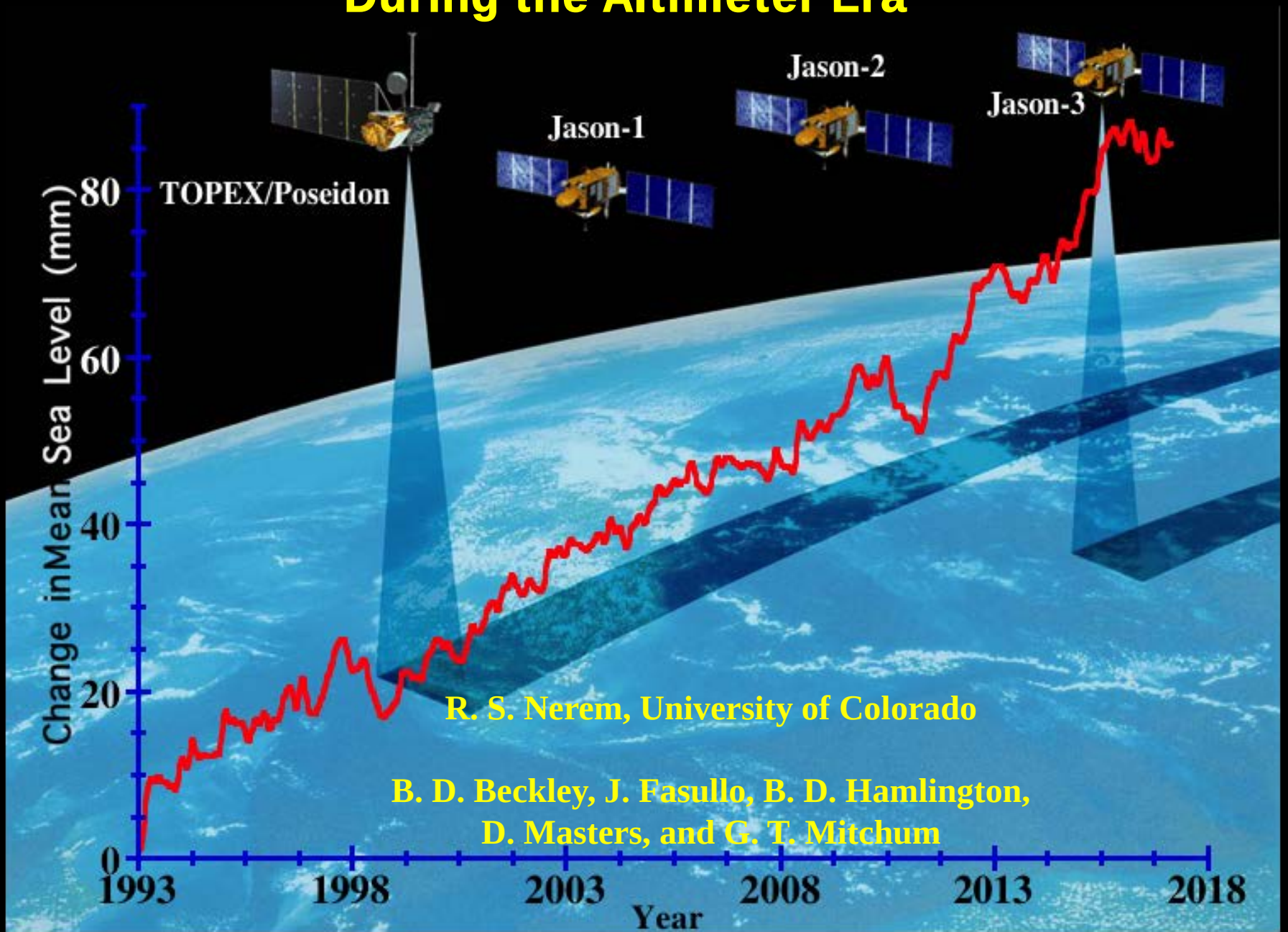
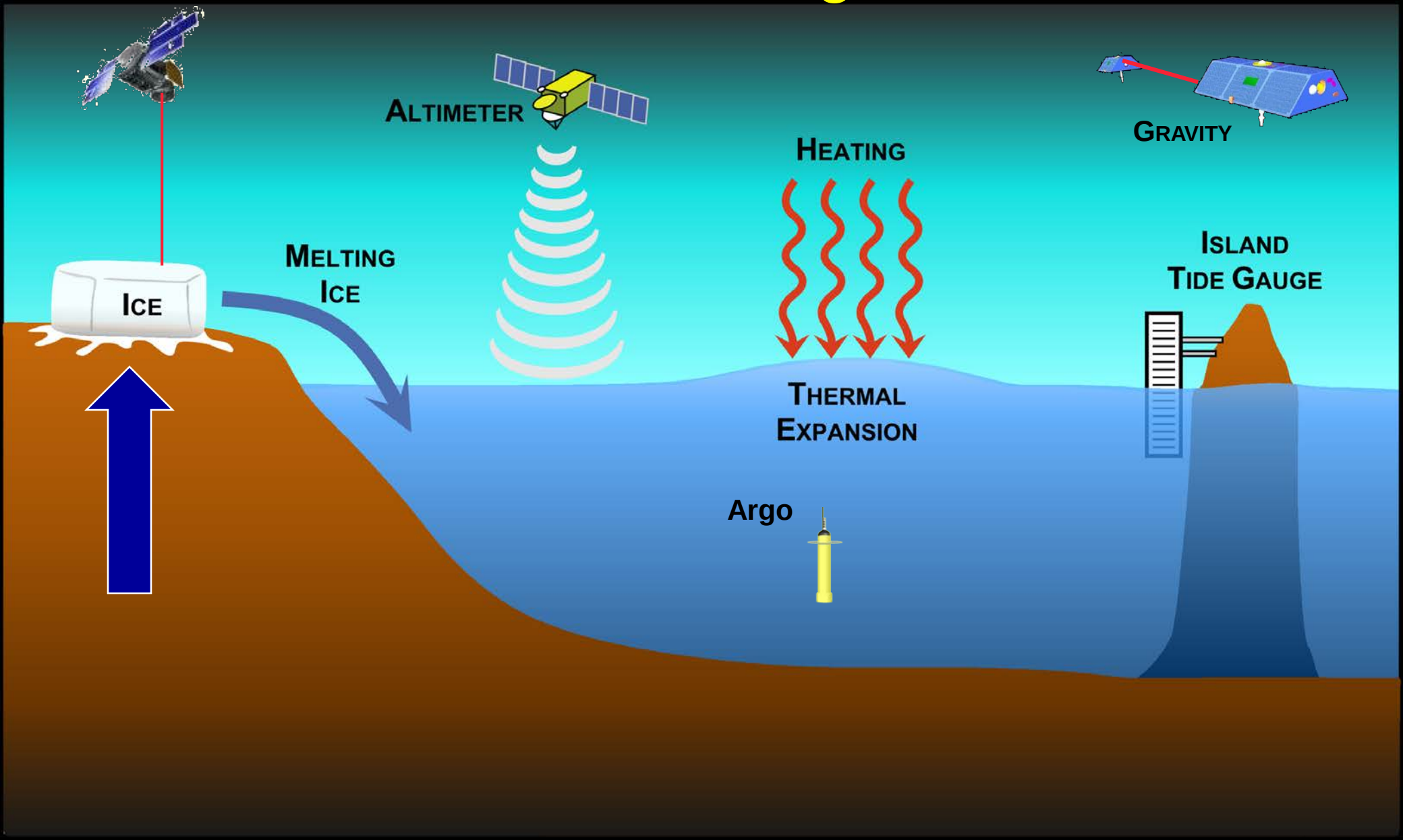
Understanding the Acceleration of Sea Level Rise During the Altimeter Era



