Towards a Roadmap for Future Satellite Gravity Missions

Session B3
Data Processing, Modeling & Interpretation

Co-Chairs
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Session Background

Future Satellite Gravity Missions (FSGM) are based on technological improvements and mission requirements and designs, different to GRACE (will be covered in other breakout sessions).

This session focuses on anticipated challenges in the improved analysis and use of data from FSGM.

The context includes use of data from

- GRACE-like low-low satellite tracking (LL-SST) missions
- GOCE-like satellite gravity gradiometer (SGG) missions
- Low-Earth orbiters (LEO) using GNSS, satellite laser ranging (SLR) or radiometric (DORIS) tracking from ground or space and
- any combinations thereof.

Within this context, we focus on three important topics:

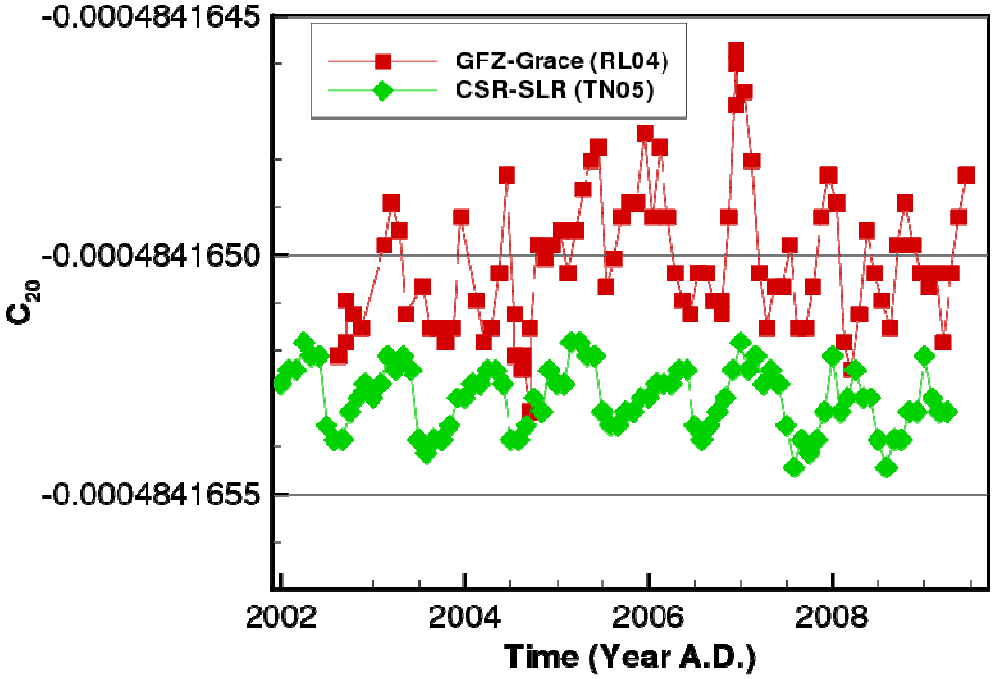
Topic 1: Useability

For a diverse variety of users, as evidenced by the work of the existing satellite gravity community, how can we make the satellite gravity measurements as well as data products more useable? For example, specific questions include:

