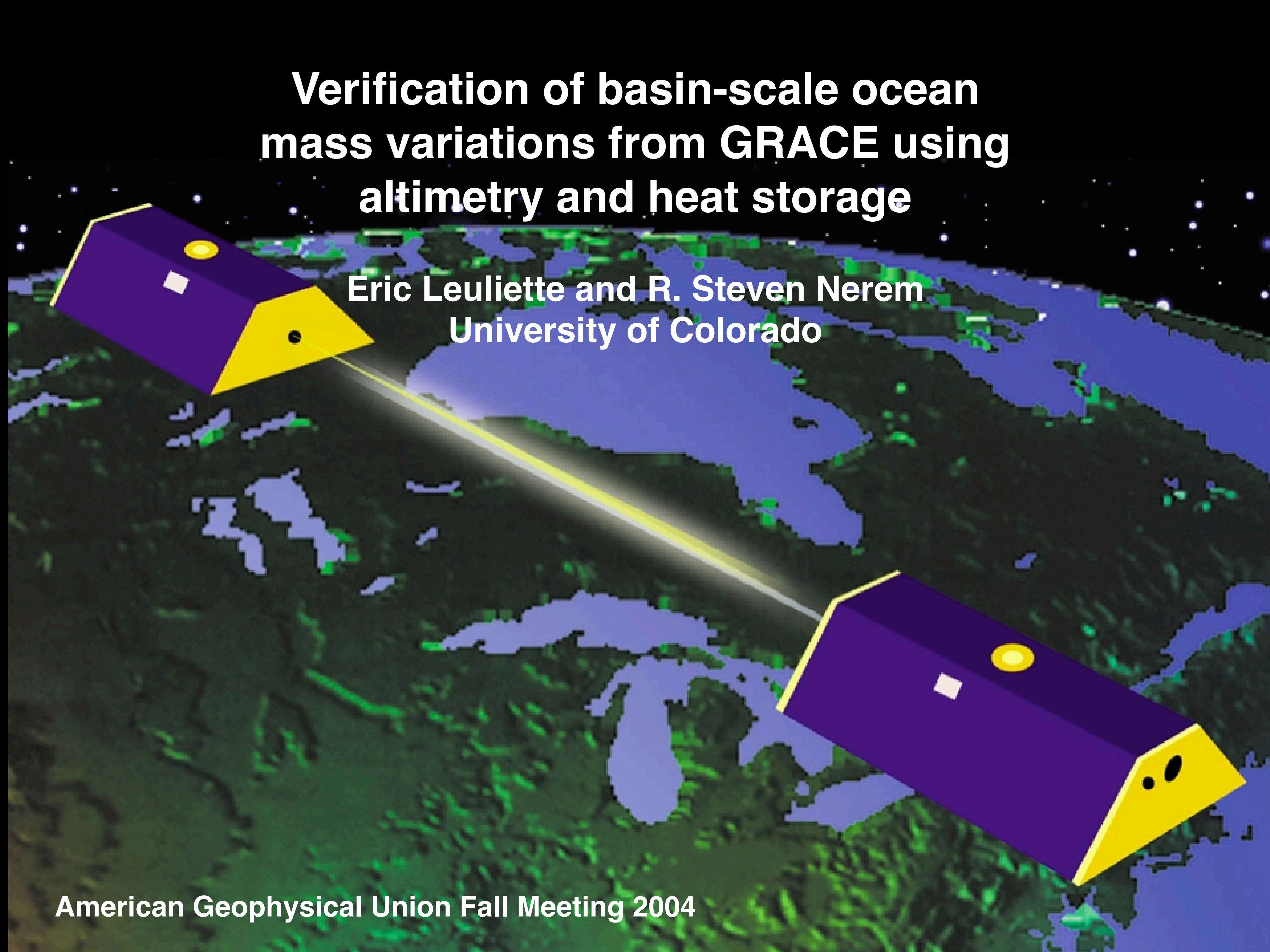
Verification of basin-scale ocean mass variations from GRACE using altimetry and heat storage

Eric Leuliette and R. Steven Nerem
University of Colorado



American Geophysical Union Fall Meeting 2004

GRACE verification using heat storage

Chambers *et al.* [2004] showed that GRACE observations of ocean mass variations are consistent with a seasonal mean climatology determined from satellite altimetry corrected for steric variations.

GRACE observations should also be consistent with contemporaneous altimetry and in situ steric observations.

The combination of altimetry and heat storage measurements offers an additional method to validate GRACE ocean mass measurements at basin spatial scales.

