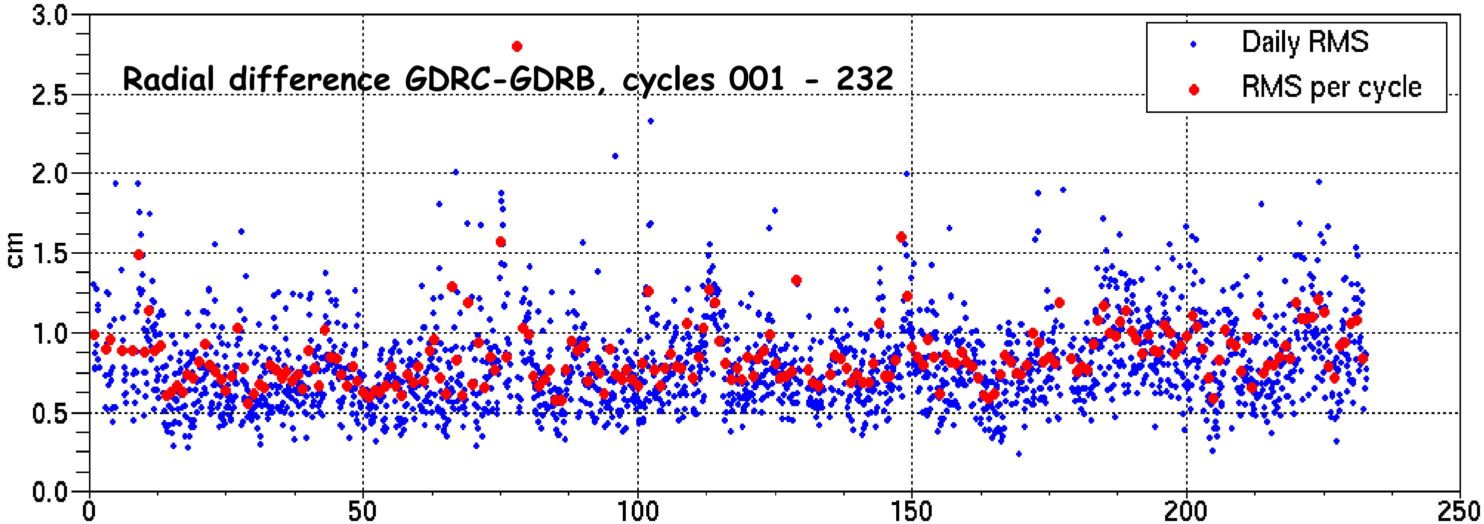
POD/Geoid splinter summary

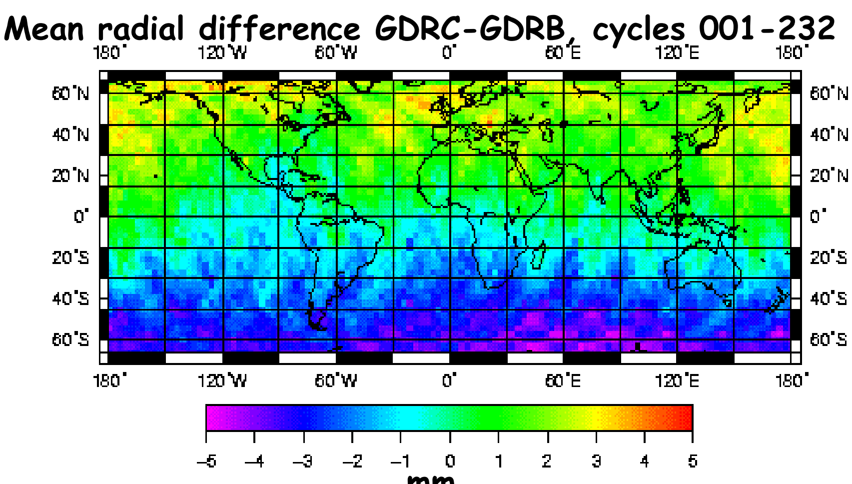
GDR-C standards summary

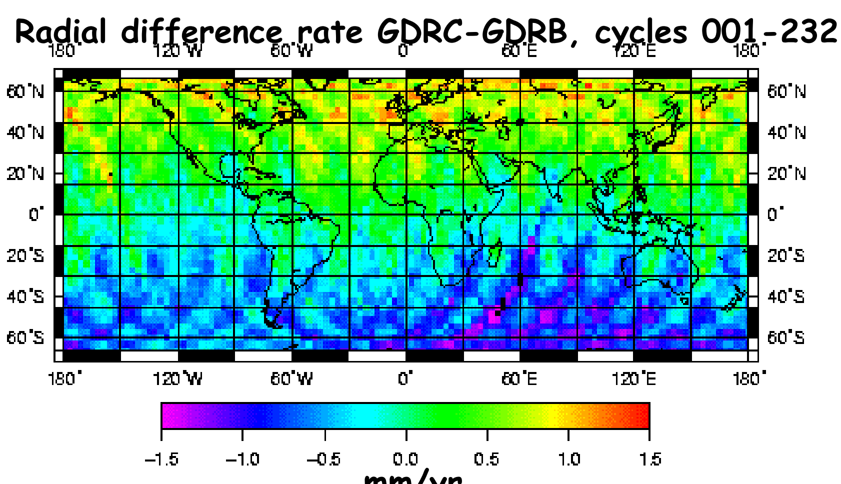
- Complete reprocessing of Jason-1 cycles 1 → now
  - Reference Frame: ITRF2005
  - Time Varying Gravity: annual and atmospheric gravity (NCEP,IB)
  - Reduced weight of GPS wrt to SLR and Doris (more robust when GPS tracking was reduced)
  - Use of SAA model extended after the Doris instrument change



Comparison between GDR-C and GDR-B orbits

