

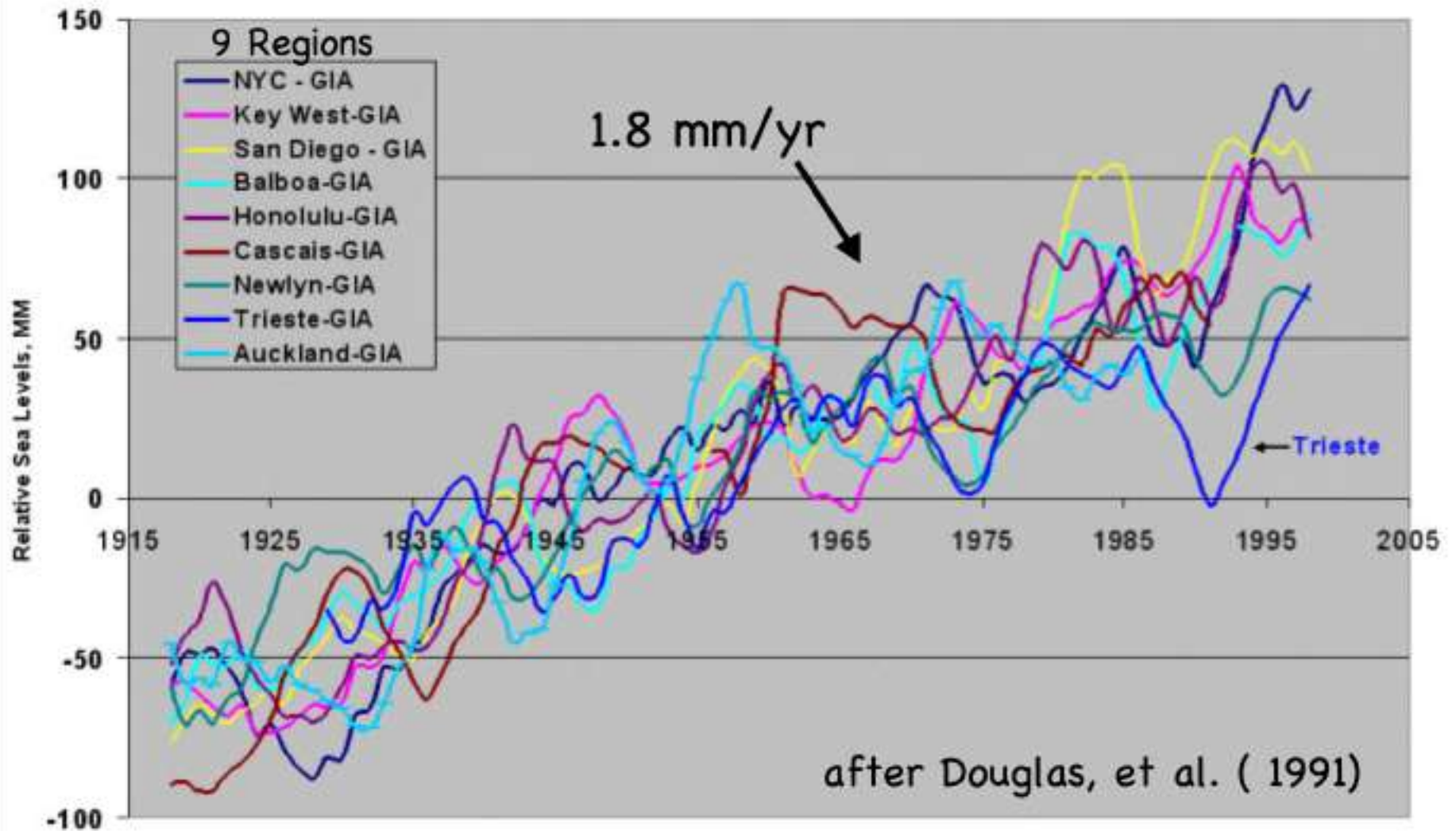


Global Sea Level Rise: The Past Decade versus The Past Century

Laury Miller

Laboratory for Satellite Altimetry,
NOAA/NESDIS

Tide Gauge Relative Sea Levels wrt Means of 1916-87



The IPCC Controversy

- **1995 IPCC -- Wide agreement.**
Gauge measurements of sea level, 1.5–2.0 mm/yr. Most rise due to thermal expansion, the rest due to melting of continental ice.
- **2001 IPCC -- Consensus collapsed.**
New estimates of ocean warming put thermal expansion at 0.5 mm/year and other terms thought to be even smaller.

Direct Observations
of Sea Level Rise

Tide Gauge
(glacial
isostatic
adjusted)

1.5 mm/yr

≠

Estimated Contributions
To Sea Level Rise

Thermal Expansion (Volume)
+ Mountain Glaciers (Mass)
+ Greenland Ice Sheets (Mass)
+ Antarctic Ice Sheets (Mass)
+ Terrestrial Storage (Mass)

0.7 mm/yr

(IPCC, 2001)

The "Attribution Problem"

Either the tide gauges are biased high, as some suggest, due to abnormal local warming effects,

or

one (or both) of the mass & volume estimates is too low.

Two Solutions

1. "The gauges are biased high."

The rise is only 0.5 to 1.0 mm/yr and it's mostly thermal.

Cabanes, Cazenave & LeProvost (2001)

2. "It's the mass, maybe".

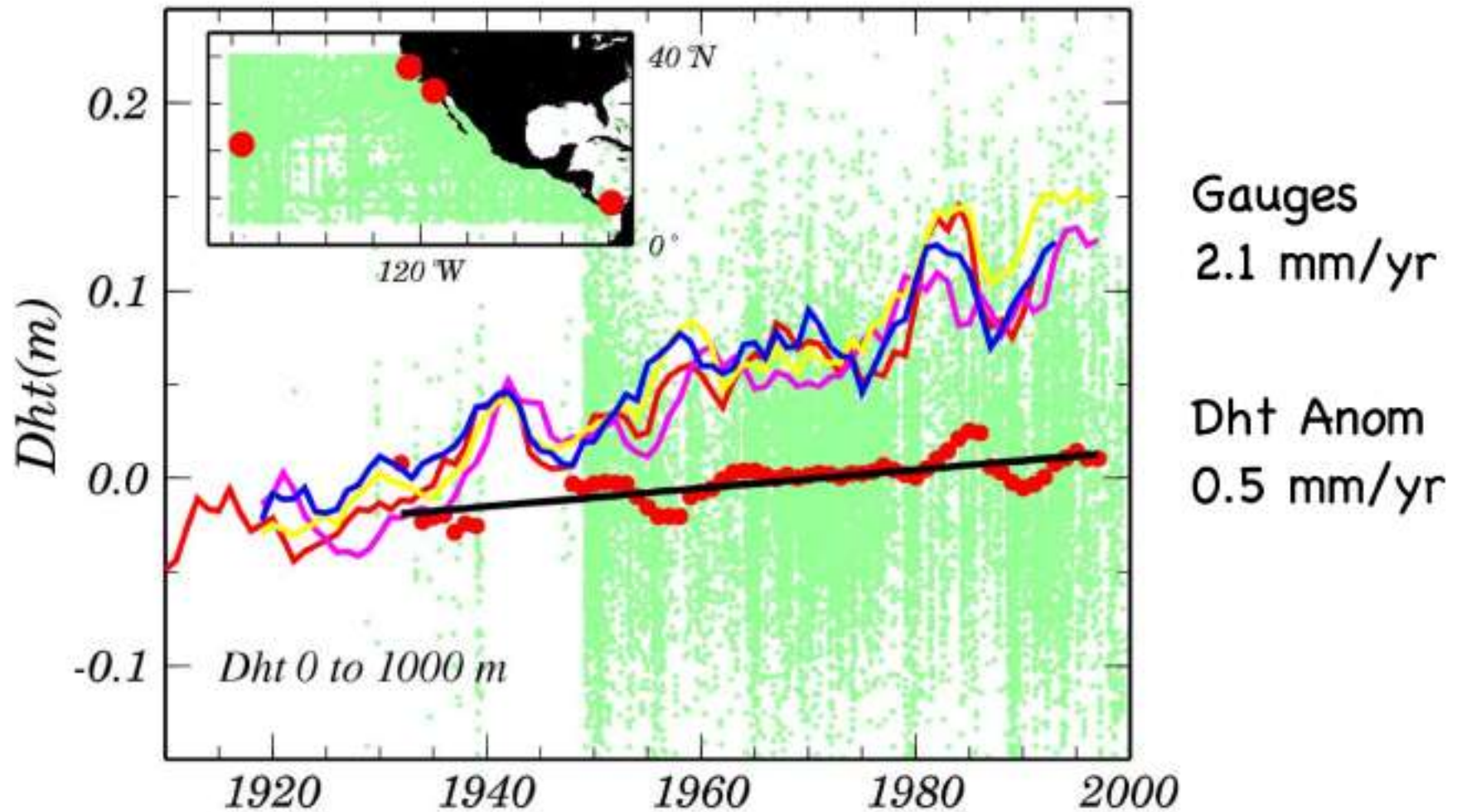
Antonov, Levitus & Boyer (2002)