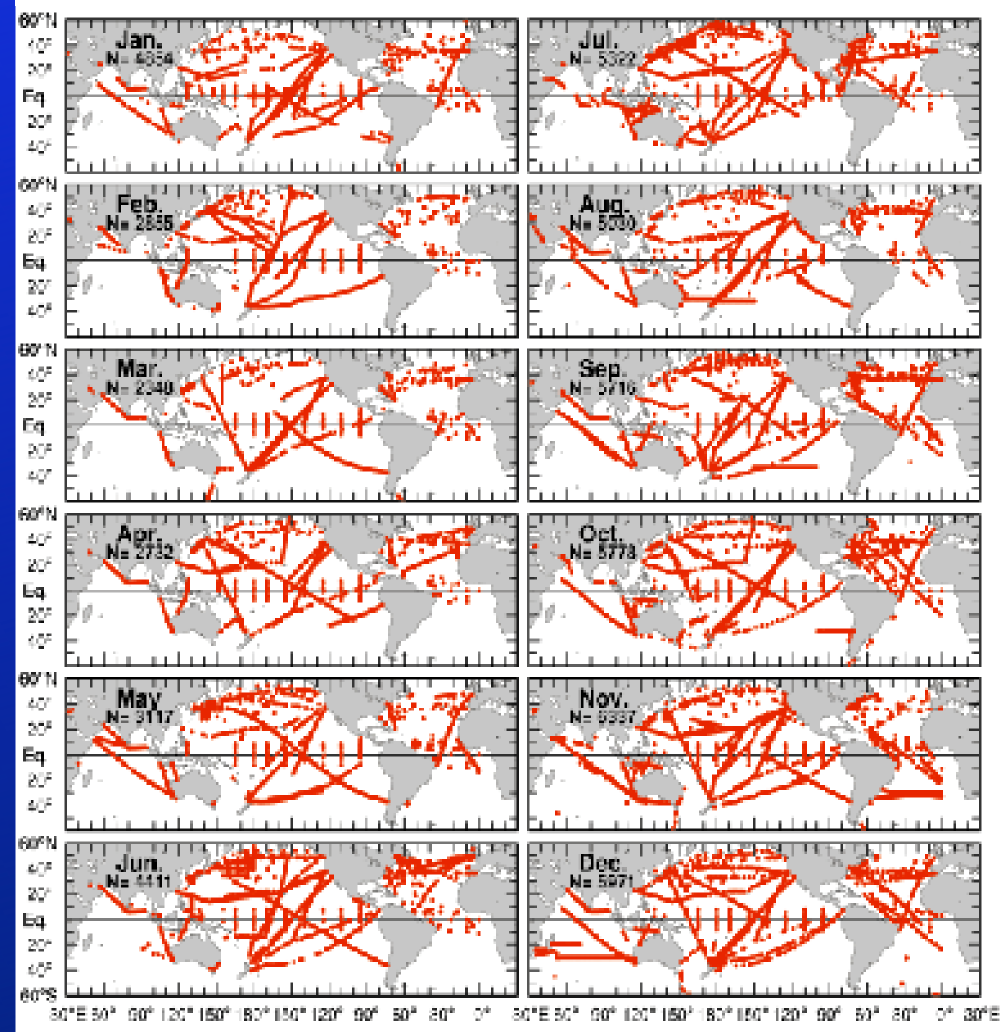
JEDAC Heat Storage Analysis

The Joint Environmental Data Analysis Center (JEDAC) at the Scripps Institution of Oceanography receives bi-monthly XBT temperature-salinity profiles from the Global Temperature-Salinity Profile Program (GTSPP).

GTSPP quality controls profile data for location, duplicates, outliers, and instrument malfunctions.

GTSPP
Global Temperature Salinity Profile Program

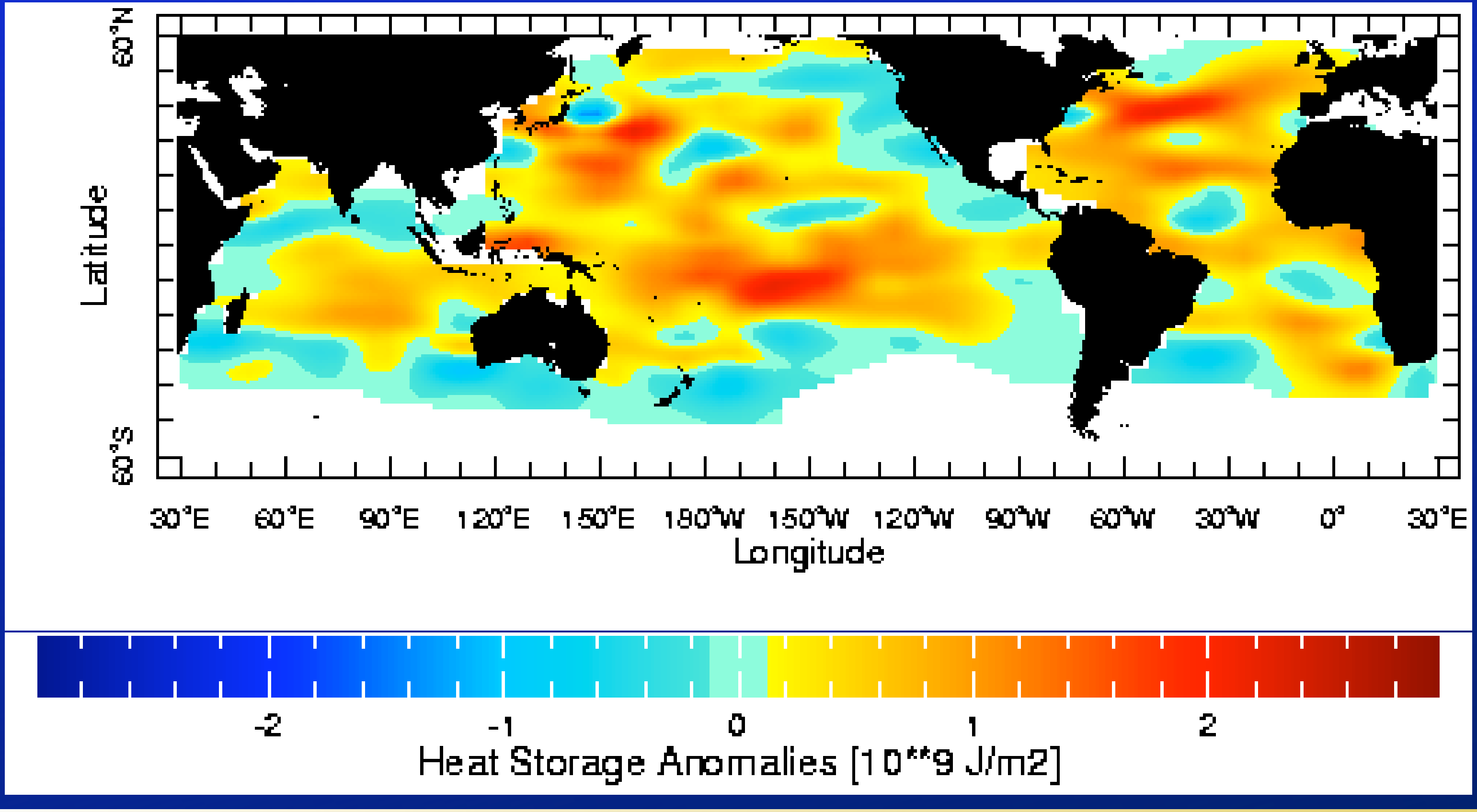
Distribution of Observations for 2003



JEDAC Monthly Heat Storage

The JEDAC applies an optimum interpolation algorithm to derive the heat storage content integrated over 0–400m depth.

Monthly heat storage content grids are provided as anomalies with respect to a climatology.



