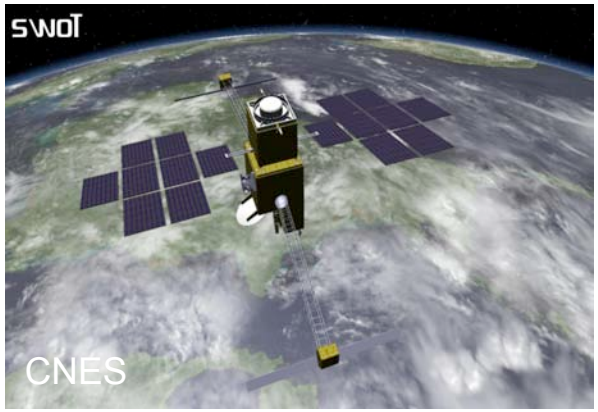


SWOT Mission Science Document

Sea-Level Change

C.K. Shum[1], Anny Cazenave[2], R. Steven Nerem[3]

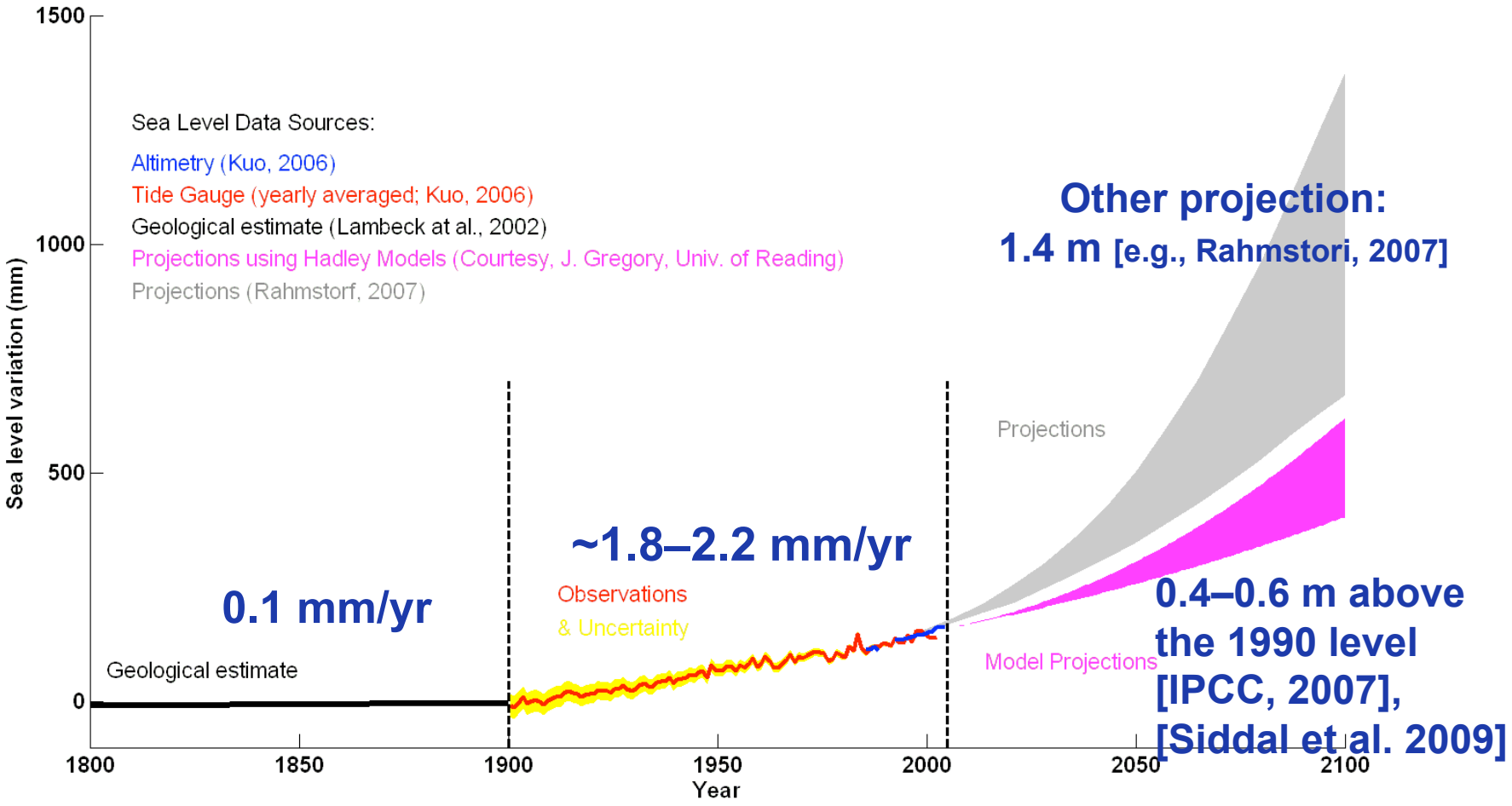
[1]Ohio State Univ., [2]CNES/LEGOS, [3]Colorado Univ.

SWOT Science Working Group Meeting

Crystal City Sheraton, Arlington, VA

March 1–2, 2010

Global Sea Level Rise: Estimation & Prediction (1800-2100)



Bindoff et al. [2007], Shum et al. [2008]

State of the Sea-Level Budget: Closure between Geophysical Explanation and Observations of Sea-Level Rise

2001 IPCC Explanation vs Observation [*Church et al.* 2001]:
0.65±0.84 vs 1.5±0.5 mm/yr, *Unexplained:* –0.13 to 1.83 mm/yr

2007 IPCC FAR [*Bindoff et al.* 2007]: 1.1±0.5 vs 1.8±0.5 mm/yr
***Unexplained:* 0.0 to 1.4 mm/yr**

Post-2007 IPCC Assessment: *Large Discrepancies!*
Antarctica: –0.12 to 0.40 mm/yr
Greenland: –0.03 to 0.63 mm/yr
Thermal expansion: 0.2 to 0.6 mm/yr
Glaciers/ice caps: 0.52 to 1.4 mm/yr
Water impoundment in reservoirs: –0.55 mm/yr
Terrestrial hydrology: 0.07 to 0.27 mm/yr