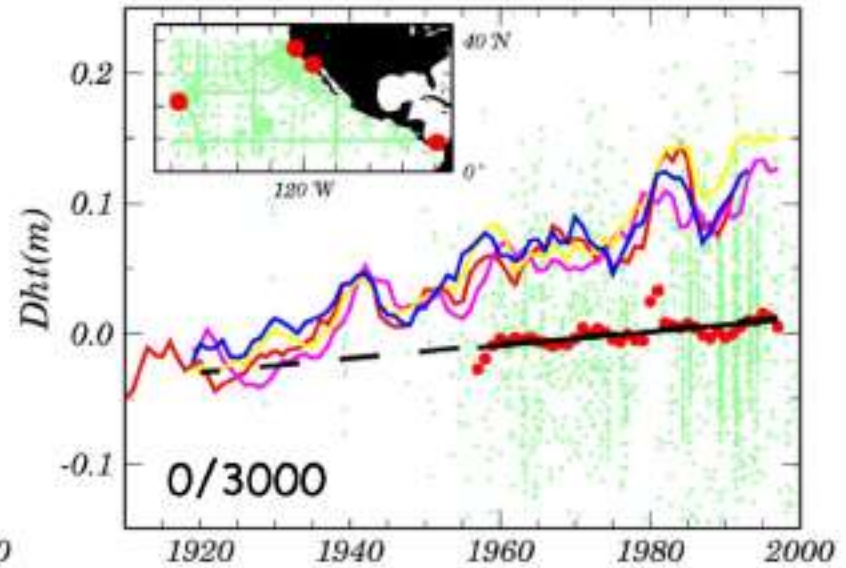
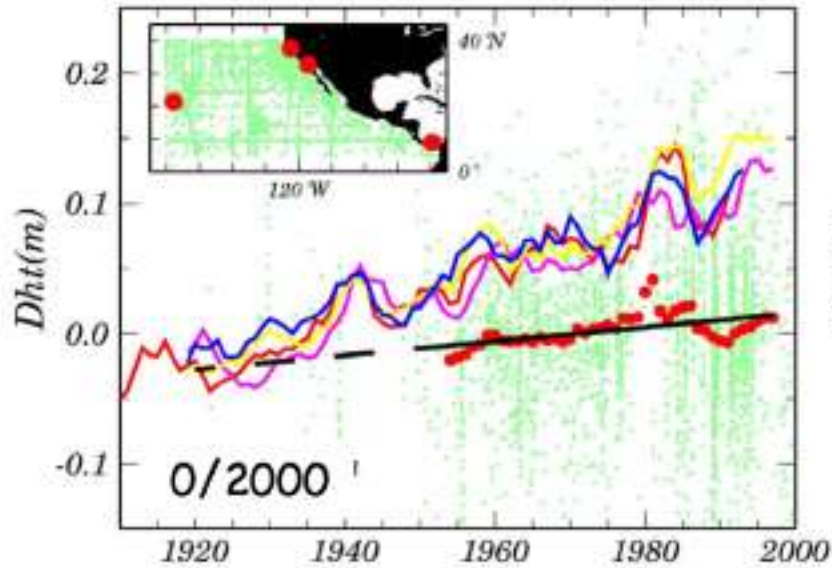
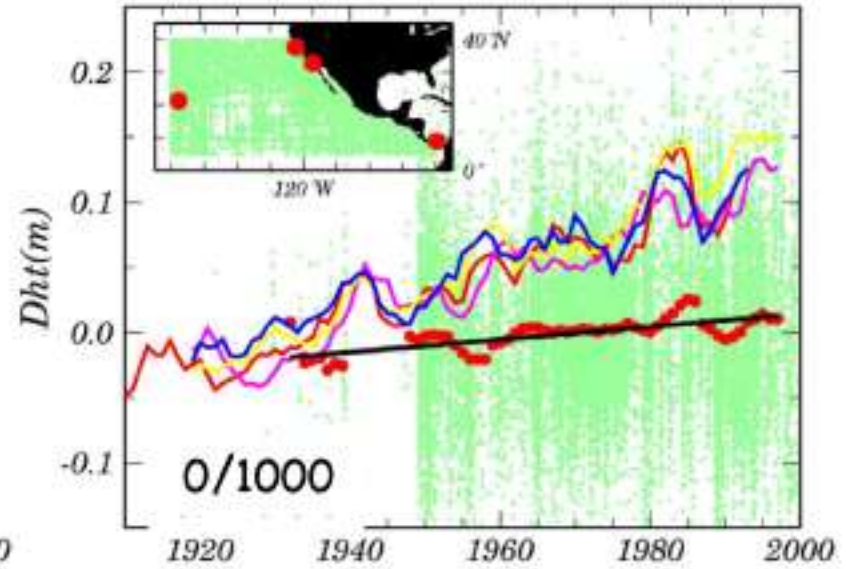
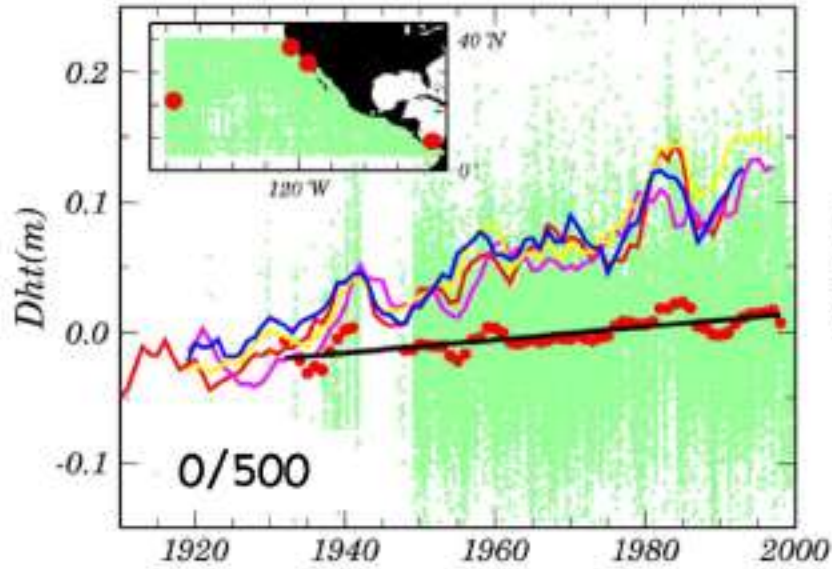
Mass & Volume Contributions
To 20th Century Global Sea
Level Rise Laury Miller &
Bruce C. Douglas, *Nature*, 25
March 2004

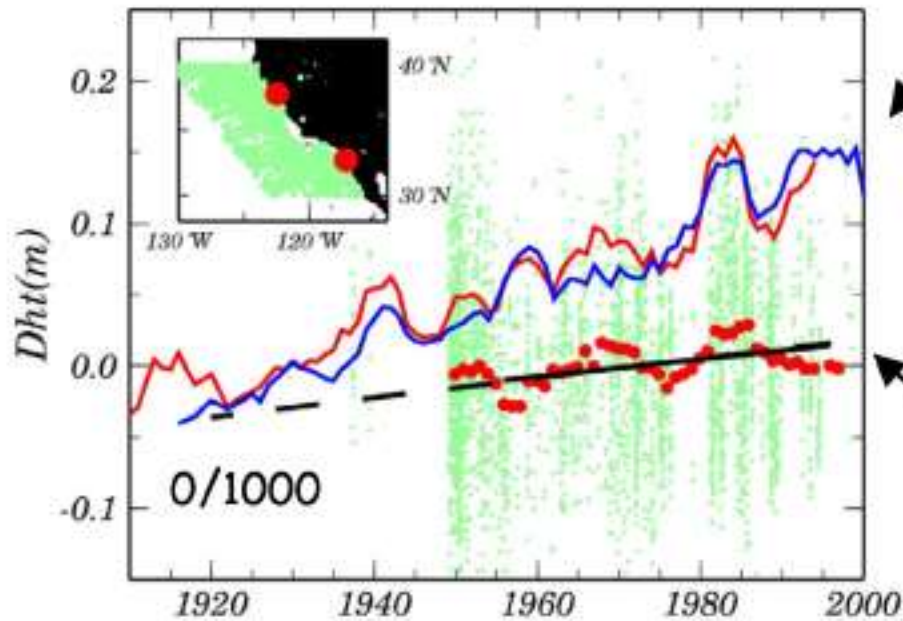
Dynamic Ht Anomaly (0/1000) vs. Gauge Sea Level (San Francisco, San Diego, Honolulu, Balboa)

