

# The new GFZ EIGEN-GRACE06S Gravity Field Time Series

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# Current Status RL04 Processing

- As part of GRACE SDS, GFZ provides EIGEN-GRACE05S (=RL04) time series since end of 2006
  - Currently, **91 monthly** solutions have been processed and published for the measurement period **08/2002 until 07/2010**
  - The RL04 Time series is widely used to investigate various time-varying mass variation signals (as the continental hydrological cycle, ice mass change in Antarctica and Greenland or secular effects induced by Glacial Isostatic Adjustment)
  - Error level of RL04 still about a factor of 15 above the pre-launch simulated baseline accuracy due to:
    - inaccurate instrument data
    - inaccurate background models
- striping artefacts,  
→ the solutions need a filtering before using it for further analysis
- ☞ GFZ will reprocess the complete GRACE Mission using improved background models and updated processing standards

# RL05 Reprocessing

## Background models and standards:

|   | Currently: RL04                          | New: RL05  |
|---|--|--|
| A priori Static Gravity Field                     | <u>EIGEN-GL04C</u>                       | <u>EIGEN-51C</u>                                       |
| Time-variable Gravity Field                       | none                                     | Trend/Annual/<br>Semiannual Model<br>derived from RL04 |
| Secular Rates                                     | $C_{20}, C_{30}, C_{40}, C_{21}, S_{21}$ | <u>none</u>  |
| Ocean Tides                                       | FES2004                                  | <u>EOT10a (preliminary)</u>                            |
| Atmospheric Tides S1, S2                          | Bode-Biancale 2003                       | Bode-Biancale 2003                                     |
| Atmospheric and Oceanic Non-tidal Mass Variations | AOD1B RL04                               | AOD1B RL04   |
| Ocean Pole Tide                                   | Desai [2002]                             | Desai [2002]   |
| Solid Earth & Pole Tides                          | IERS2003                                 | IERS2003   |
| 3 <sup>rd</sup> Body Ephemerides                  | JPL DE403                                | <u>JPL DE405</u>                                       |

# RL05 Reprocessing

## Overview of changes in RL05 processing standards:

- Improvements of the L1B data:

- new level 1B data (K-Band Range Rate & Star Camera data), presently 1 year (2008) has been provided by CSR (draft v.02)

- Improved GPS processing:

- new GPS PSOs incl. phase windup correction & absolute antenna phase center variations (PCV)

- GFZ derived GPS antenna maps for GRACE

- Reprocessed all GPS constellations (orbits, clocks)

- More dense accelerometer parameterization:

- 6-hourly biases in radial, along-track and cross-track direction

- 6-hourly scale in along-track direction

- Change in the combination of GPS-SST and K-Band Range-Rate:

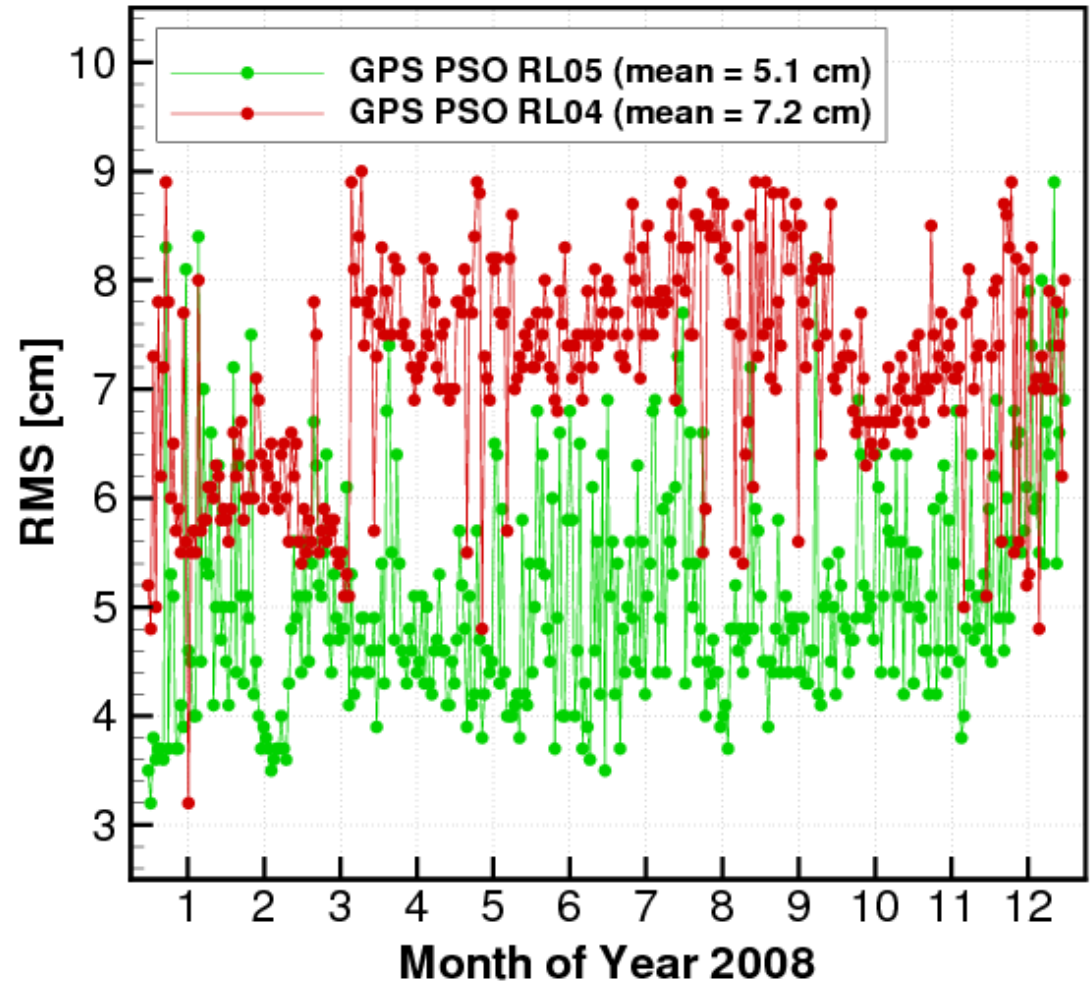
- No contribution of GPS-SST to the estimated spher. harm. coeff. for degree  $n > 80$

