What kind of gravity field model for satellite altimetry?

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Plan

- New “Release 2” models from CNES/GRGS:
  - a time-series of truly 10-day gravity field models from spherical harmonic degree 1 to 50;
  - a mean satellite-only gravity field model up to degree and order 160, in which annual and semi-annual periodic components as well as drift are modelled up to degree 50 (called EIGEN-GRGS.RL02)
- Quality evaluation of variable RL02 solutions over sea and ocean in comparison with altimetry
- POD tests with different types of time variable models
- Prospective

RL02 GRGS MEAN FIELD: (1) static, secular and periodic terms

- 10-day normals from GRACE+Lageos are accumulated over the period 2003 / 2004 (both corrected for Sumatra static effect) / 2005 / 2006 / 2007, introducing for each 10-day period and for each gravity parameter until degree 50, six new mean parameters: bias, slope, 2 annual and 2 semi-annual periodic terms.

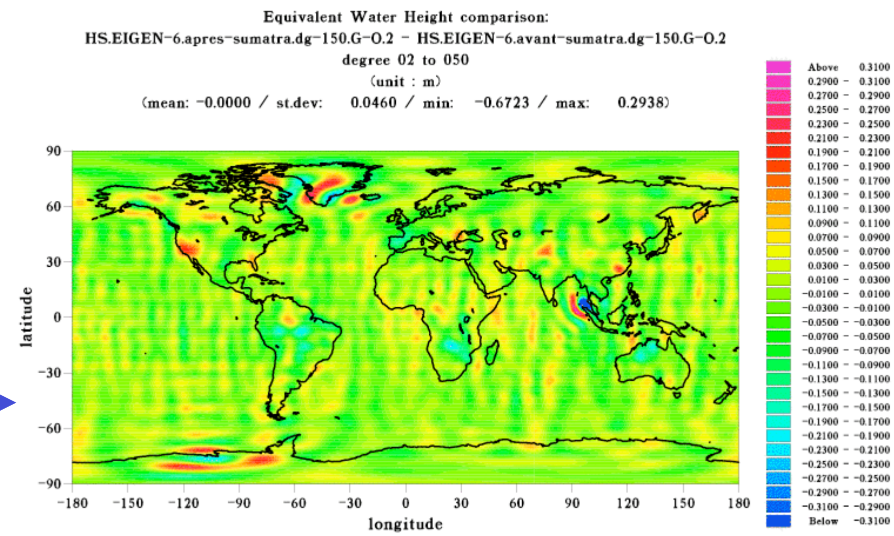
  $$G(t)=G(t0)+DOT*(t-t0)+C1A*\cos(\omega_a*(t-t0))+S1A*\sin(\omega_a*(t-t0))$$
  $$+C2A*\cos(\omega_{sa}*(t-t0))+S2A*\sin(\omega_{sa}*(t-t0))$$

  with t0=2005.0

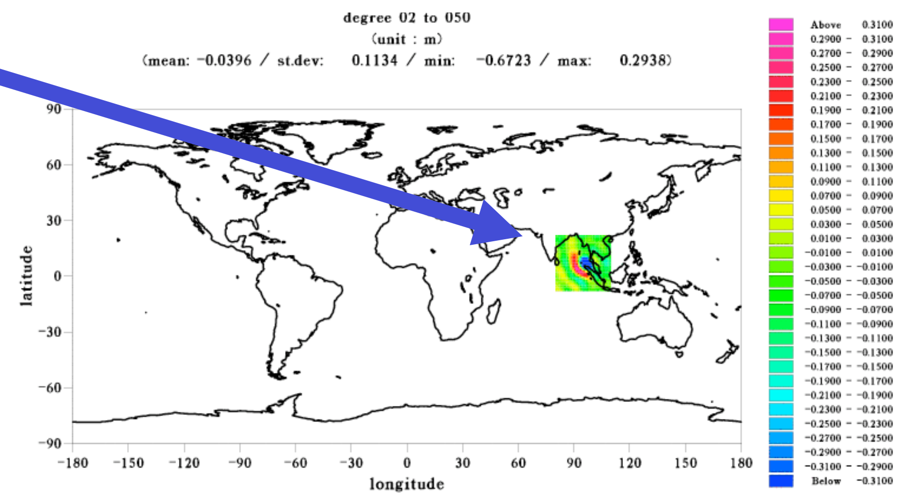
- The final cumulated equation contains six parameters for each coefficient until degree 50 (G(t0), DOT, C1A, S1A, C2A, S2A), and one parameter per coefficient from degree 51 to 160. All parameters are solved-for in one run.

RL02 GRGS MEAN FIELD: (2)
Dealing with Sumatra earthquake

- A separate accumulation is done for the years 2003-2004 and 2005-2006-2007;
- A common solution is computed with the SH below degree 50 being kept separated;
- A grid « after December 24, 2004 » minus « before » is computed;



- This grid is limited to the Sumatra area and converted back in SH coefficients;



- The SH coefficients of this « mean Sumatra effect » are then injected in the 2003-2004 subset as a constant correction;
- The mean (static+periodic) solution can now be produced