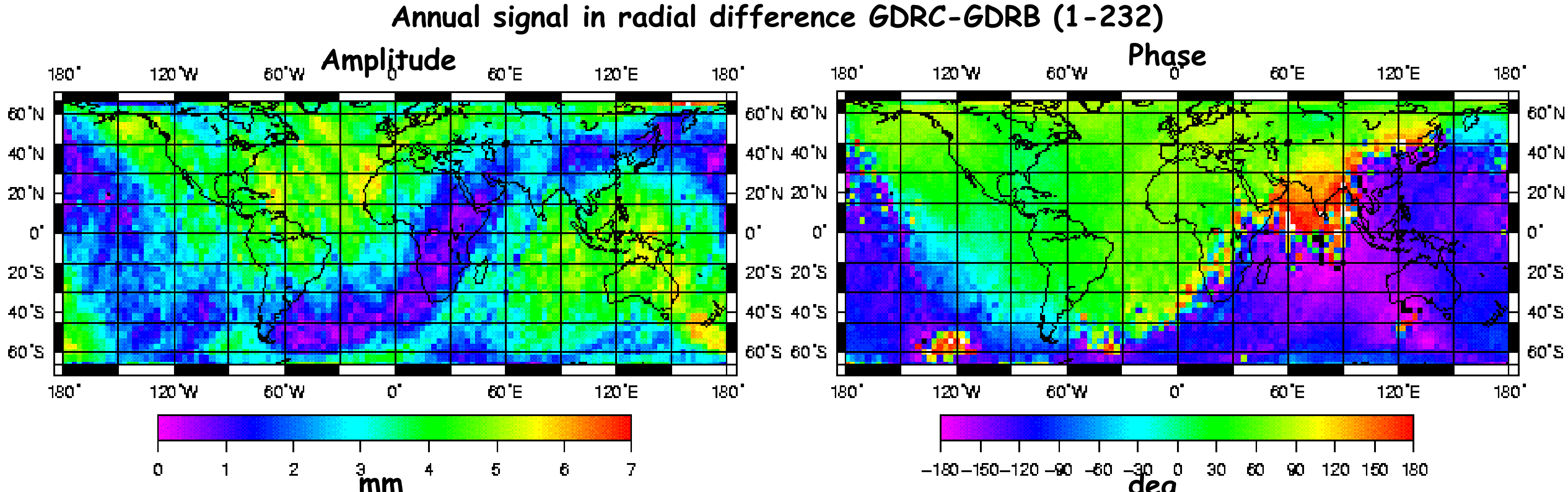
- **Reference frame : from ITRF2000 hybrid configuration to a fully consistent ITRF2005 configuration**
  - **SLRF2005 station coordinates and biases (bias per pass is solved for a few stations)**
  - **DPOD2005 Doris coordinates**
  - **GPS constellation:**
    - JPL solution (sp3, clk) @IGS (consistent with IGS05)
    - Ephemeris aligned by JPL to ITRF05 before GPS week 1400, clocks unchanged
  - **Polar motion consistent with ITRF05**