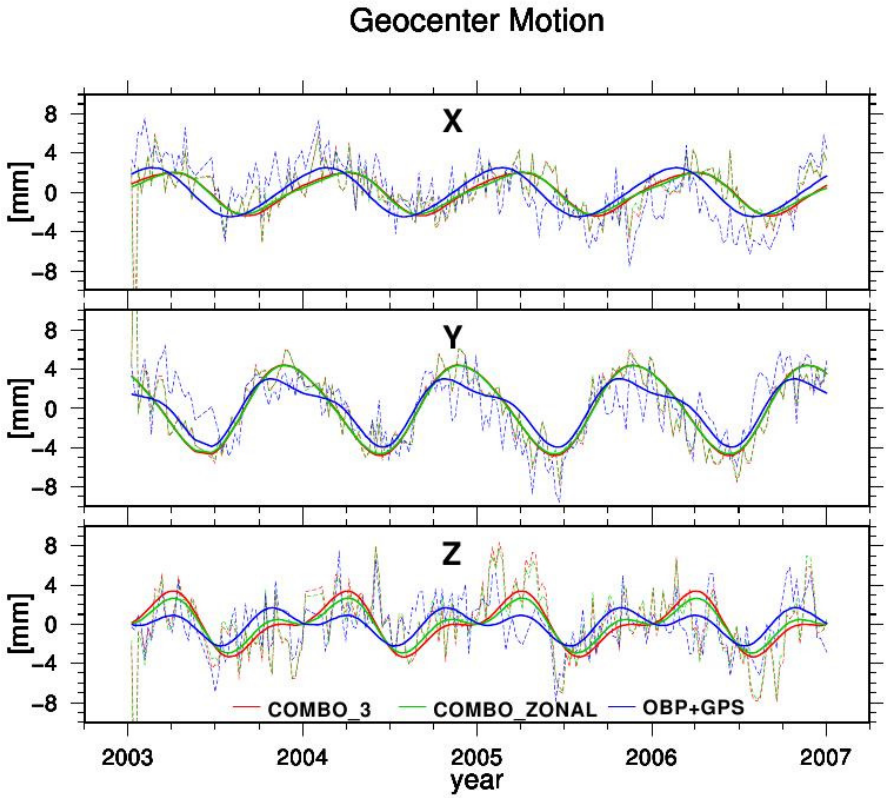
- Do we need additional L1A/L1B , L2 products or even L3 products?
- What ancillary satellite data is necessary for Level-1 and Level-2 analysis/interpretation?
- Role of "ground-truth" or "a priori" knowledge of the structure of the process being observed. What information is necessary for Level-1 and Level-2 analysis? And is it available in a simple-to-use form?
- Enforcing mutual consistency in the combination of multi-technique products e.g. GOCE+GRACE; or degree-1 harmonics; or GRACE+SLR; etc.

Topic 1: Usability (Examples)