RL02 GRGS MEAN FIELD: (3)
static, secular and periodic terms

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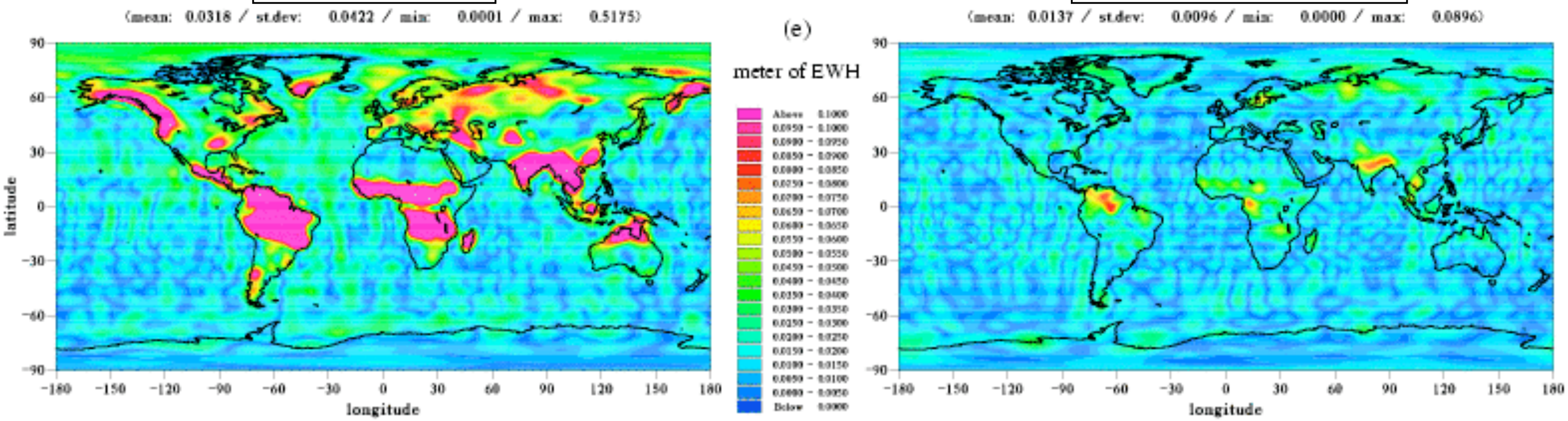
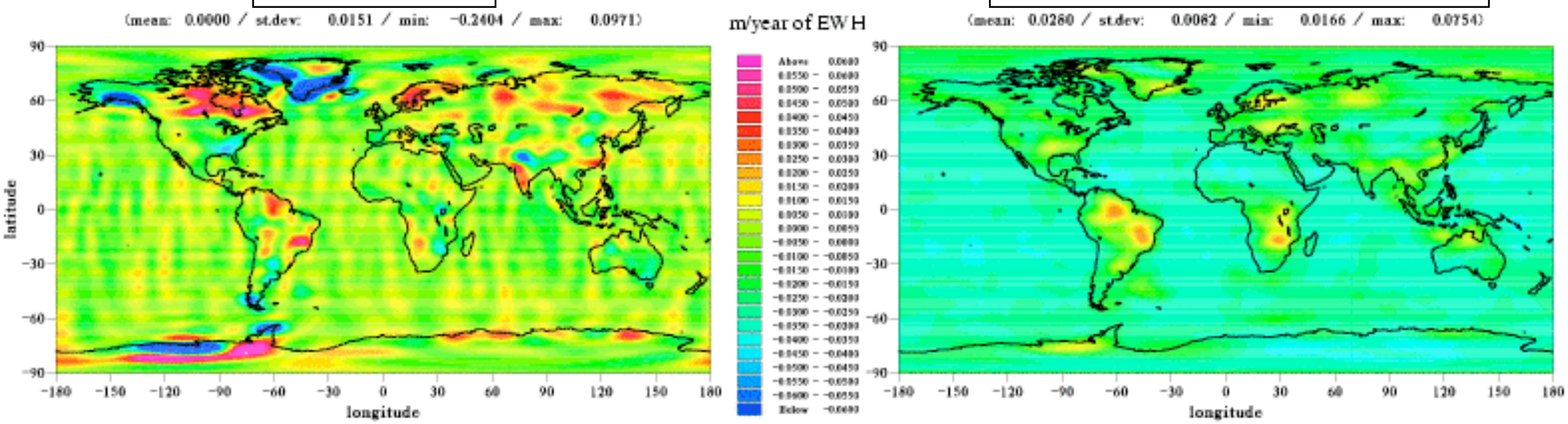
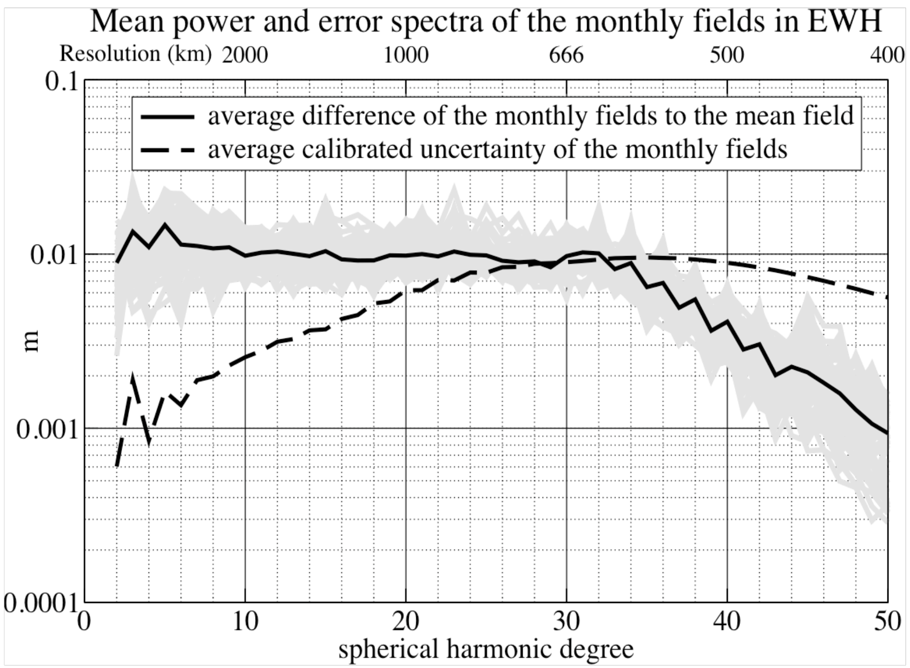