Post-2007 Assessment: *Unexplained:* –0.26 to 1.42 mm/yr

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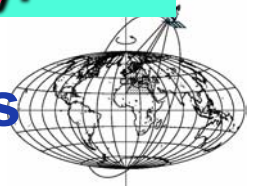
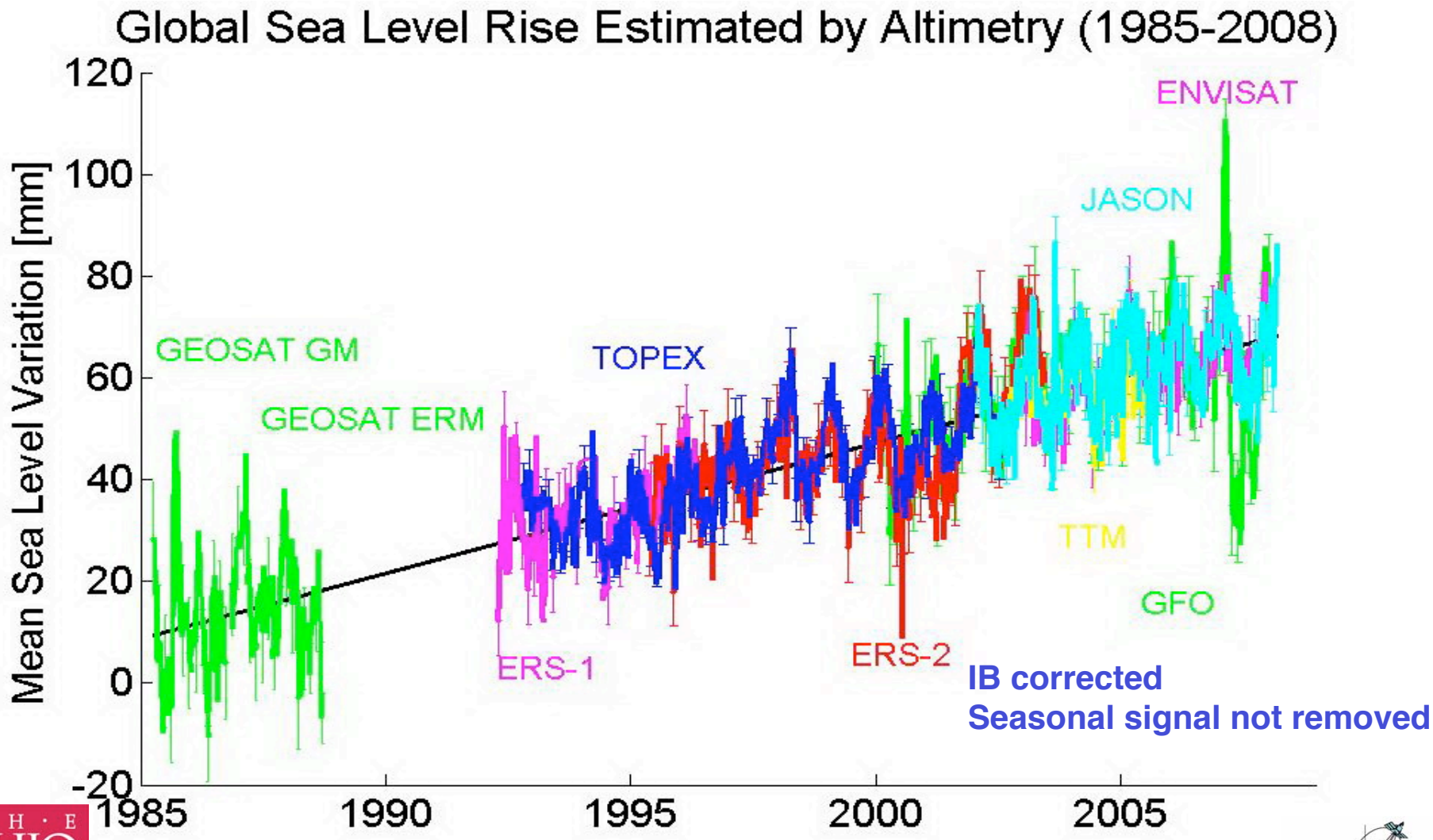
Goal is to reduce the uncertainty in observations



Global Sea Level Rise Observed By Satellite Altimetry (1985–2008)