December 2003

Converting Heat Storage Content to Steric Height

Convert heat storage (ΔH) in J m^{-2} to steric height ($\Delta\zeta$) in meters with

$$\Delta\zeta = \frac{\alpha_{mix}}{\rho_0 C_p}\Delta H$$

$$\alpha_{mix} = 3000 \times 10^{-7}\mathrm{K}^{-1}$$
$$\rho_0 = 1027\ \mathrm{kg\ m}^{-3}$$
$$C_p = 4000\ \mathrm{J\ kg}^{-1}\mathrm{K}^{-1}$$

Limitations

Poor spatial coverage in the Southern Ocean

This analysis restricts all observations to be north of 30°S.

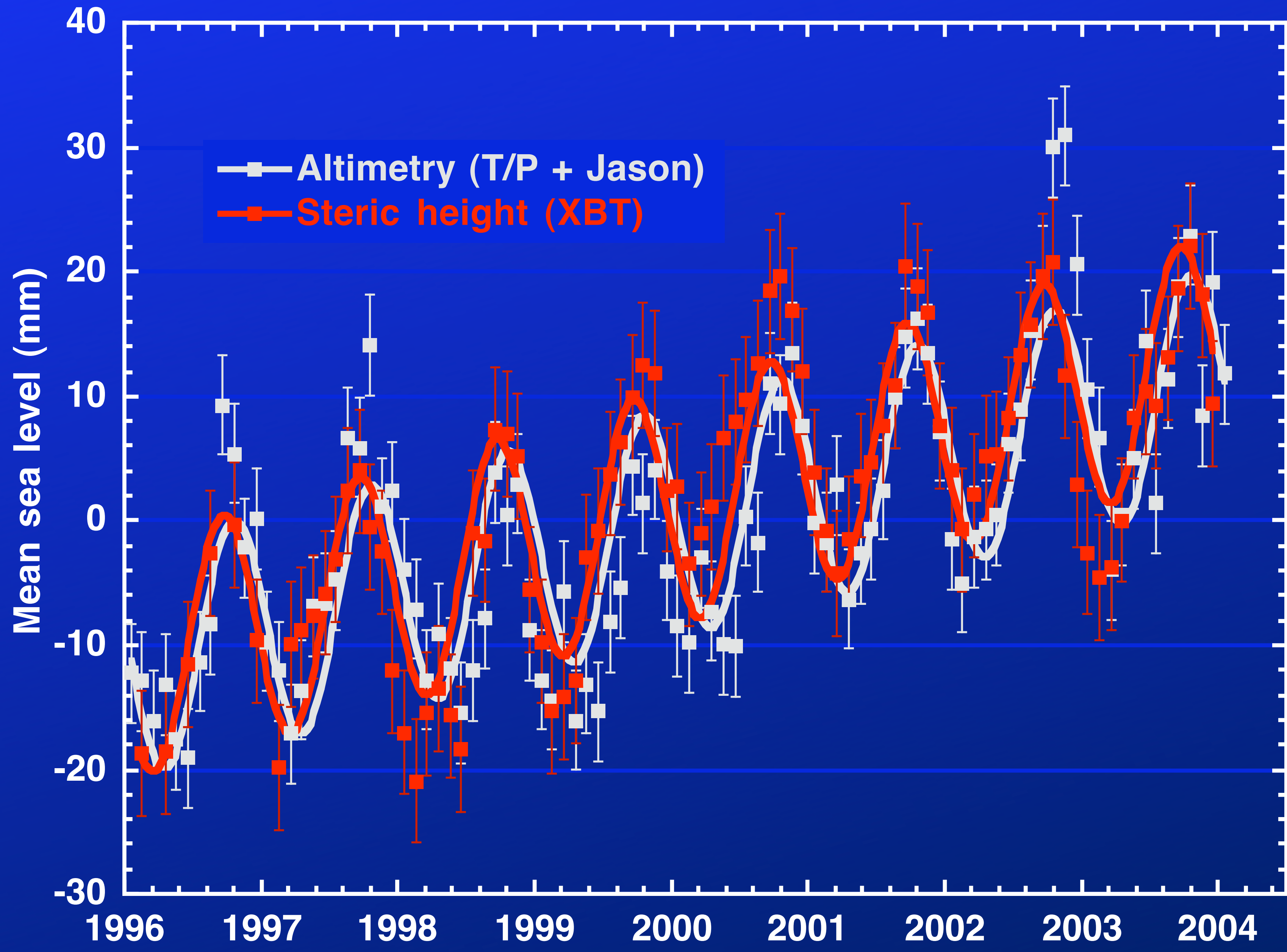
Ignores haline effects

Salinity variations are important locally.

Some oceanography ignored

Ekman pumping, equatorially trapped Kelvin waves, and baroclinic Rossby waves, etc.