TREND | **Non-periodic residuals**



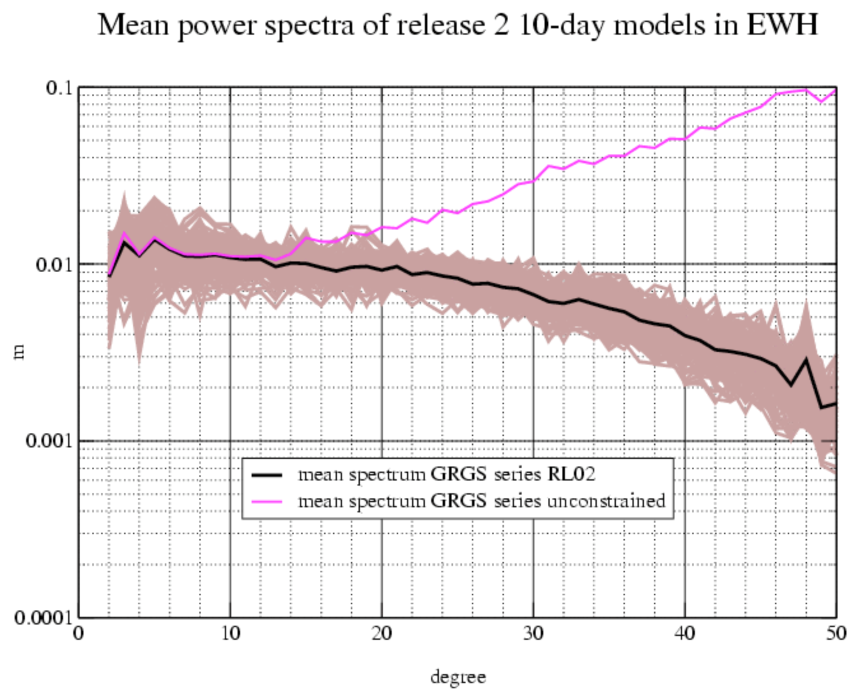
Constraining the power spectra

Spectra of the release 1 solutions: Sharp decrease after degree 30.



constrained to the *mean model* EIGEN-GL04S according to an empirical degree variance law (Kaula type)

Spectra of the release 2 solutions: Gradual, more power at higher degrees.



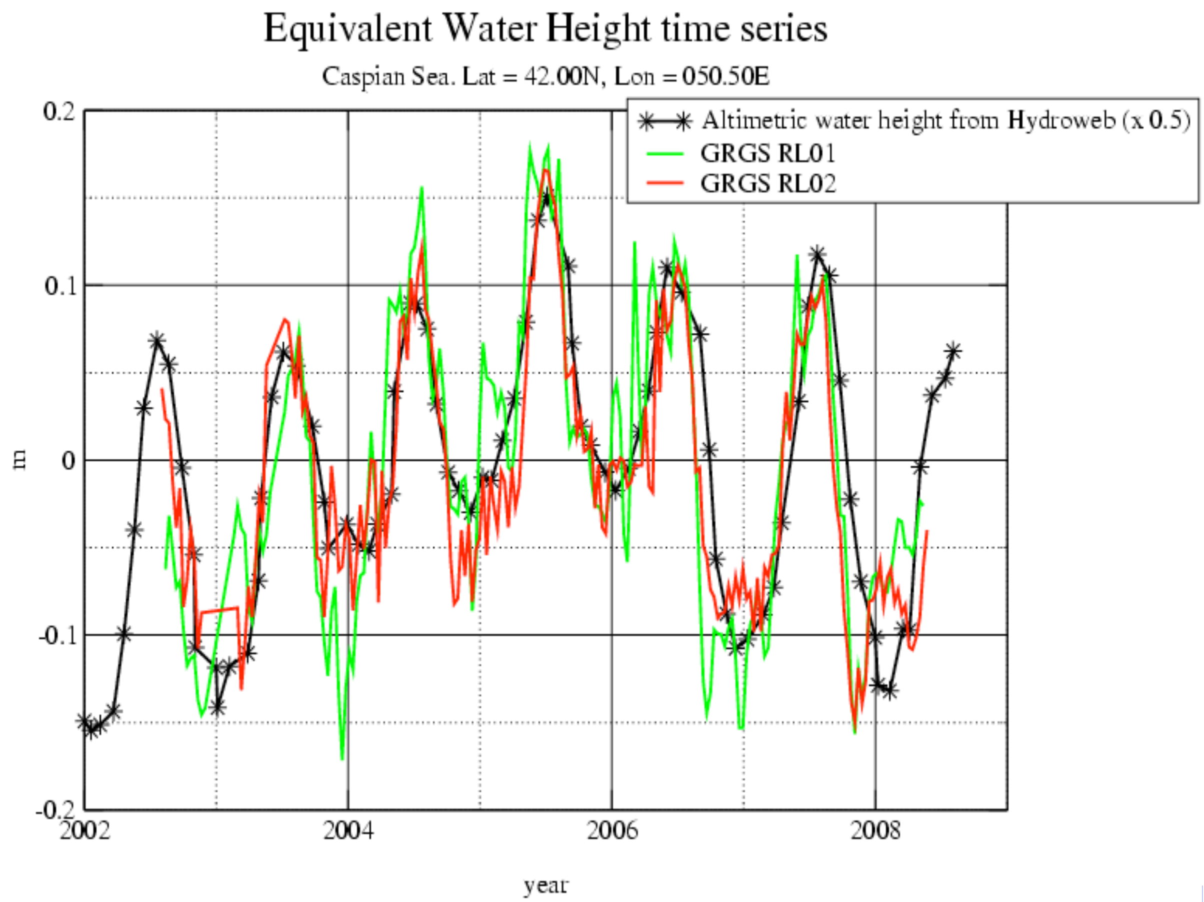
constrained to the *mean periodic model* EIGEN_GRGS.RL02 according to the a posteriori covariance matrix

(Uncertainties reduced by a factor 2)

Validation of RL02 on the Caspian Sea

GRACE RL01 and RL02 models are compared in the Caspian Sea with satellite altimetry anomalies from Hydroweb/LEGOS (http://www.legos.obs-mip.fr/soa/hydrologie/hydroweb/Stat)ionsVirtuelles/Caspian.html).
No temporal filtering is applied to the data.
The figure below shows that the RL02 series (red) matches better the altimetry signal (black) than the RL01 series (green). There does not seem to be any lack of power in the RL02 series and there is clearly less noise than in RL01, although the RL02 series is only based on 10-day data batches, while RL01 is based on three consecutive 10-day batches, technique which brings some temporal smoothing.