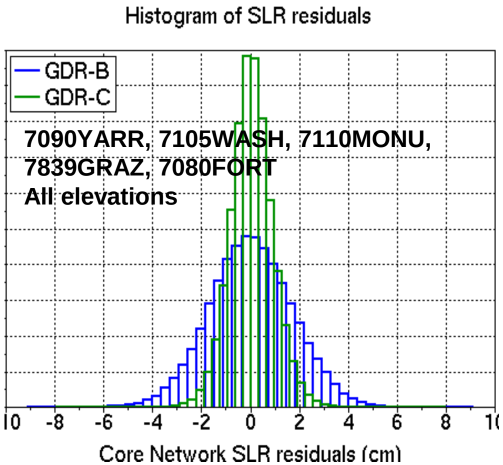
Comparison between GDR-C and GDR-B orbits

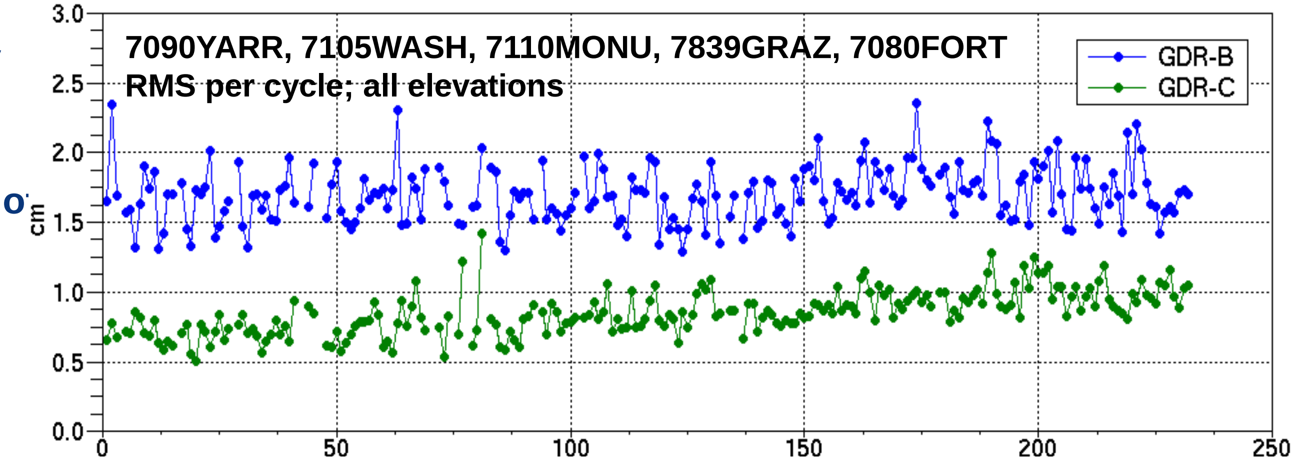
- Static gravity field: EIGEN-CG03C → EIGEN-GL04S
- Time varying components :
  - Annual + Semiannual (no drifts) from EIGEN-GL04S-ANNUAL model
  - Atmospheric gravity from AGRA files produced at GSFC
- These effects induce a time varying radial difference with an annual component that can reach 6 mm amplitude