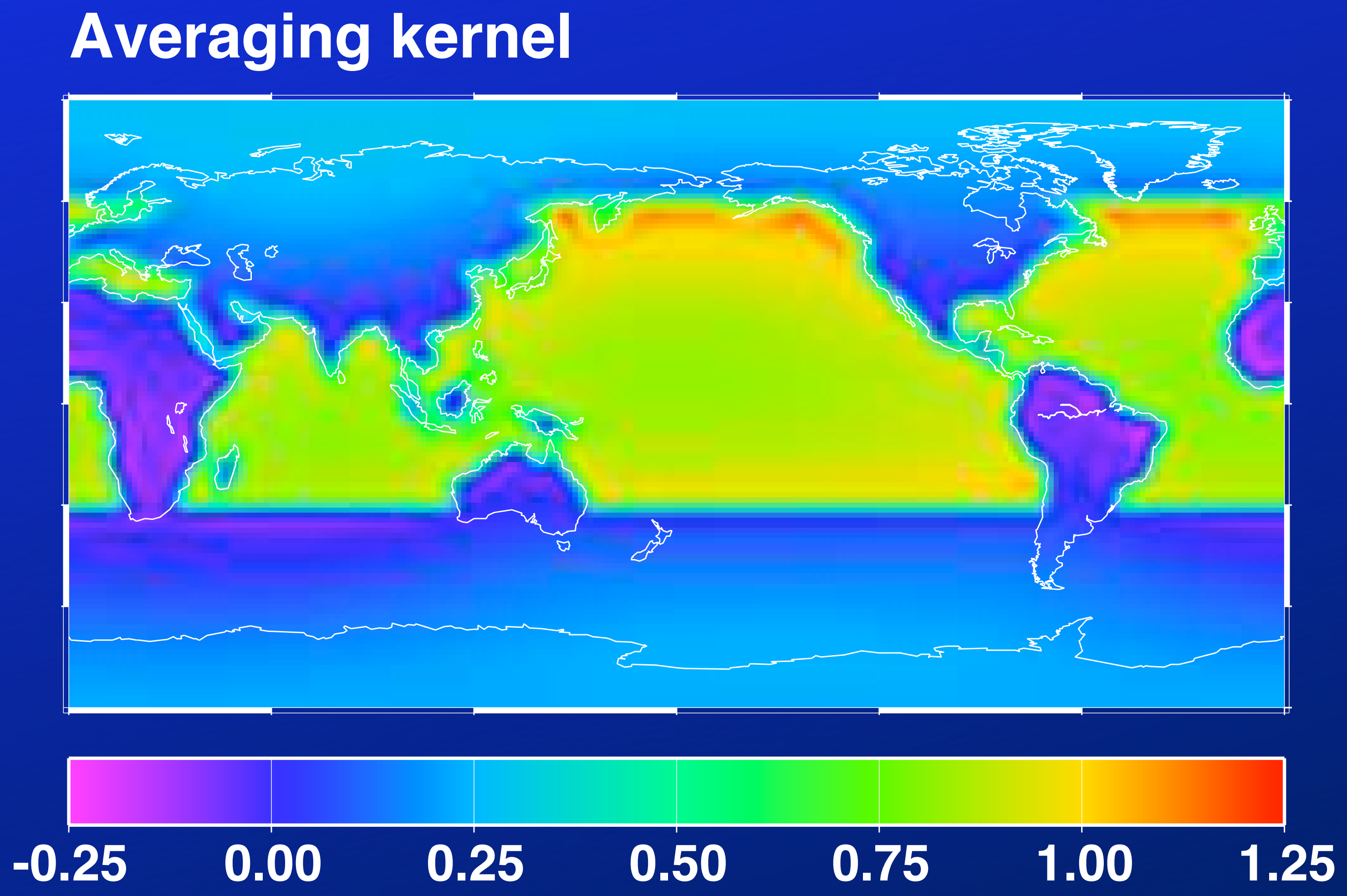
Sea level: Altimetry vs. Steric (Heat Storage)



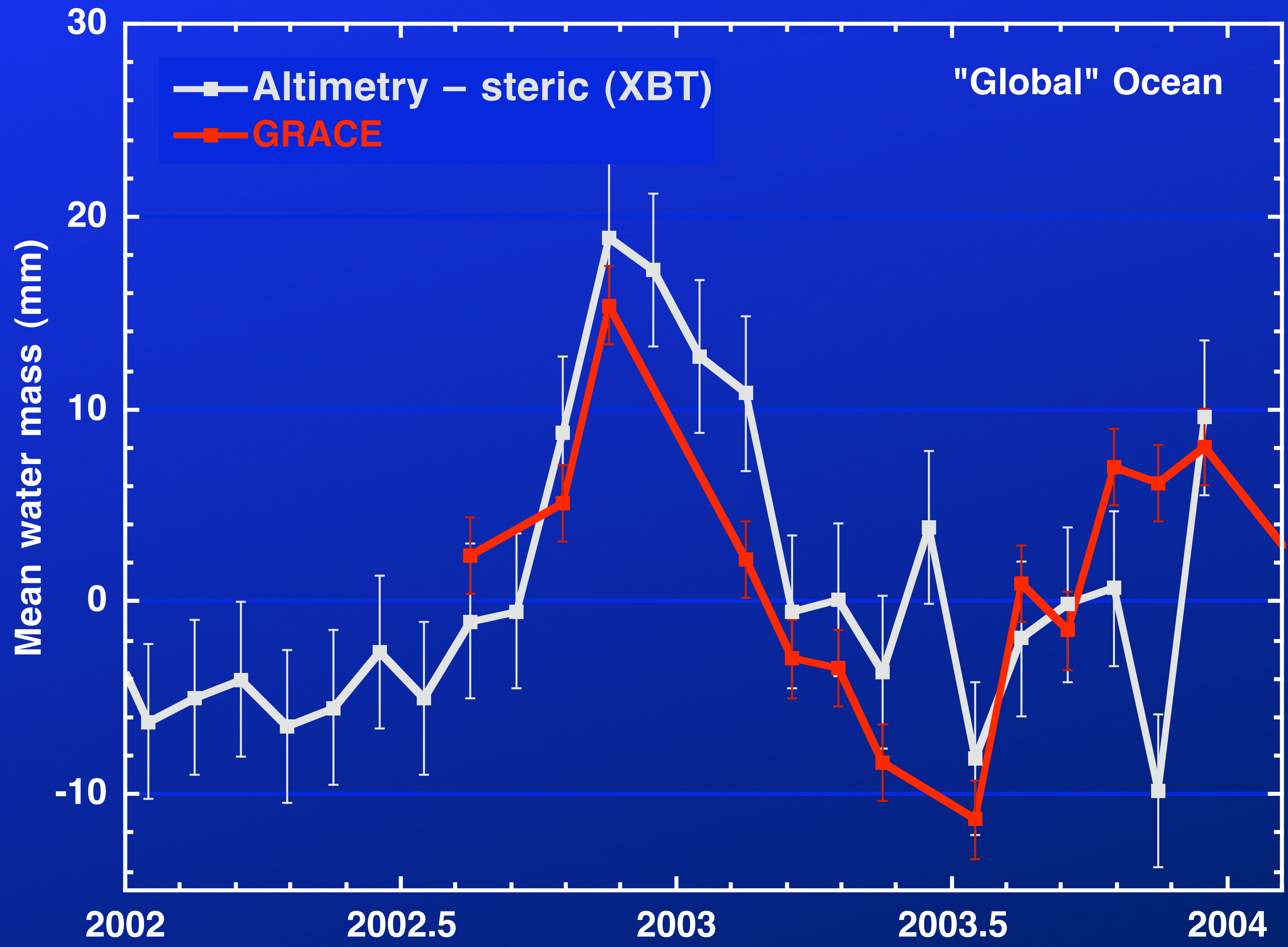
GRACE data processing

- The barotropic model removed as part of GRACE processing has been restored.
- The ocean pole tide has been applied to be consistent with TOPEX/POSIEDON and Jason altimetry.
- Geocenter (degree 1) variations from annual fits to SLR analysis (Chen *et al.*, 1999) have been included.