The size of the Caspian Sea (maximum width 400 km) is exactly the minimum reachable with spherical harmonic degree 50 (dg 50 ⇔ minimum wavelength 7.2° / 800 km at the Earth's surface ⇔ resolution 3.6° / 400 km

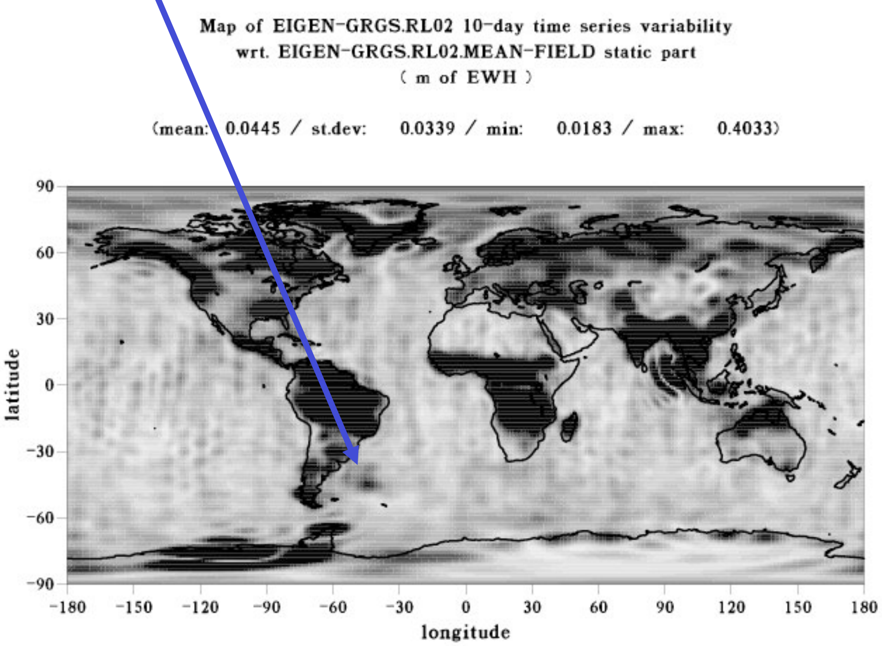


Validation of RL02 on a sea region

Ideal test zone for GRACE time series solutions:

- **availability of very accurate "ground truth" data,** ← **reliable open-ocean altimetric time series**
- **significant gravity signal, if possible non periodic-only,** ← **strongest GRACE signal on the oceans**
- **good insulation from strong distant hydrology signals.** ← **far away from the continental hydrology**

A good candidate for such a spot is an oceanic area in the South Atlantic, off the coast of Argentina, called the **Zapiola Gyre**. The coordinates of the centre of the Zapiola Gyre are: 45°S, 45°W.

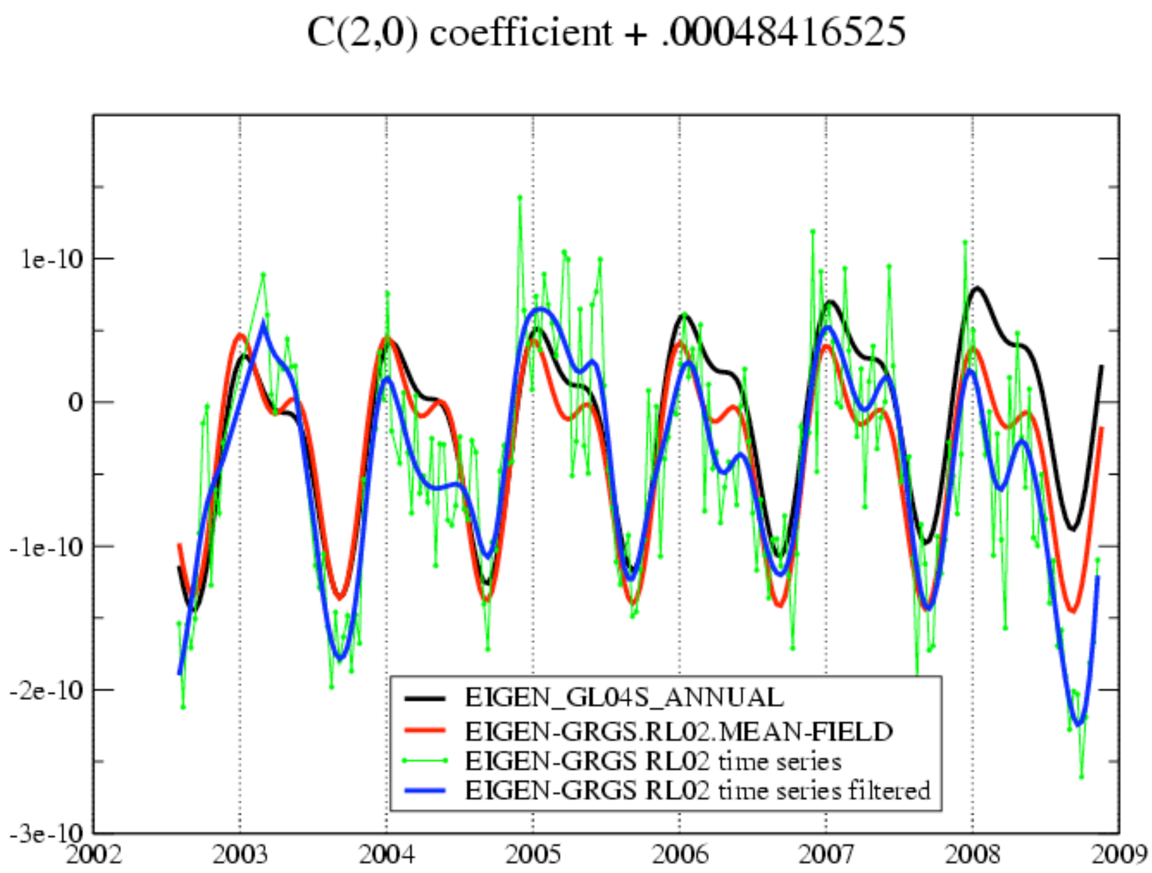


RMS of SLA alone = 9.13 cm
RMS of SLA – GRACE:

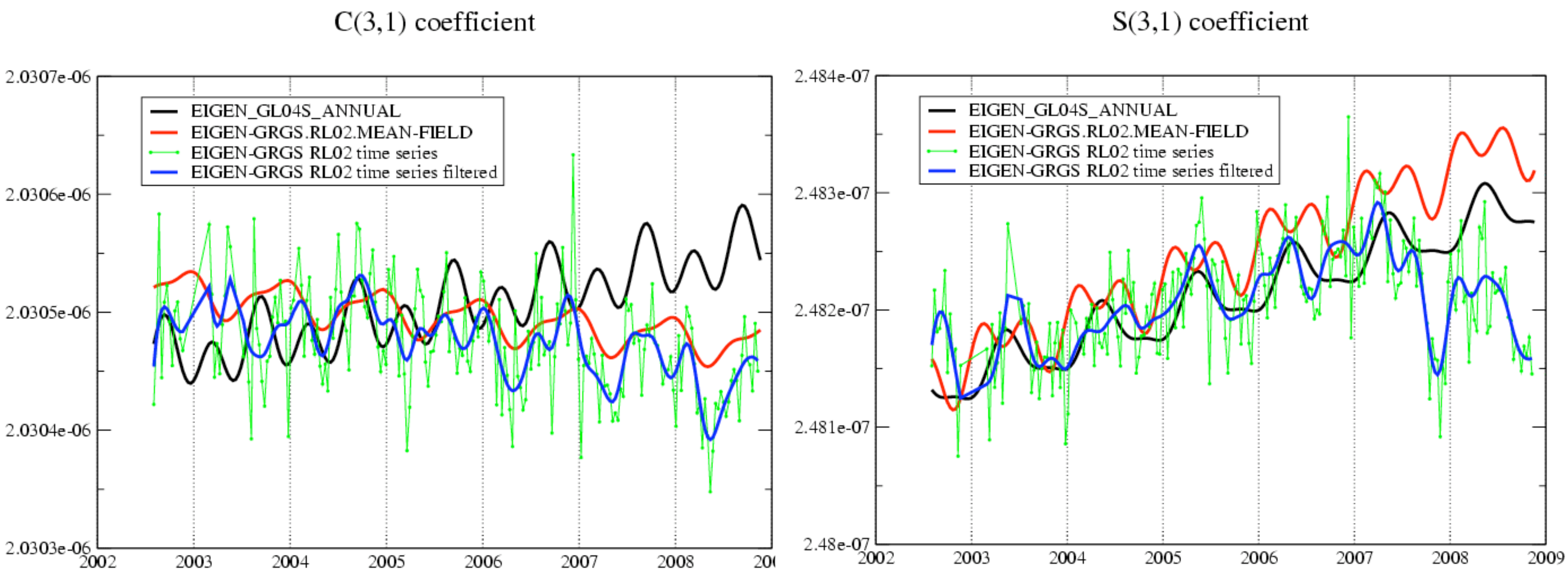
2x2° Altimetric Sea Level anomalies – 2x2° GRACE solutions (rms in cm)	
GRGS 30-day (RL01)	8.55
GRGS 10-day (RL02)	7.83
CSR04 monthly (300 km smoothing)	7.71
CSR04 monthly (500 km smoothing)	8.11
GFZ04 monthly (300 km smoothing)	7.50
GFZ04 monthly (500 km smoothing)	8.12
JPL04.1 monthly (300 km smoothing)	8.05
JPL04.1 monthly (500 km smoothing)	8.42

Smoothing the s.h. coefficients

Vondrak-type filtering with a cut-off of 90 days.