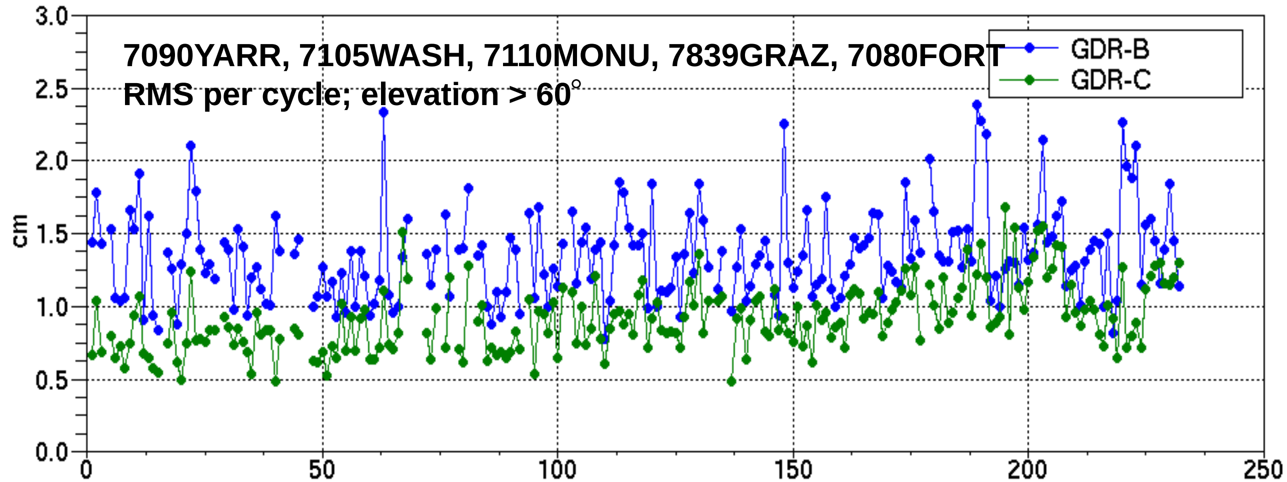


SLR residuals on GDR-B and GDR-C orbits

- Improved orbit accuracy cross- and along-track (new GPS-phase maps)
- Stronger relative weight of SLR measurements accentuates the improvement