ancillary satellite data

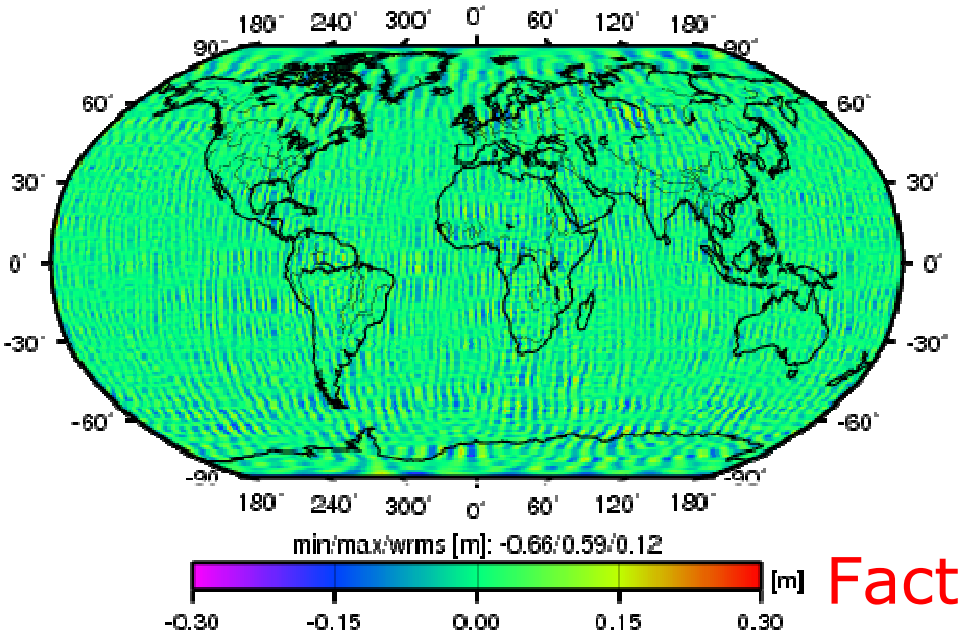


mutual consistency in the combination



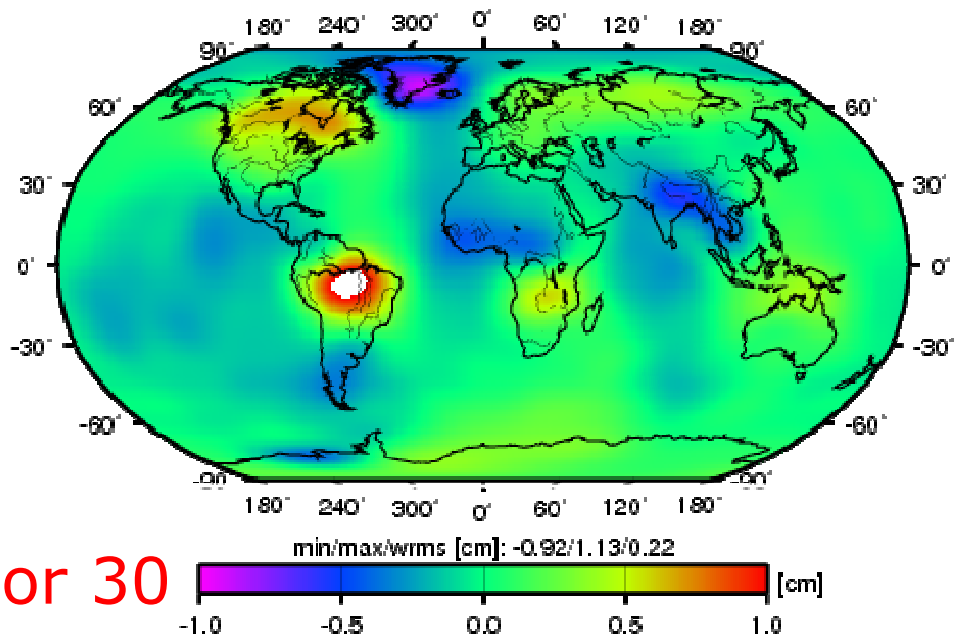
From Rietbroek et al., 2009

Topic 1: Usability (Examples)



GFZ RL04
4/2008 – EIGEN-GL04C
no filter

Factor 30



GFZ RL04
4/2008 – EIGEN-GL04C
Kusche filter (400 km)

- A-posteriori filtering necessary or use GRACE-TELLUS products
- new SDS L3 products (constrained/Masscons) for RL05?

Topic 2: Algorithms

Analyses of the data from the ongoing satellite gravity missions are helping us identify deficiencies in the conventional satellite geodetic methods (dynamic approach (SDS, GRGS), mass con solutions (GSFC, JPL), boundary problem (Bonn), …)

What are the future directions for algorithmic improvements? Topics include

- numerical,
- computational,
- parameterization, and
- modeling

aspects of the satellite geodetic methodology.