# RL05 Reprocessing

## Improvement of GPS Precise Science Orbits:

⇒ reduction of 3D RMS  
w.r.t. IGS orbits

⇒ final RL05:  
GPS PSOs incl. ITRF2008  
stations and an optimized  
data screening  
**are planned to be  
generated soon**



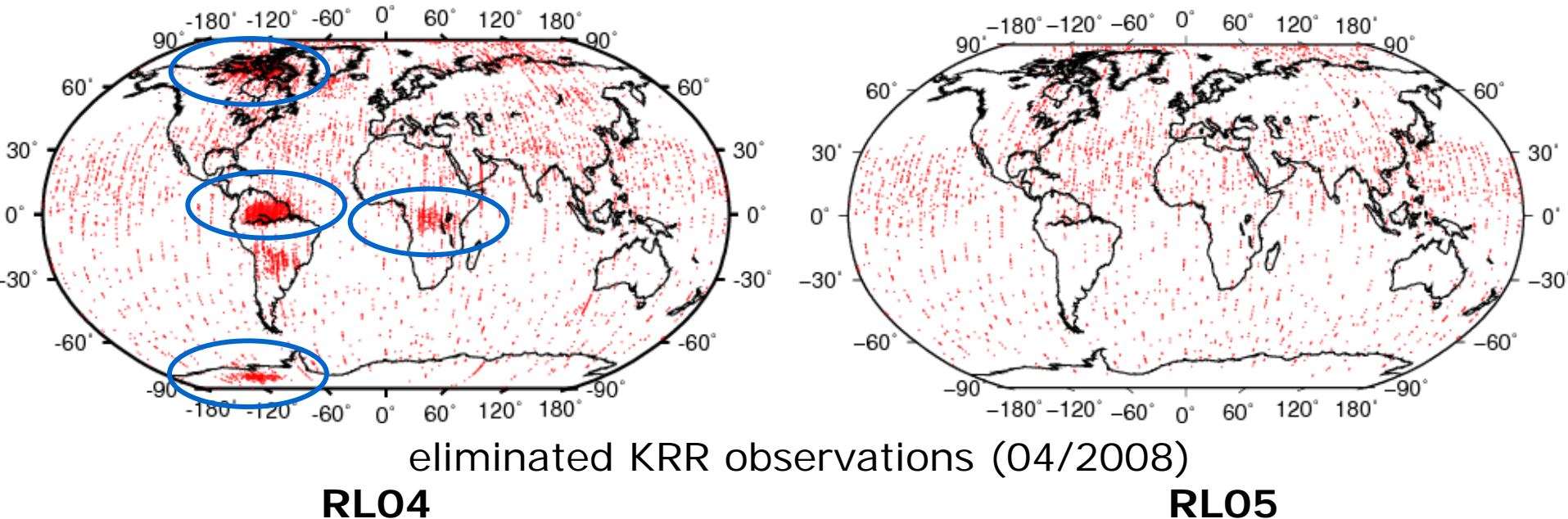
# RL05 Reprocessing

**Reduction of the impact of the Time-variable Gravity Field on the data screening:**

Additionally changed: The KRR elimination criterion from 3-sigma to 5-sigma

⇒ decrease of KRR residuals by ~25%

⇒ much more KRR observations are used (~98% RL05 vs. ~80% RL04)  
in particular in regions with the large time variations in the gravity field