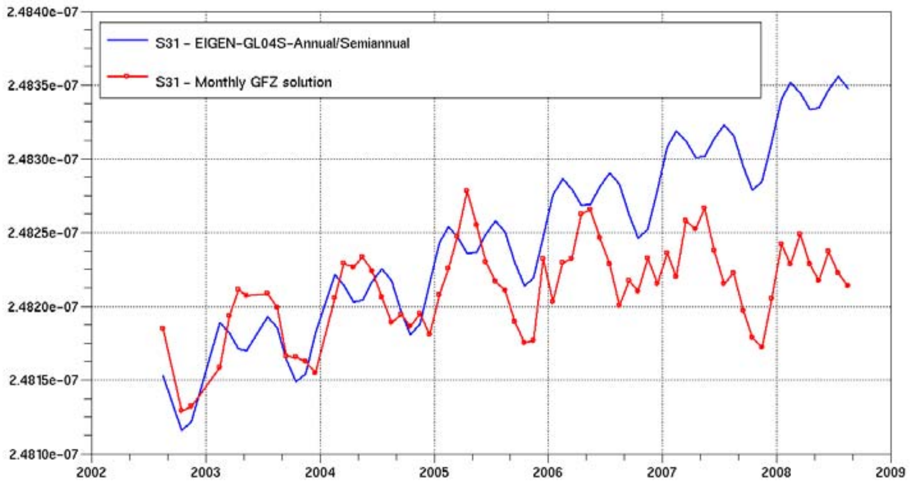


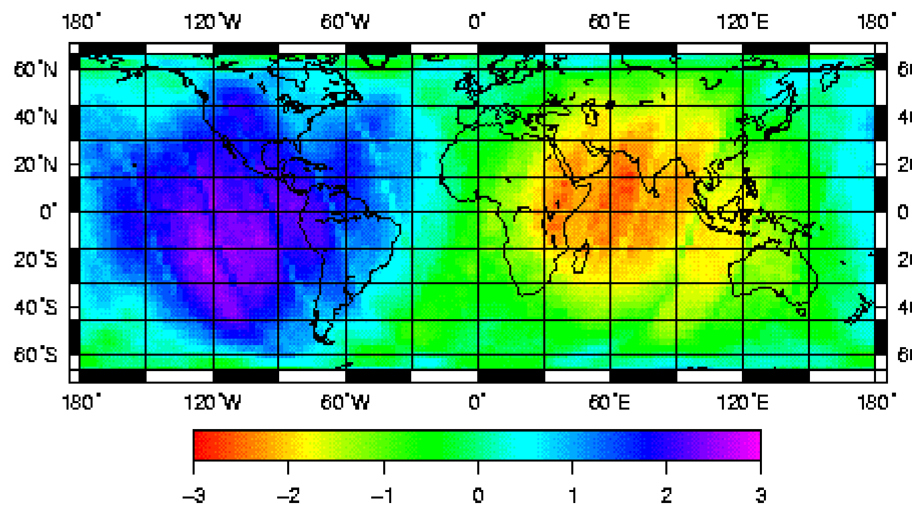




The GDR-C orbit “problem”

- Jason-1 orbit is sensitive to order 1 terms in the gravity field
- EIGEN4-GL04S-ANNUAL drifts were estimated using GRACE data from 02/03 to 07/05
- over that period S3,1 drifted significantly, it has since leveled off
- extrapolation of drifts leads to unacceptable results: all drifts have now been removed from the GDR-C standards (except for those included in the IERS standards)





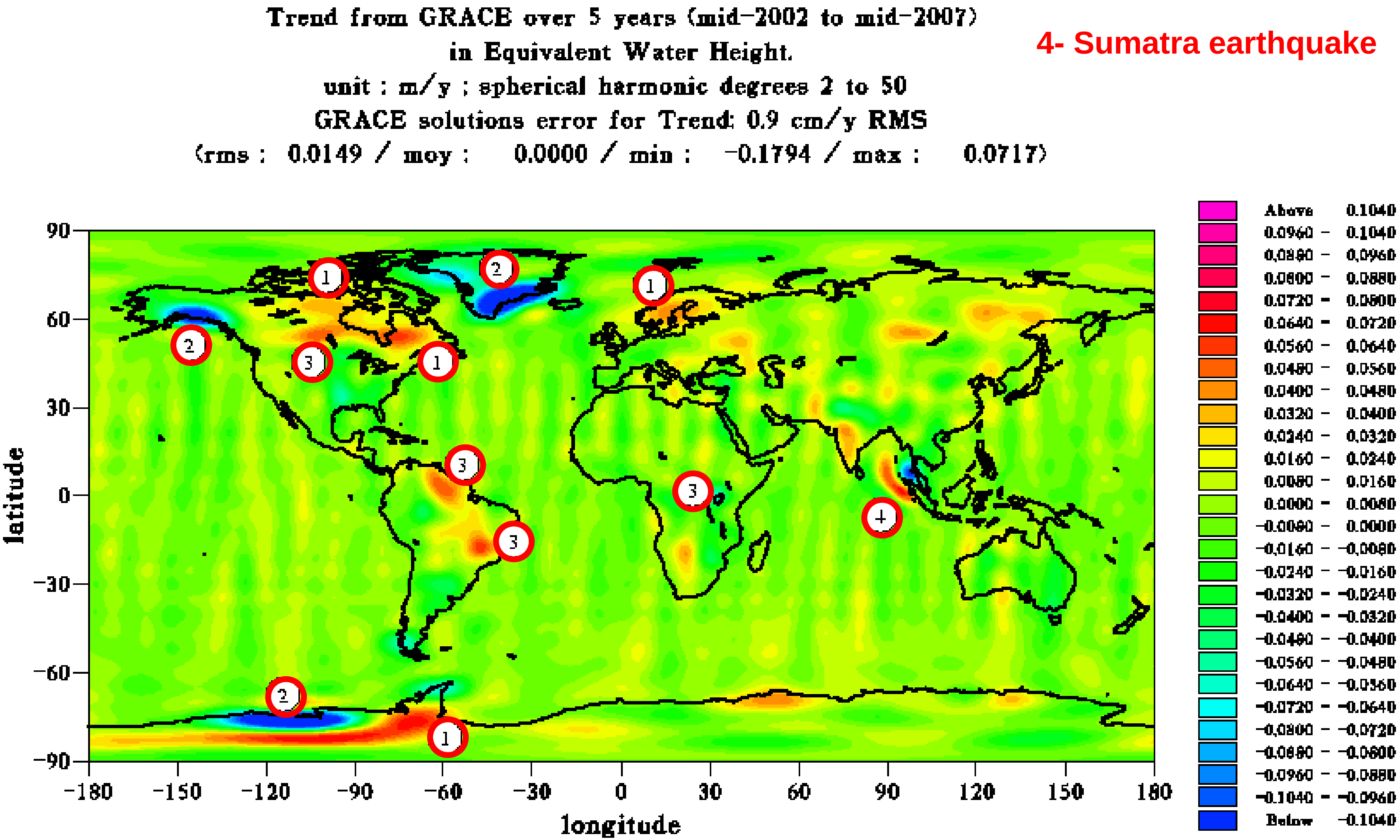
Radial difference rate (mm/yr) due to the drifts of EIGEN-GL04C-ANNUAL

