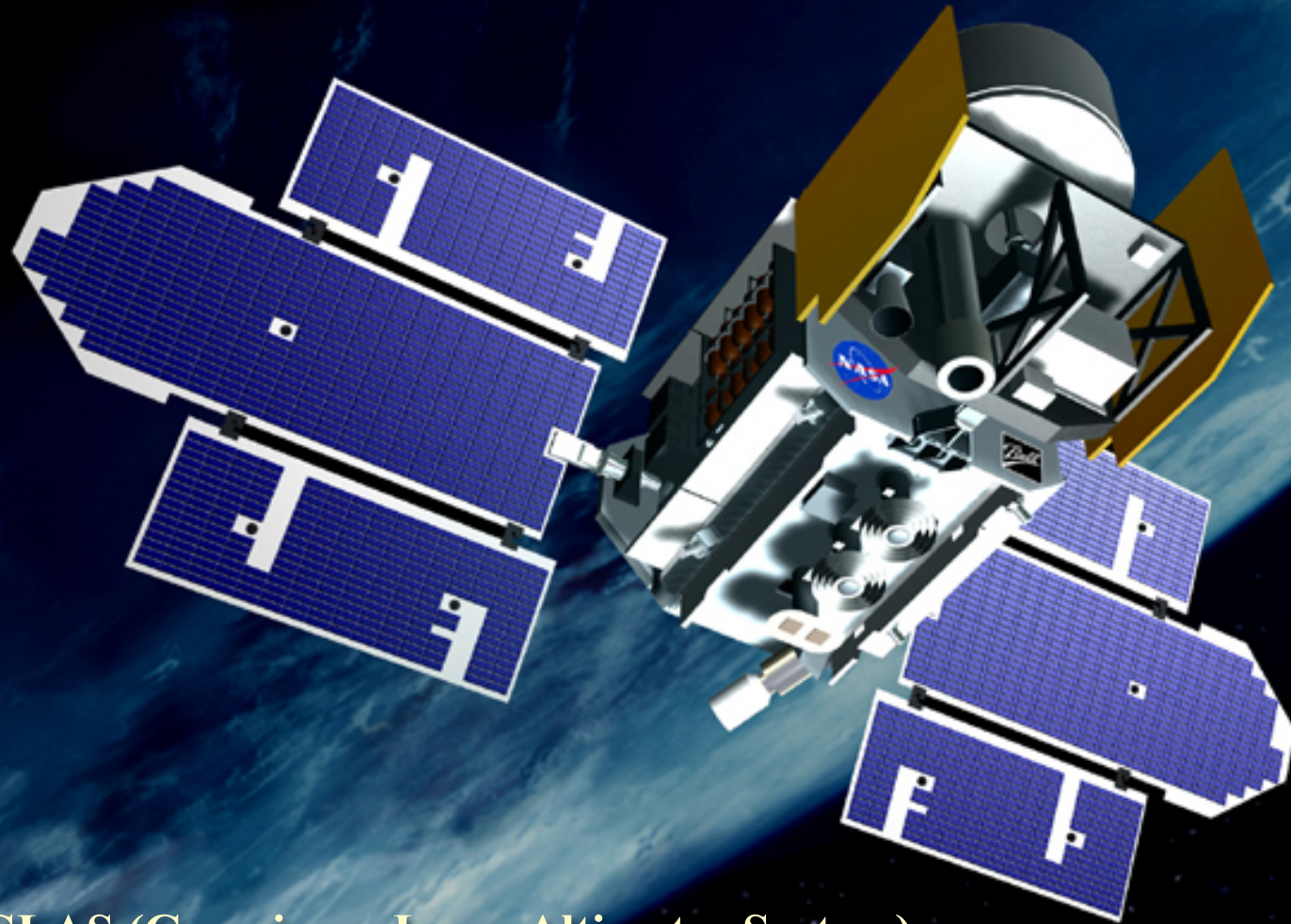
To measure water and snow/ice change on the Earth surface.