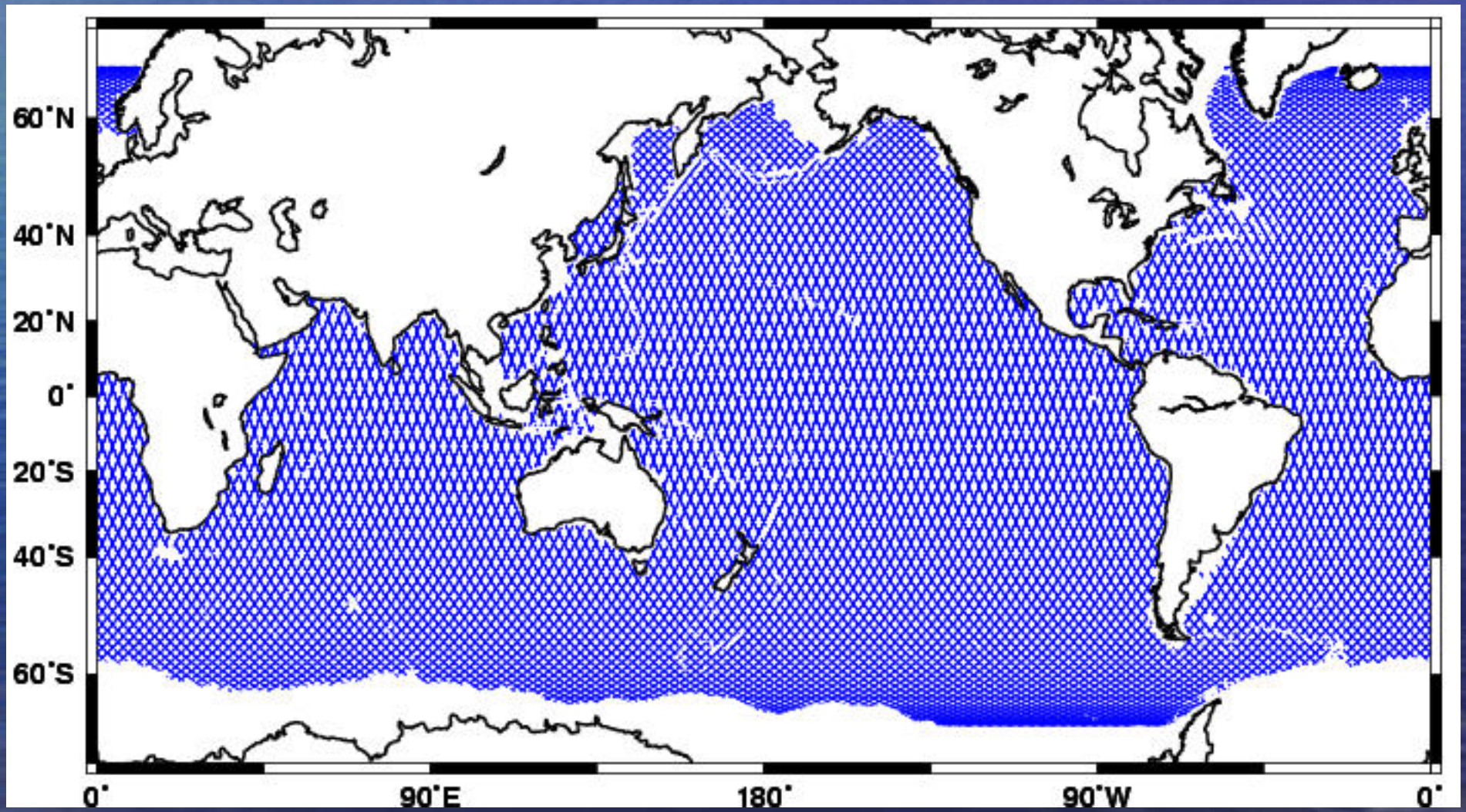
R. S. Nerem, University of Colorado

B. D. Beckley, J. Fasullo, B. D. Hamlington,
D. Masters, and G. T. Mitchum

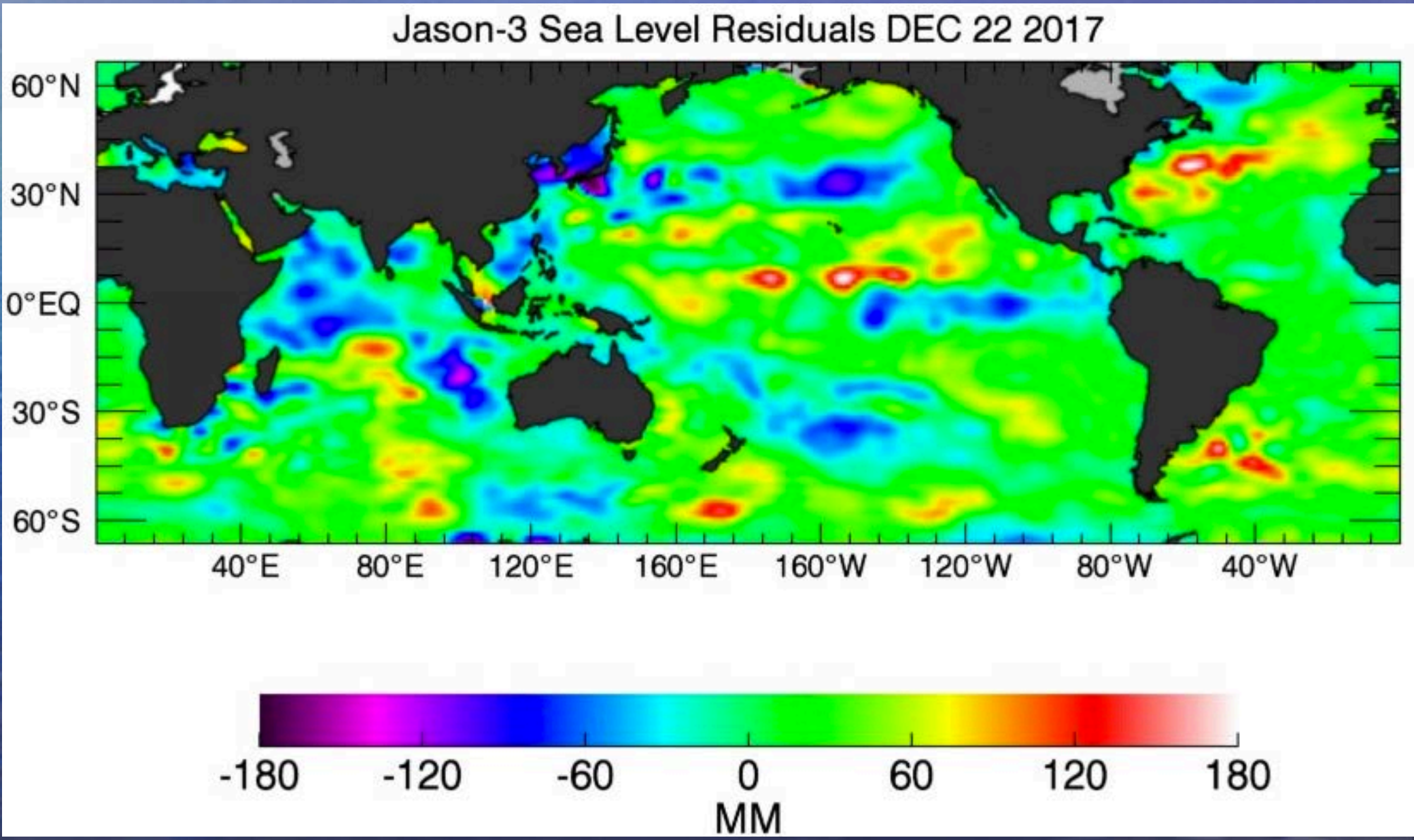
Tools for Measuring Sea Level



TOPEX/Poseidon and Jason 10-day Groundtrack



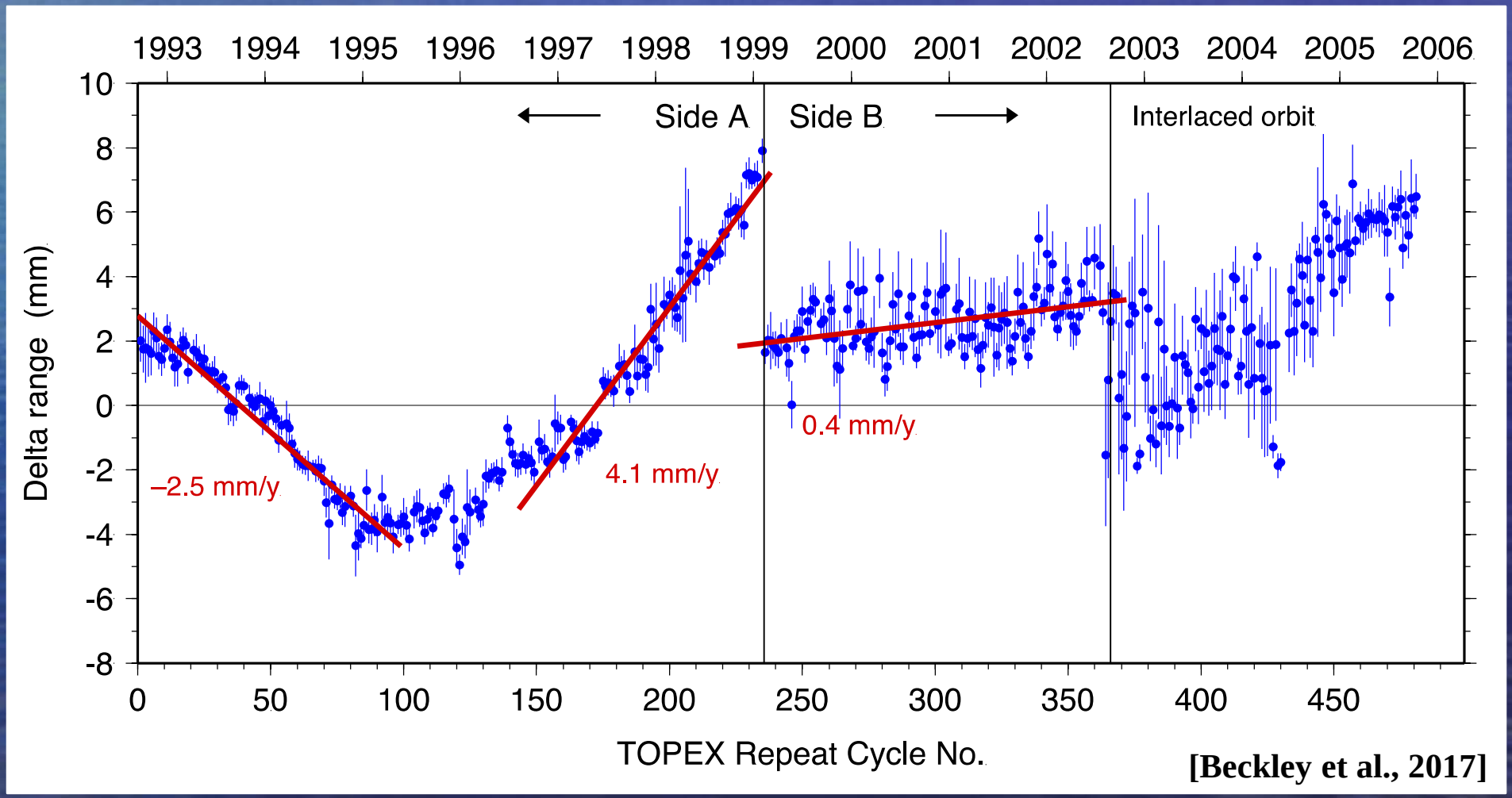
Jason-3 Sea Level



Overview

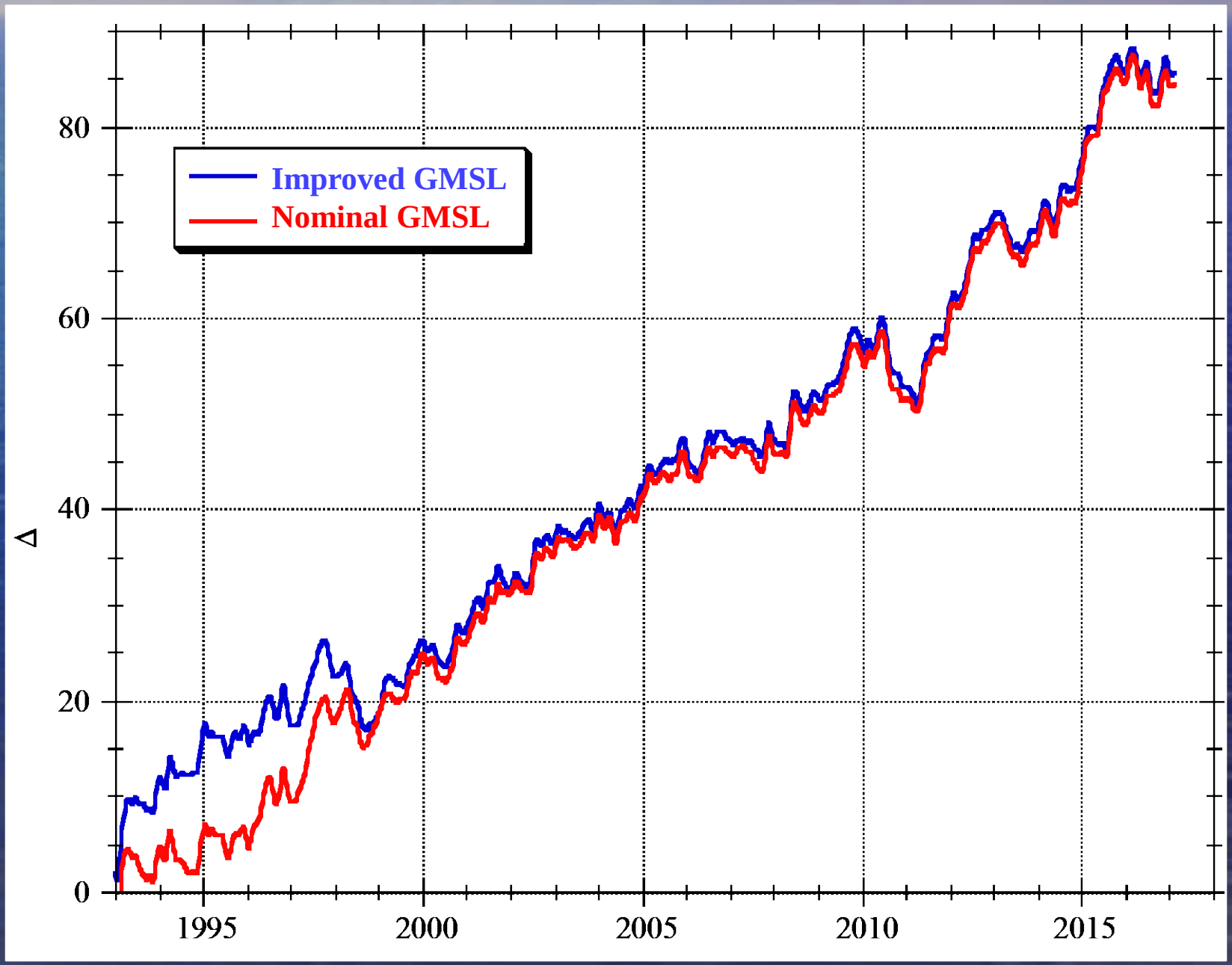
- Updates to the TOPEX data
- The Eruption of Mount Pinatubo
- Impact of ENSO Variability
- Error Assessment Using Tide Gauges