Eastern Pacific



No Change of Trend With Depth





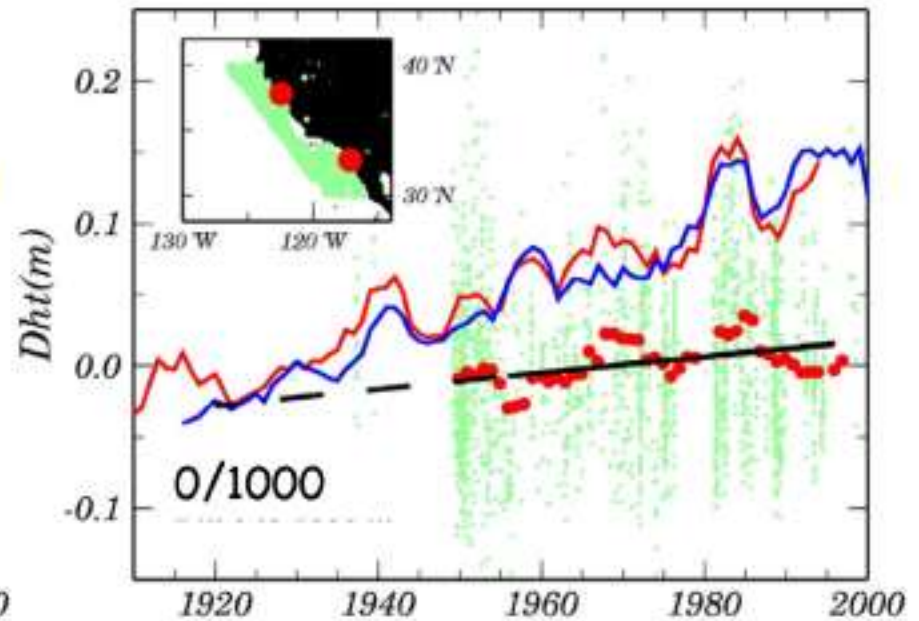
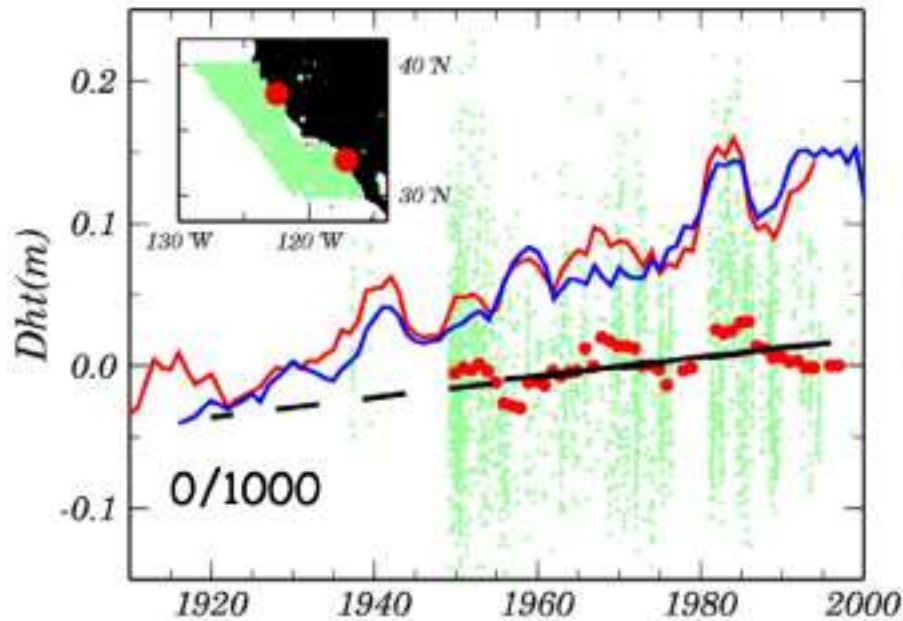
2.1 mm/yr

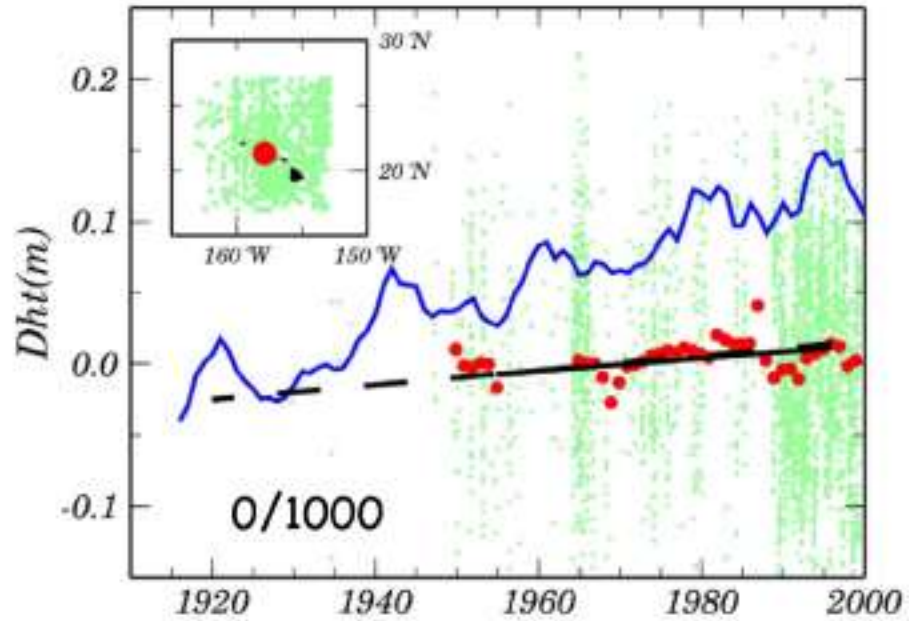
Dyn Ht Anomaly

vs.

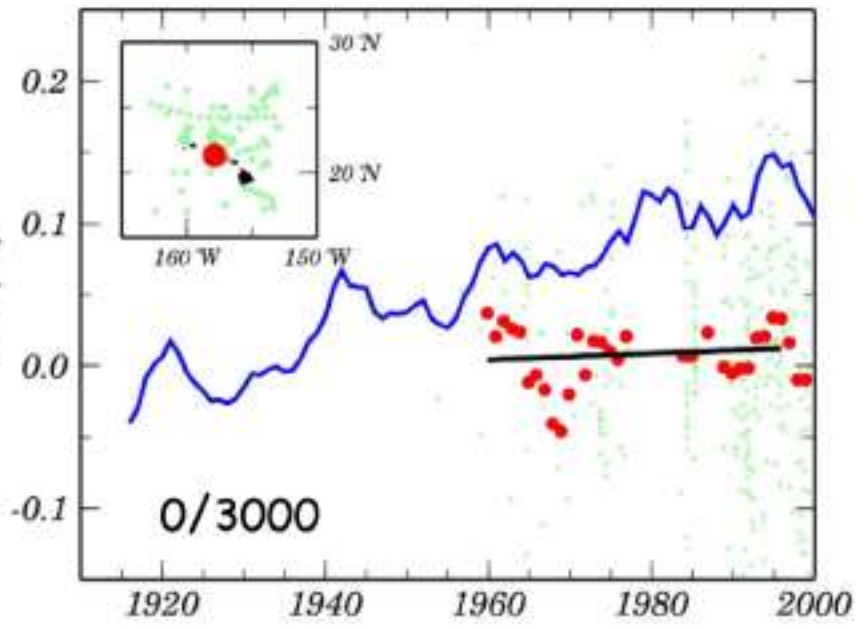
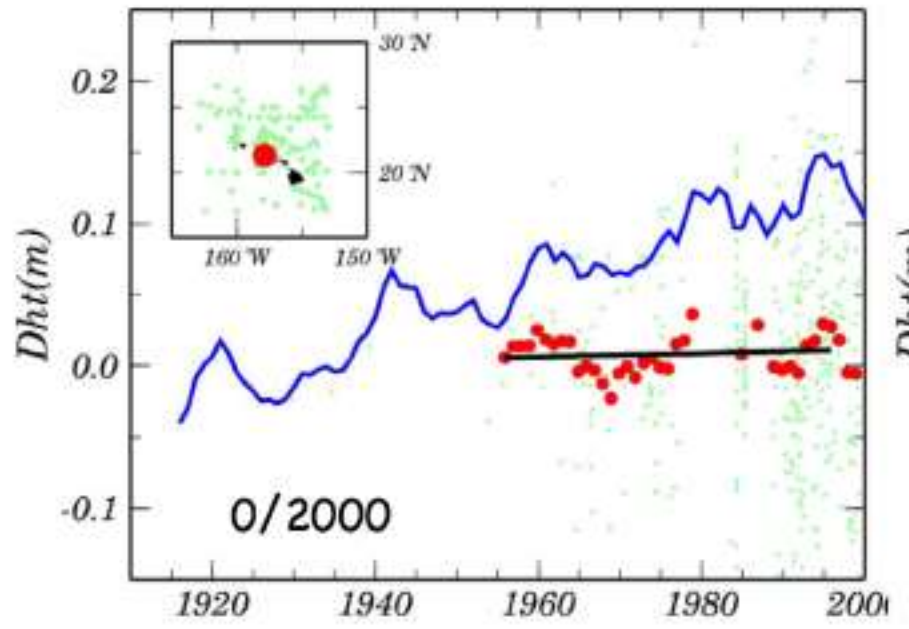
Distance Off West Coast