Estimated sea level trend (1985–2008): 2.7±0.4 mm/yr

After GIA correction (ICE4G): Trend = 2.9 mm/yr



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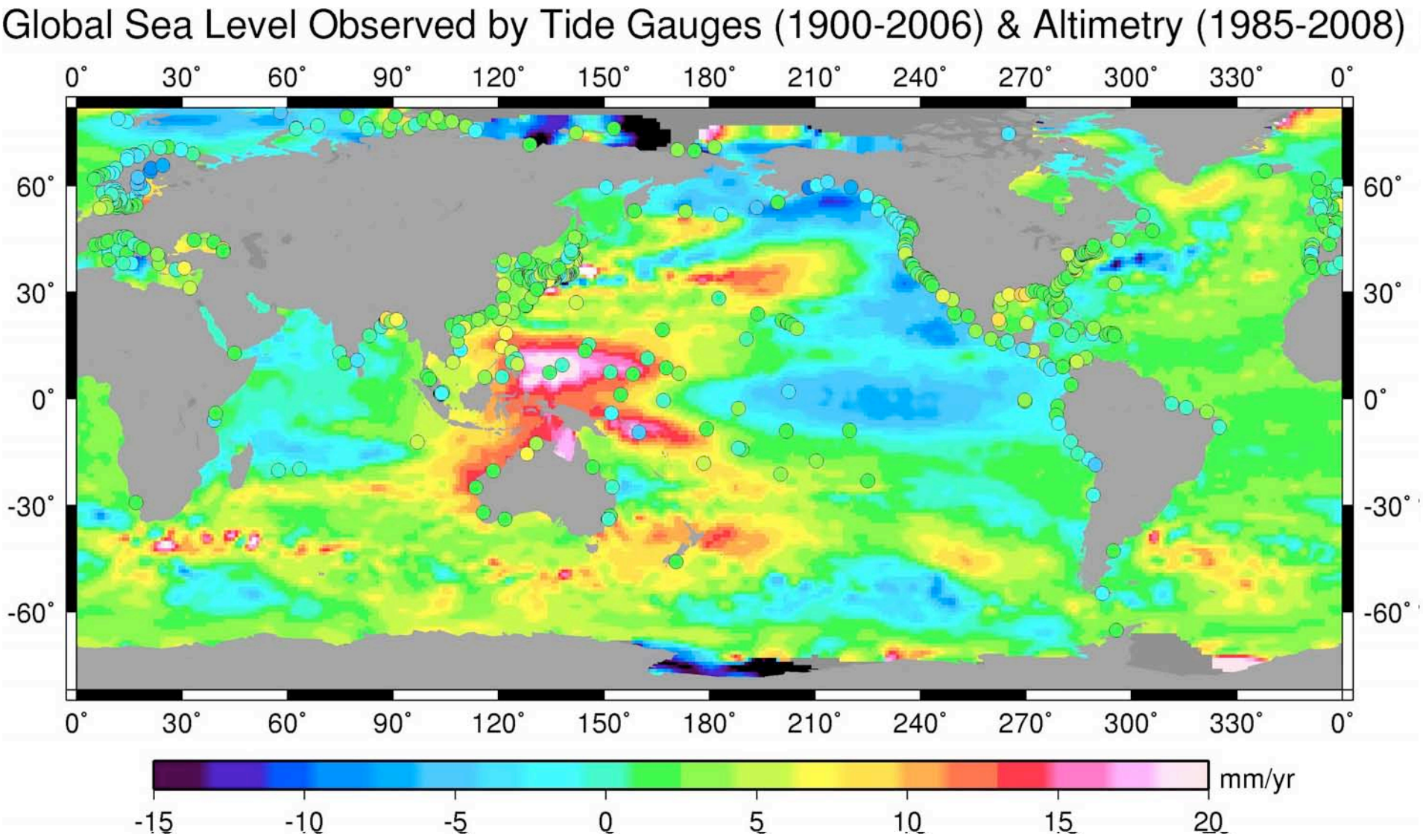
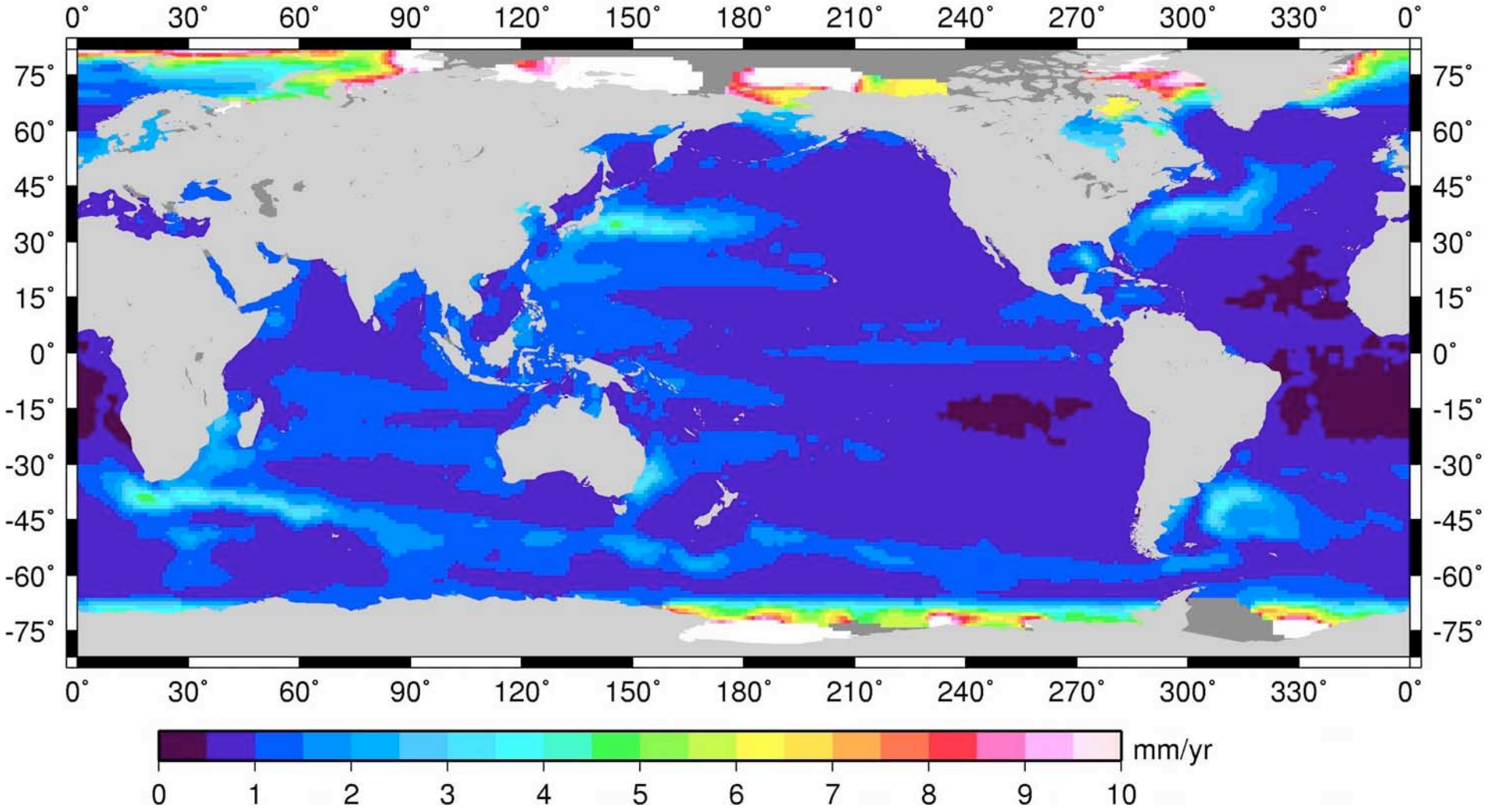
Satellite Altimetry Reveals that Sea-Level Rise is not Uniform



Altimetry estimated trend (1985–2008): 2.7±0.4 mm/yr, 2.9 mm/yr w/ GIA correction

Tide gauge estimated sea-level trend (1900–2006): 1.7 mm/yr

Error Estimate of Global Sea Level Trend Observed by Altimeters (1985-2007)