- Impact of Decadal Variability
- Validation Using GRACE
- What It Might Tell Us About the Future

Effect of Cal-Mode Correction on TOPEX GMSL



[Beckley et al., 2017]

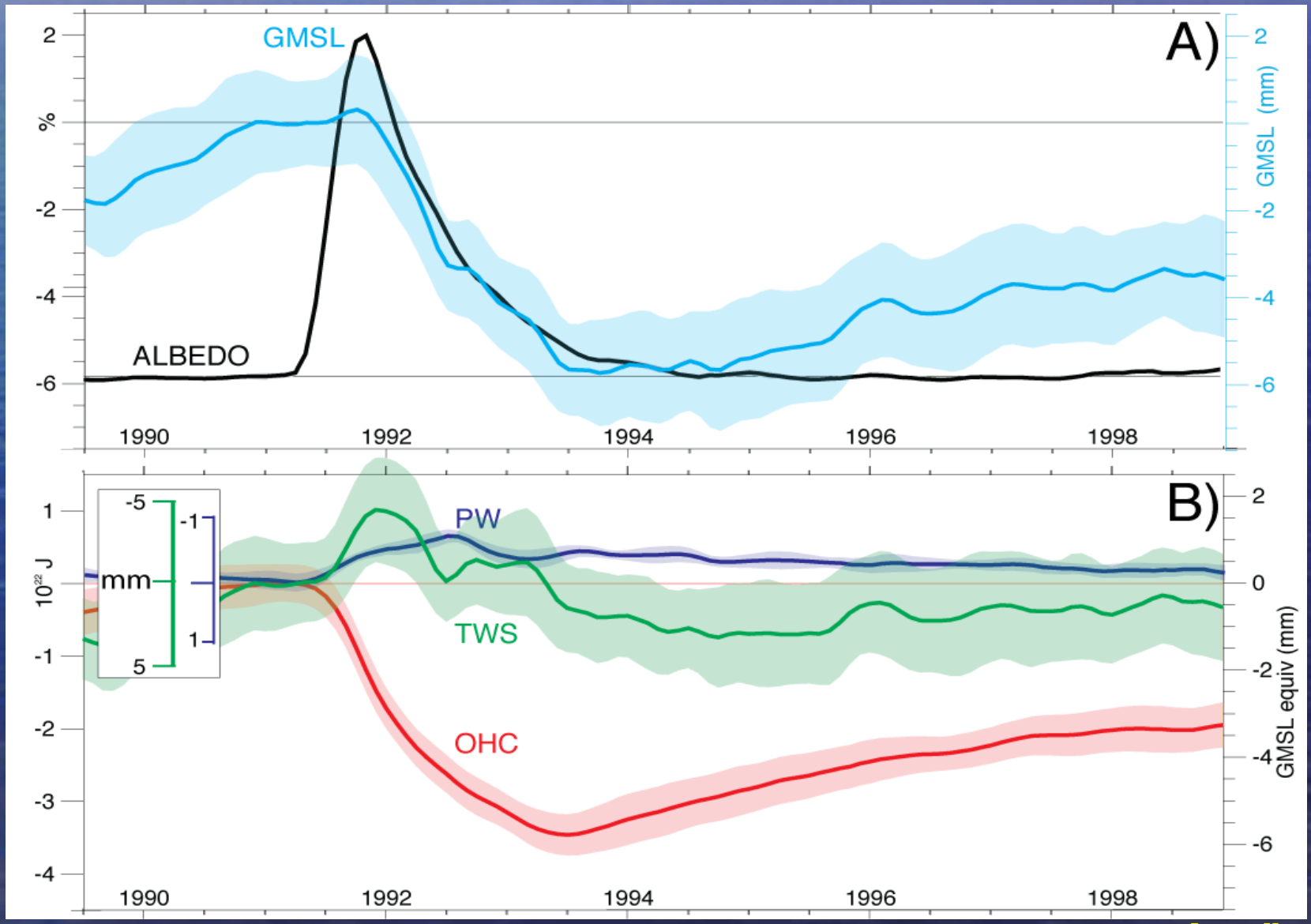
Effect of Cal-Mode Correction on TOPEX GMSL



The 1991 Eruption of Mount Pinatubo

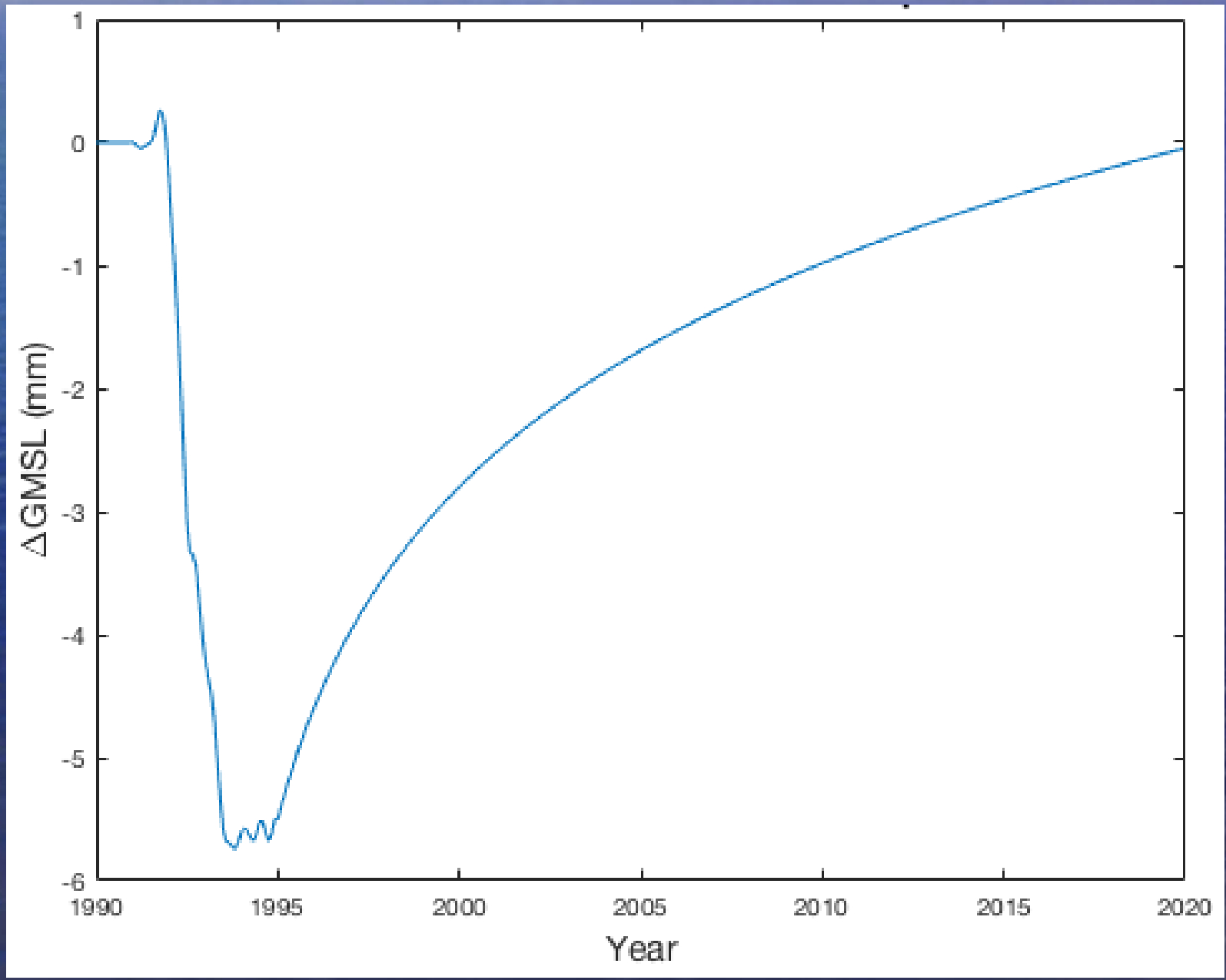
- June 15, 1991
- 2nd largest eruption of the 20th Century
- ~25 Tg of stratospheric aerosol loading
- Global cooling of ~0.5 C, substantial ozone depletion