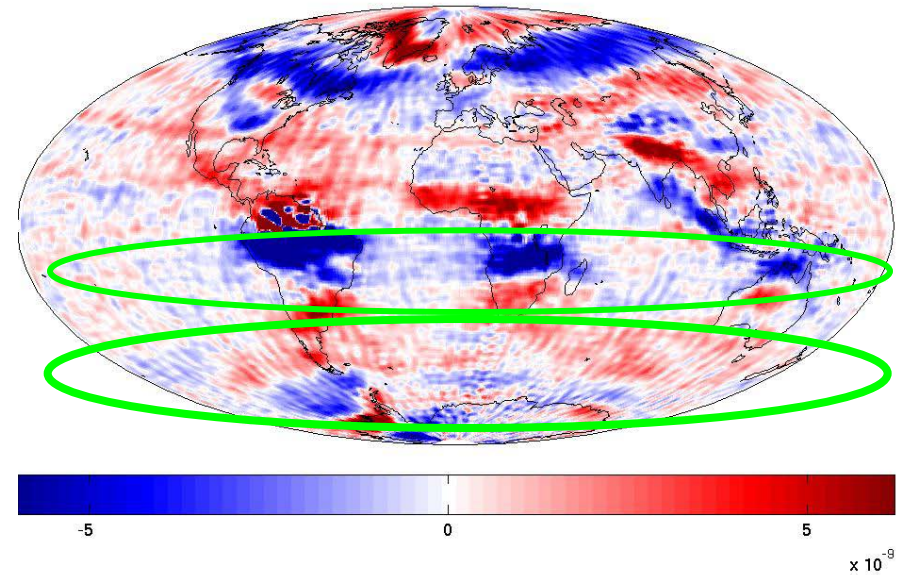
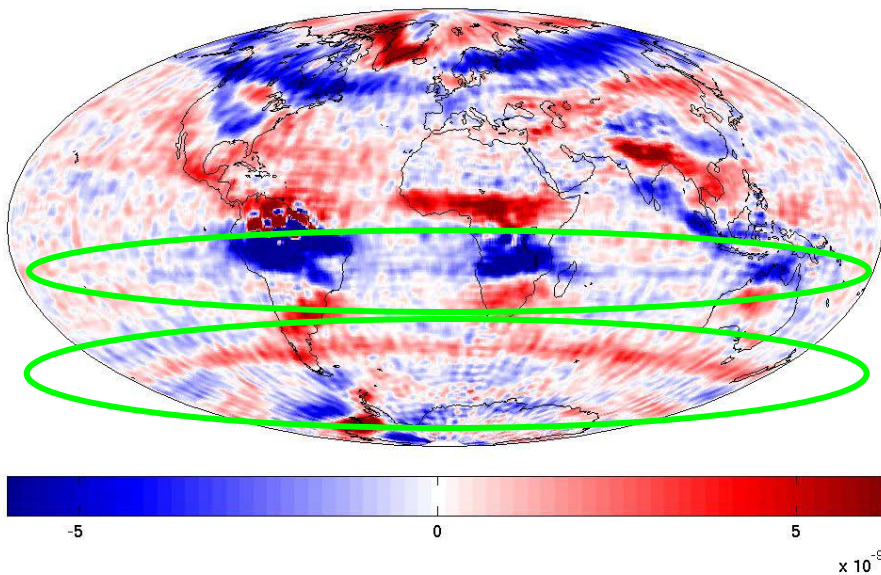




# RL05 Reprocessing

## Effect of the improved KBR1B & SCA level 1B data:

⇒ reduction of spurious horizontal striping patterns



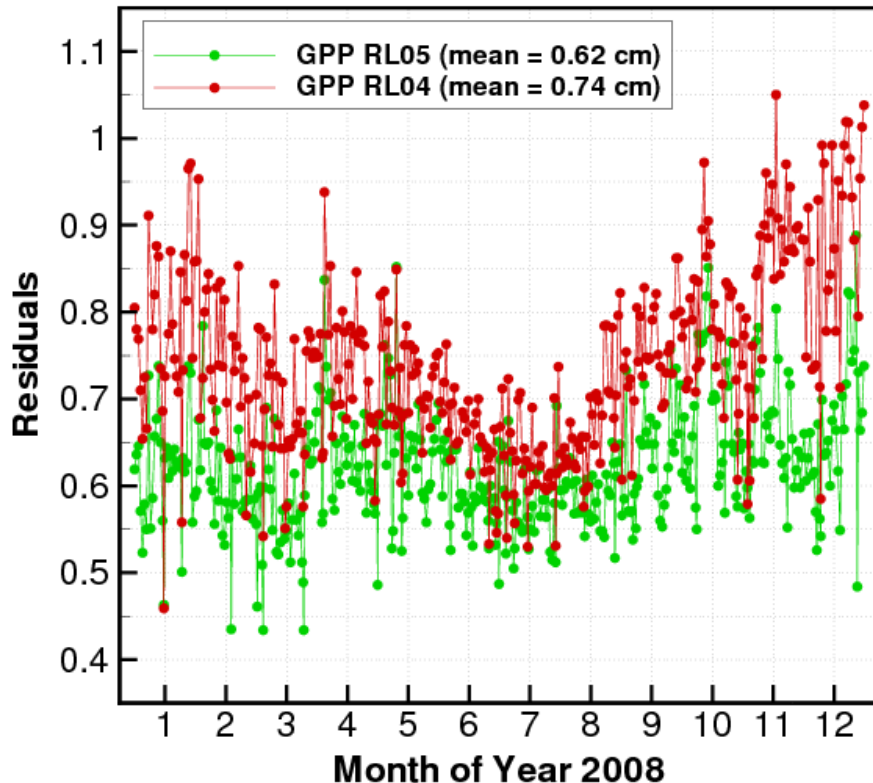
A posteriori K-Band Range-Accelerations (for the monthly solution April 2008)