Estimated sea-level trend (1985–2008): 2.9±0.4 mm/yr

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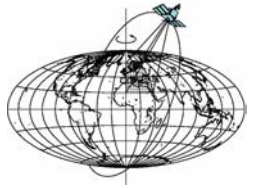
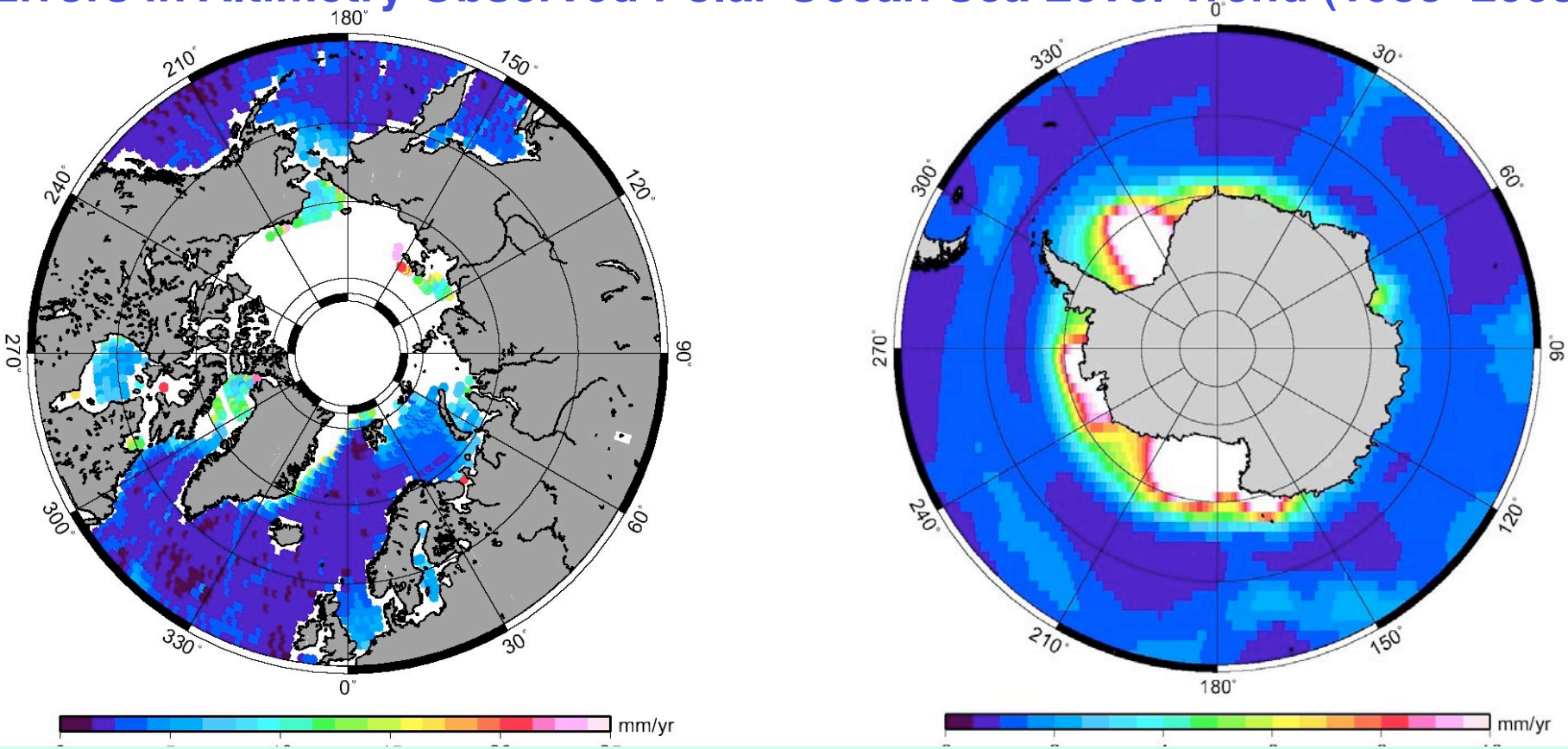
Much larger errors in the polar oceans



SWOT Sea-Level Rise In High-Latitude Regions

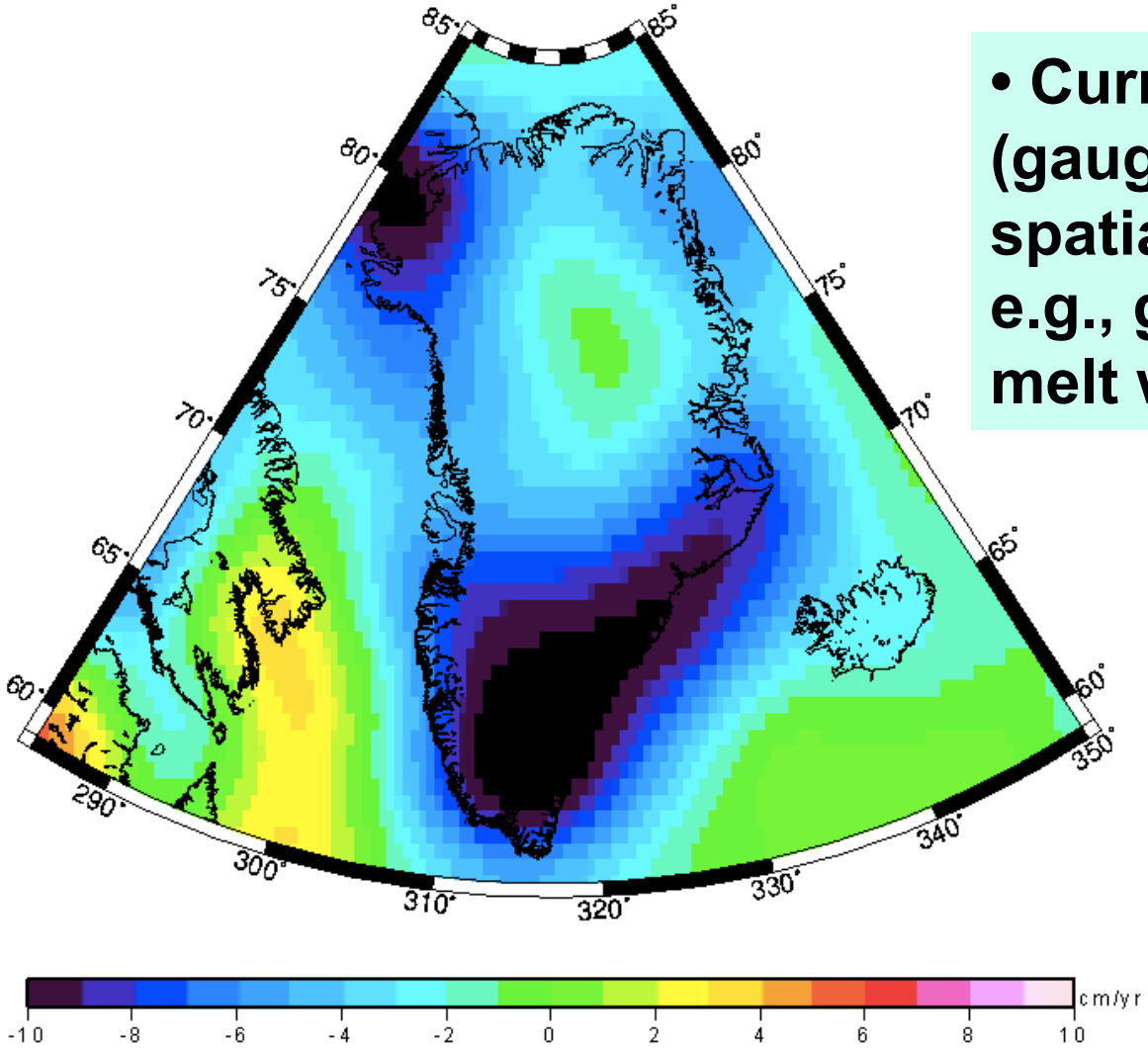
Errors in Altimetry Observed Polar Ocean Sea Level Trend (1985–2008)