Effects of Mt. Pinatubo Eruption in 1991

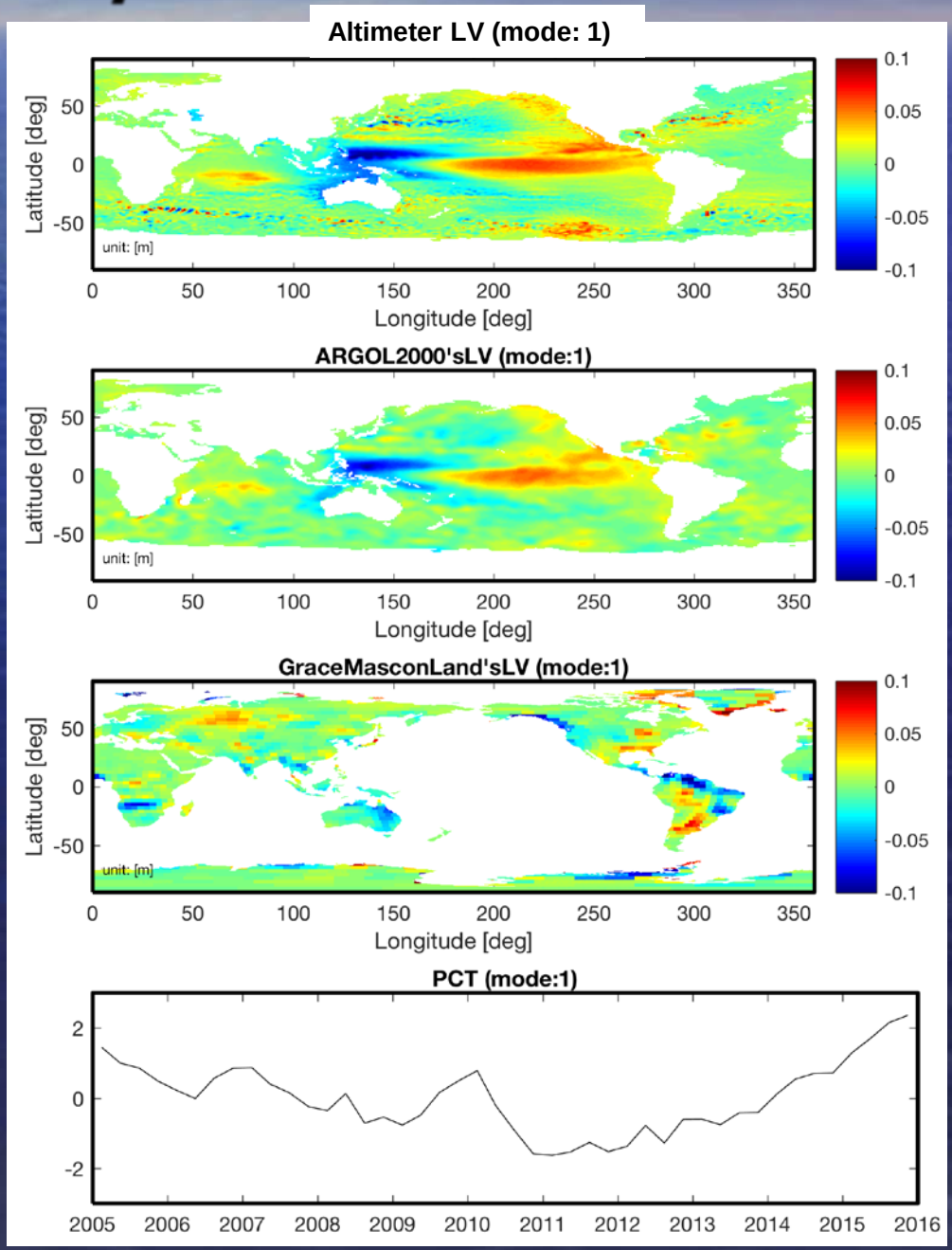


[Fasullo et al., 2016]