**RL04**

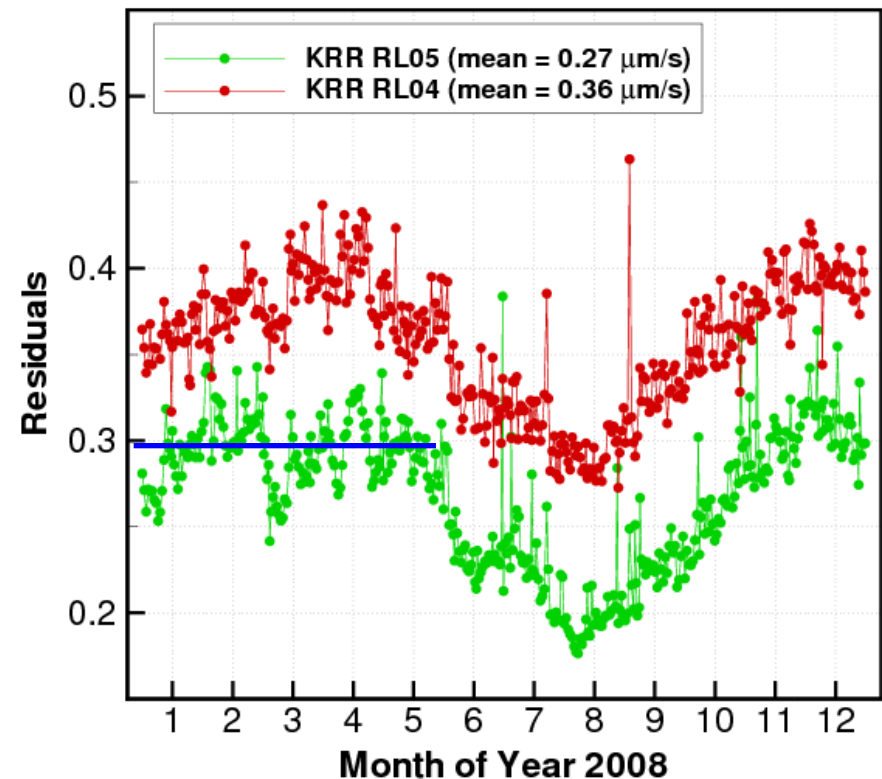
**RL05**

# RL05 Reprocessing

Reduction of the residuals of the GPS phase & K-band range rate observations (a-priori, i.e. in the observation equations):



