Mean Sea Level Monitoring in the 1990s: Observations and Causes

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Questions to be Addressed

- What have we learned from a decade of precision altimetry?
- How well are the instruments calibrated?
- Can we see climate variations in the altimeter record?
- What does the tide gauge record tell us?
- Has there been a recent acceleration in sea level rise?
- What evidence is there to differentiate contributions to sea level rise?
Altimeter Data Processing

- **TOPEX “Classic”**
  - MGDRs with GCP-C
  - TMR drift
  - GCP-C yaw correction
  - GOT99b tides
  - Chambers SSB
  - 1.4 mm A/B bias

- **TOPEX Tandem**
  - Same as TOPEX, but uses its own along-track mean (adjusted to Jason)

- **Jason**
  - GDRs
  - 154 mm bias with respect to TOPEX
  - Experiments with different orbits, SSB corrections
Jason vs T/P MSL: Calibration Phase

TOPEX/POSEIDON vs Jason-1, bias = 154 mm

rms difference = 1.6 mm
Jason vs T/P MSL: Tandem Phase

r₉MSL (mm)

Jason cycle

T/P cycle

TOPEX-Tandem
Jason-1

rms difference = 3.2 mm
Global Mean Sea Level from T/P

No-IB Correction Applied
Seasonal Variations Removed
GMSL Variations from T/P and Jason-1

Rate = 2.8 ± 0.4 mm/year

(0.4^2 = 0.1^2 + 0.4^2)

Formal Error Calibration Error

No-IB Correction Applied
Seasonal Variations Removed
60-Day Smoothing Applied
Tide Gauge Calibration Sites
Drift: $-0.12 \pm 0.07$ mm/yr
Drift, TOPEX-A: $-0.37 \pm 0.15$ mm/yr
Drift, TOPEX-B: $+1.56 \pm 0.33$ mm/yr
Drift, cycles 1–63 = −5.7 ± 1.0 mm/yr
Sea Level Rise Versus Latitude
Percent Contribution to Global Trend

![Graph showing percentage contribution to global trend across different latitude bands.]
Sea Level Trends: 1993-2003
EOF Modes 1 and 3

SSH 1 (23.3%) 0.28 mm/yr
SSH 3 (6.7%) 0.15 mm/yr
EOF Modes 2 and 4
GMSL Variations from T/P and Jason-1

No-IB Correction Applied
Seasonal Variations Removed
60-Day Smoothing Applied

Rate = 2.8 ± 0.4 mm/year

(0.4^2 = 0.1^2 + 0.4^2)

Formal Error  Calibration Error
Detrended PDO vs MSL

Correlation (0.46) significant at the 95% level
Global EKE Variations from TOPEX

Rate = 2.4 cm$^2$/sec$^2$/year

[Leben and Powell, 2003]
Sea Level Rise Estimates Over Time

Sea level trend computed using data available to date
The Detection Problem

- **Question:** How long of an altimetric GMSL series do we need to have good confidence that the sea level rise we are observing is related to climate variations?
- Tests using different proxies for sea level variability (SOI, SST, PDO, tide gauge sea level reconstructions) all suggest about a decade of averaging is needed to have confidence in the rate at the 0.5 mm/year level.
- Tests using AOGCMs reach similar conclusions [Lowe & Gregory, 2003].
- **Answer:** We are close, but……
- **Next Question:** If we have confidence in the altimetric rate, does it represent a recent acceleration relative to historical sea level rise estimates?

→ Next IPCC Assessment
Tide Gauge Sea Level Reconstruction

Chambers et al., 2002

#TPcyc

Cazenave/Nerem 11/03
Detrended Mean SST vs MSL

- Detrended Seasonal Removed
- 60-Day Smoothing

**Y-axis:**
- MSL
- SST

**X-axis:**
- Year

**Legend:**
- MSL
- SST

**Graph:**
- Shows the relationship between detrended mean sea level (MSL) and sea surface temperature (SST) over a period from 1994 to 2004.
Detrended SOI vs MSL

![Graph showing detrended SOI vs MSL with若您想要的文件类型。](image-url)