Global Long-Term Climate Change Signatures from GRACE



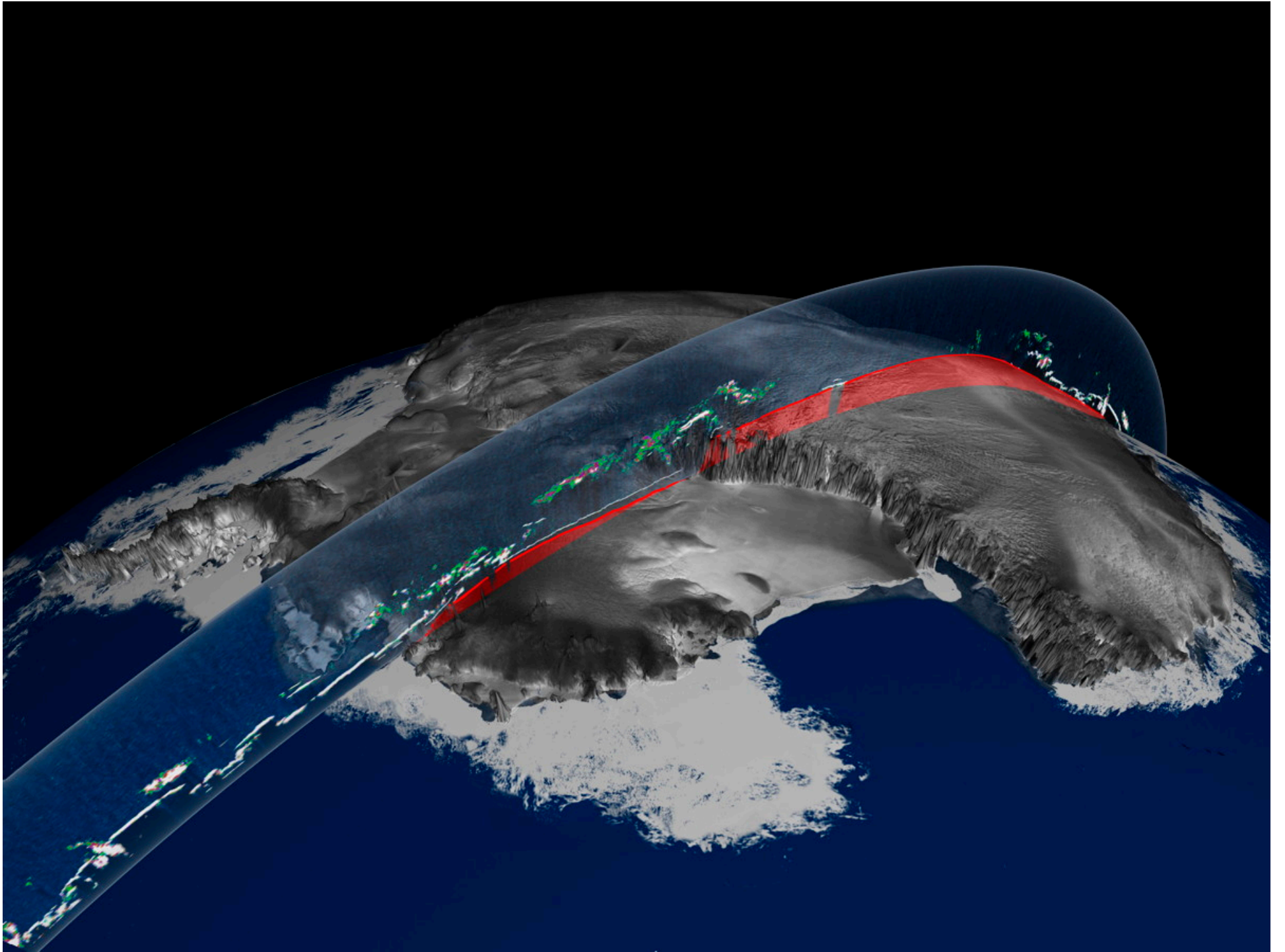
ICESat

(Ice, Cloud, and land Elevation Satellite)

