Combining Jason-1 Altimetry & GRACE Time-Variable Gravity to Study Steric Sea Level

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- Chambers [*JGR*, 2006] evaluated the combination of GRACE and Jason-1 data to measure steric sea level (SSL)
  - » Used initial release of GRACE gravity field coefficients
  - » Error @ 1000 km half-wavelength smoothing ~ 2.5 cm RMS
  - » Identified several problems in GRACE data
- Recently, CSR, GFZ, and JPL have re-processed GRACE data
- Swenson and Wahr [2005] have also found systematic errors in coefficients and suggested a filter to remove
- Examine the effects of both the re-processed fields and new filter in improving accuracy

"Monthly" RL-02 coefficients
Compute anomalies
↓
Add $\Delta C_{1,}$ values from SLR [*R. Eanes*, 2000]
↓
Filter coefficients to remove systematic errors [Swenson & Wahr, 2005]
↓
Add back "monthly" coefficients of AOD model to restore modeled low-frequency ocean bottom pressure
↓
Convert to maps of equivalent water thickness @ R = 500 km & R = 750 km
↓
GRACE maps that can be subtracted from altimetry maps to estimate SSL

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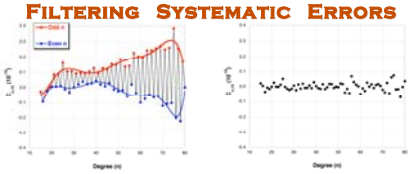
Filtering Systematic Errors



Order 15 coefficients from CSR_RL02 for February 2003

Residual coefficients after removing estimated systematic errors

- Optimized filter by minimizing residuals of GRACE - (Jason-1 - WOA01)
- 7x7 portion remains unchanged
- Fit a 7th order polynomial to other coefficients up to order 80.
- Ignore orders above 80 (set to zero).

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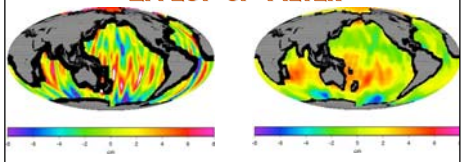
Effect of Filter



Map at R=500 km Smoothing using unfiltered coefficients CSR_RL02, February 2003

Map at R=500 km Smoothing using filtered coefficients CSR_RL02, February 2003

- Maps look better (i.e., reduced vertical stripes)
- Can we quantify the improvement?

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- Compare GRACE monthly maps to maps of predicted signal over the ocean
  - » Predicted = Jason-1 SSH - WOA01 SSL

$$\Delta(\phi,\lambda,t) = \left[\Delta\eta_{\text{GRACE}}(\phi,\lambda,t) - \left(\Delta\eta_{\text{Jason}}(\phi,\lambda,t) - \Delta\eta_{\text{WOA}}(\phi,\lambda,t)\right)\right]$$

  - » Compute variance of all residuals (time and space)
  - » Upper-bound on error
    - Assumes Jason-1 and WOA01 have no errors
    - Interannual SSL variations not modeled
      - » Estimate and remove trend to from GRACE and Jason-1 maps to reduce this somewhat

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Source of GRACE Data	Smoothing Radius 500 km	Smoothing Radius 750 km
CSR_RL02, unfiltered	15.4 cm²	5.7 cm²
CSR_RL02, filtered	7.5 cm²	4.7 cm²
GFZ_RL03, filtered	7.3 cm²	4.6 cm²
JPL_RL02, filtered	7.3 cm²	4.6 cm²
Average of 3	**6.5 cm²**	**4.0 cm²**

- Variance of residuals (GRACE - (Jason-WOA)) for 17 months in common
  - » Feb - May 2003, July-Dec 2003, Feb - June 2004, Dec 2004, Jan 2005

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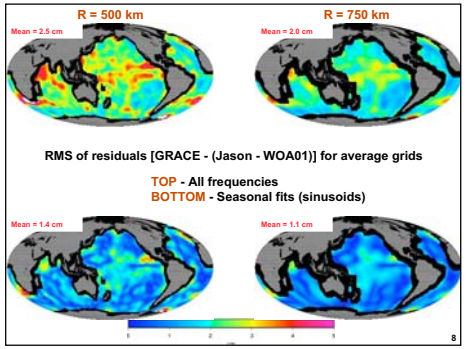

RMS of residuals [GRACE - (Jason - WOA01)] for average grids

TOP - All frequencies
BOTTOM - Seasonal fits (sinusoids)

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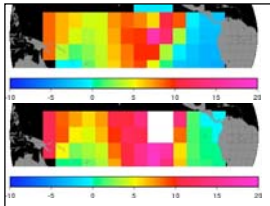
Conclusions

- With new GRACE gravity fields and post-processing filter, accuracy of ocean mass maps has increased significantly
  - » Before, RMS error ~ 2.5 cm for R = 1000 km
  - » Now, RMS error ~ 2.0 cm for R = 750 km & 2.5 cm for R = 500 km
  - » Errors in seasonal signal ~ 1.1 cm and 1.4 cm RMS
- Part of this estimate is interannual variability
  - » Jason-GRACE fits monthly thermosteric data better than WOA01

Interannual Variability

- WOA01 has no interannual variability
- Some of the "error" on previous plots may be due to unmodeled interannual steric variability
- To quantify, compute thermosteric sea level (TSL) in tropical Pacific for 2003-2004
  - » Mainly from TAO array (best time-sampling)
  - » For each TSL observation, compute residuals with WOA01, and Jason-GRACE (all at 500 km smoothing)
  - » Grid TSL and residuals onto monthly 10° grids
  - » Compute variance reduction



Var(TSL) - Var(TSL-WOA01)
Reduced in 63% of grids
Increases in 37% of grids

Mean Reduction = 4.9 cm²

(TSL) - Var(TSL-(Jason-GRACE))
Reduced in 95% of grids
Increases in 5% of grids

Mean Reduction = 8.9 cm²

Variance Reduction in cm²

- Positive values mean variance is reduced
- Negative values mean variance has increased

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