1- Post-glacial rebound

2- Glacier melting

3- Hydrological trends

4- Sumatra earthquake



3- Should we use « secular trends » or « broken line » ?

➢ **In some cases, a "broken line" seems more appropriate (e.g. Greenland) or C2,0**

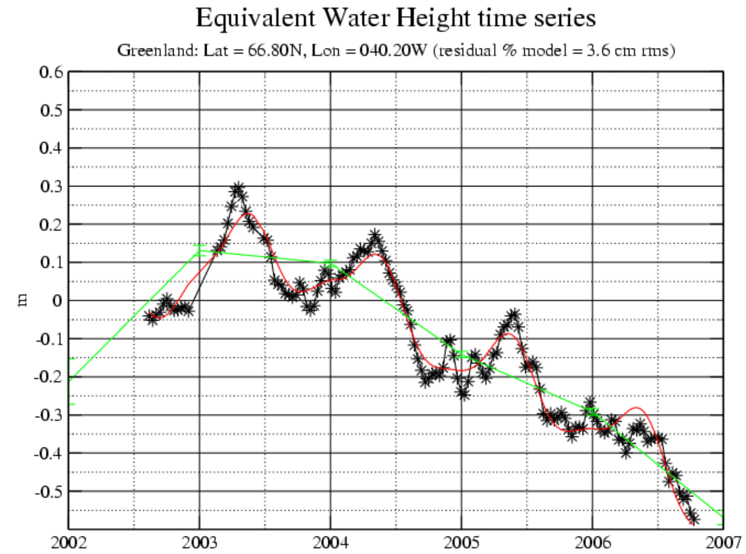
BUT…

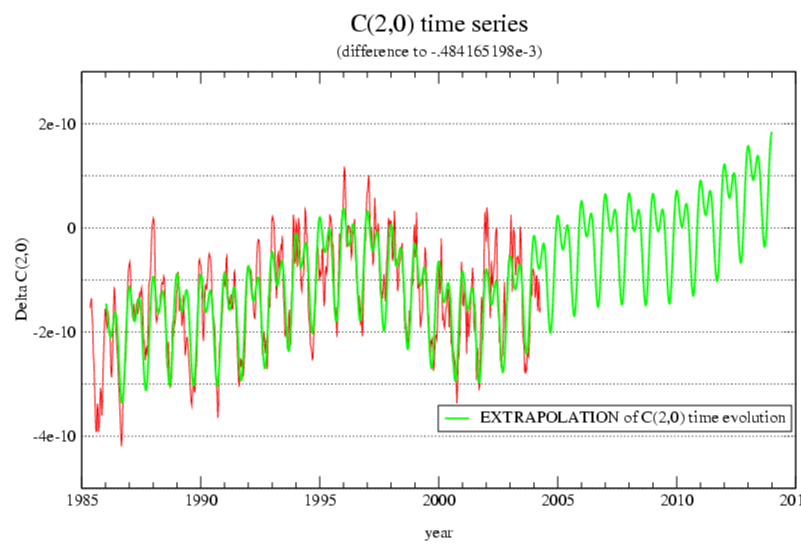