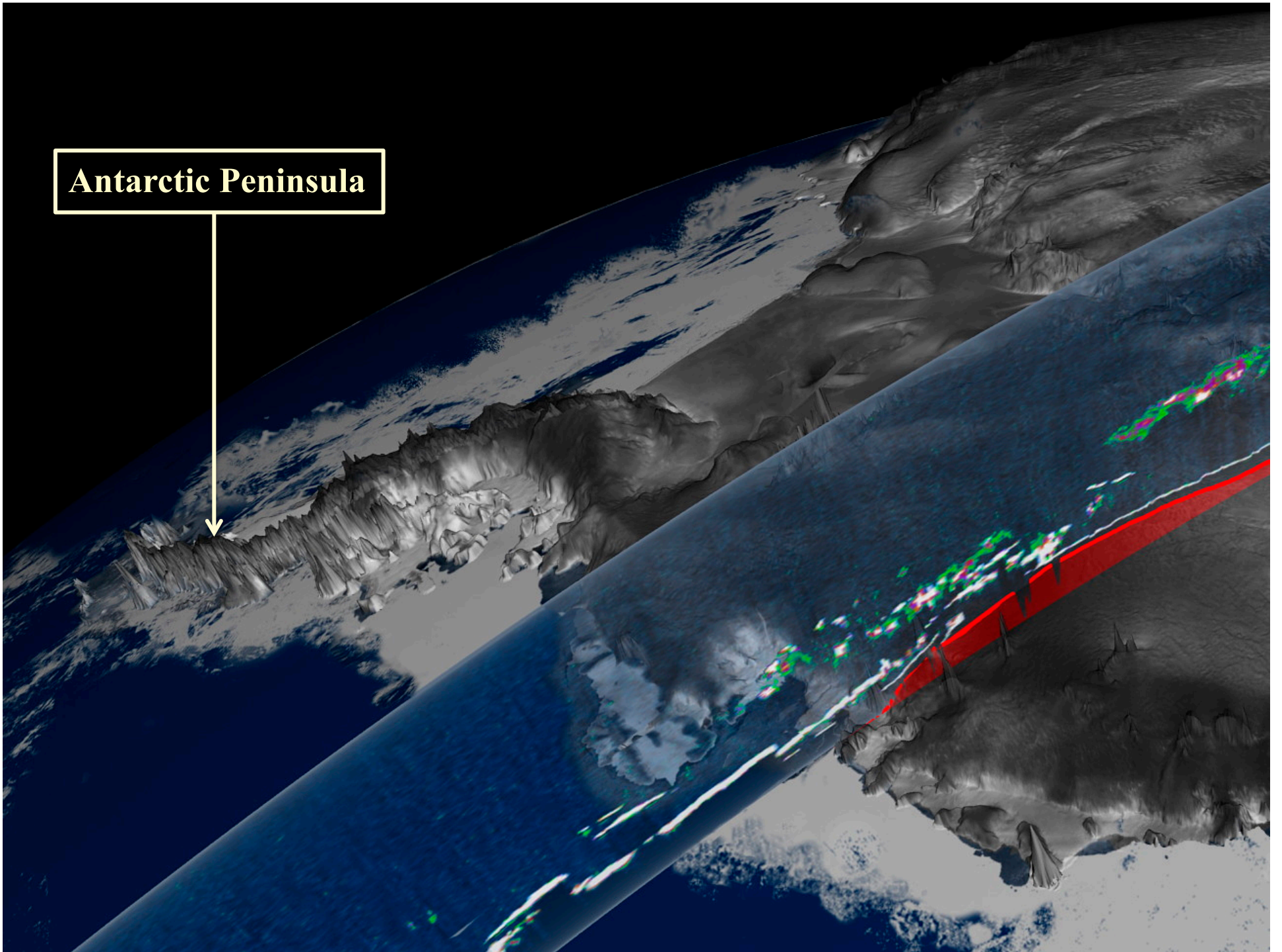


GLAS (Geoscience Laser Altimeter System)