- Lack of high-latitude sea-level tide gauges, & they are significantly affected by uplifts due to GIA & elastic loading. Current altimetry lacks spatial resolution.
- Significant climate signals in polar oceans: ice mass loss from ice-sheets, permafrost, glacier melts (e.g., Alaskan, Patagonia and Swalbard), higher warming of the Arctic Ocean, water storage changes in Arctic river basins.

SWOT Sea-Level Rise In High-Latitude Regions

GRACE water thickness trend over Greenland, 2002–2009



CSR RL04 Data Product, destripped, 200 km filtering, ICE5G (VM4) GIA and geocenter corrections applied

- Current observations (gauges & altimetry) lack spatial resolution to detect, e.g., glaciers & ice-sheet melt water signals

- GRACE ocean (bottom pressure) observations lack spatial resolution and also have signal leakage problems

SWOT Sea-Level Rise In High-Latitude Regions

SWOT contributes towards addressing the following science questions:

- **Is sea level rising faster in the Arctic Ocean in response to higher ocean warming?**

- **What is the contribution of polar ocean to global sea level rise?**

- **Can we detect or quantify the sea level rise signal resulting from accelerated ice-sheet and glacier melt?**

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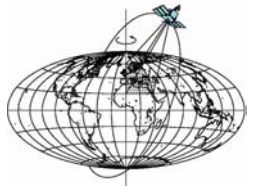
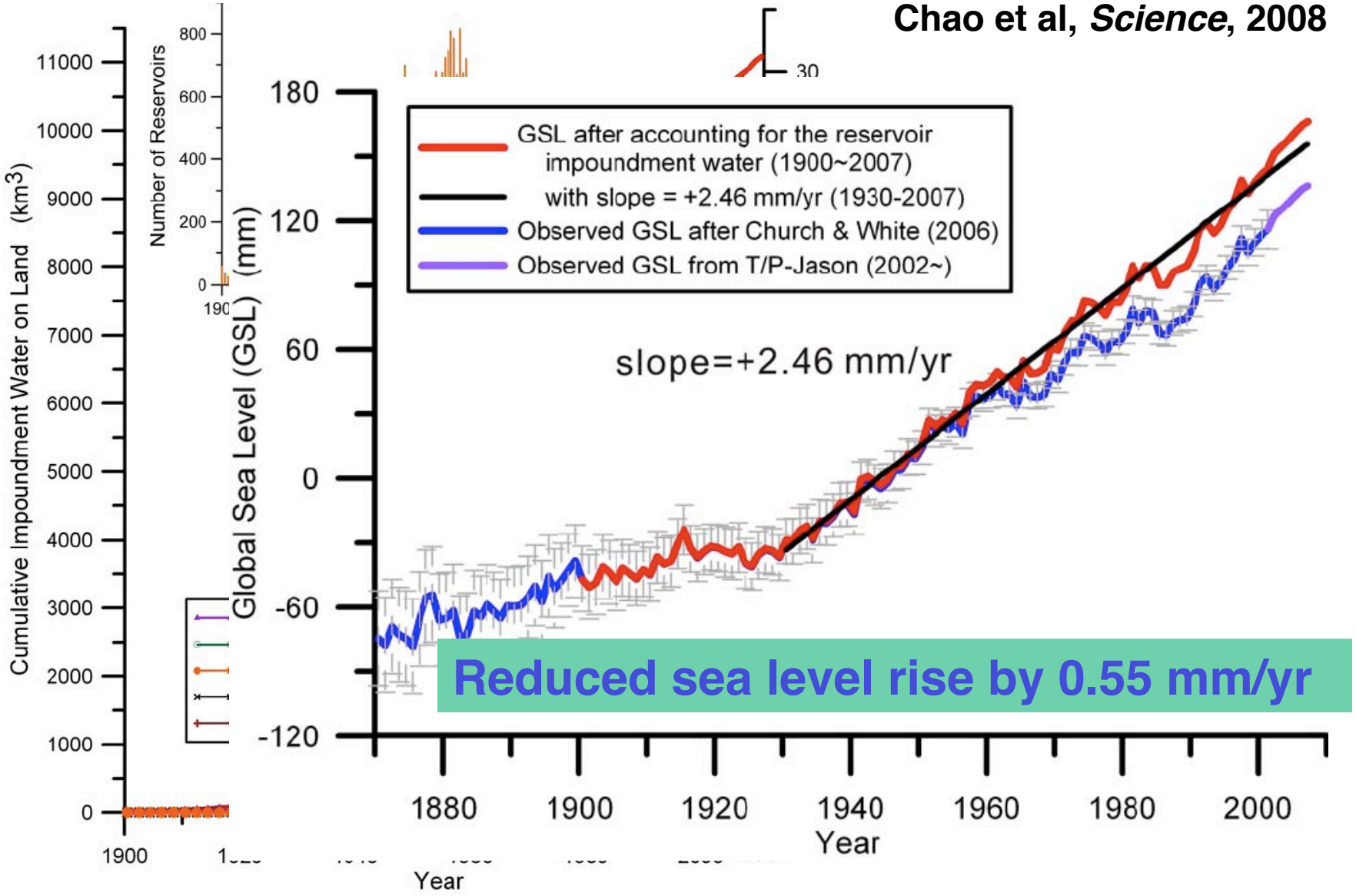