➢ **More parameters → more noise ;**

➢ **More difficult to implement for users ;**

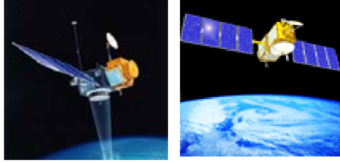
➢ **Problem of predictability (extrapolation) ;**

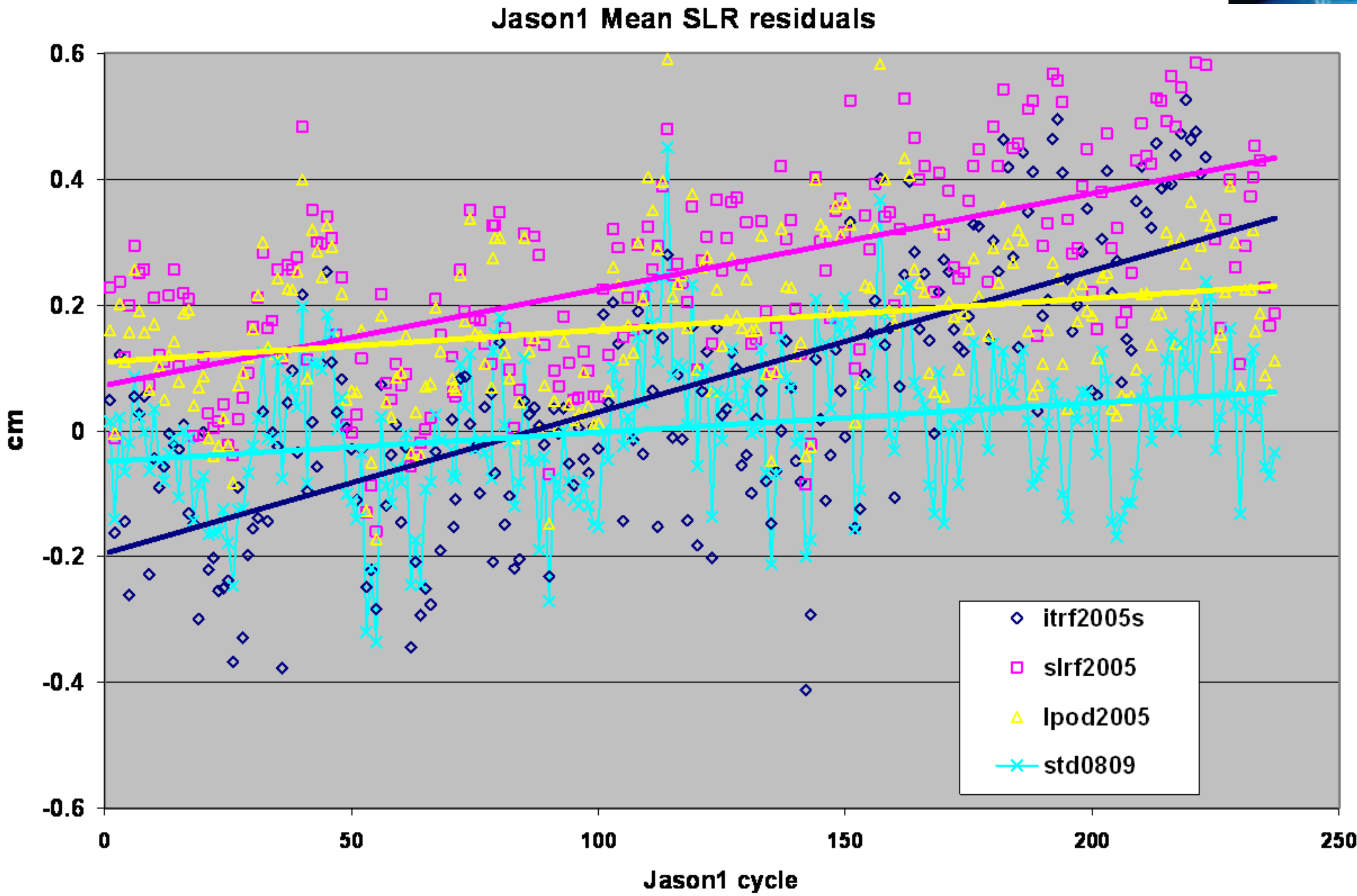
➢ **If great accuracy is needed, then the time series solution can be used !**