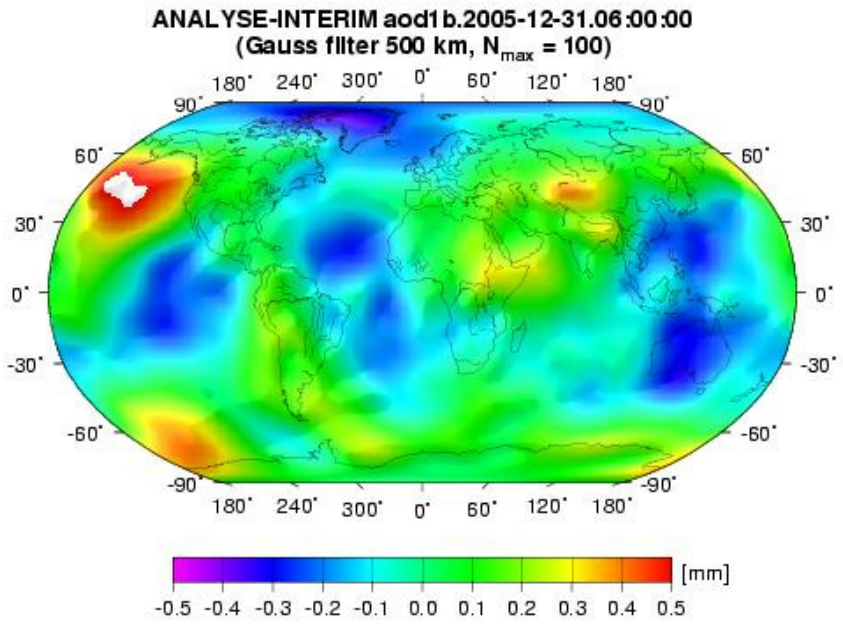
Topic 3: De-Aliasing

This refers to the use of a priori gravity field models to remove the contributions to the measurements from short-period geophysical variability, before estimates of the lower-frequency variability are extracted. Interesting questions include:

- To what extent do we have to improve the background models for future gravity missions?
- Is it necessary to improve these independently from the gravity missions? Or can we simultaneously solve for some components of the background models?
- Can we use assimilation/modeling methods to eliminate the need for de-aliasing?

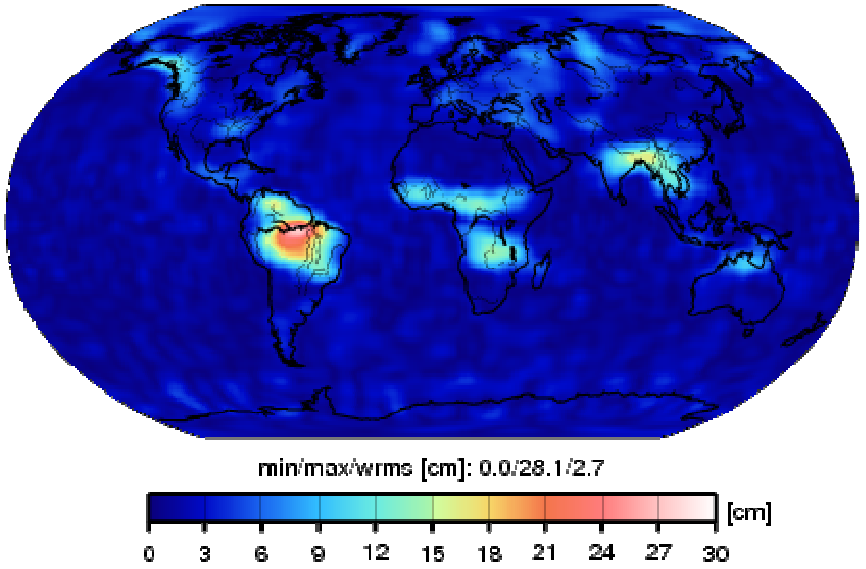
Topic 3: De-Aliasing (Examples)

- Atmosphere, non-tidal oceans and hydrology models are represented in empirical time series
- Models are the result of non-geodetic actvities: not safe in continuity, uniformity of standards, long-term trends