Effect of Pinatubo Eruption on GMSL

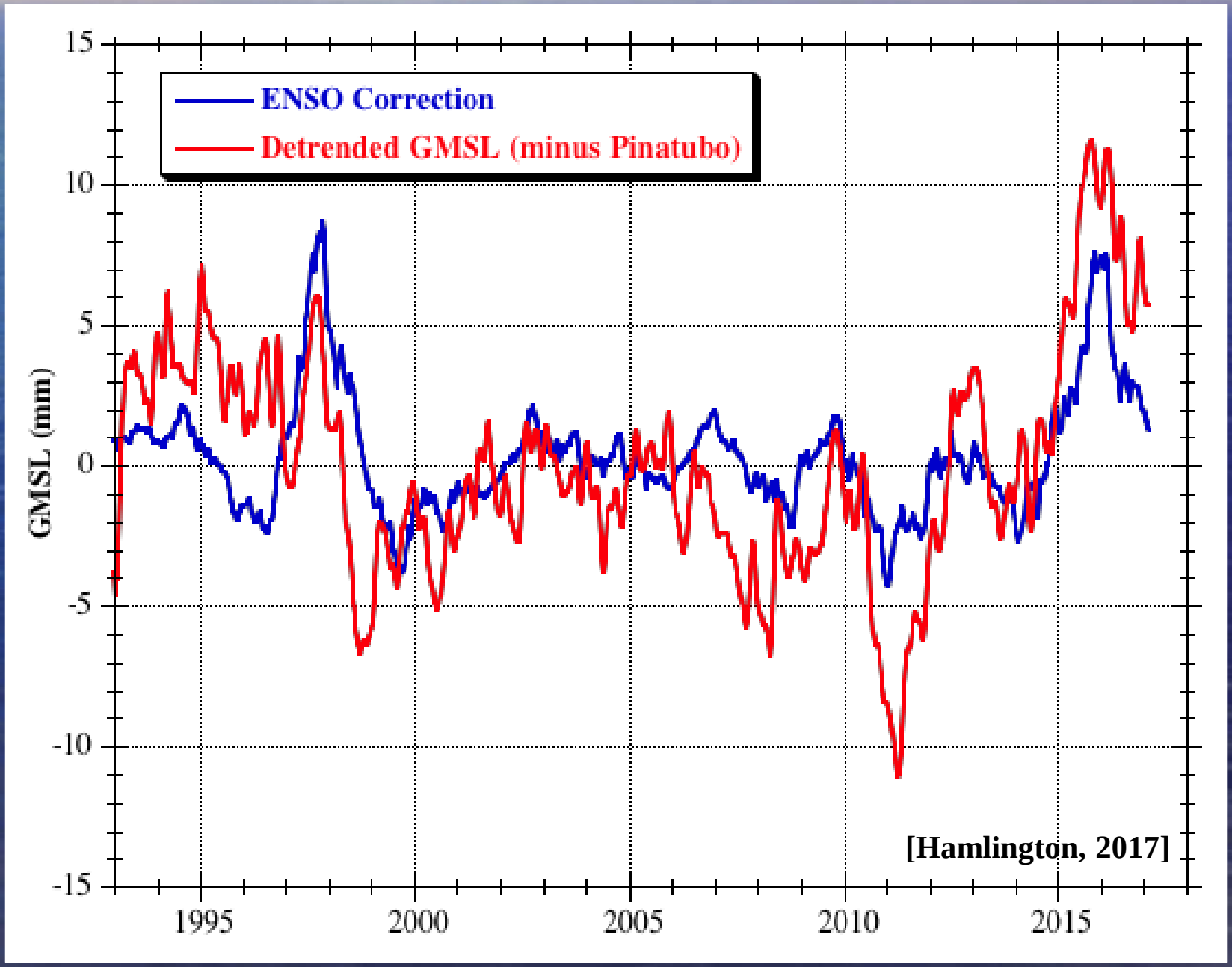


ENSO/PDO GMSL Correction

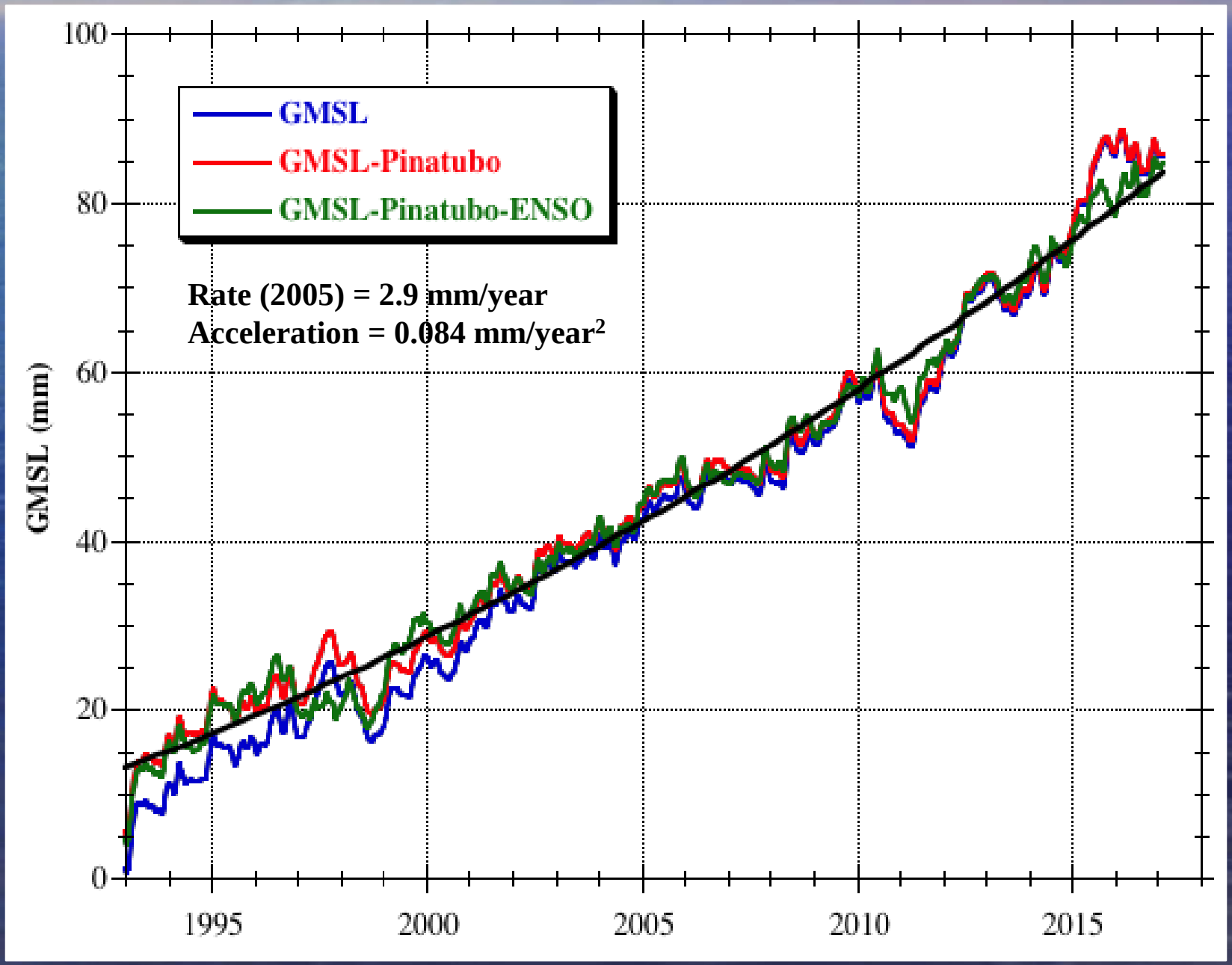


[Hamlington, 2017]

ENSO GMSL Correction



Correcting GMSL for Pinatubo and ENSO

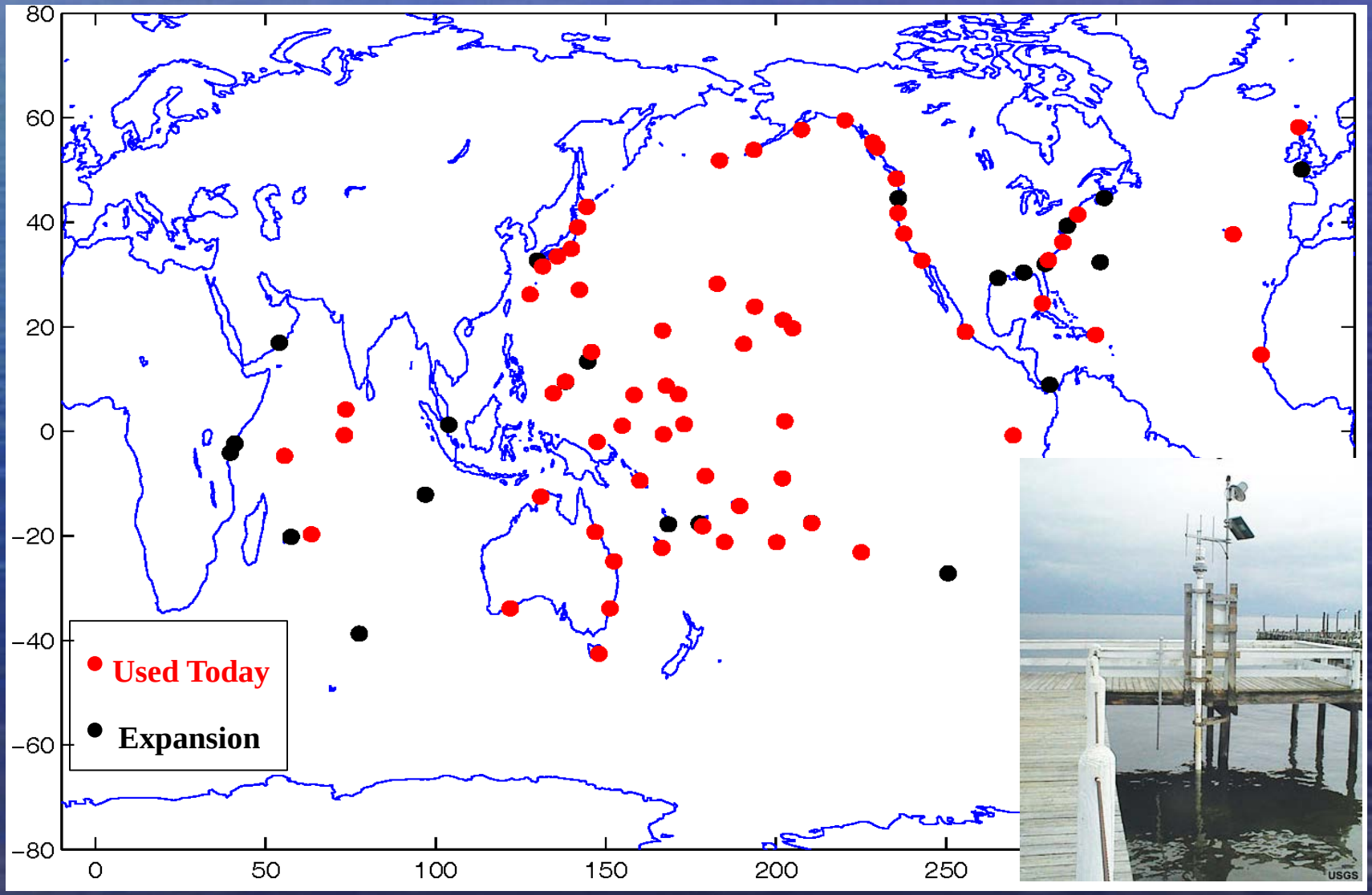


GMSL Acceleration Estimates

Case	Acceleration (mm/yr^2)
Nominal	0.082
Cal Mode Removed	0.097
Pinatubo Removed	0.117
ENSO Removed	0.084

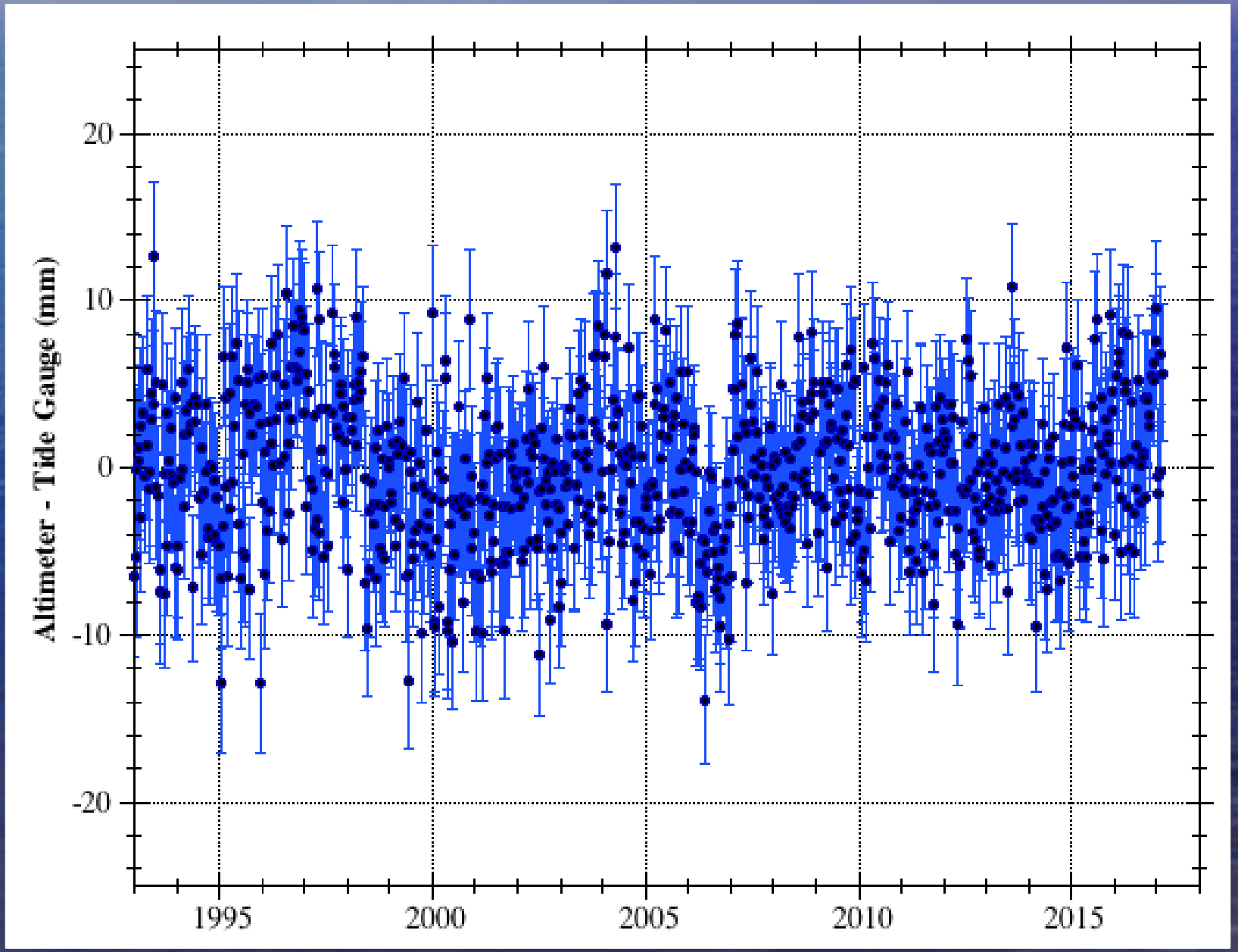
What are the errors in this acceleration estimate?