SWOT Hydrologic Contributions to Sea-Level Rise

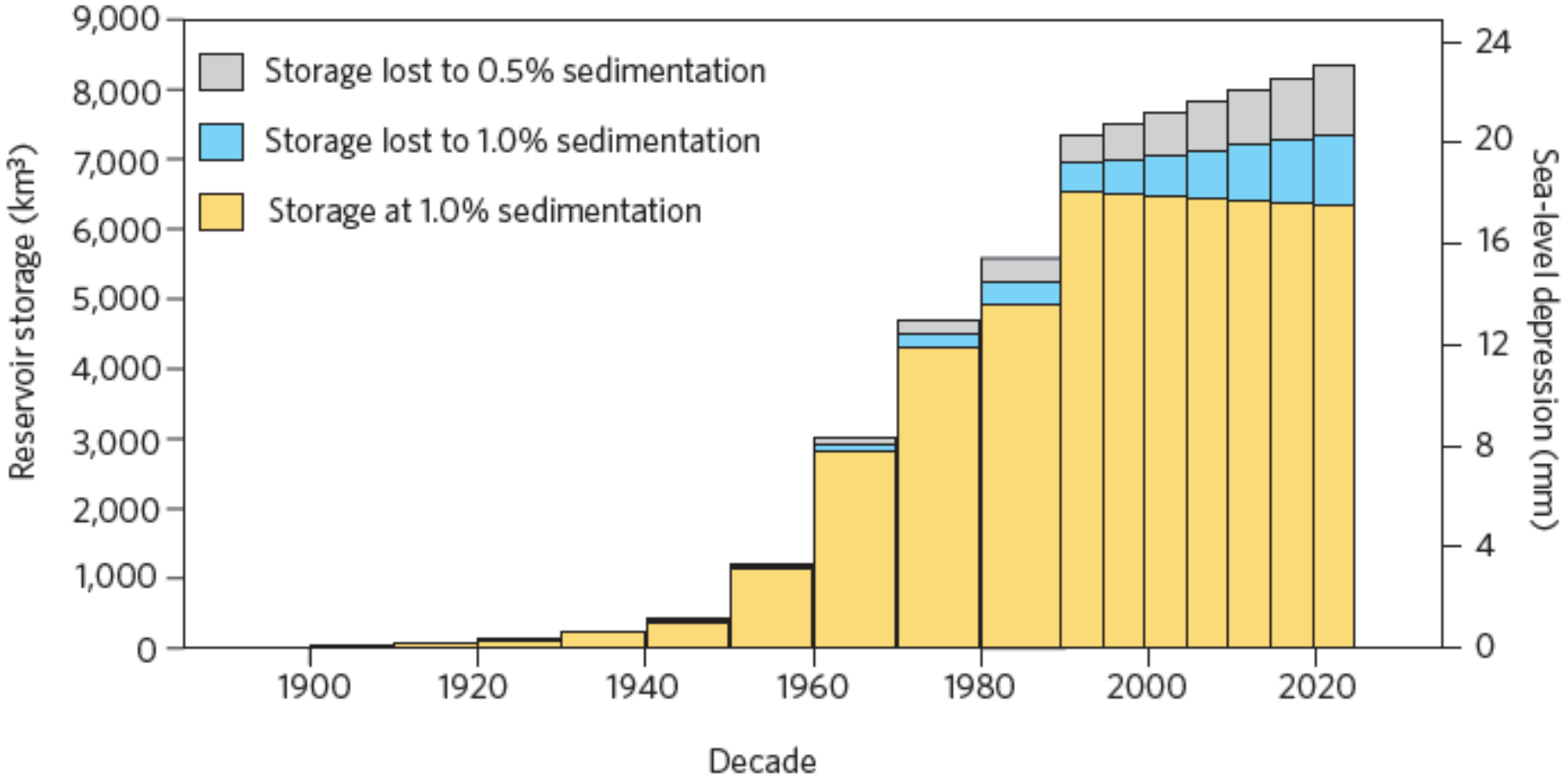
Human-Impoundment of Water in Reservoirs