GPS phase



K-band range rate

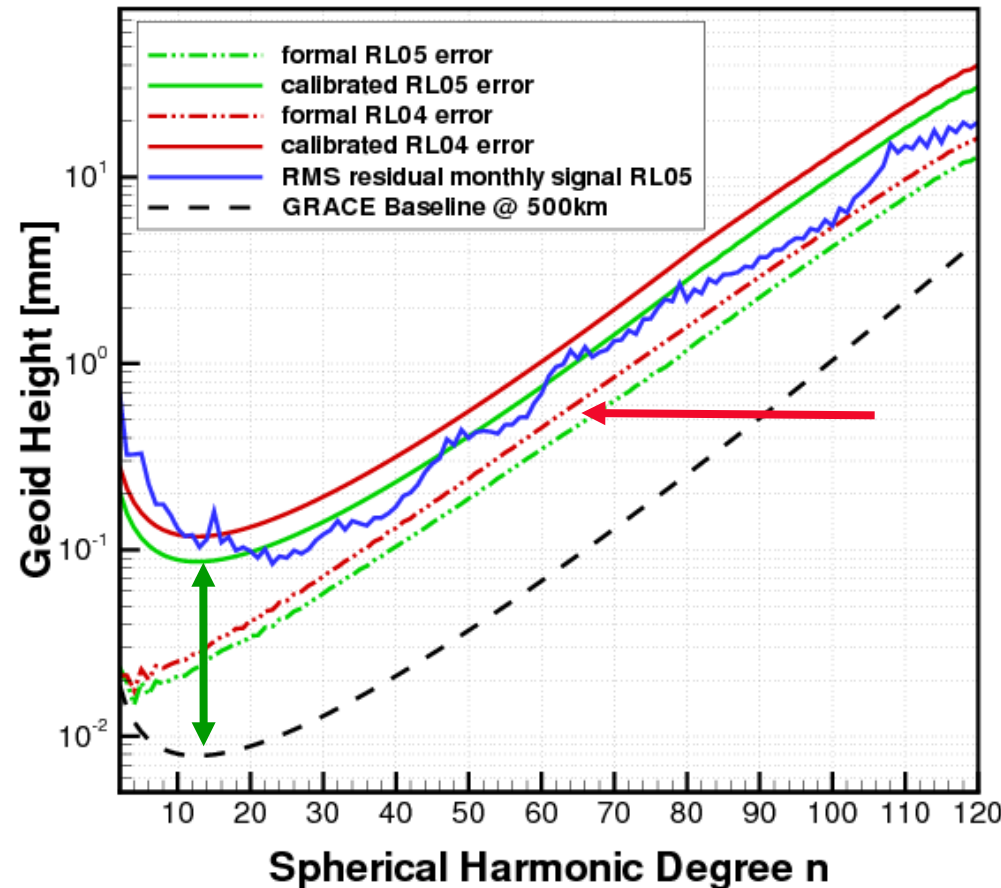


# Validation of RL05 Results

→ Presently 1 Year (2008) of RL05 monthly solutions has been processed for first validation purposes

## Improved error characteristics:

- formal errors decreased
- calibrated errors closer to GRACE baseline:  
RL04  $\approx 15$  x baseline  
RL05  $\approx 11$  x baseline
- reduced striping: RMS of unfiltered solution in terms of EQWH w.r.t. a static field (EIGEN-GRGS-RL2) is reduced  
→ 04/2008: RL04 65cm  
RL05 45cm



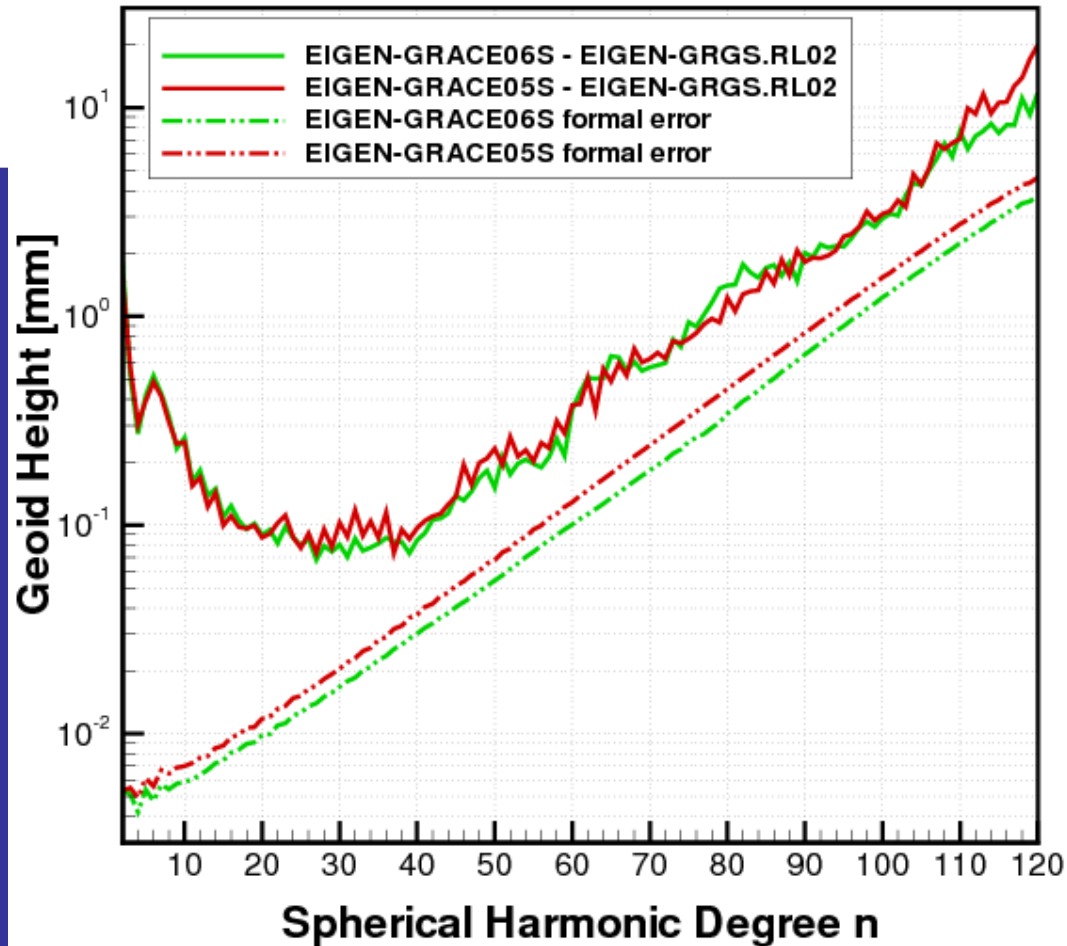
# Static Solution

- Preliminary static solution, computed from 12 months (2008), resolution 120x120
- ⇒ Improvement in higher degrees
- ⇒ Decrease of errors