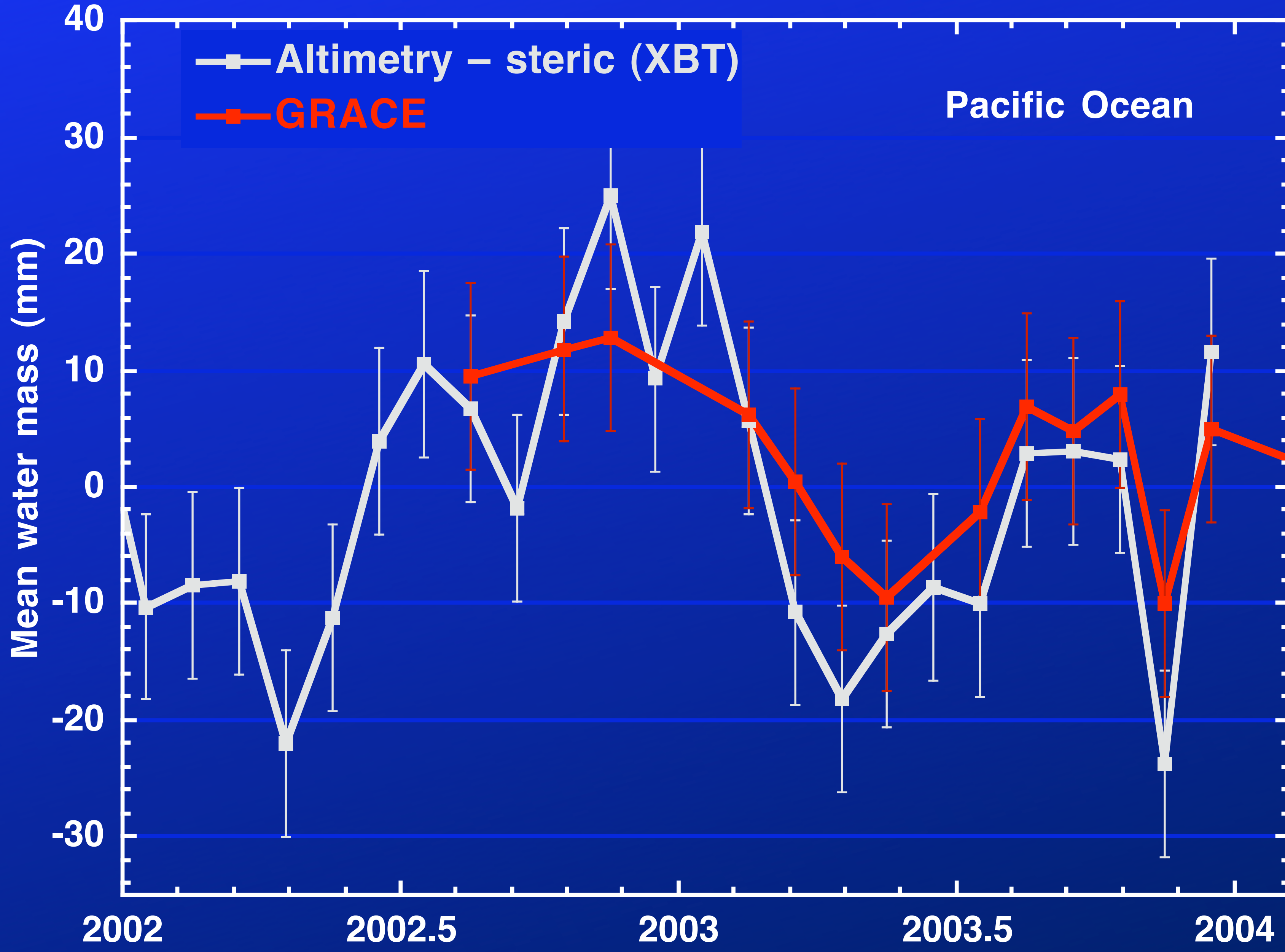
Mass variations computed from GRACE coefficients weighted with an averaging kernel. [Swenson and Wahr, 2002]