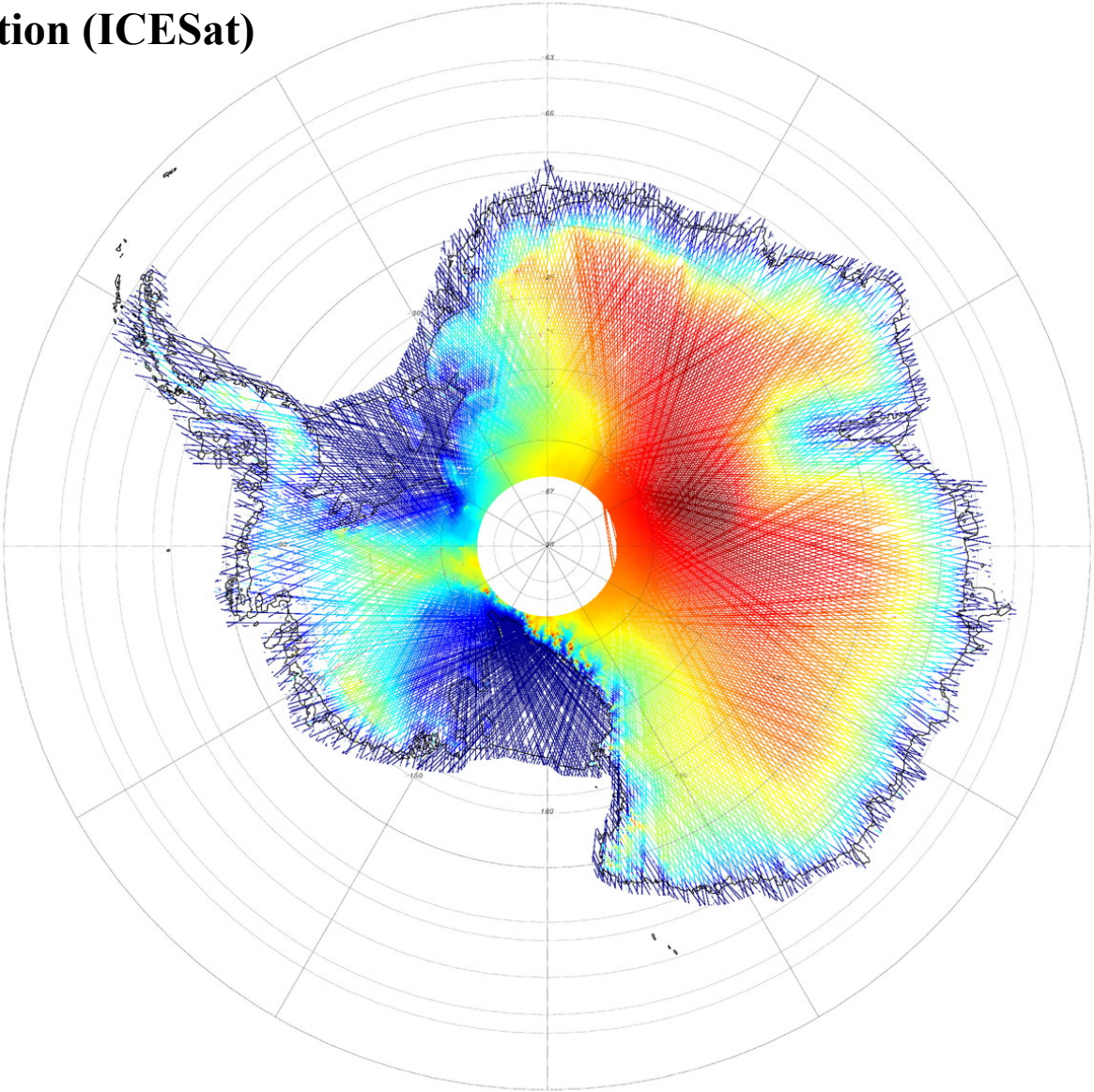




Antarctic Peninsula



Antarctic Elevation (ICESat)



Elevation (m)