Orbit test for **GFZ-1**, table shows mean RMS for SLR [cm]\*\*

| truncation | RL05  | RL04  |
|------------|-------|-------|
| 120x120    | 13.83 | 14.35 |
| 110x110    | 12.62 | 12.94 |
| 100x100    | 14.20 | 14.54 |
| 90x90      | 8.06  | 8.06  |
| 80x80      | 10.70 | 10.70 |
| 70x70      | 11.98 | 11.99 |
| 60x60      | 20.18 | 20.18 |
| 50x50      | 31.68 | 31.68 |

\*\* 5 x 3-days arcs October 1995  
2029 SLR observations



# Static Solution

## GOCE orbit adjustment fit:

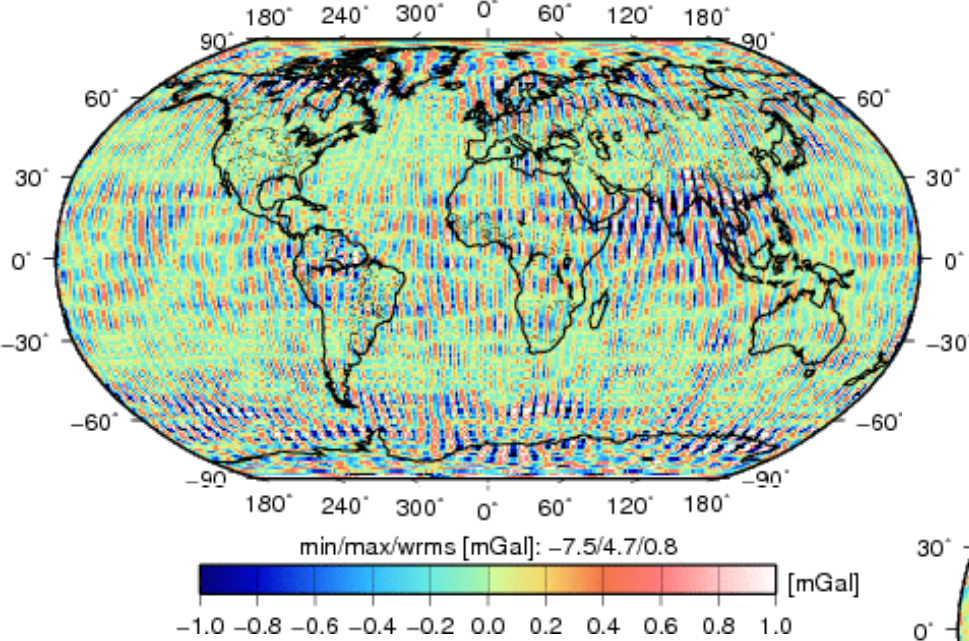
- **Dynamic orbit computation**
- Observations: **GO CONS SST PKI 2I** (kinematic orbit positions, consolidated product)
- **60 arcs** (01.11. – 31.12.2009), Arclength = **1.25 days**
- Rms values [**cm**] of the orbit fit residuals (mean values from the 60 arcs)
- Parametrization:  
Accelerometer **biases**: 2/rev for cross track / radial / along track  
Accelerometer **scaling factor**: along track fixed (set to 1.0), 1/arc for cross track / radial

| Gravity field model  | / max. d/o | 120x120   |
|----------------------|------------|-----------|
| EIGEN-51C            |            | 3.2 ± 0.9 |
| ITG-GRACE2010s       |            | 3.3 ± 1.0 |
| GOCO01S              |            | 3.3 ± 1.0 |
| EIGEN-6Sp**          |            | 3.2 ± 1.0 |
| GFZ GRACE 2008 RL 04 |            | 3.6 ± 1.2 |
| GFZ GRACE 2008 RL 05 |            | 3.4 ± 1.2 |