0.7 mm/yr



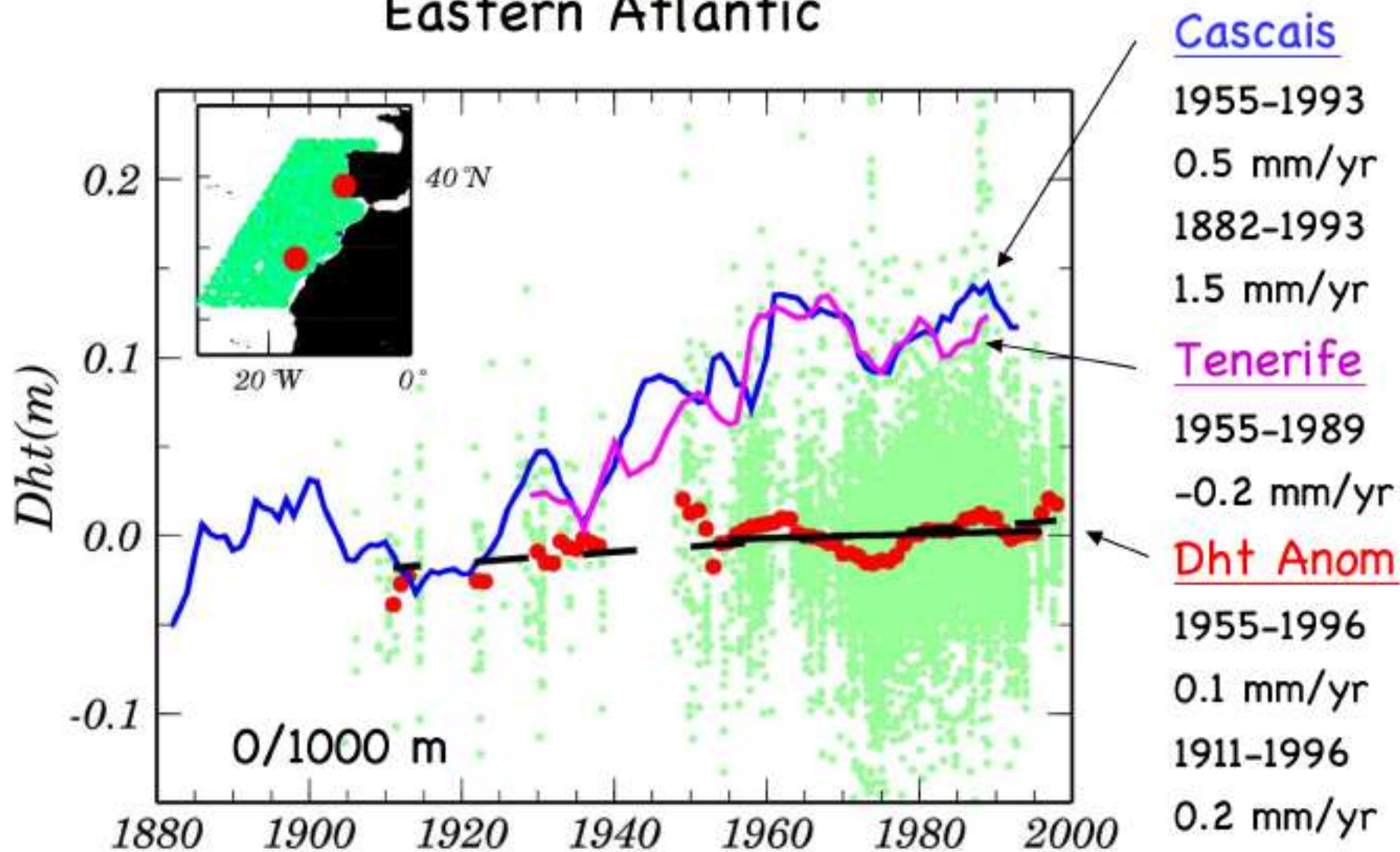


Dynamic Ht Anomaly
vs.
Depth at Honolulu

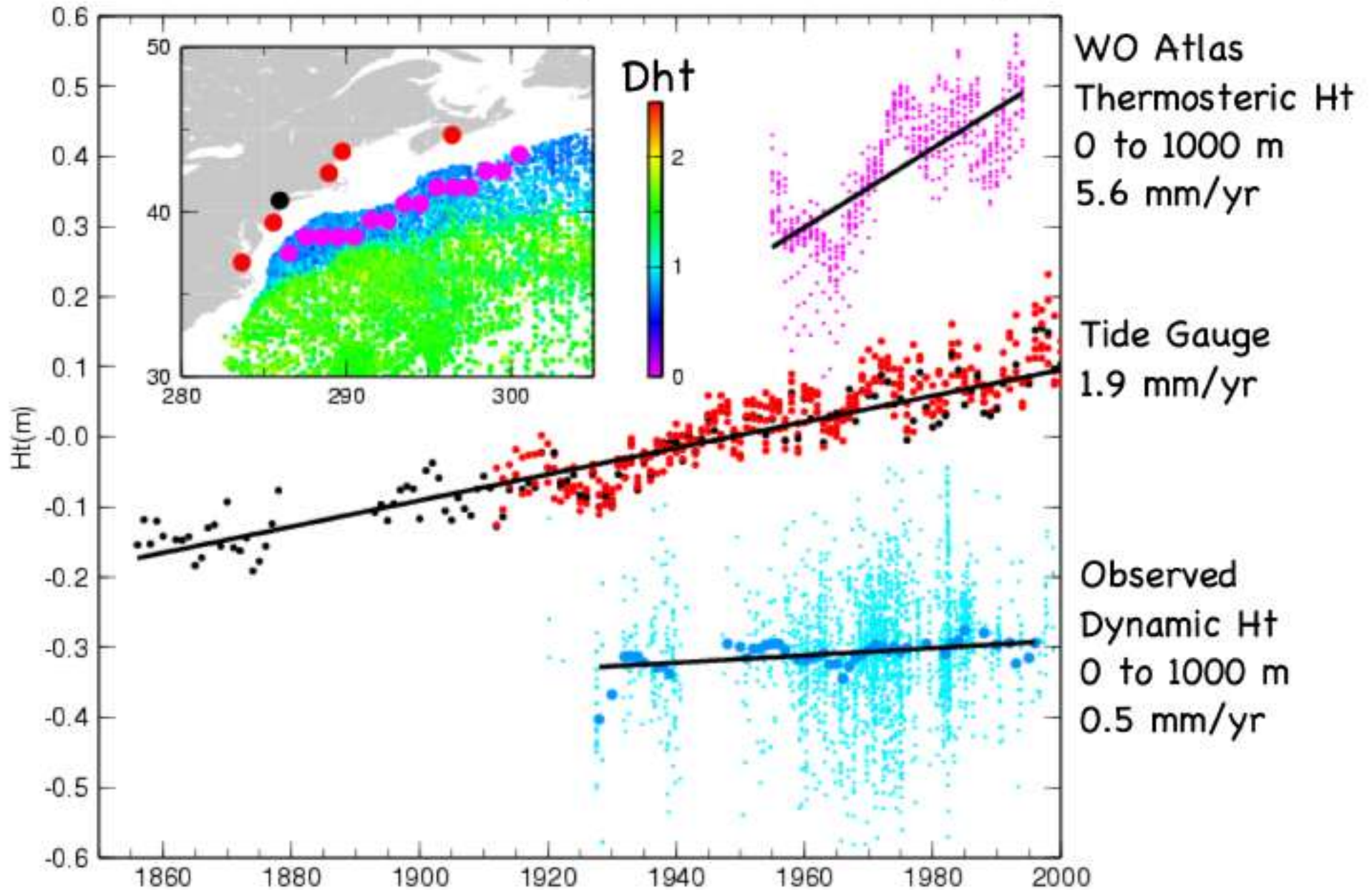


Dynamic Ht Anomaly vs. Gauge Sea Level

Eastern Atlantic

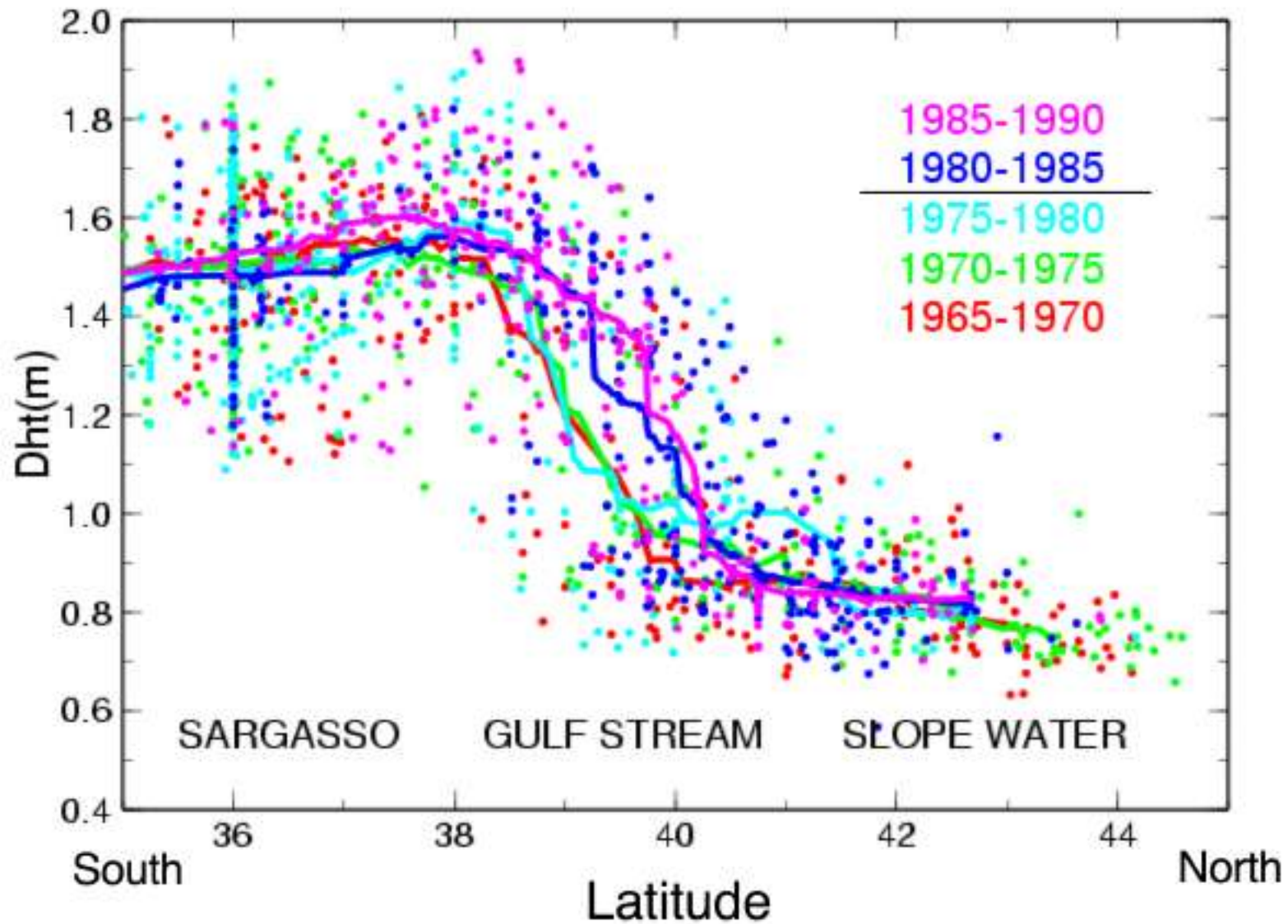


Western Atlantic Dynamic Ht vs Gauge Sea Level



North/South Position of Gulf Stream

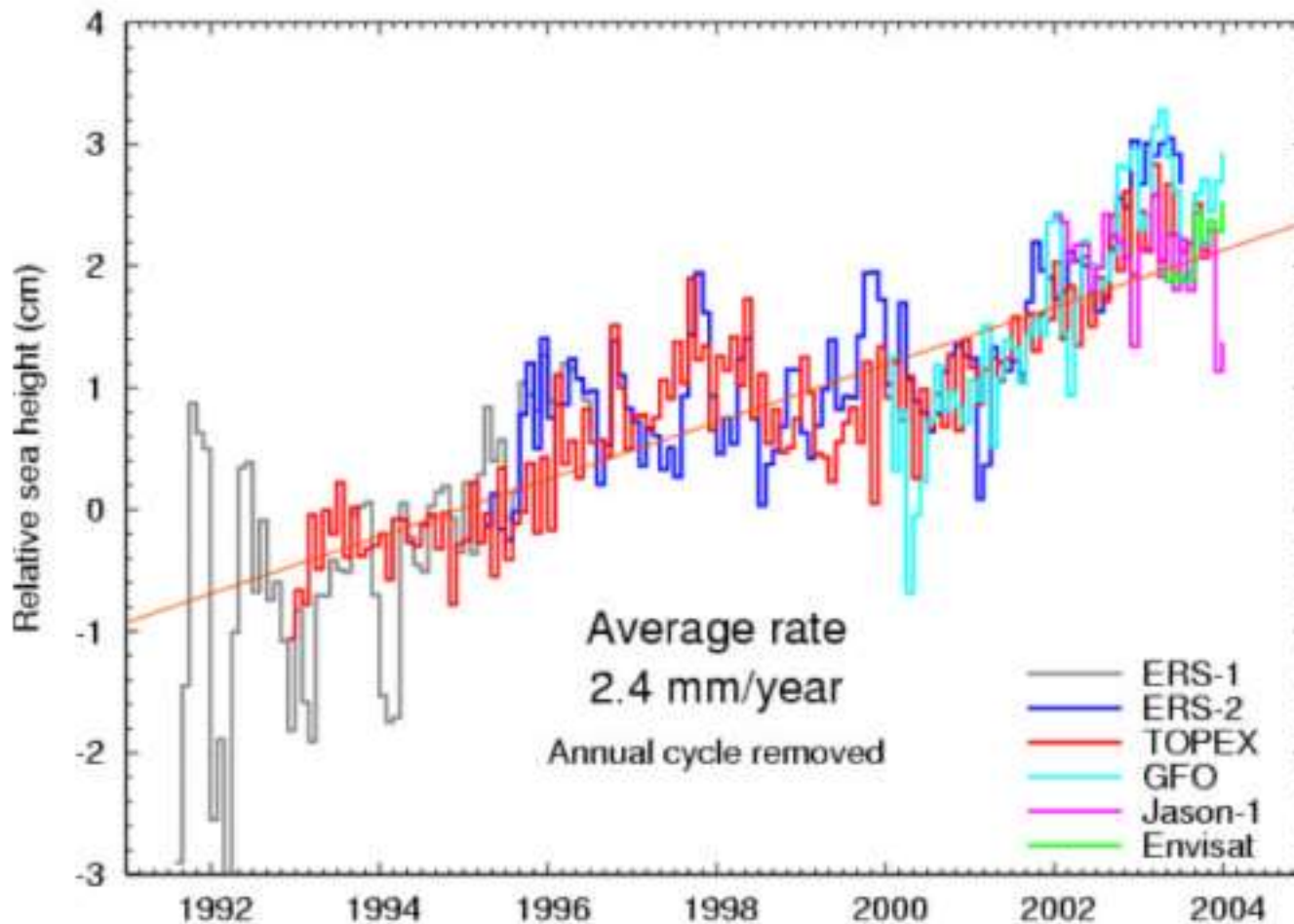
Dynamic Ht (0to1000m) Between 55W & 65 W



CONCLUSIONS

- Tide gauges are not biased high.
- 20th century rate for sea level rise is close to **2 mm/yr**, near the upper bound of the IPCC2001 report.
- Surprisingly, most of this is due to mass increase -- presumably melting of continental ice -- rather than the conventional explanation of ocean warming