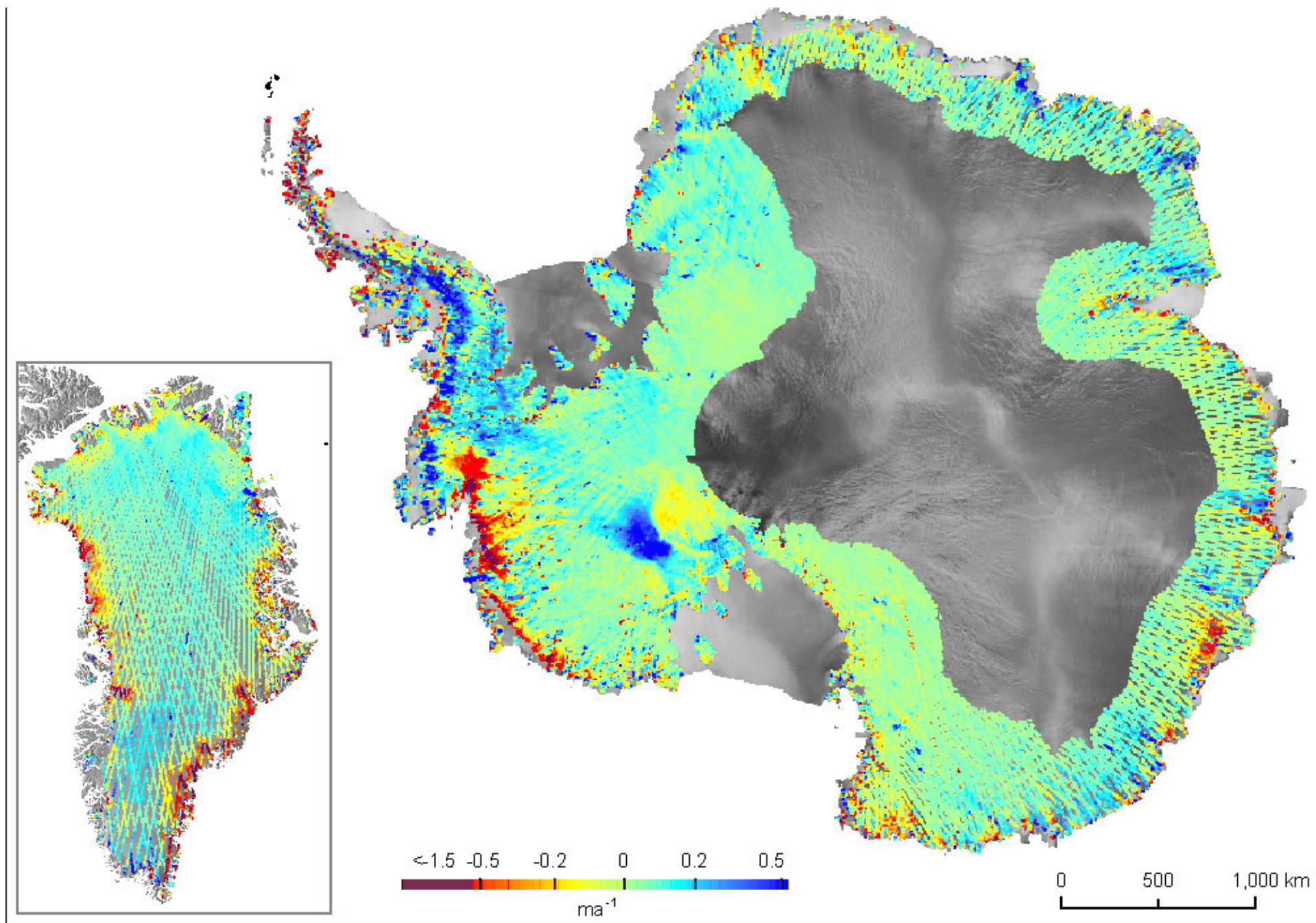


0

2000

4000

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

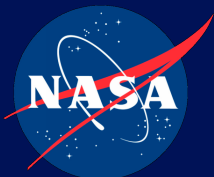
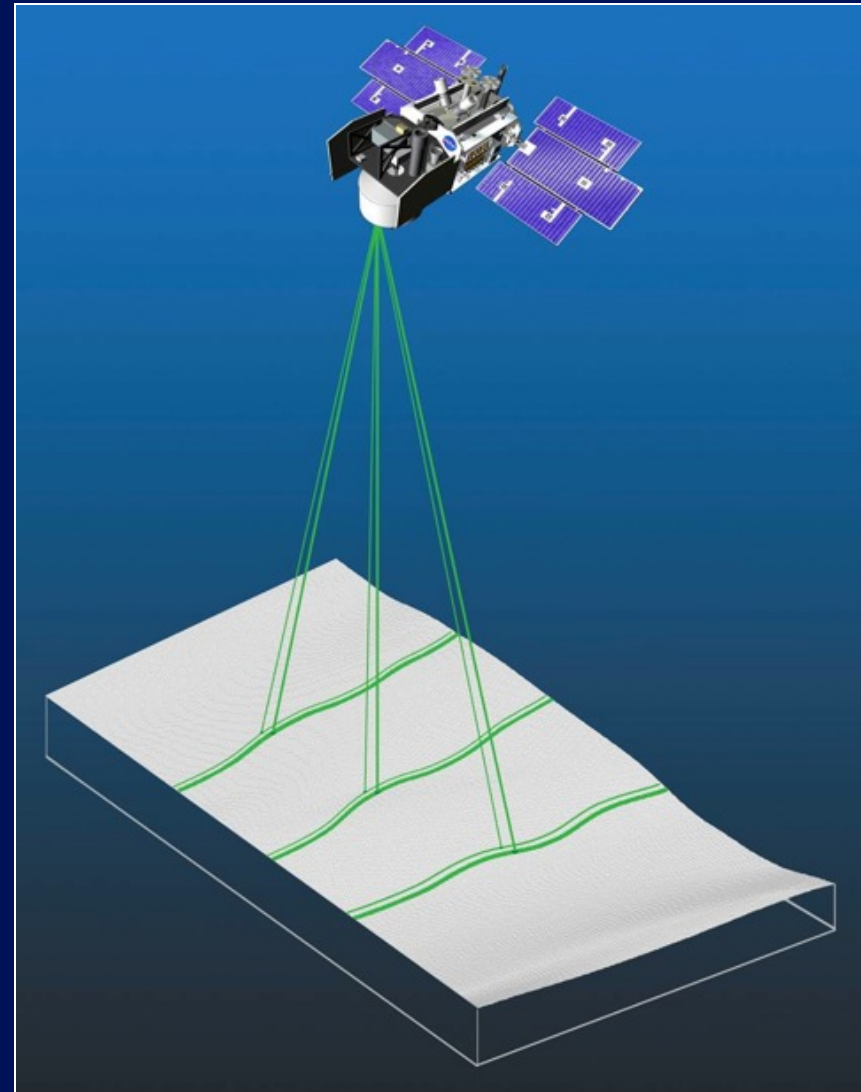


ICESat-2

(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.