\*\*unpublished preliminary GRACE-GOCE model from GFZ/GRGS

# Static Solution

Gravity anomalies (n=2,...,120) w.r.t. ITG-Grace2010s

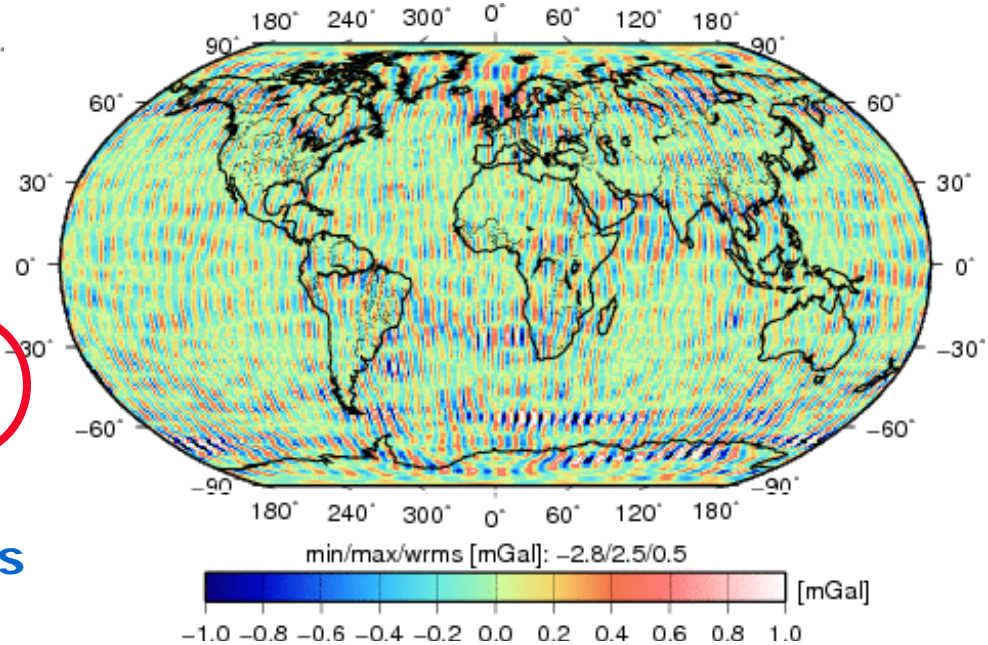


**RL04**

min/max/wrms: -7.5/4.7/0.8

→ Reduction of the stripes

**RL05**  
min/max/wrms: -2.8/2.5/0.5

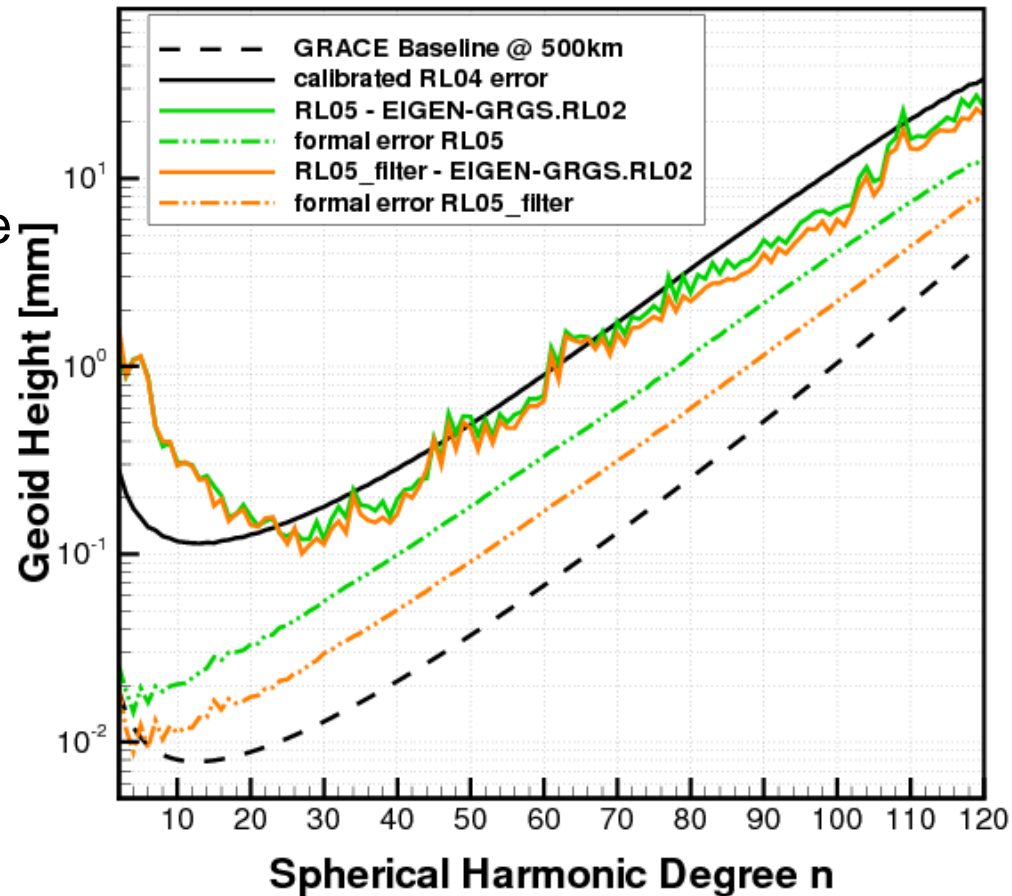




# De-Correlation Filter

→ Development and test of a dedicated de-correlation filter for GRACE

- A retro-regressive filter shall remove the specific error characteristics of the GRACE KRR observation equations
- Promising results in a simulation environment (see EGU2010 poster: EGU2010-8272)
- First test with real GRACE data:
  - ⇒ decrease of formal errors
  - ⇒ slight reduction of the noise