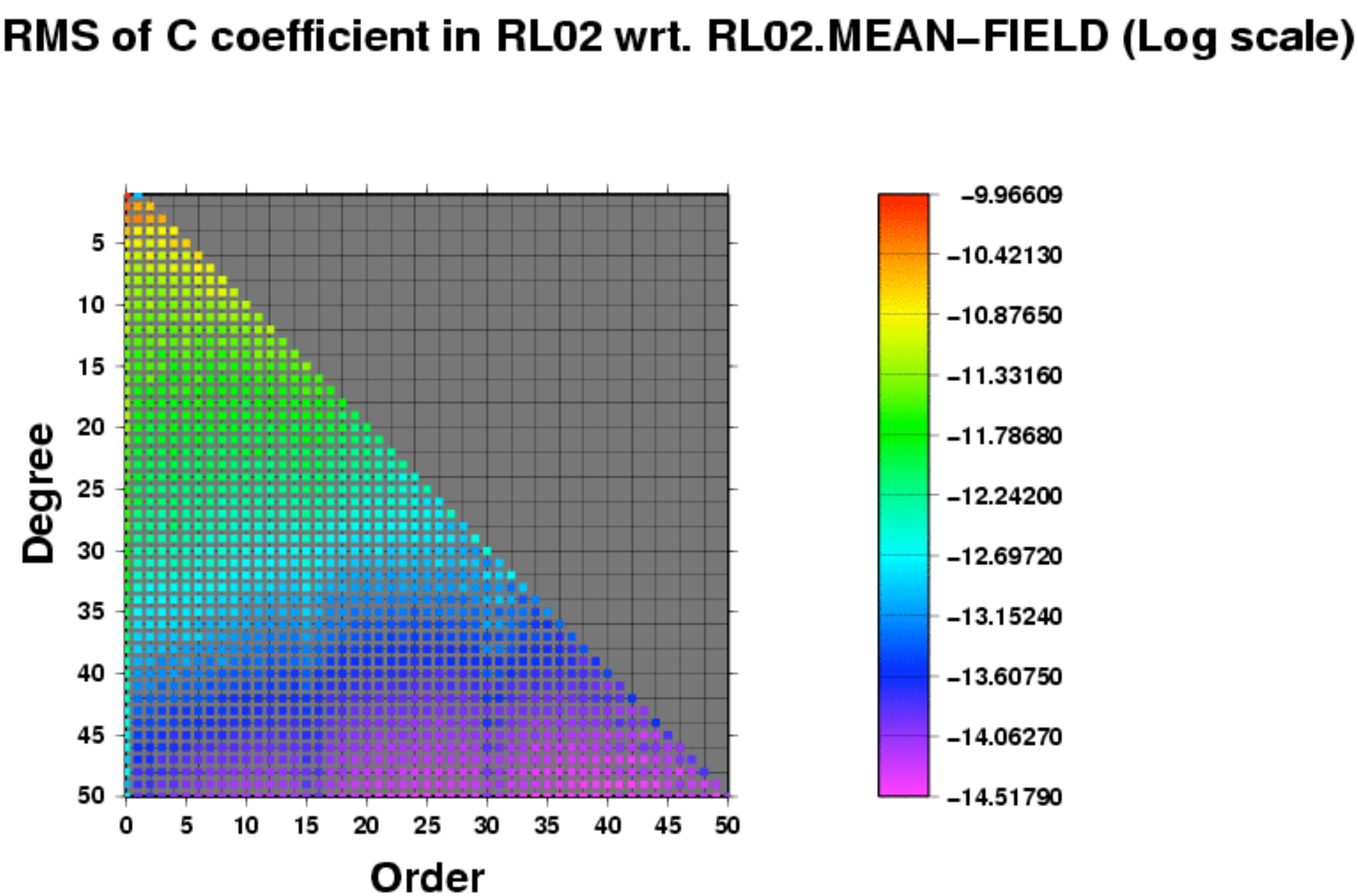
Smoothing the s.h. coefficients



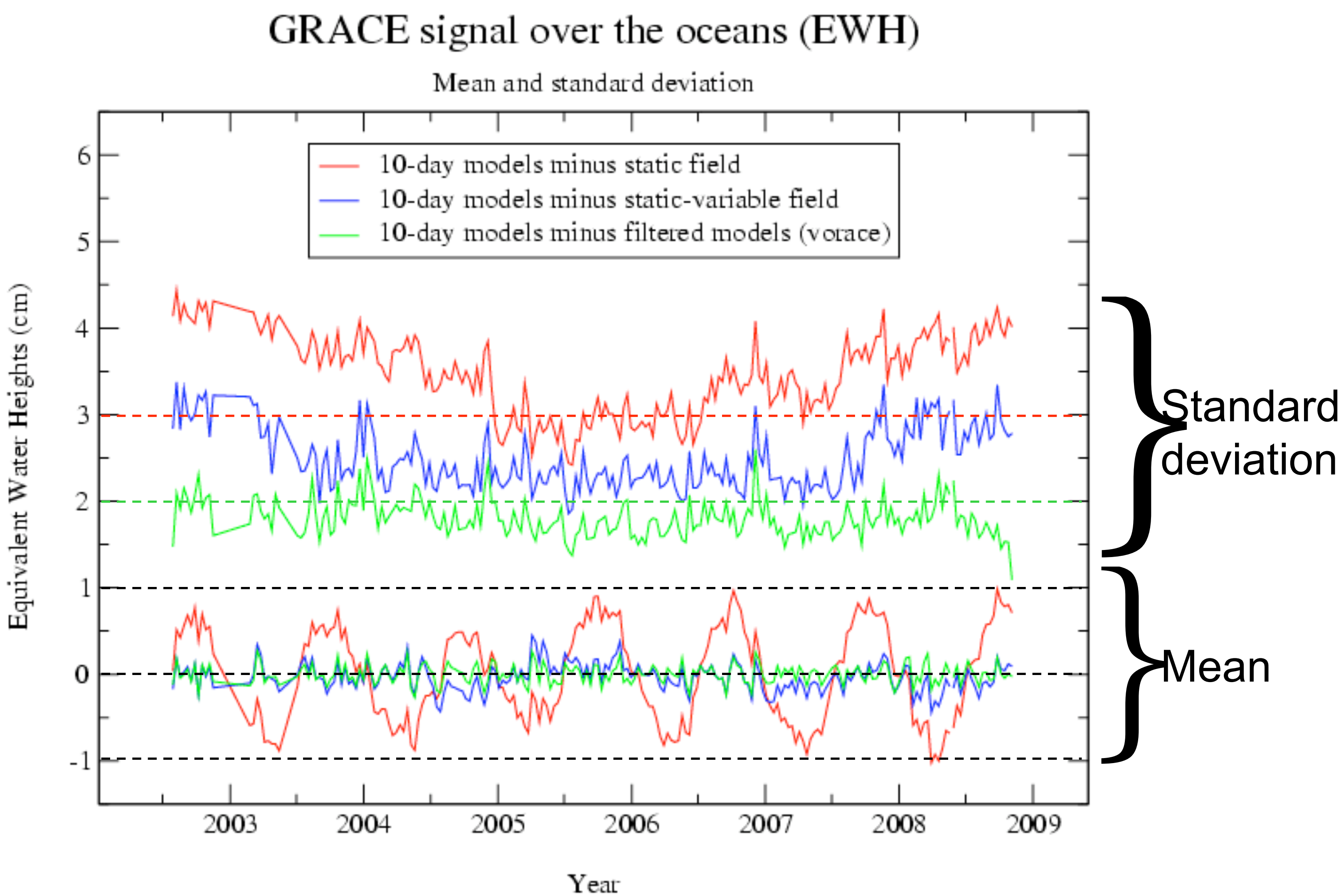
On the contrary of the adjusted model EIGEN-GRGS.RL02 with drift and periodic terms, the smoothed model can follow the slope changes