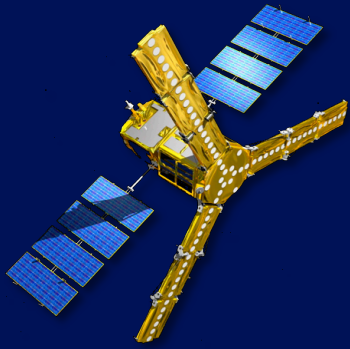


European Space Agency



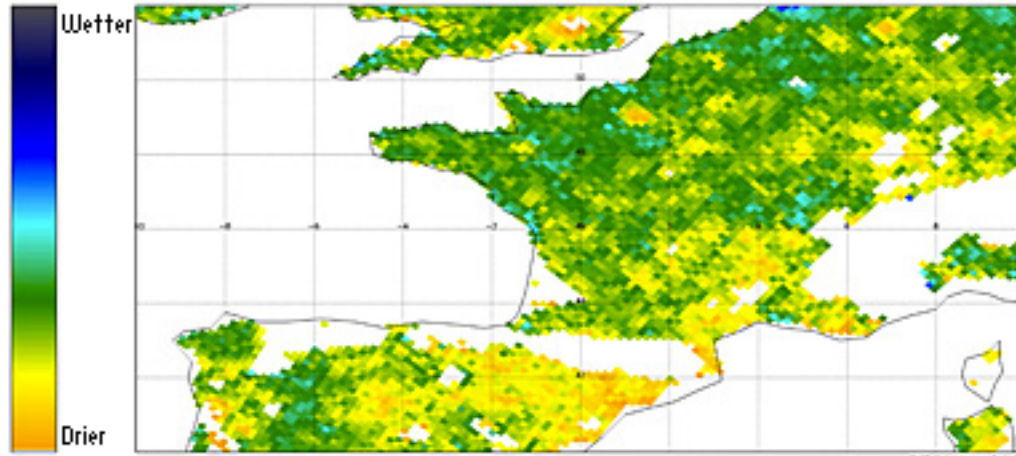
ESA's SMOS Mission
(Soil Moisture and Ocean Salinity)

Launched on 2 November 2009