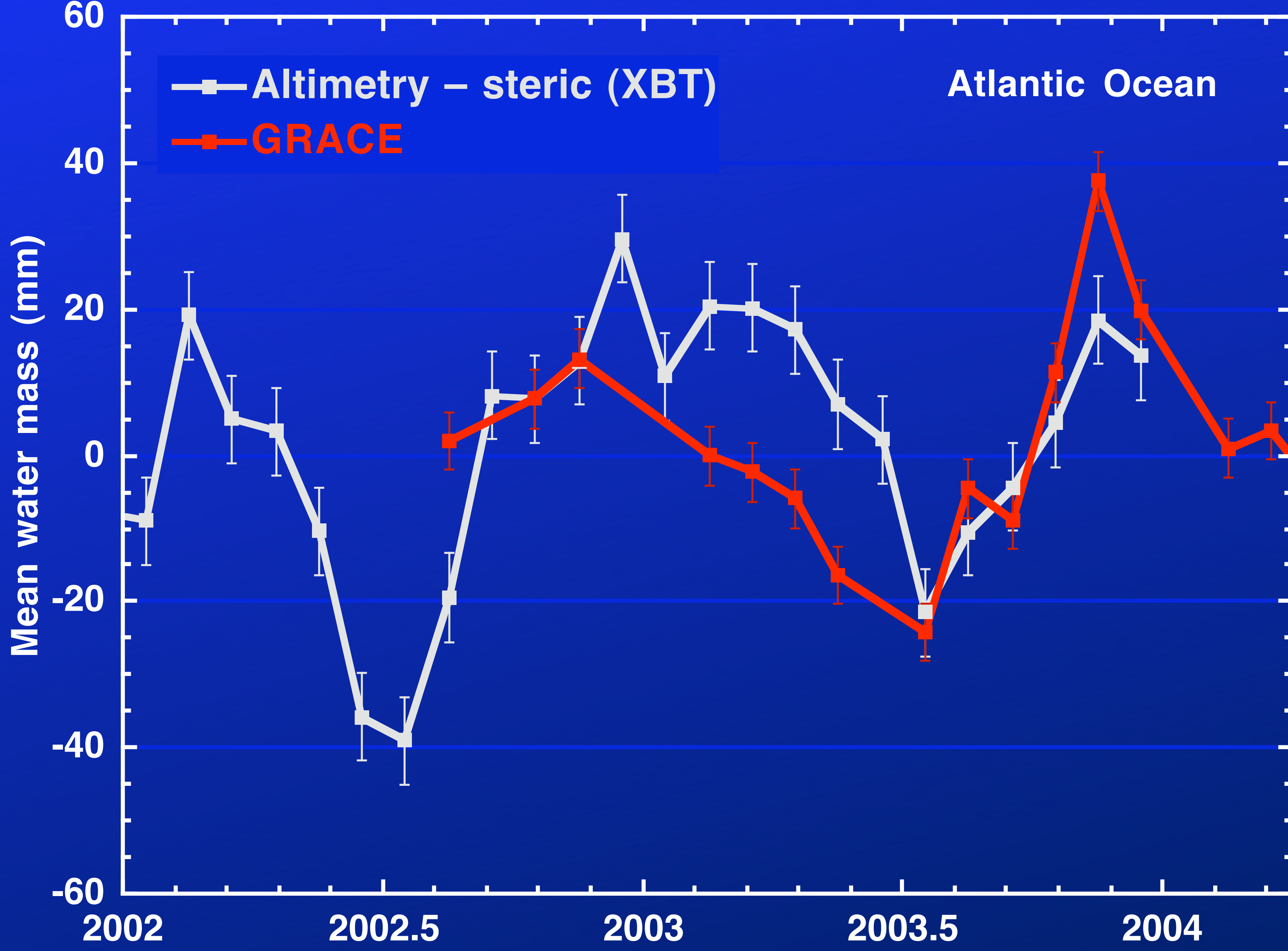
Global Ocean (60°N – 30°S)