Smoothing the s.h. coefficients

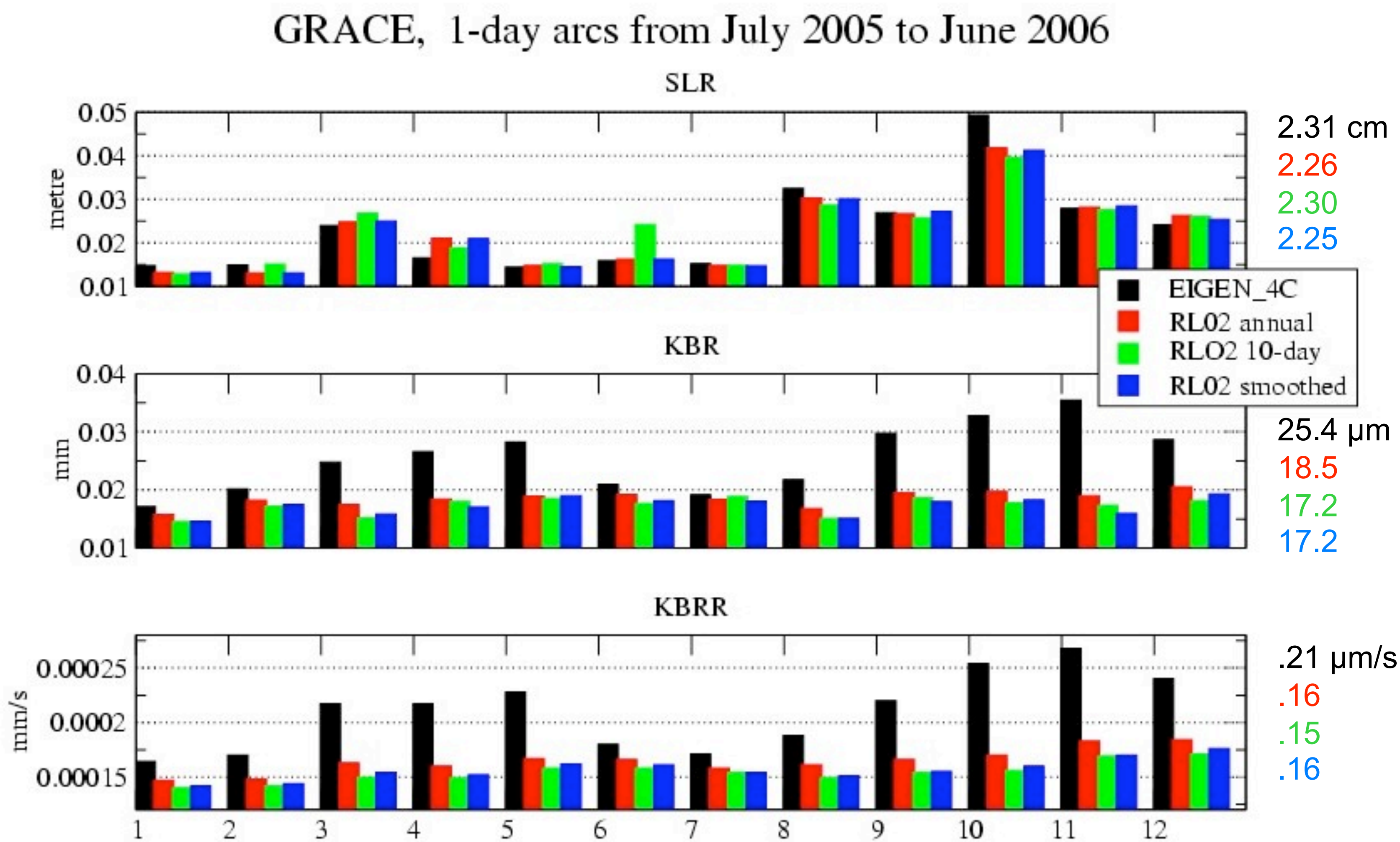
A filtering alternative to study the noise over the oceans