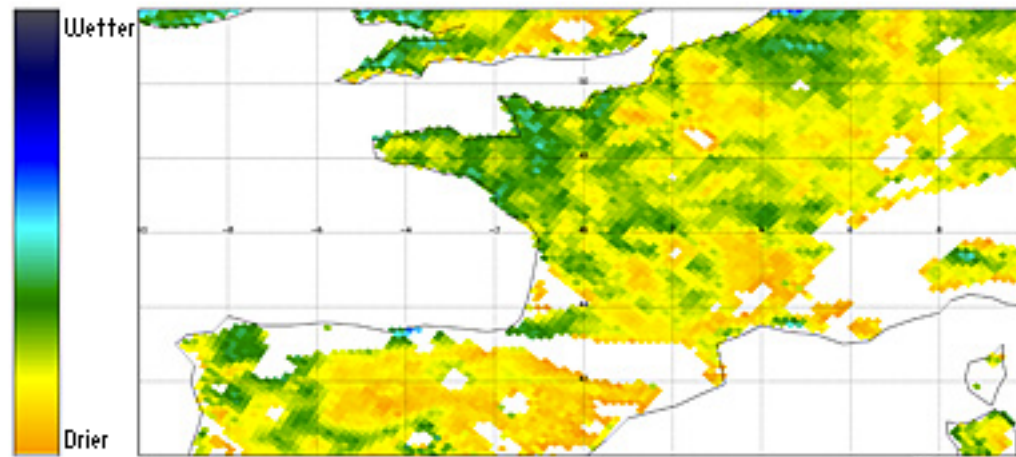


SMOS

Preliminary Results



April 2010



April 2011





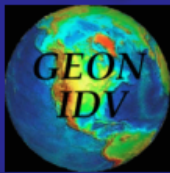
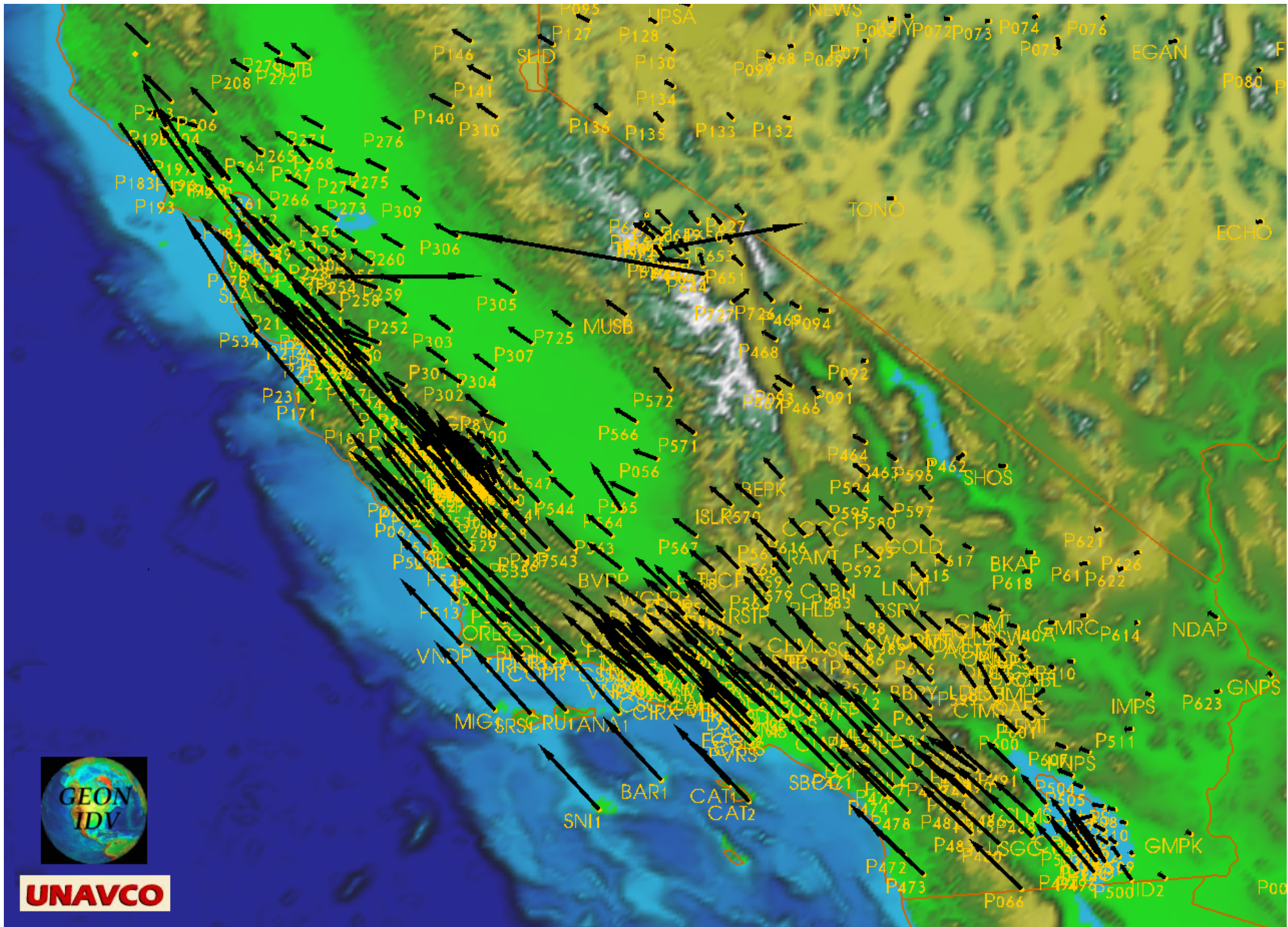
CryoSat-2 - Cryosphere Satellite