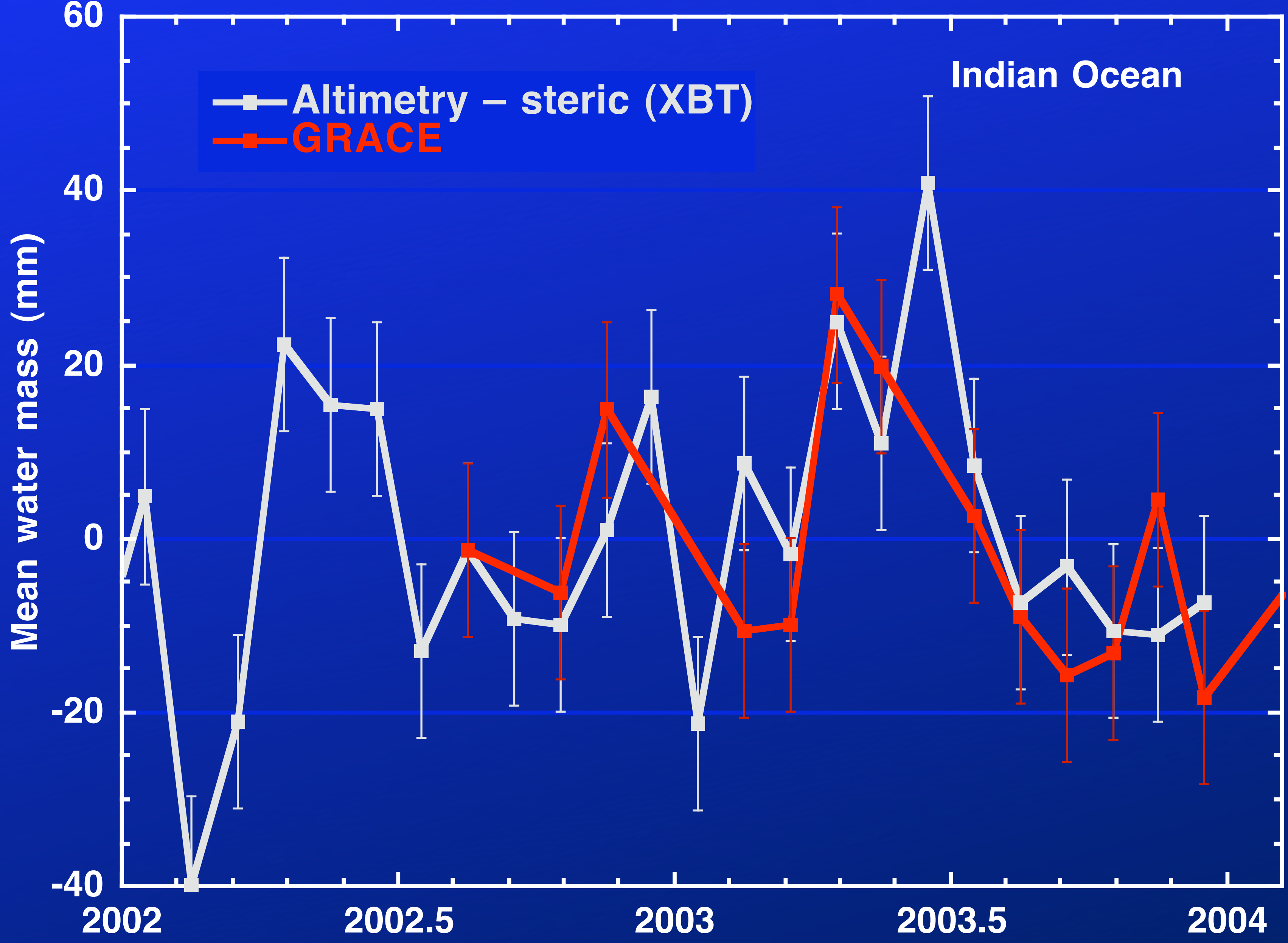
Pacific Ocean



Atlantic Ocean



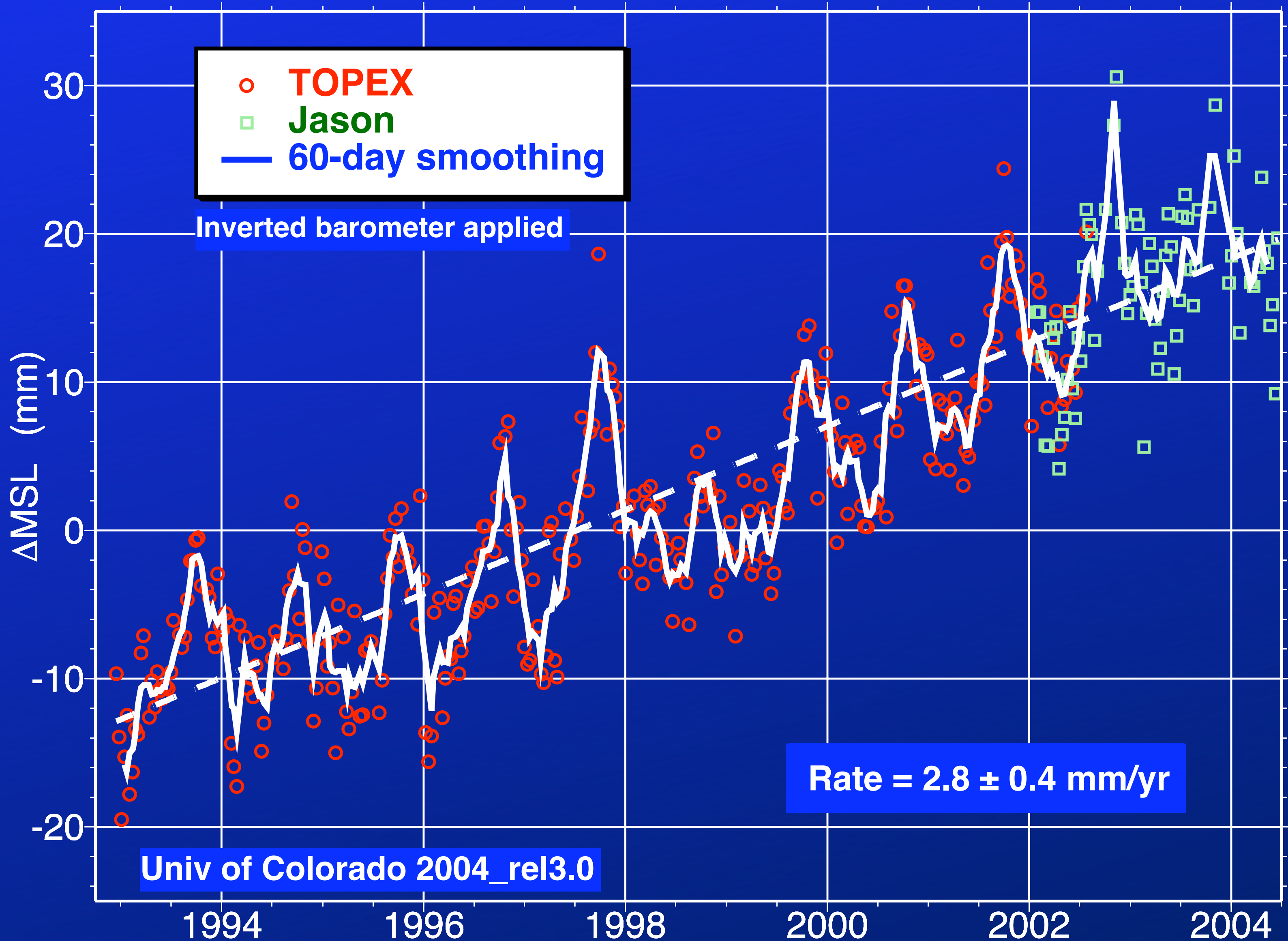
Indian Ocean



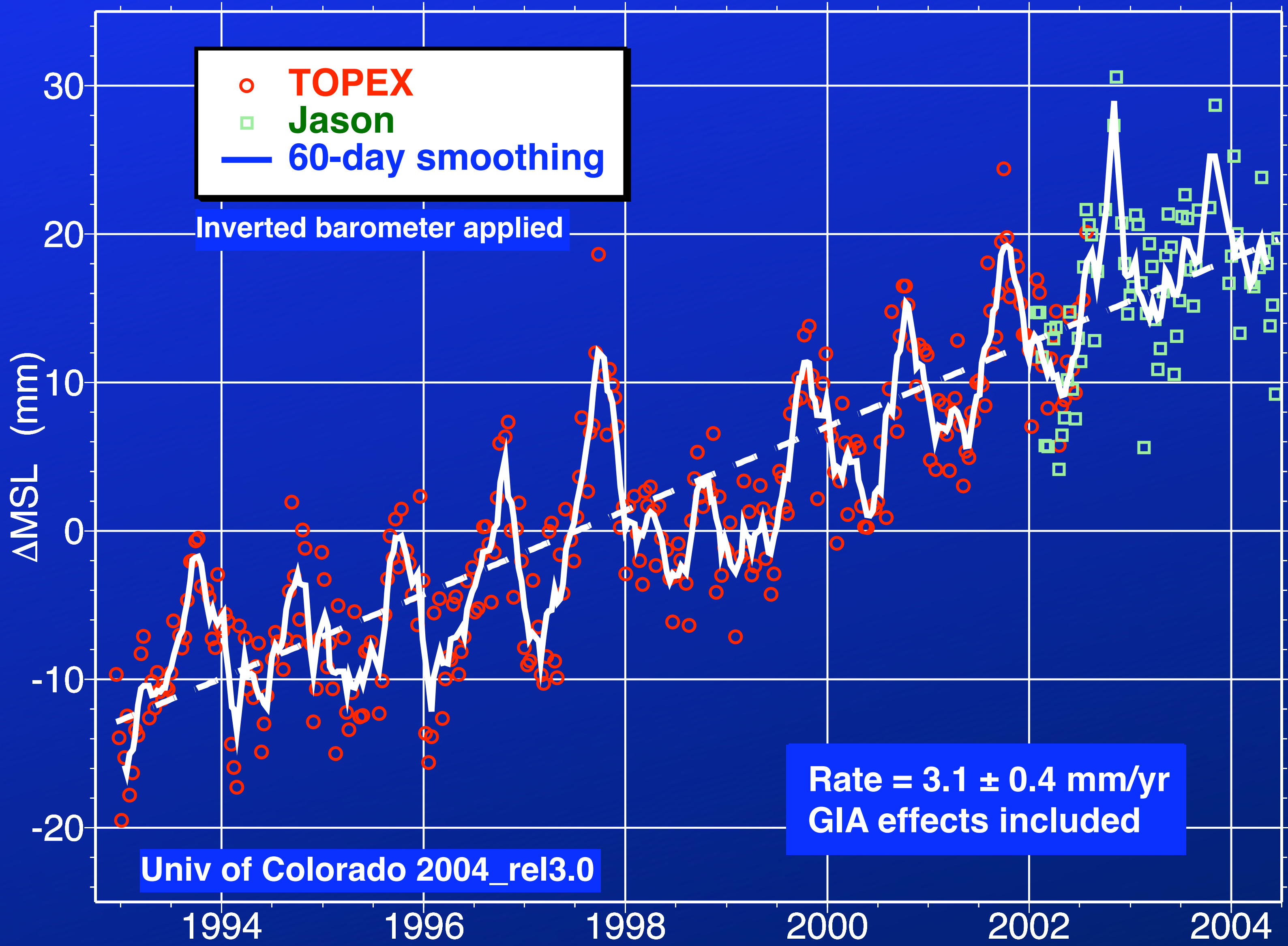
Residuals

Basin	rms (mm)	correlation (n=13, $r_{95\%}$ = 0.56)
Global	6.2	0.67
Pacific	7.4	0.93
Atlantic	15.5	0.50
Indian	10.3	0.70

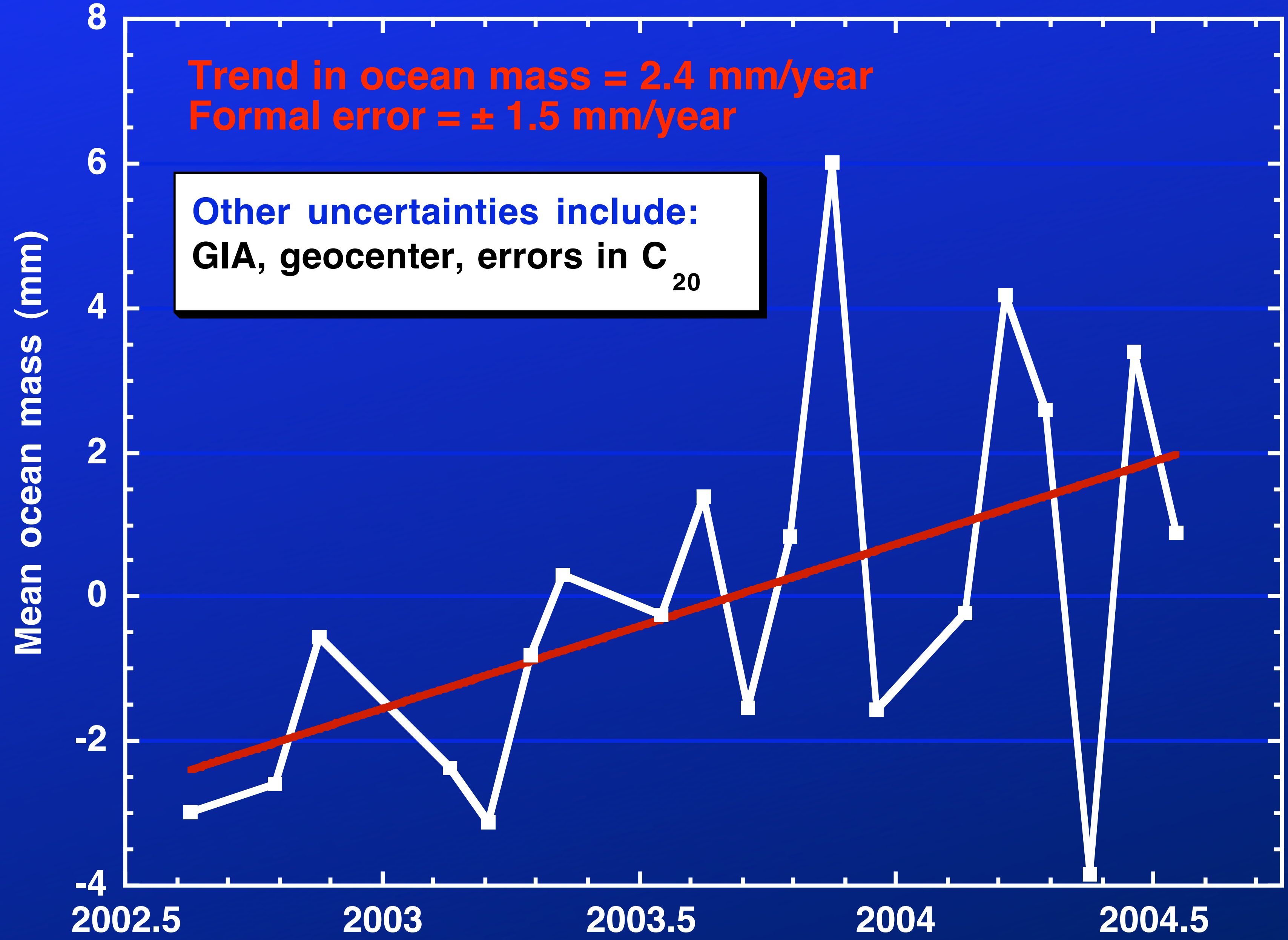
Global mean sea level (altimetry)



Global mean sea level (altimetry + GIA)



GRACE eustatic estimates



Conclusions

GRACE ocean mass measurements can be validated at basin spatial scales with a combination of altimetry and heat storage measurements.

Globally, the two methods are consistent to 6 mm rms. Agreement in the Pacific and the Indian oceans is significant, while the residuals in the Atlantic show a large interannual difference.

Reprocessed GRACE fields and a longer time series could increase the strength of the validation. Unfortunately, the JEDAC Heat Storage Analysis ended in 2003.