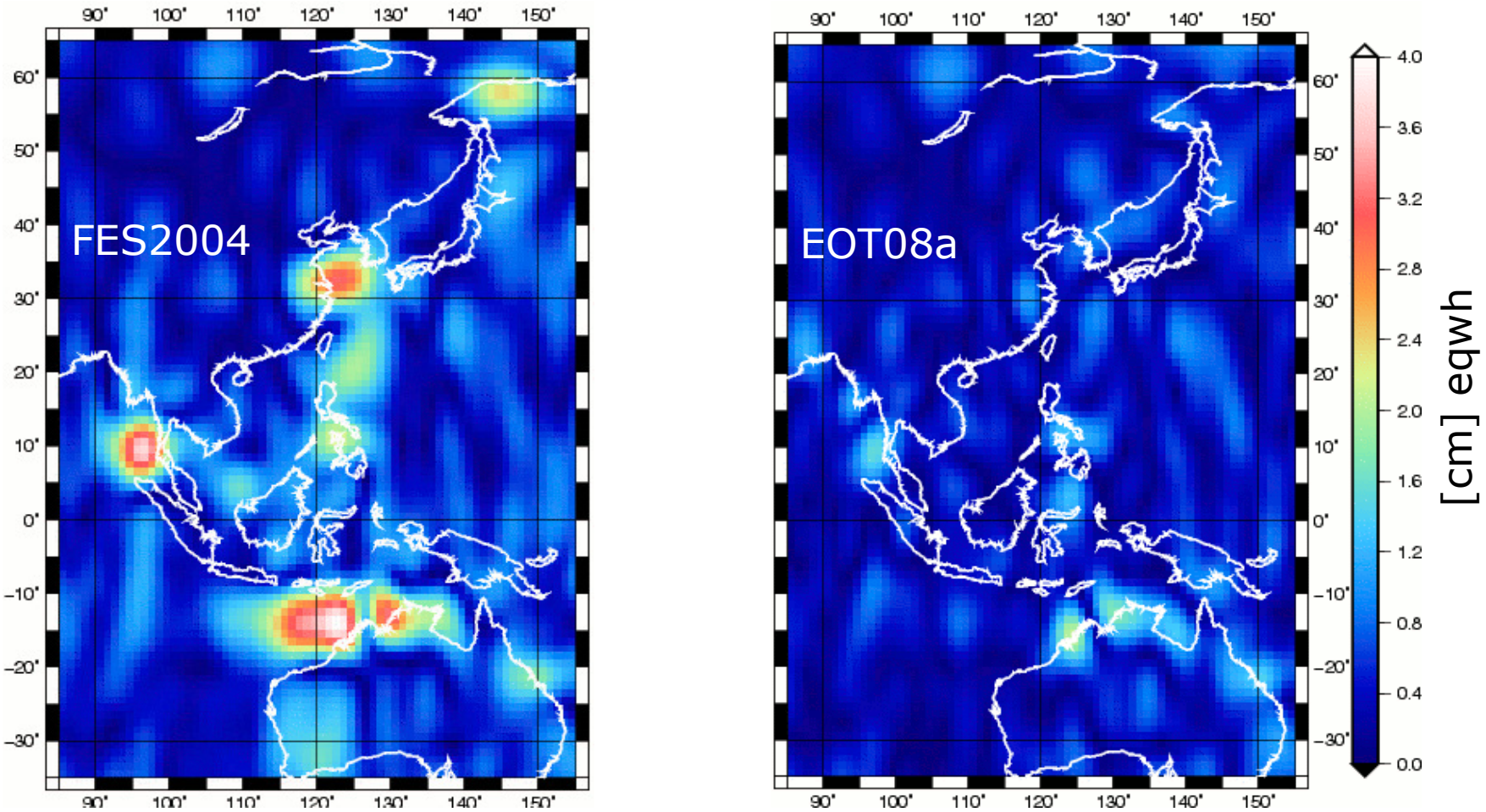
wRMS=0.16mm (only atmosphere)

Annual Hydrology from GFZ RL04



Topic 3: De-Aliasing (Examples)