Multi-satellite Altimetric Sea Level Change: 1992 to 2003

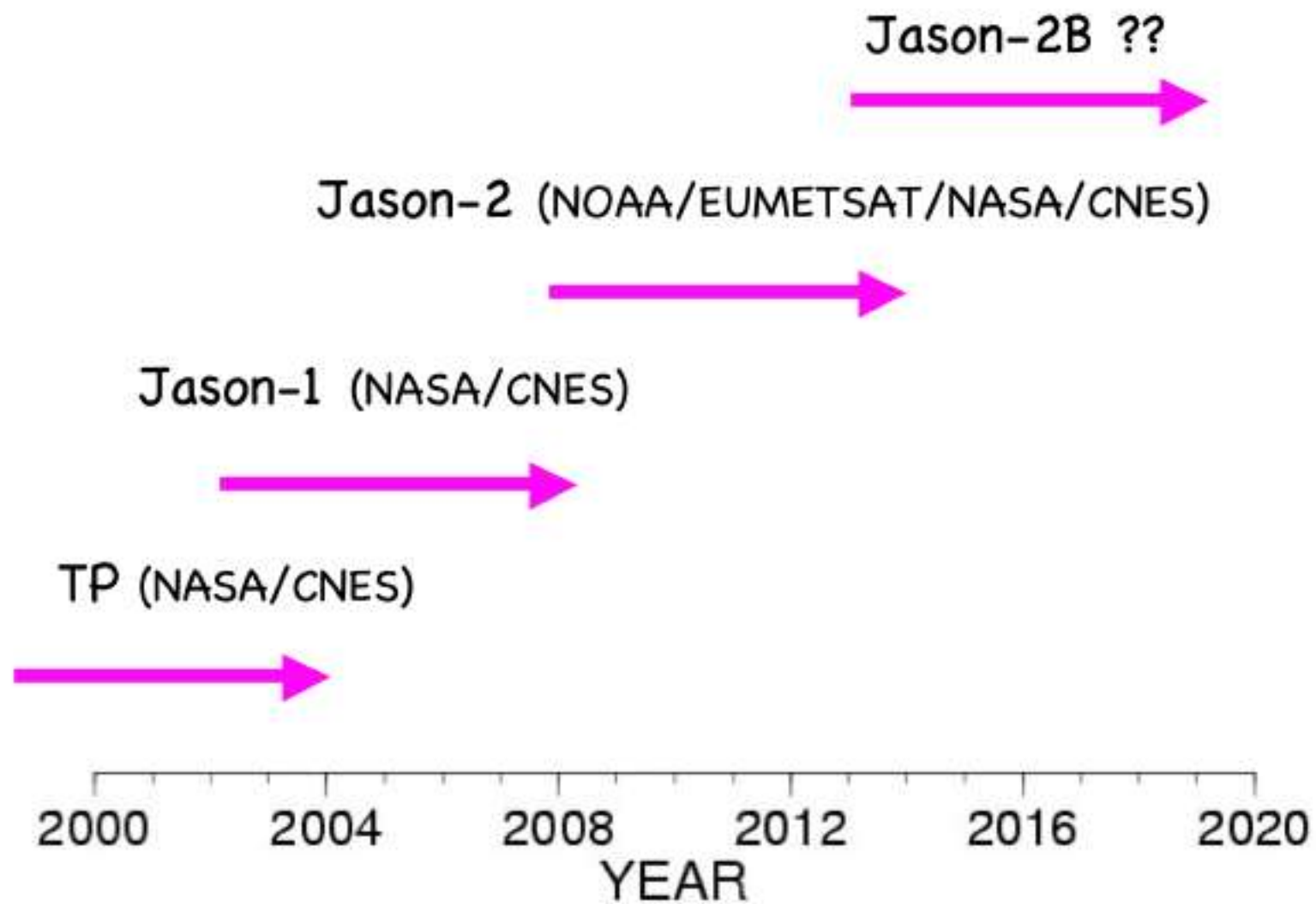


Remko Scharroo/NOAA

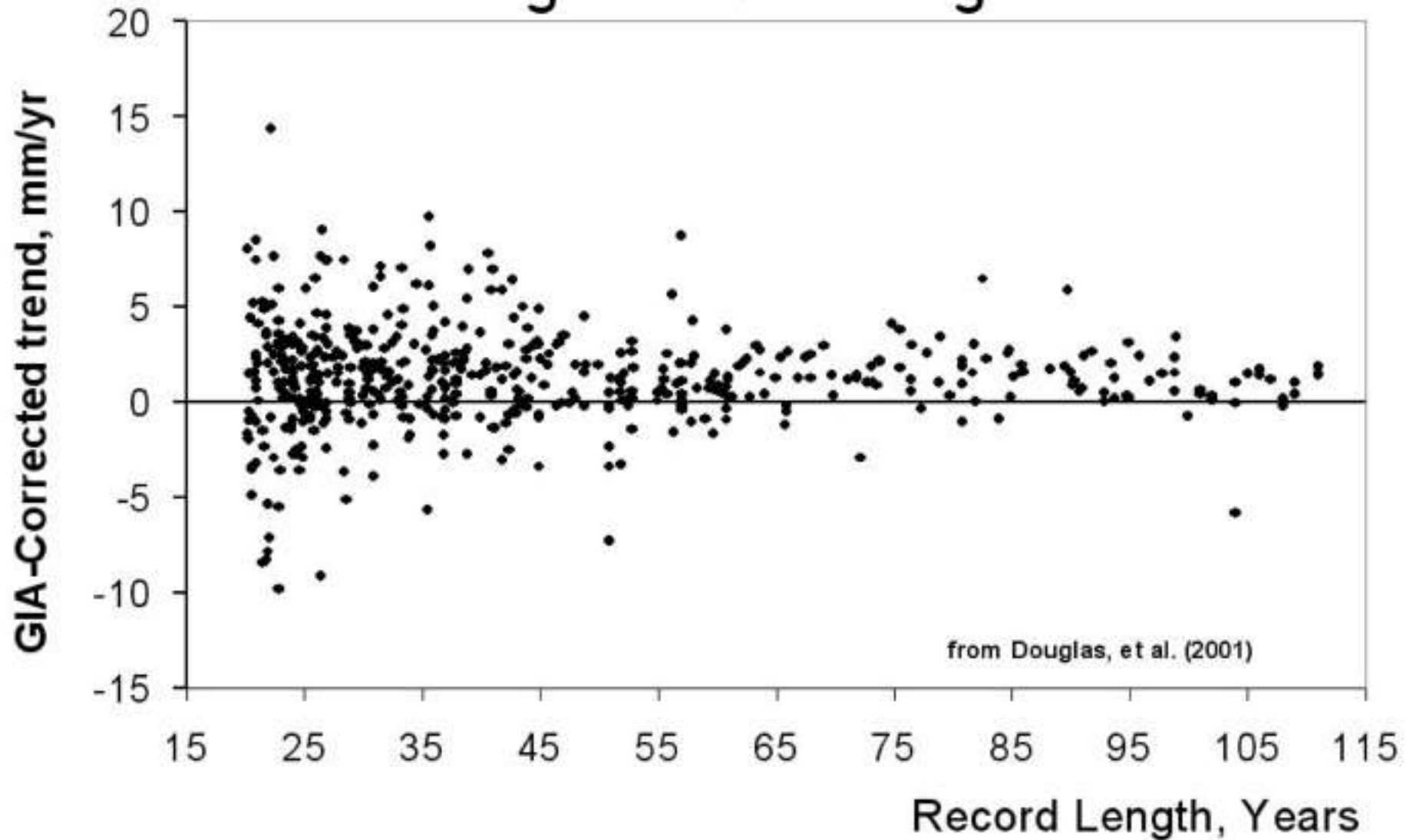
Sea Level Observing System Issues

- Keep the TP/Jason altimeter time series going
- Keep the tide gauge calibration network going
- Keep the ARGO profiling array going
- Pay more attention to the "Early Detection Problem"
- Get a new metric

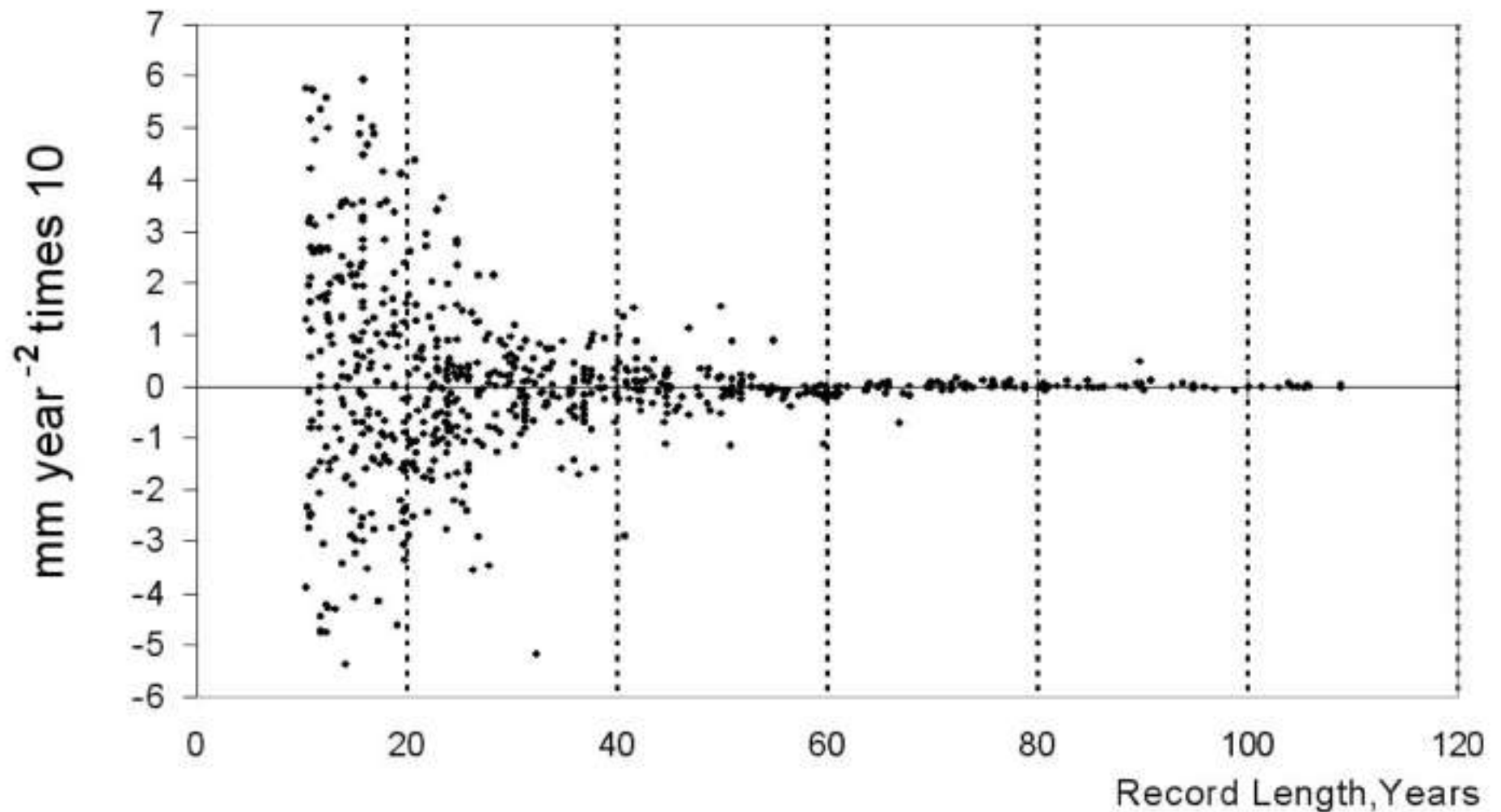
Keep TP/Jason Series Going



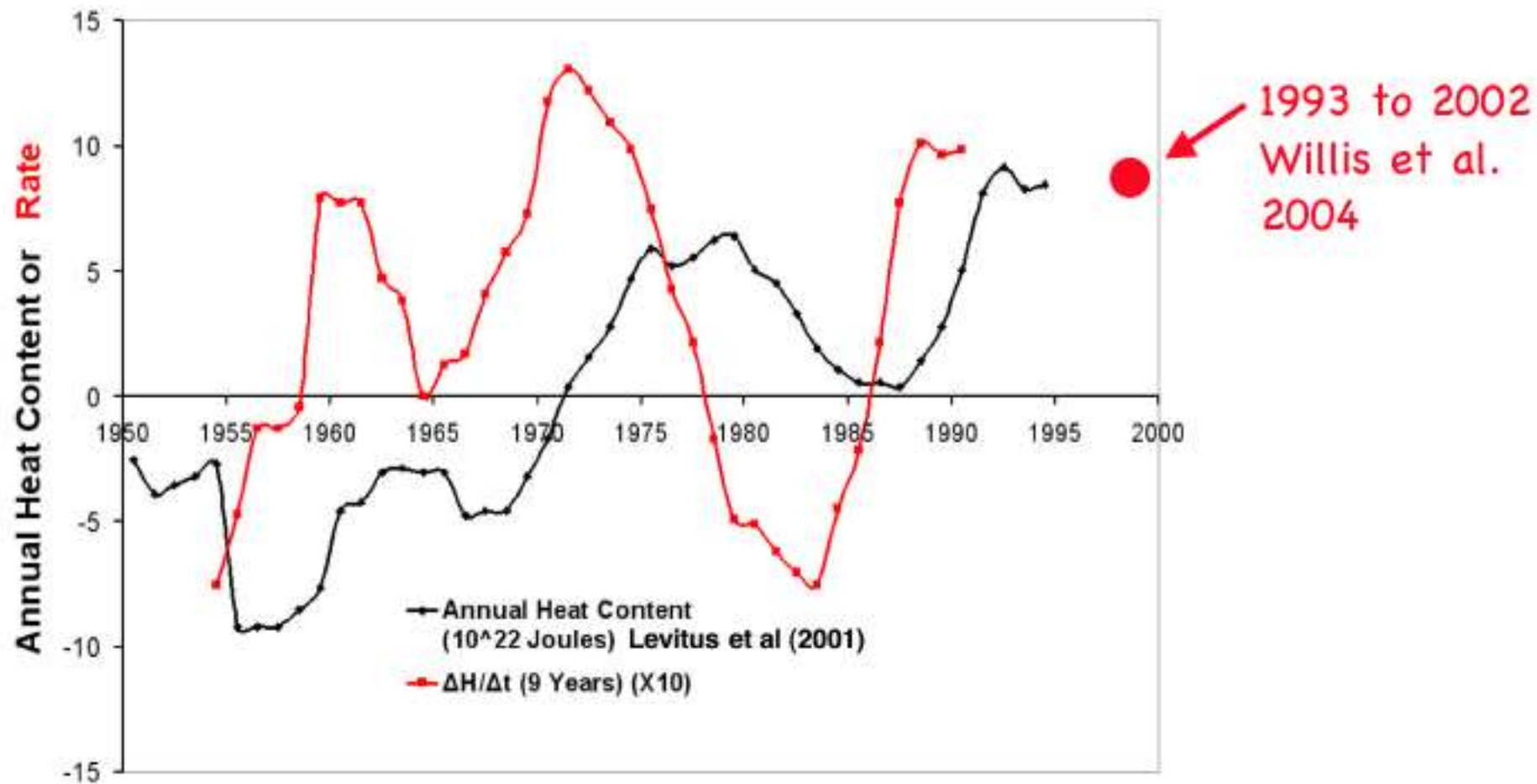
Sea Level Trends As A Function of Tide Gauge Record Length