(To measure snow and ice change)

Launched on 8 April 2010

Global Positioning System (GPS)



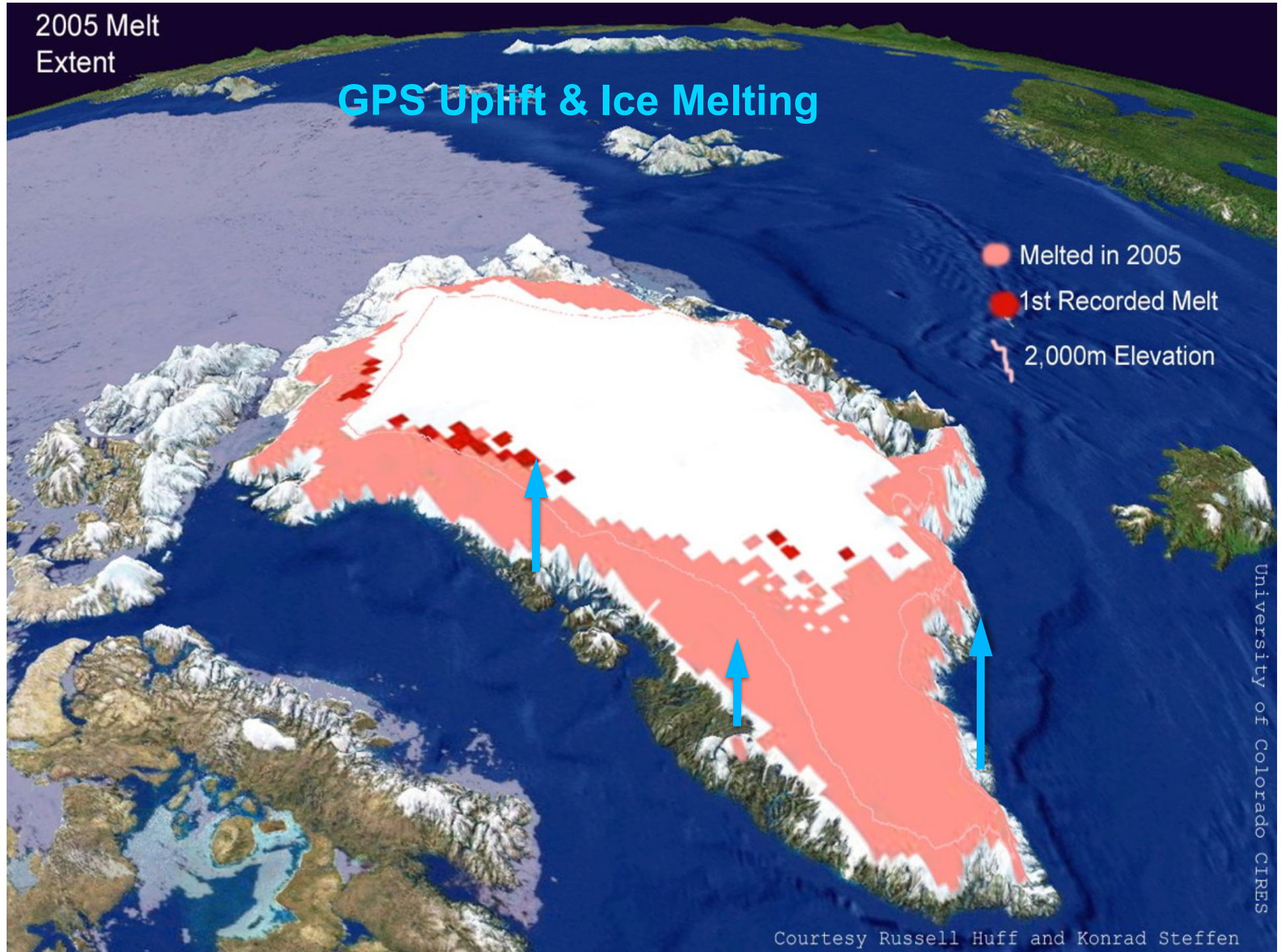


UNAVCO

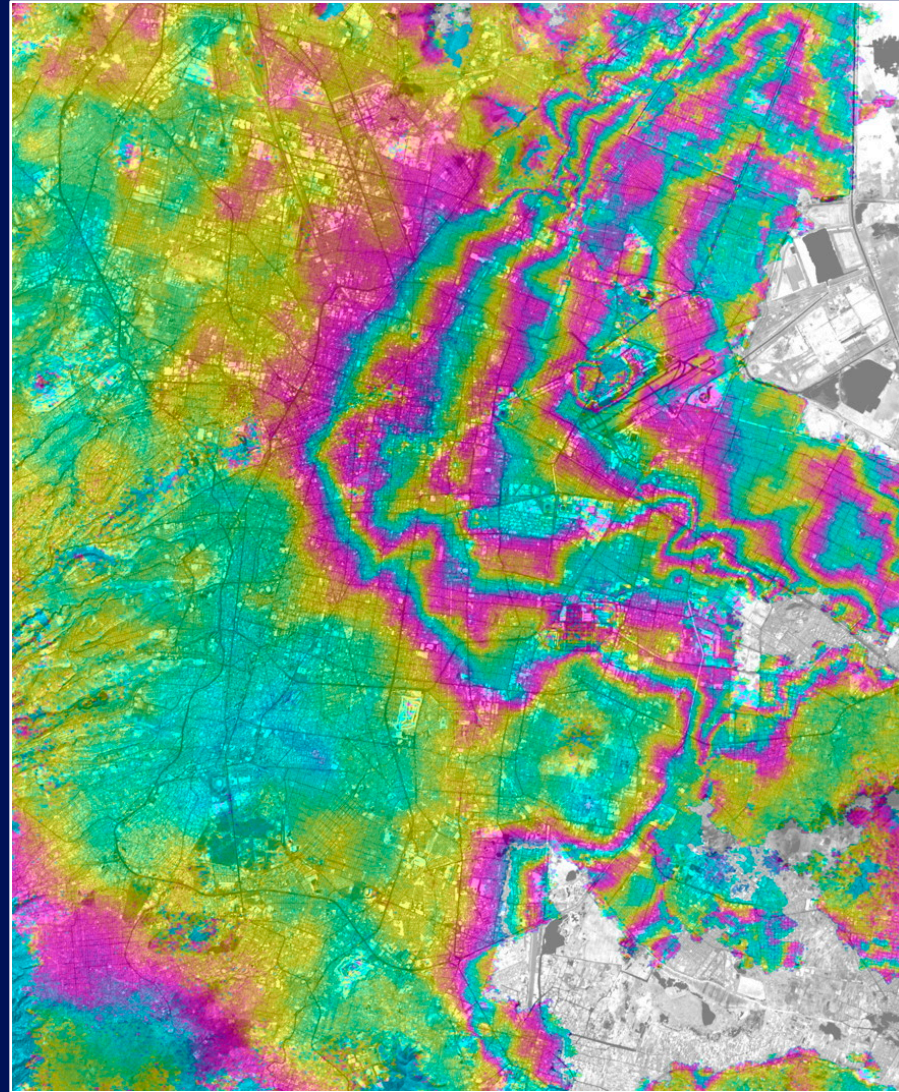
2005 Melt
Extent

GPS Uplift & Ice Melting

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

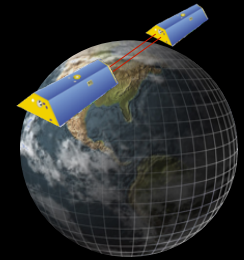


InSAR measurements indicate land subsidence in Mexico City.



The three 'pillars' of geodesy:

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





Thanks!

The Magic Blue Marble