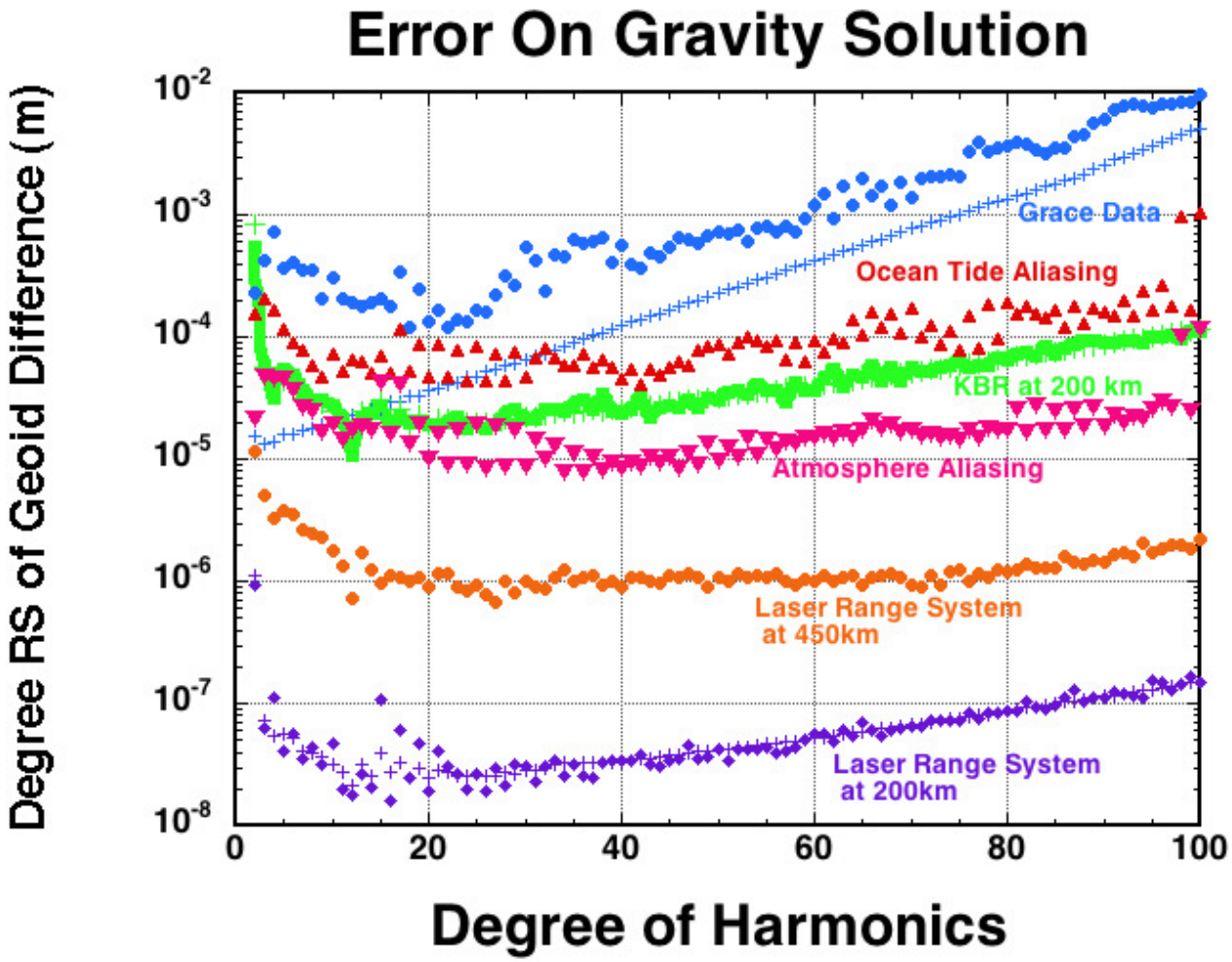
S2 (161d) signal in GFZ RL04 (FES2004) and with EOT08a (EOT10ag planned)



From Bosch et al., 2009

Topic 3: De-Aliasing (Examples)

from Mike Watkins :



Session Outline: Block 1 (1:20)

- Introduction (10')

- 4 invited speakers (15'):
  - ~~Frank Lemoine (GSFC): "The Role of Ground-truth Information"~~ (stabilization incl. taxonomy, ground truth data, a-priori knowledge, …)
  - Jürgen Kusche (U Bonn): "Methodological aspects related to gravity analysis from future missions"
  - Tonie van Dam (U Lux): "Can geodetic Data be used as a Complement to Satellite Gravity Data in the Future"
  - Pascal Gegout (DTP/GS): „Background Models used in geodetic Data Processing"
  - ~~Frank Lemoine (GSFC): Ocean Tide Issues (from R. Ray)~~
  - Contributed abstract by Bender et al. "Local Analysis Approach for Short-wavelength Variations in the Geopotential"

- Each speaker was requested to summarize a list of "key questions" or "challenges": Consolidation (10')

Major Outcome

All talks covered the 3 topics (usability, algorithms and de-aliasing), but surly not everything which was on the agenda and which might be a key question for a future gravity mission has been discussed (partly due to cancelled talks and limited time).