Tide Gauges Used for Cal/Val



Updated from [Mitchum, 2000]

Altimeter – Tide Gauge Sea Level



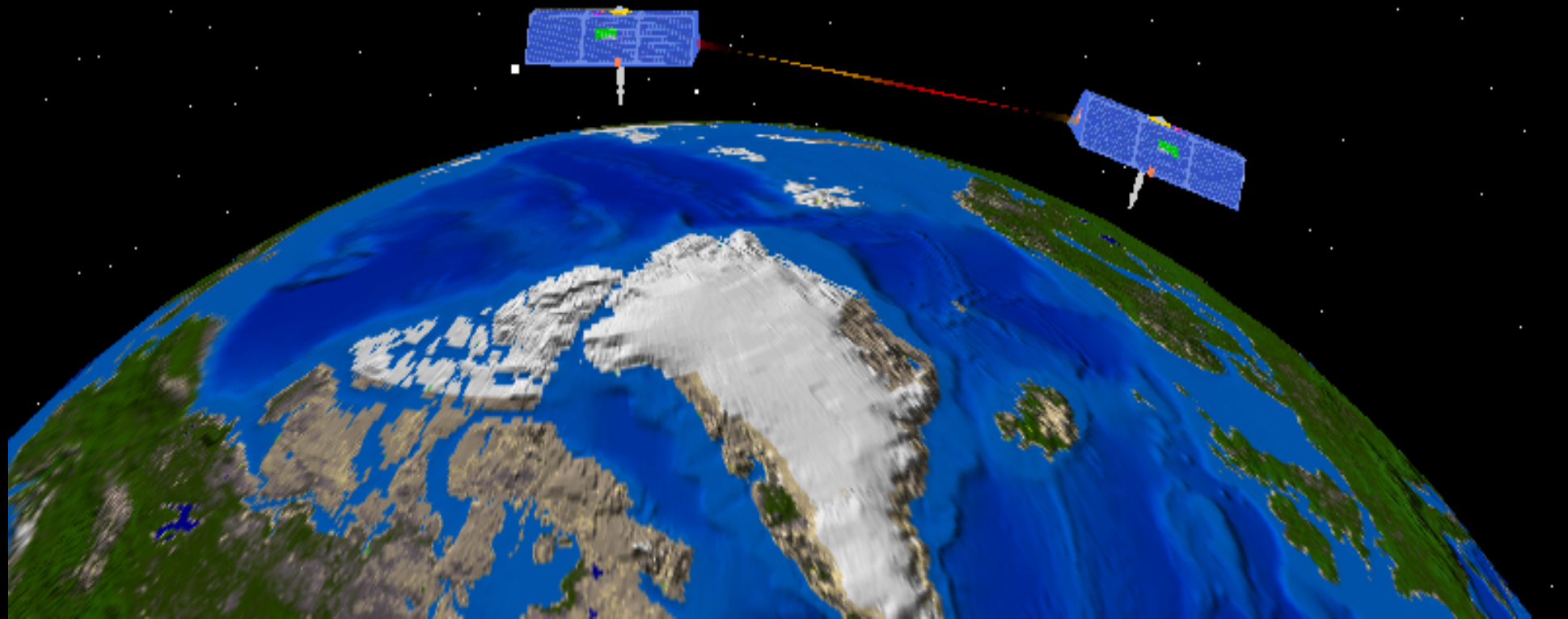
Acceleration Error Assessment

Error	Source	Acceleration Error (mm/yr^2) 1σ
Altimeter Measurement Errors	Tide Gauge Calibration	0.011
Decadal Variability	Cryosphere (Wouters et al., 2013)	0.014
	TWS (NCAR LE)	0.0054
	Thermosteric (NCAR LE)	0.0075
	Precipitable water (NCAR LE)	0.0013
Pinatubo Correction Error	NCAR LE	0.01
ENSO/PDO Correction Error	Coupled EOF Analysis	0.01
Total	RSS	0.025

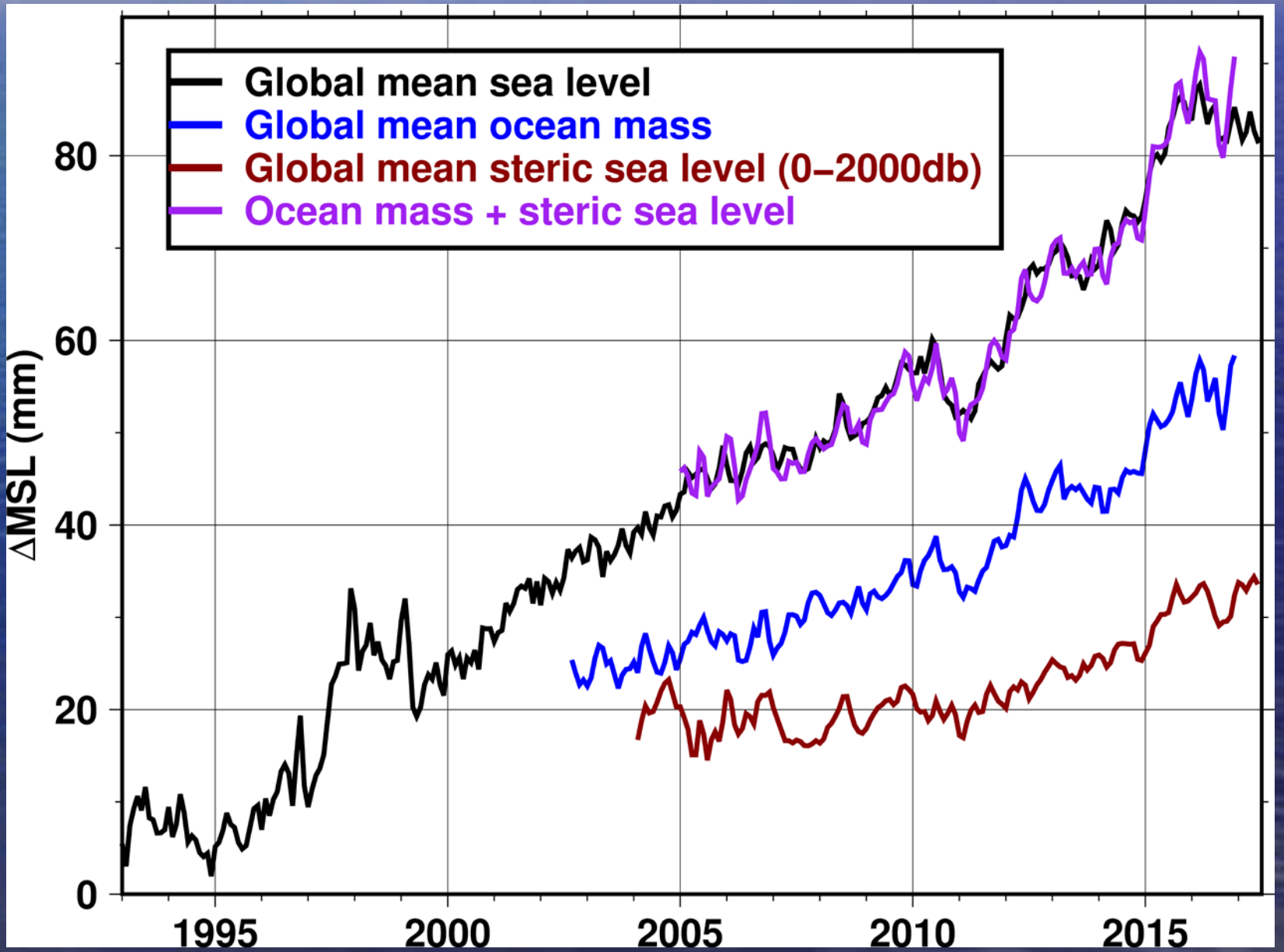
Climate Change-Driven GMSL Acceleration = 0.084 ± 0.025 mm/yr^2