Chao et al, *Science*, 2008



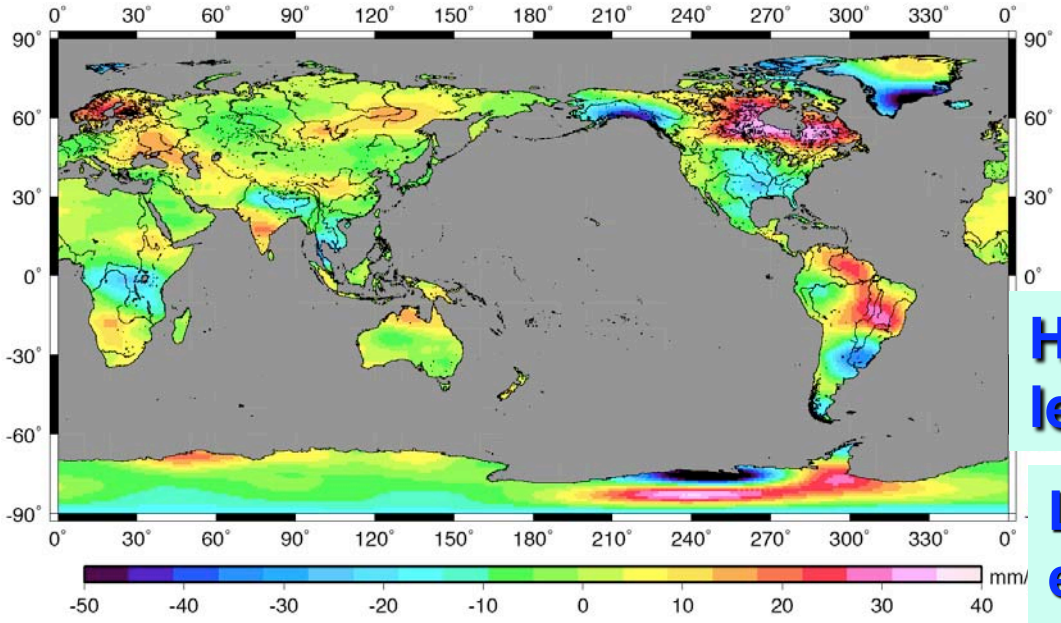
Reduced sea level rise by 0.55 mm/yr

SWOT Hydrologic Contributions to Sea-Level Rise



- **Accumulated global reservoir water storage 1900–2025: water storage loss (1900–2005) due to sedimentation slowed down and even may have reversed sign [Fig. from E. Clark, U. Washington; Lettenmaier & Milly, *Nature*, 2009]**

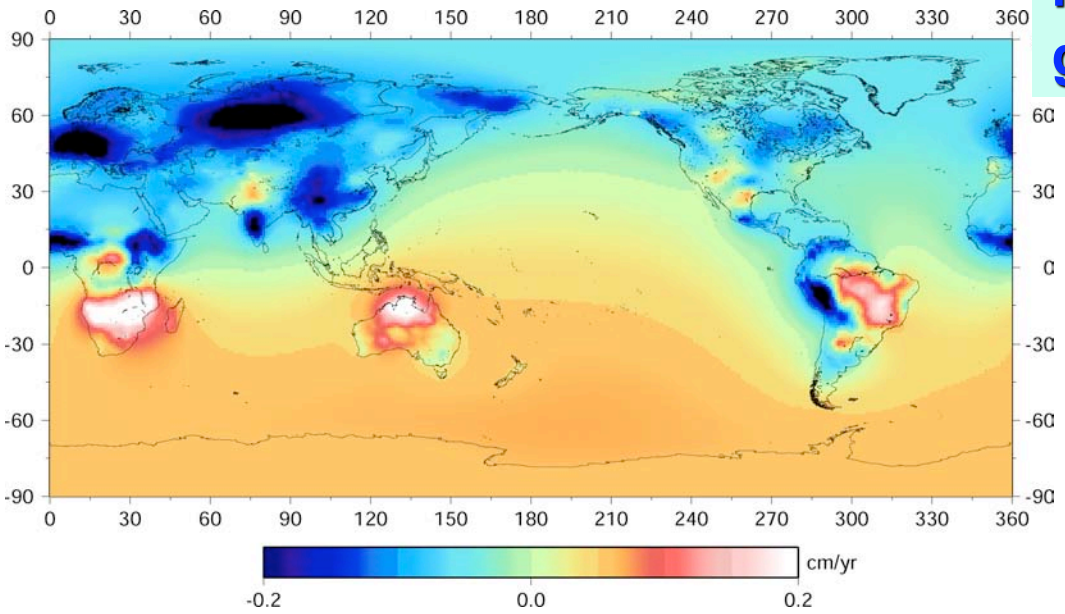
SWOT Hydrologic Contributions to Sea-Level Rise



GRACE observed land water mass gain/loss, 2002–2007, (CSR RL04 used, GIA not removed)

Hydrologic contribution to sea-level rise: 0.07 to 0.27 mm/yr

Limitations: hydrologic model error; GRACE error (coarse resolution, signal contains GIA, glacier, snow, others)



GLDAS model predicted land water balance (2002–2007, excluded ice-sheets). Predicted sea-level change due to self-gravitational (elastic loading) included.

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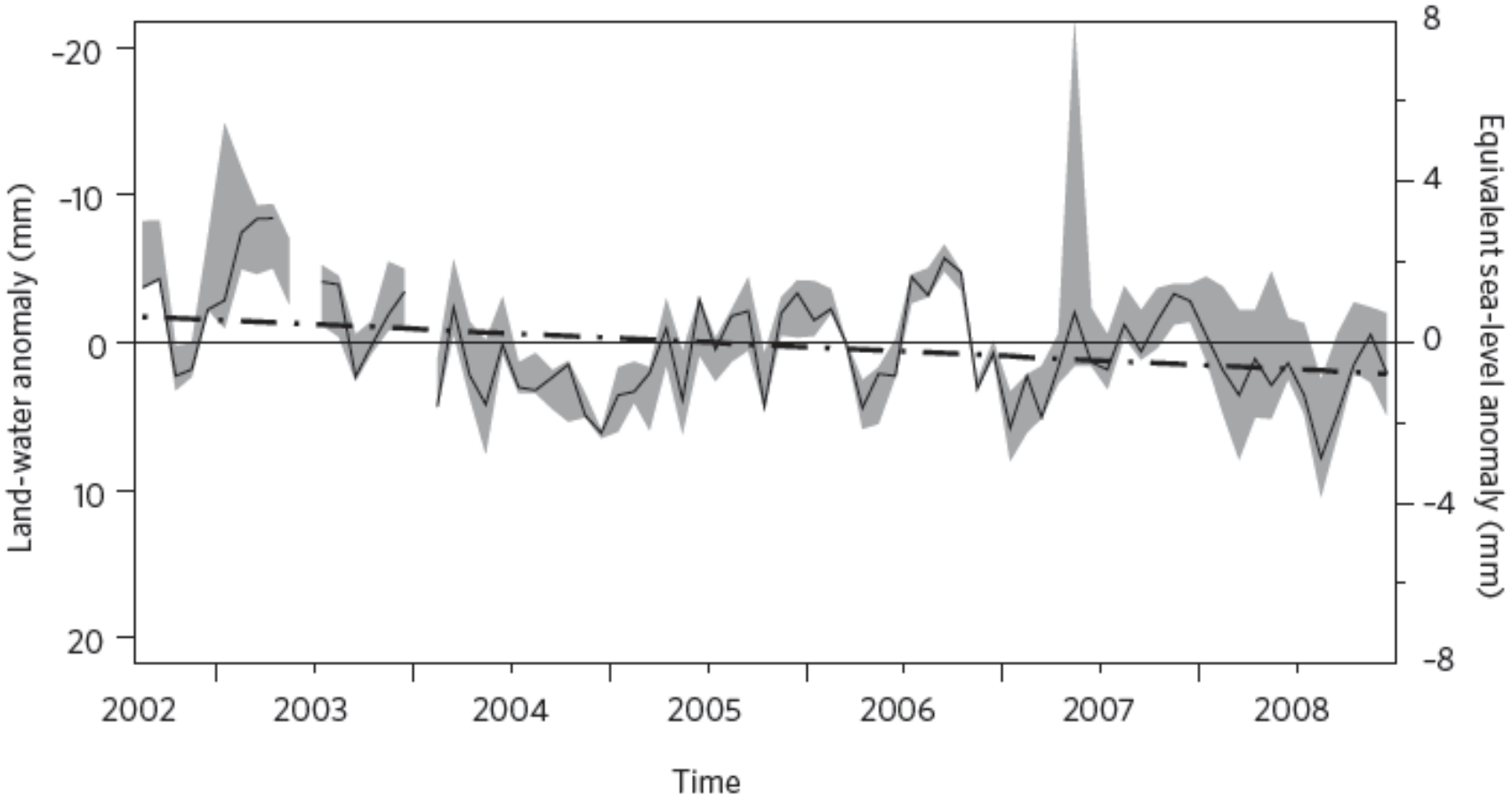
SWOT Hydrologic Contributions to Sea-Level Rise