Overall requirement:

- reduce aliasing (tidal and non-tidal mass variations, atmosphere, hydrology)
- reduce distortion (GRACE is a non isotropic instrument): influences mass estimates
- better separation of effects (dependent on the quality of the background models)

Major Outcome (1)

- **Data Usability**

  - Need ancillary data (GPS/OPB/SLR) to strengthen deficient low degree harmonics
    - degree 1 (needed for combination altimetry/gravity) e.g. from GPS/OBP or combination GPS/OBP/GRACE
    - degree 2 (from SLR, TN05)
    - More detailed s/w comparisons of SDS centers necessary (on the way)

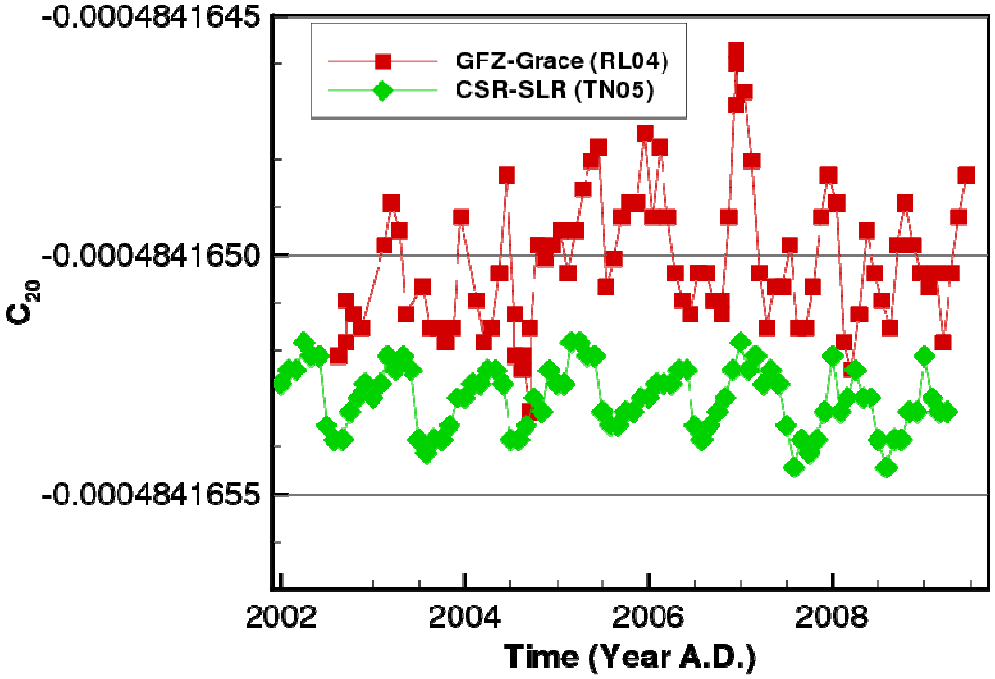
  - Combination with GPS/OBP and SLR has potential to extrapolate GRACE back and forward in time (in case we do not get a gap filling mission), limited to approx. n=10 and n=4, respectively (sparse network)

  - It could be a target for future missions to better resolve low degrees (important for climate analysis) -> Deg. 1 / geocenter requires an improved absolute measurement (GNSS) rather than relative MW/Laser Link