GRACE

Gravity Recovery and Climate Experiment

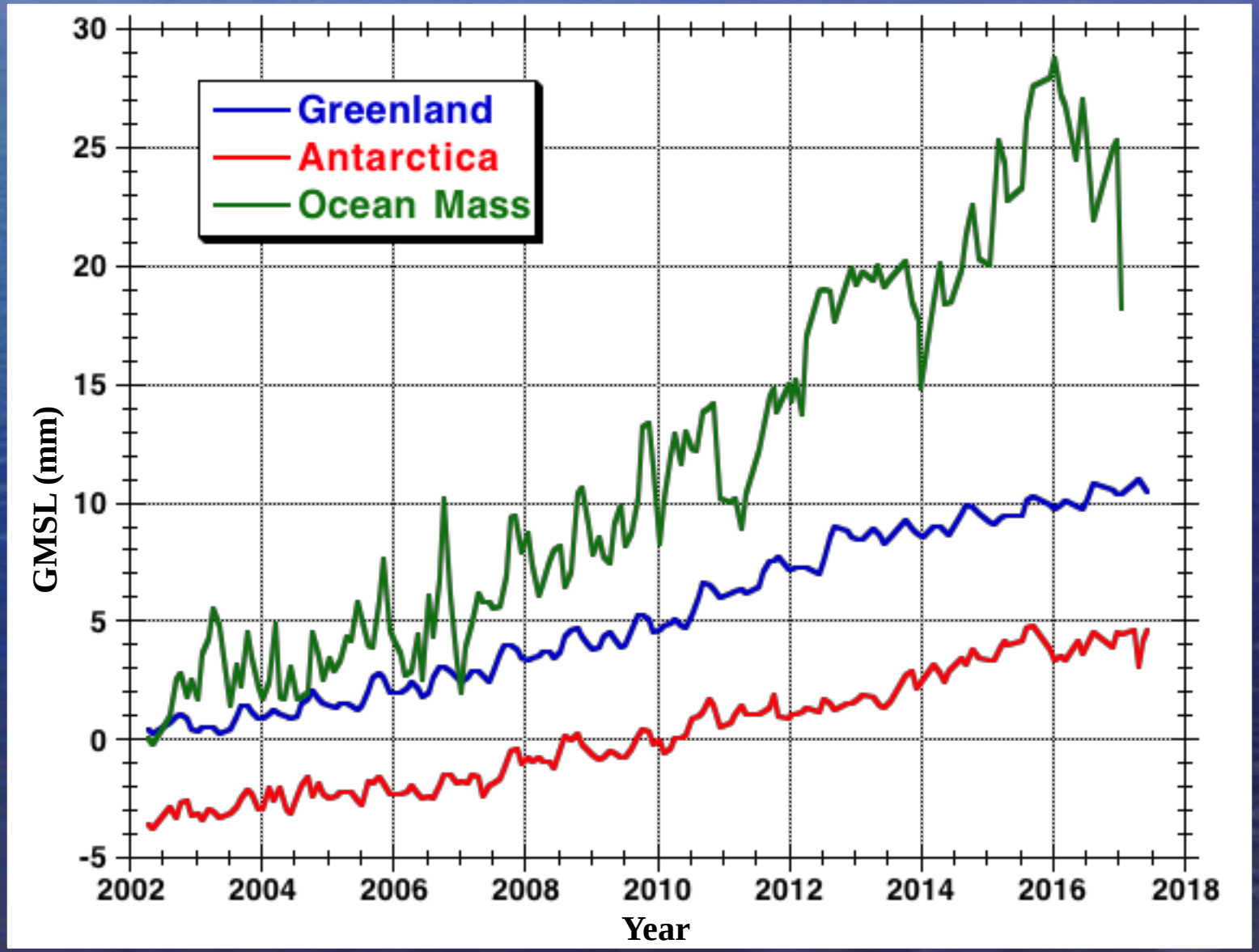


Agreement of Altimetry, Gravity, and Argo

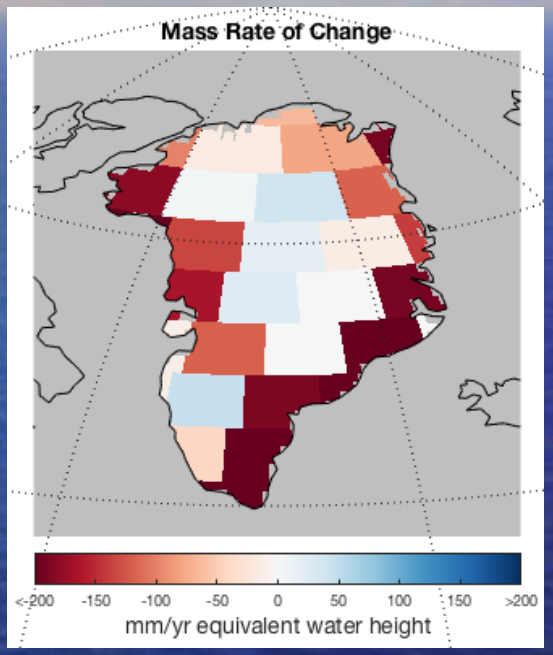


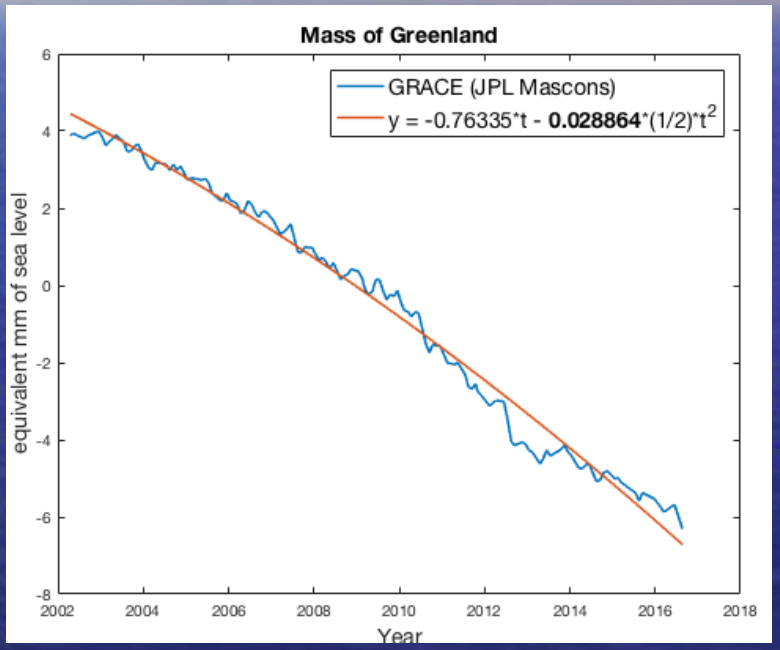
[Leuliette, 2017]

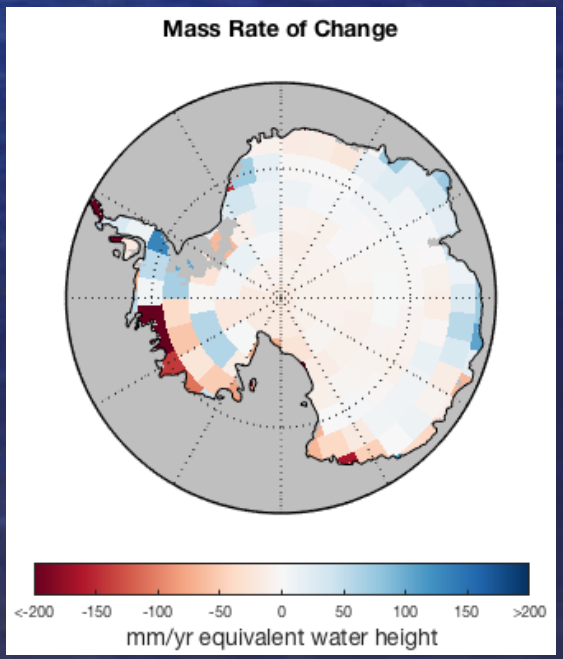
GRACE Mass Estimates (JPL Mascons)

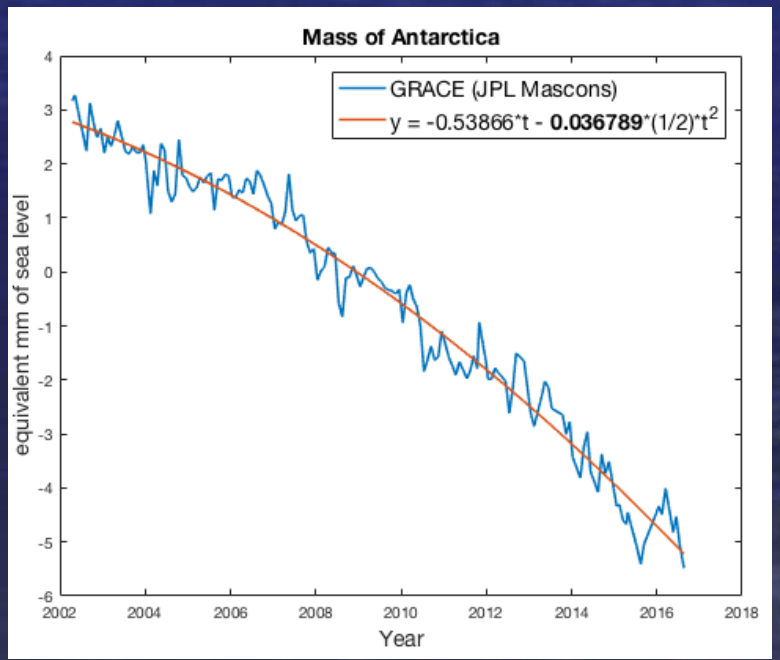


GRACE (2002-present)