- **GRACE (several solutions) estimated land water (including glaciers) contribution to sea-level [Lettenmaier & Milly, *Nature*, 2009]**

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SWOT Hydrologic Contributions to Sea-Level Rise

- SWOT will help constrain the total terrestrial land water contribution to sea-level rise by accurately measuring the surface water gain/loss

- SWOT can potentially reduce the uncertainty of the estimated anthropogenic effect of human impoundment of water in reservoirs and its resulting negative impact on global sea level rise

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SWOT

Coastal Impacts of Sea-Level Rise

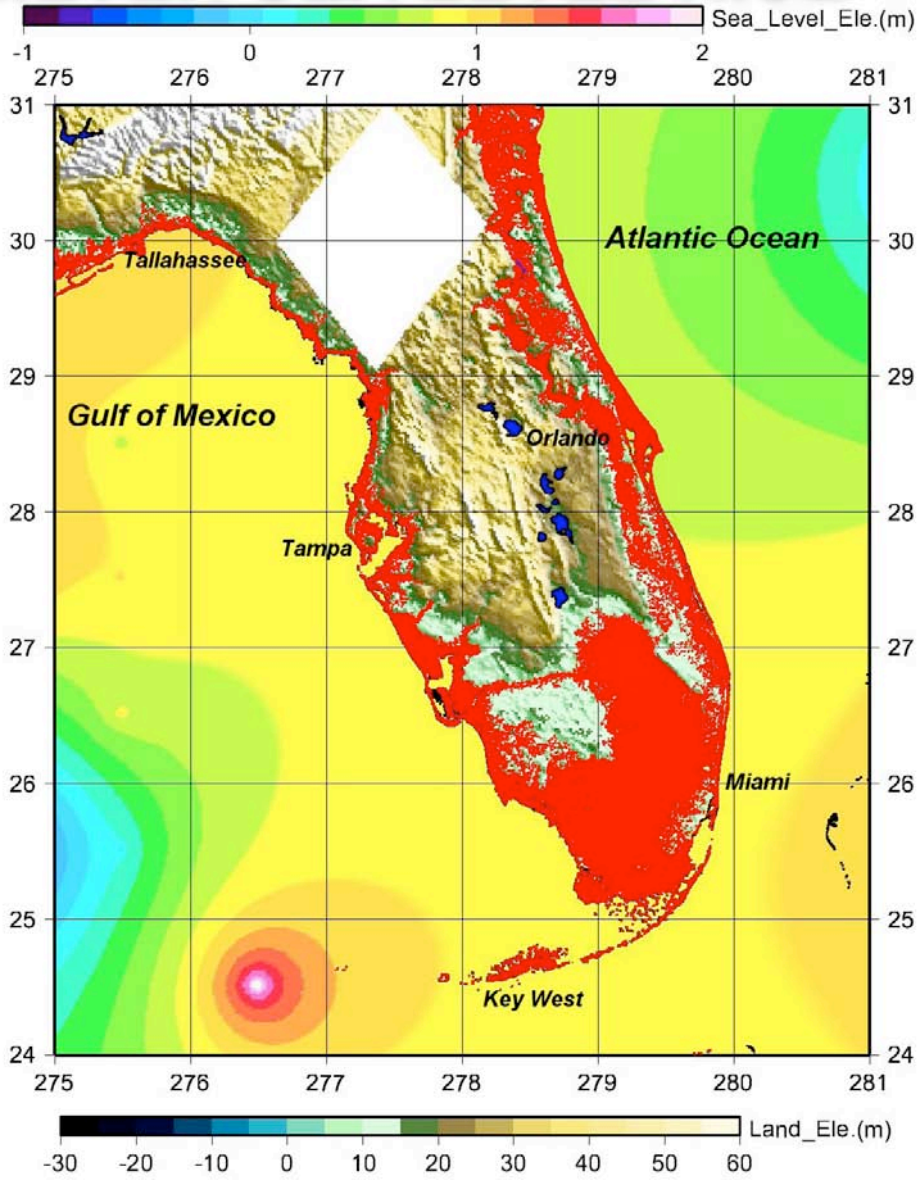
LAND LOSS DUE TO 5 METER SEA LEVEL RISE

Land Elevation Modeled Using SRTM 50-m DEM

- Assumed vertical datum is perfect and accounted for the temporal variations

- Current limitation of spatial resolution on coastal sea-level is grossly inadequate to study coastal impact of sea-level rise

Sea-level trend model based on altimetry determined trend



SWOT

Coastal Impacts of Sea-Level Rise

- Unlike conventional altimetry, SWOT provides accurate and high-resolution sea-level measurements at the ocean-land interface, and land topography in the coastal zones, enabling:
  - Direct & accurate link between land and sea with refined vertical datum
  - Quantification of sea-level rise hazards in the estuary and coastal regions
  - Contribution of improved storm surge prediction/ modelling in low-lying coastal regions

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