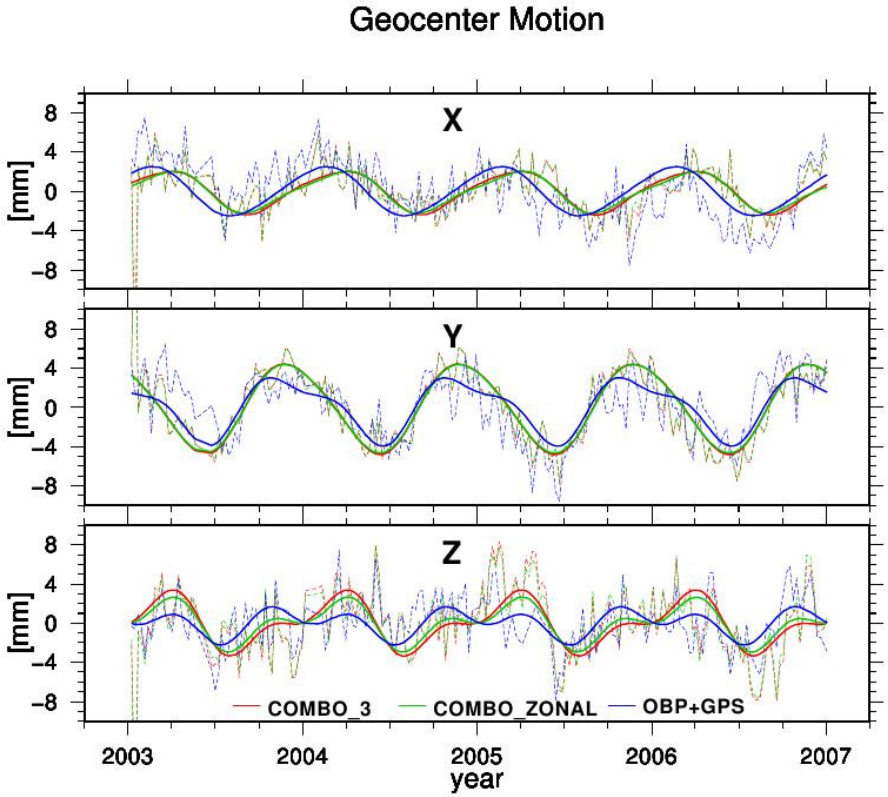
  - Wish by hydrology on more rapid data processing and product dissemination

Topic 1: Usability (Examples)

ancillary satellite data



mutual consistency in the combination



From Rietbroek et al., 2009

Major Outcome (2)

- **Data Processing / De-aliasing**
  - Some progress has been achieved since 2007
    - AOD1B
      - test ERAinterim data (more consistent)
      - use error measures of meteorological data (SPP IDEAL-GRACE project)
      - compare different 3D algorithms / standards (ellipsoid, Love number,..)
      - Open: Is a 2yrs mean sufficient to derive variability?
    - Ocean Tides
      - Empirical corrections to FES2004 (EOT08a) give regional improvements
      - Use of GRACE for ocean tide adjustment shown in several papers
      - EOT10ag on the way (combination Altimetry/GRACE)
      - Open: use pure empirical/altimetry or altimetry-assimilated hydrodynamic models? (Improve physics for shallow seas)
      - Open: Should a future mission design be capable to improve the tides?
    - Hydrology
      - Hydrological models shall be included, but still differ much
      - first attempts to assimilate GRACE
      - use GRACE annual/semi-annual signal as a-priori knowledge

Major Outcome (3)

- This all helps GRACE processing. For Future Gravity Missions with increased SST accuracy and attitude control the de-aliasing models would have to be improved dramatically! Unclear if this is feasible.

- Therefore, as for the ocean tides: Can it be a task of future gravity missions to improve atmosphere (e.g. atmospheric tides)

- Unclear if we need higher temporal (1h?) or spatial resolution (0.5 degrees for non-tidal ocean models) for future mission de-aliasing models

- Can atmospheric fluctuations be recovered from local approaches (e.g. for South pole area, with stable atmospheric conditions and fast data collection)?

- New methods to derive/parameterize gravity models have been developed (e.g. Kalman filter using a-priori info from background models) and short-comings of other methods (step functions) identified.

Topic 3: De-Aliasing (Examples)

from Mike Watkins :