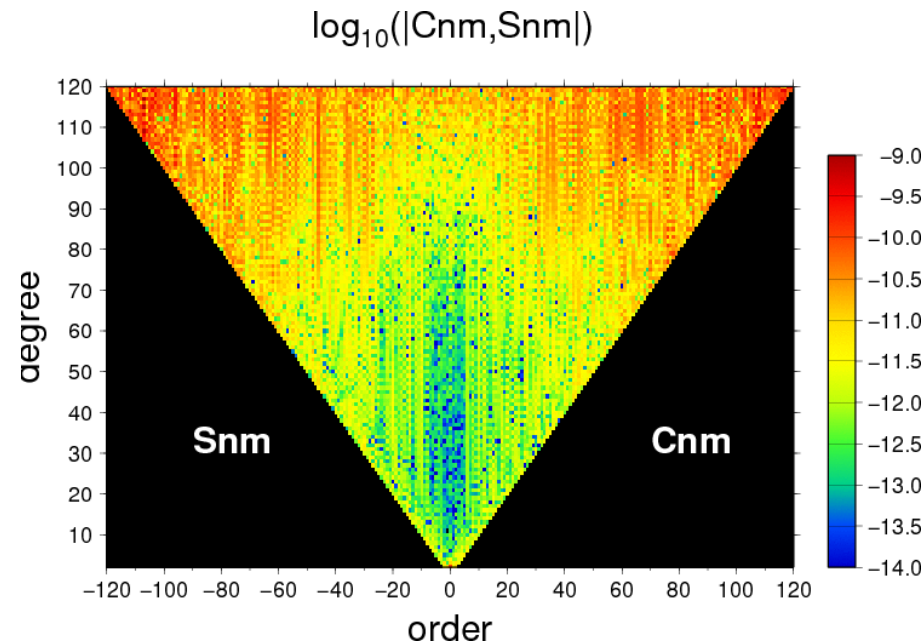




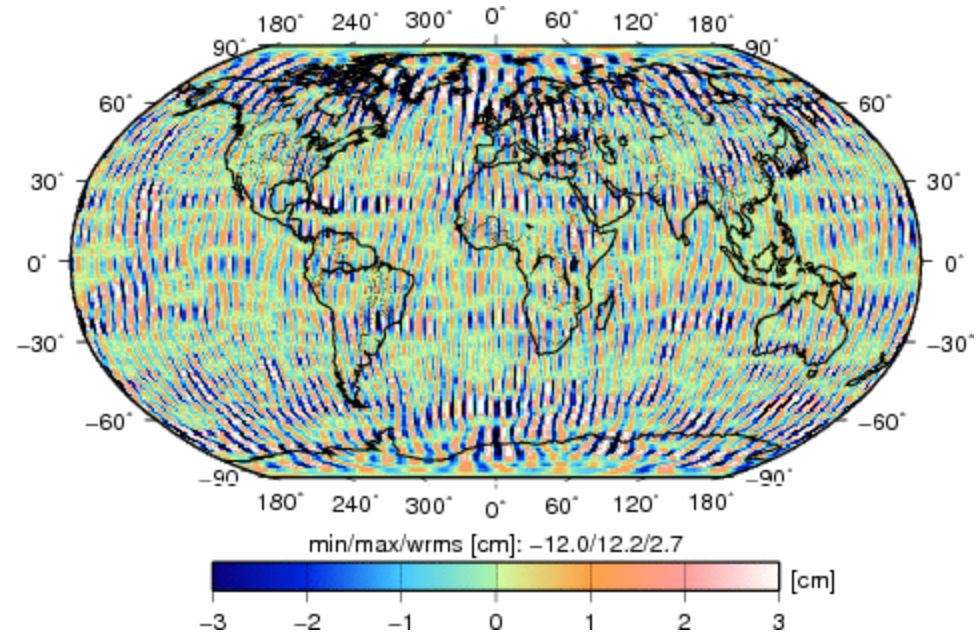
# De-Correlation Filter

- clear reduction of stripes in the higher degrees
- removal of GRACE specific order-wise error pattern

- RMS w.r.t. static field reduced from **8.4 cm to 7.3 cm** geoid height
- peak2peak of filtered vs unfiltered solution reaches 1dm geoid height



$\Delta C_{nm}/S_{nm}$  unfiltered vs. filtered solution



Diff. unfiltered vs. filtered solution  
in terms of geoid height [cm]

# Conclusions & Outlook

- 1 Year of GFZ GRACE RL05 has been processed preliminary by applying improved background models, new (draft) L1B data and updated processing standards
- The time-series of the new RL05 monthly solutions shows improvements: smaller RMS over oceans, decreased errors, less stripes, calibrated errors at a factor 11 above baseline (before 15)
- The first 1-Year RL05 static solution also shows improvements: better orbit fits compared to RL04 and less noise in higher degrees
- A new decorrelation filter for the K-Band Range Rate data is developed and tested: Improvements mainly for higher degrees ( $> 80$ ) in a 1-year RL05 static solution

**Further work: The final reprocessing of RL05 shall include:**

- updated L1B data (JPL L1B RL02 will be provided end of 2010?),
- furtherly improved RL05 GPS PSOs
- the latest IERS standards
- Test the combination with LAGEOS to stabilize the degree 2 coefficients

**Further investigations regarding the decorrelation filter are necessary:**

**Improvements also for time-variable part?**

End of Presentation

Thank you