Sea Level Acceleration as Function Tide Gauge Record Length



Were The 1990's Extraordinary In Terms of Global Ocean Heat Content Change?

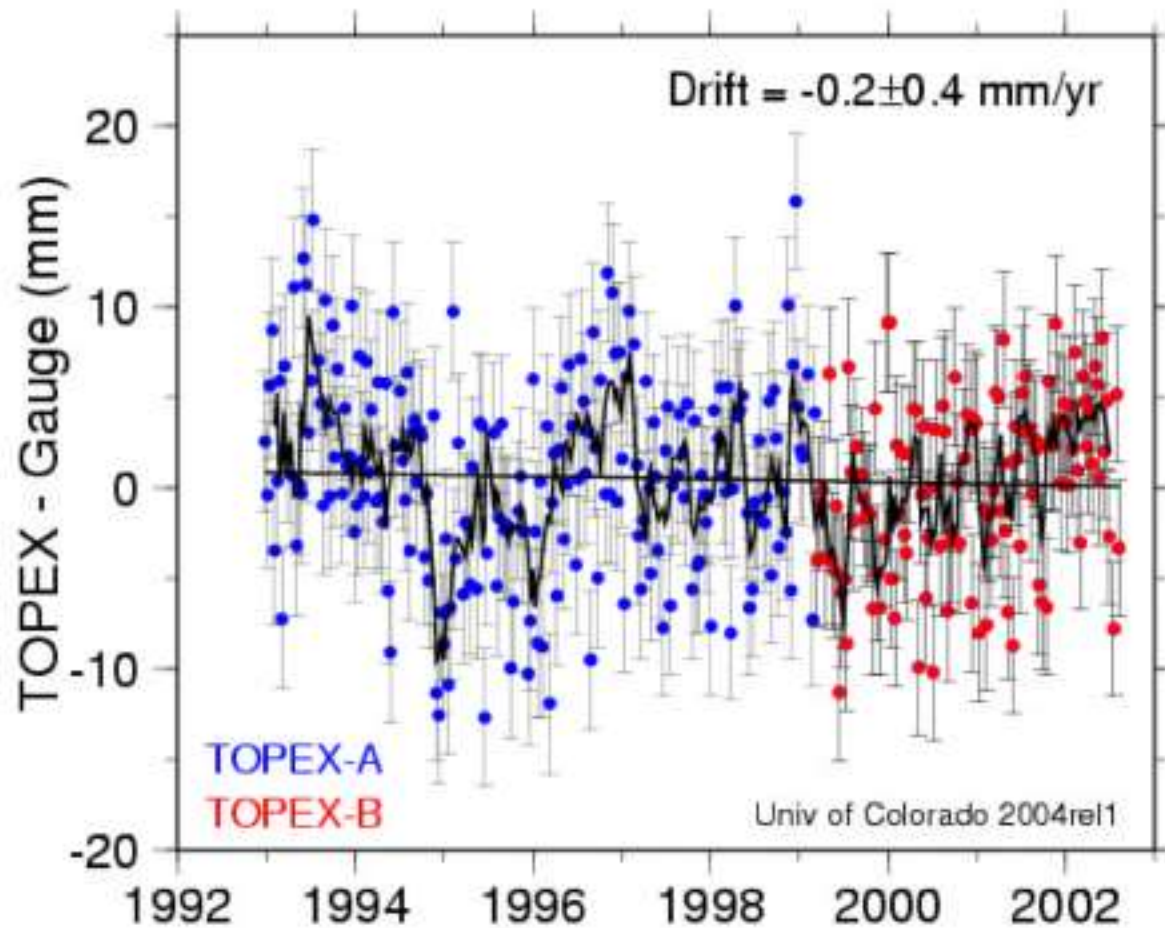


After Willis, Roemmich & Cornuelle (2004)

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TOPEX Altimeter - Tide Gauge Calibration

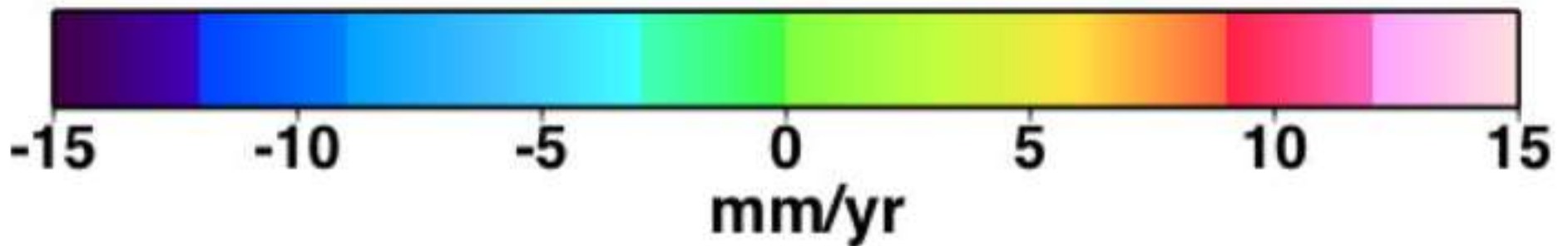
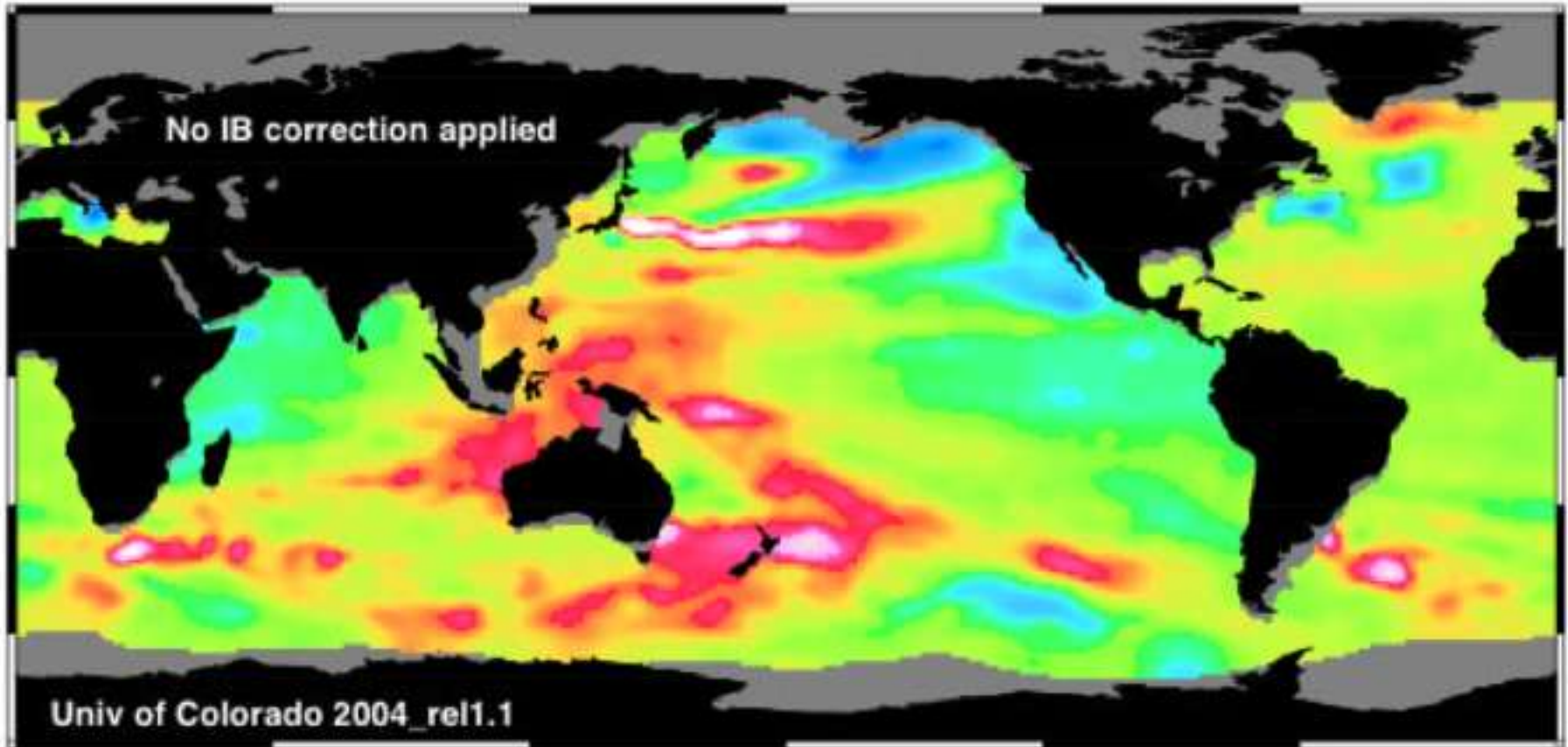