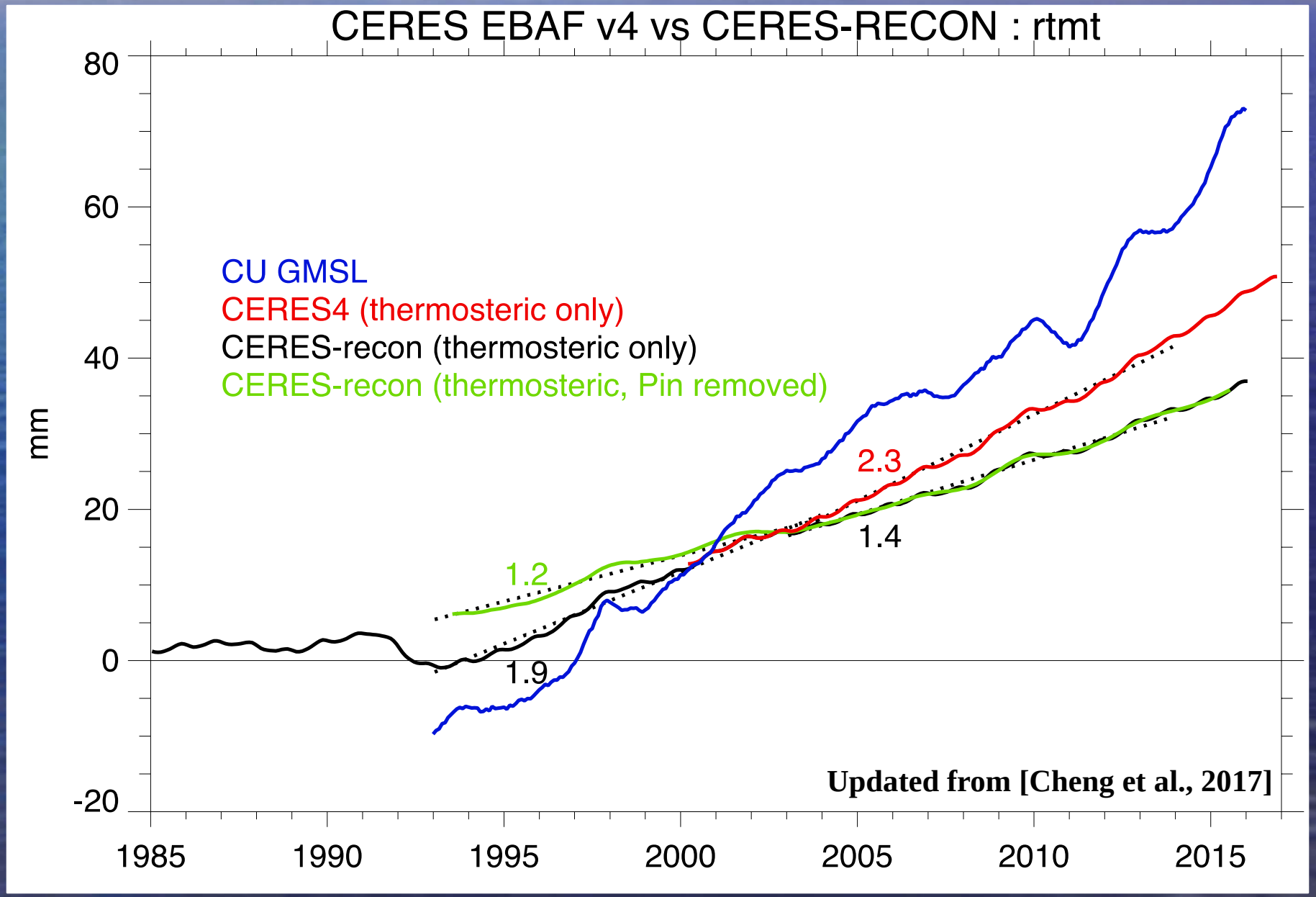








Thermosteric Sea Level Acceleration

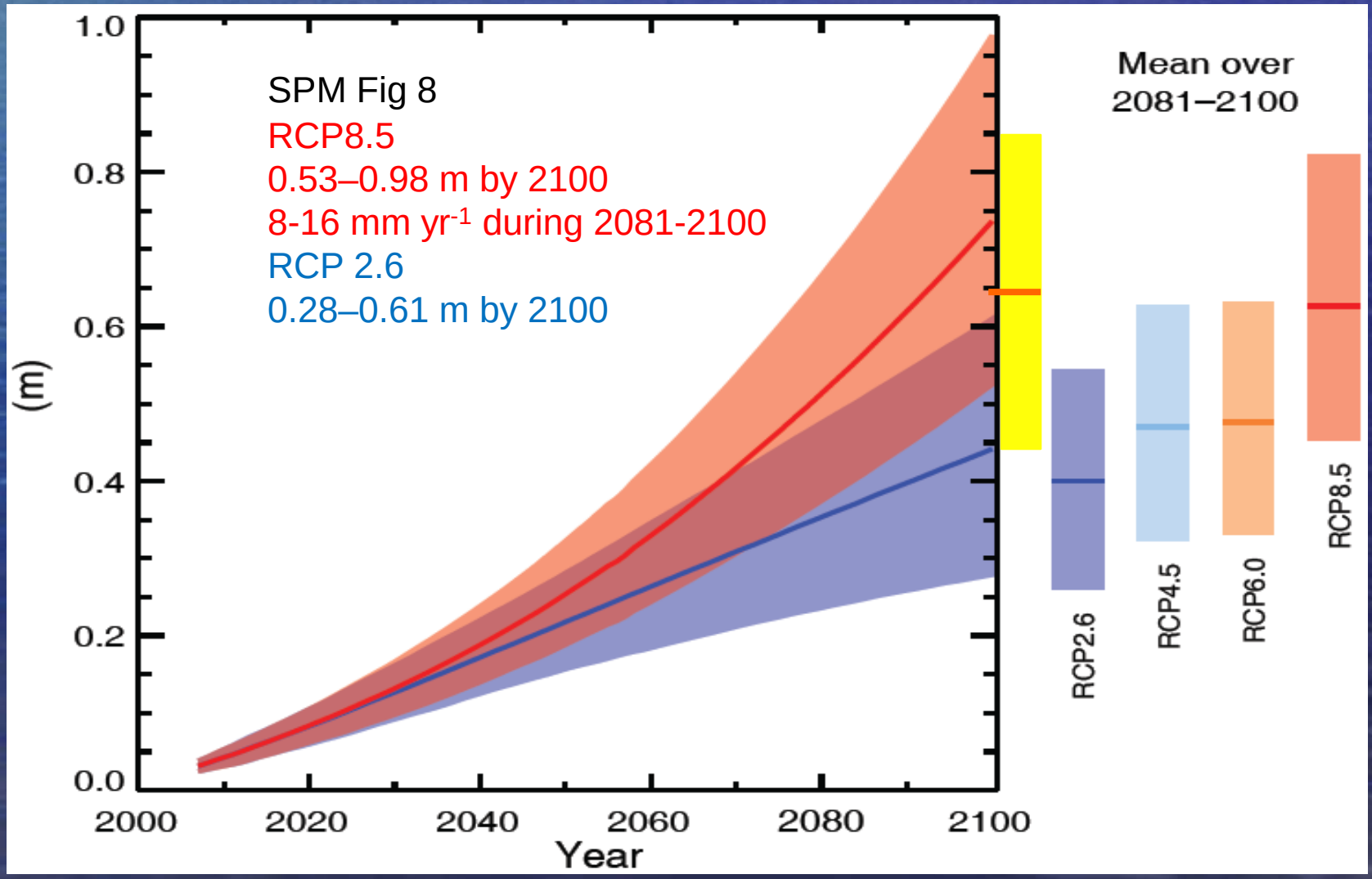


Validating the Observed GMSL Acceleration

Component	Time Period	Rate (mm/yr) Epoch 2005	Acceleration (mm/yr^2)
Greenland	2002-2017	0.66	0.0236
Antarctica	2002-2017	0.19	0.0332
Mountain Glaciers & Small Ice Caps	2002-2017	0.51	0.0094
Thermosteric (no Pin.)	1993-2015	1.65	0.0076
Components Total		**3.0**	**0.078**
Altimeter Observed	1993-2017	**2.9**	**0.084**

Projections of 21st-century GMSLR under Different RCPs from the IPCC 5th Assessment Report

Medium confidence in *likely* ranges. *Very likely* that the 21st-century mean rate of GMSLR will exceed that of 1971-2010 under all RCPs.

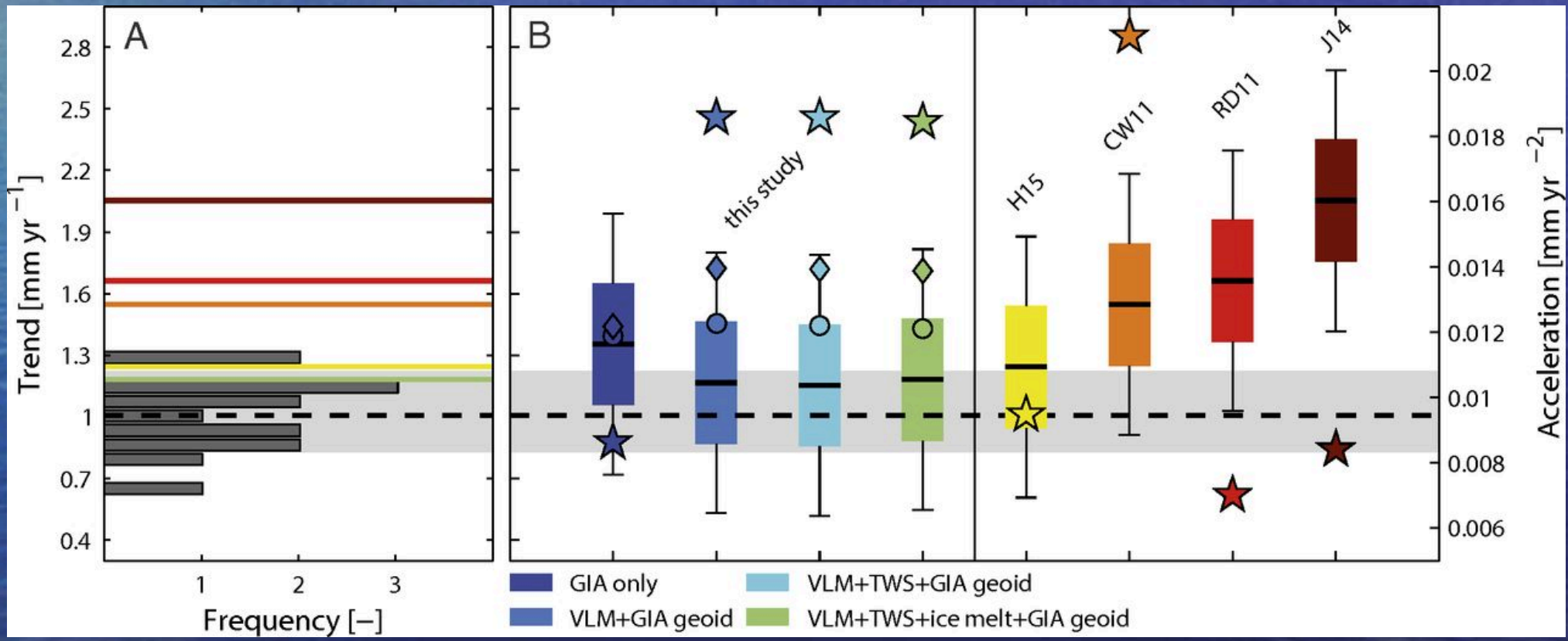


Accelerations from the IPCC AR5 Projections

2007 – 2100 (mm/yr^2)

RCP	Low	Median	High
2.6	-0.0149	0.0184	0.0185
4.5	0.0095	0.0306	0.0532
6.0	0.0286	0.0515	0.0767
8.5	0.0624	0.0975	0.1415

Tide Gauge Acceleration Estimates (1902-1990)



[Dangendorf et al., 2017]

Conclusions

- We have detected a small acceleration of global mean sea level in the satellite record of 0.084 ± 0.025 mm/yr^2.
- This acceleration has the potential to double the amount of sea level rise by 2100 as compared to sea level rising at a constant rate of ~3 mm/year, assuming sea level continues to change as it has over the last 25 years.
- Tide gauge measurements are critical for assessing the errors in this acceleration estimate.
- GRACE is a important tool for validating this acceleration and determining its cause(s).
- Estimates of the acceleration of GMSL will improve as the satellite record lengthens.


Thanks! Questions?