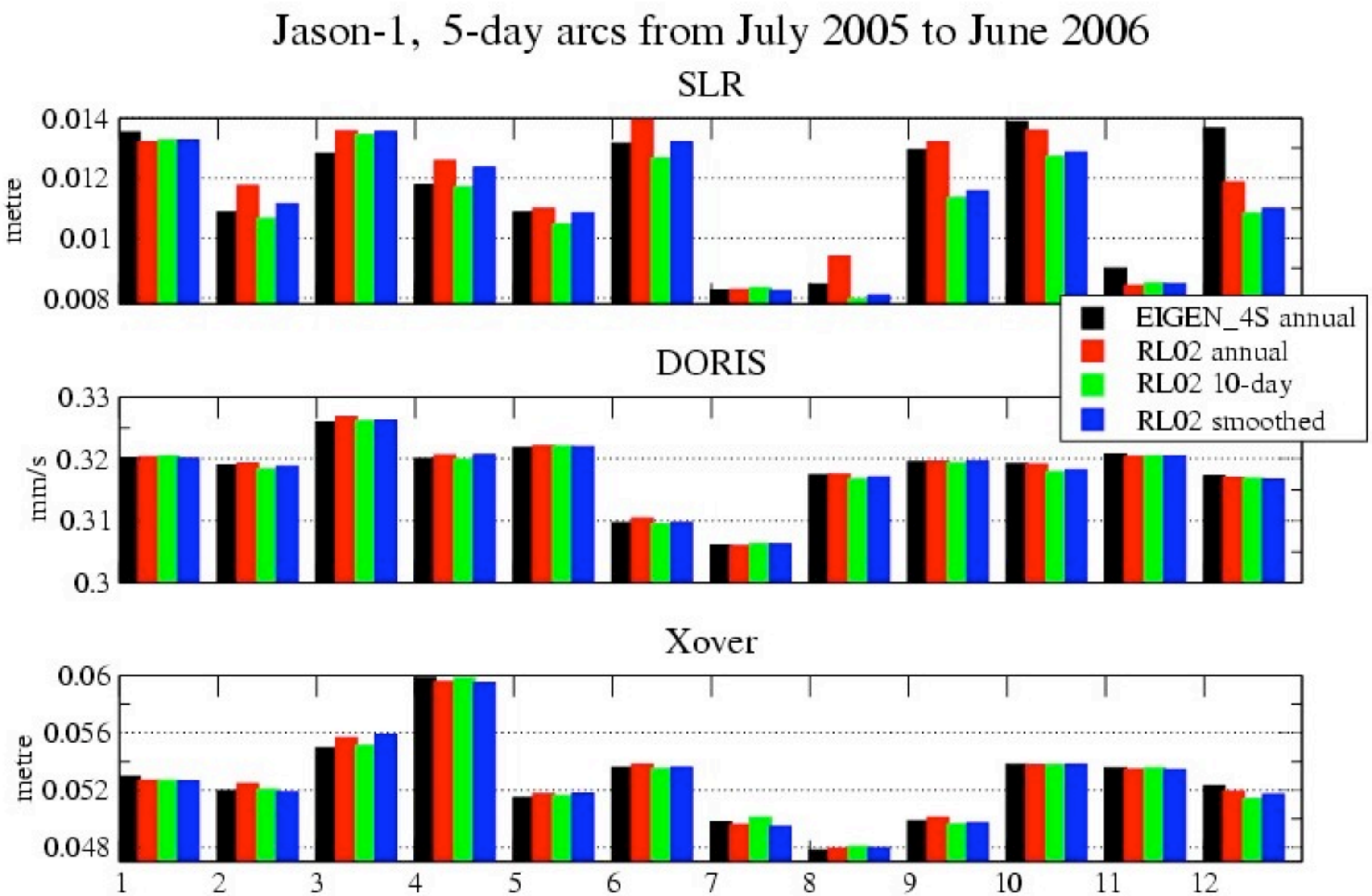
RL02 10-day solutions



GRACE orbital tests

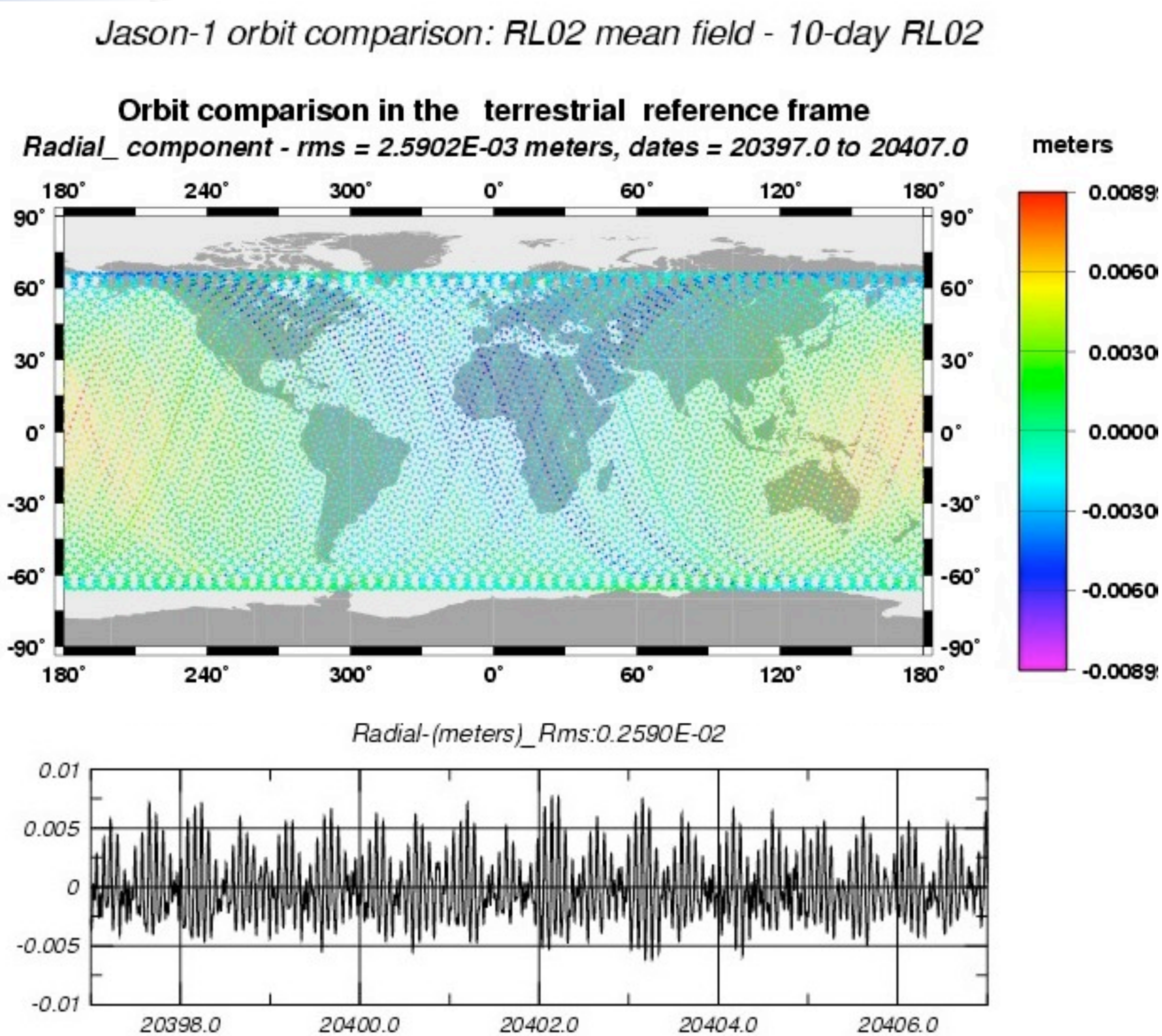


Jason orbital tests



n/s

Orbit radial discrepancies



How to progress in POD?

- Using 3 hrs aliasing a priori products (atmosphere, ocean, hydrology…) for reducing aliasing interpolation (mainly for GRACE)
- Introducing a priori continental hydrology modelling (mainly for GRACE)
- Refining non gravitational modelling (thermospheric density, radiation, thermal, macro-models)
- Relying on upgraded reference frame realization : ITRF2008
- Improving tropospheric delay correction (mainly for DORIS): line of sight computation from ECMWF 3D-model
- Validating atmospheric and hydrological station loading effects

How to progress in geoid?

- Waiting for GOCE results for resolutions from 400 km (sh degree 50) down to 80 km (sh degree 250) → ~1 cm geoid precision

- Hoping for a GRACE continuation for low degree variations (sh degrees < 50) to detect mass changes in the oceans → < 2 cm precision in equivalent water height

- Planning an improved GRACE-GOCE follow-on mission