Each point represents the average ALT-TG for 108 gauge sites

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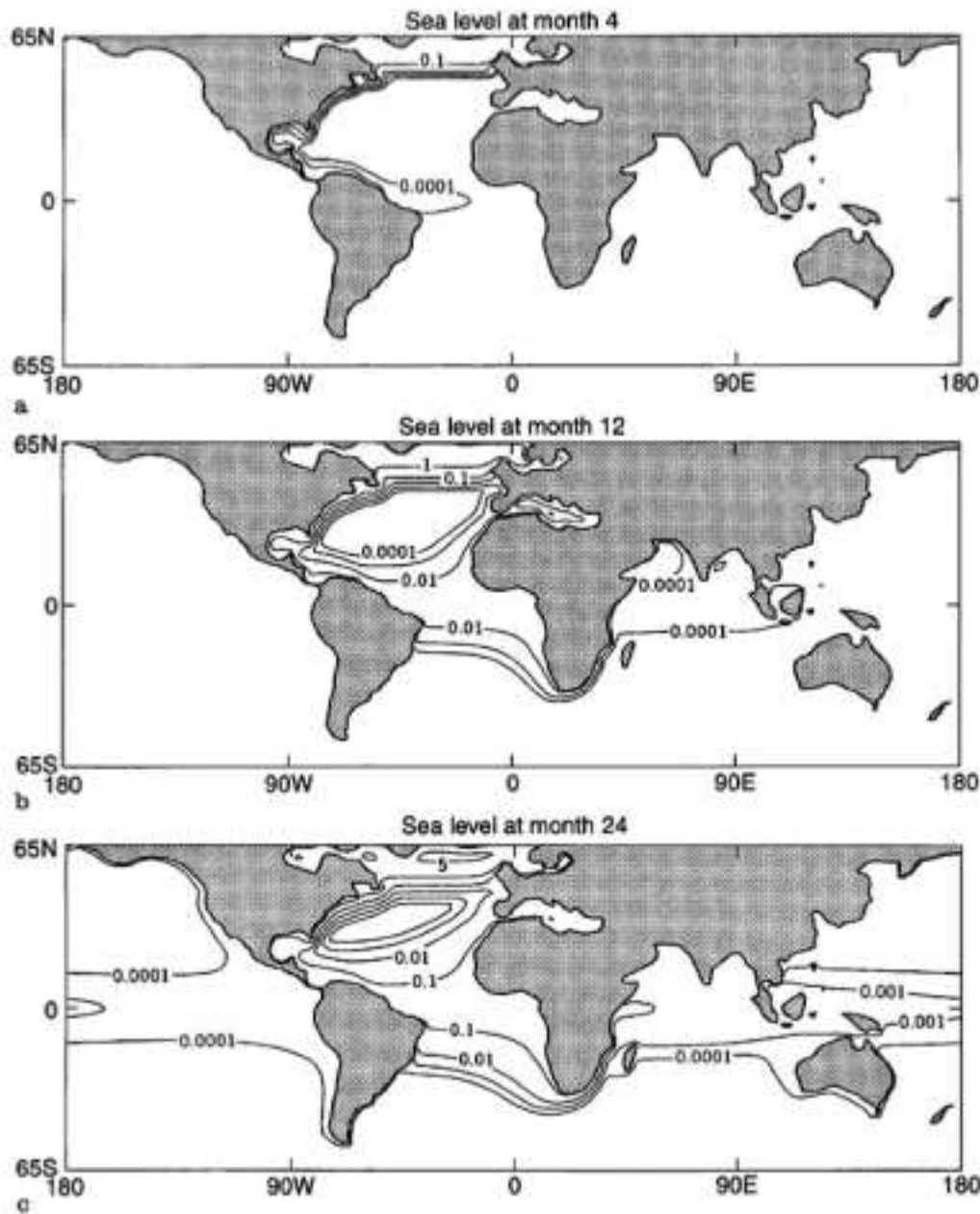
Satellite Altimeter Sea Level Trends 1993-2004



Sea Level Observing System Issues

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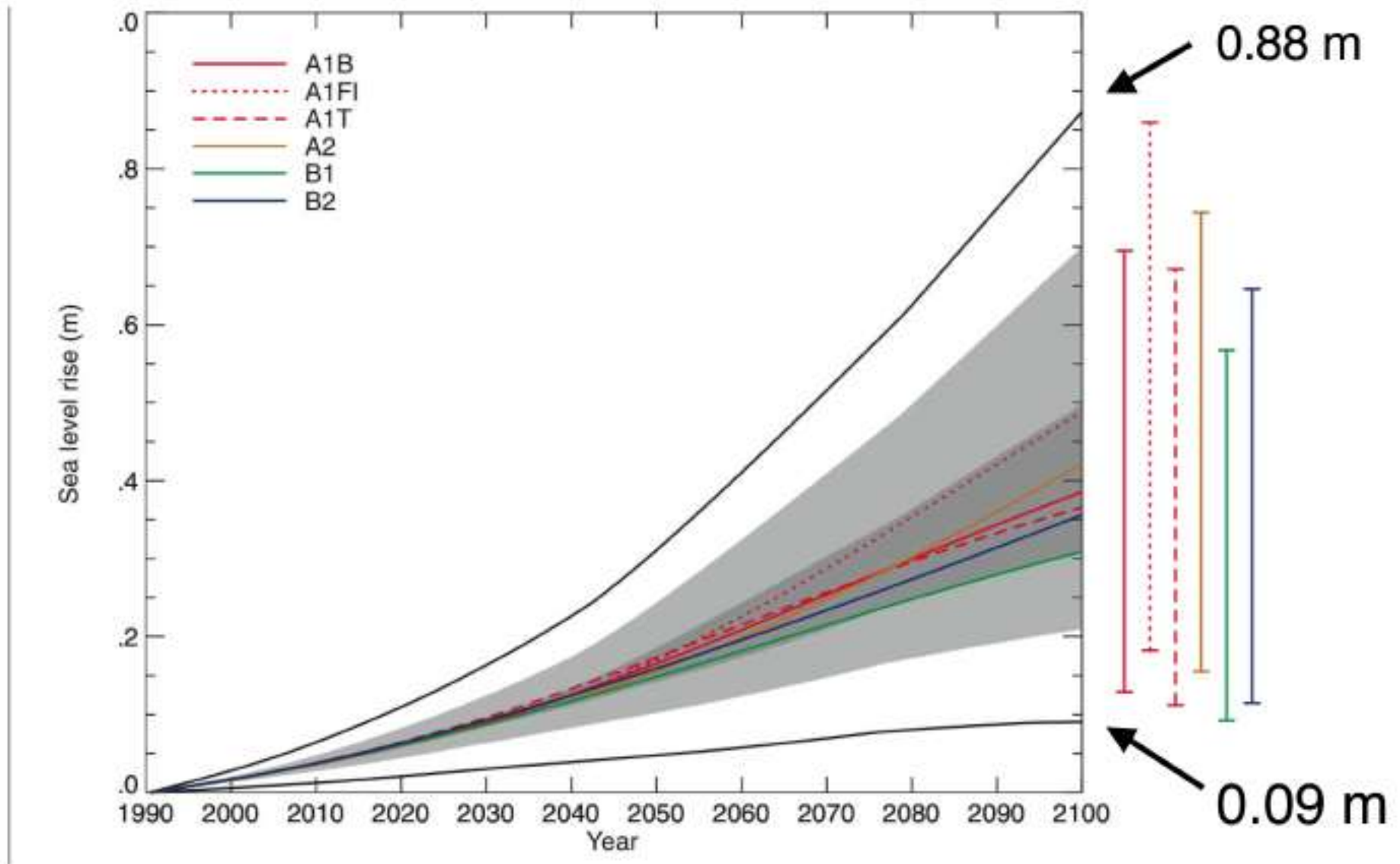
Sea Level Response
To North Atlantic
Heating Experiment
(Hsieh & Bryan, 1996)



Sea Level Observing System Issues

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- Get a new metric

Predicted Global Sea Level Rise: 1990 to 2100 for SRES Scenarios (IPCC 2001)



SO THESE SCIENTISTS DID THIS EXPERIMENT THAT IF YOU DROP A FROG INTO BOILING WATER HE JUMPS OUT.



BUT IF YOU PUT HIM IN WARM WATER AND HEAT IT SLOWLY, HE JUST SWIMS AROUND UNTIL HE'S COOKED.

WHAT'S THE POINT OF THAT EXPERIMENT?



BEATS ME.

SCIENTISTS. GO FIGURE.

PROBABLY THE SAME ONES STUDYING GLOBAL WARMING.



HEY, LET'S SWIM AROUND SOME MORE! - BA

TOLES

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