SLR Residual Analysis with Jason-1

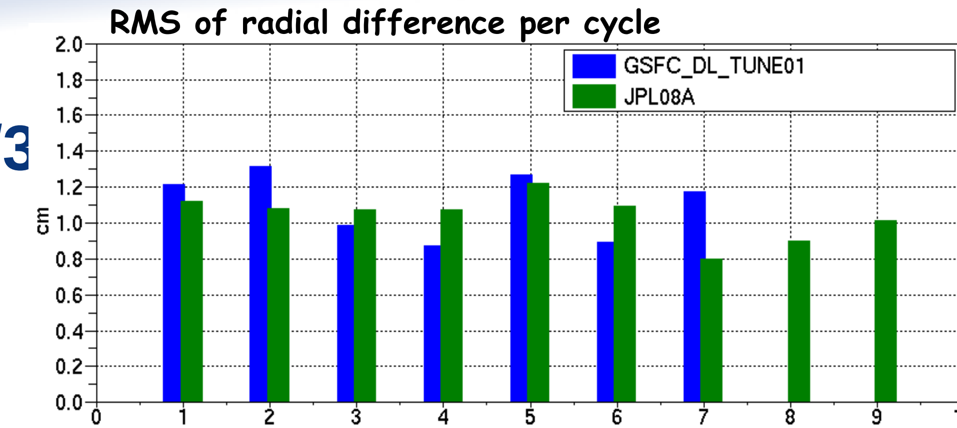


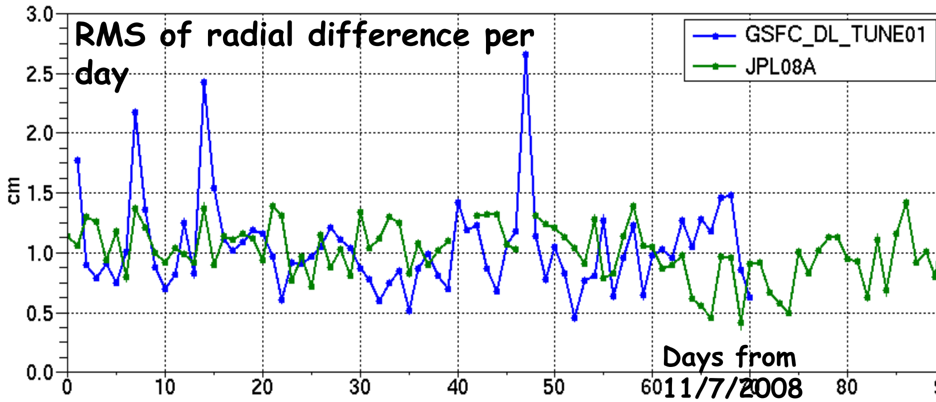


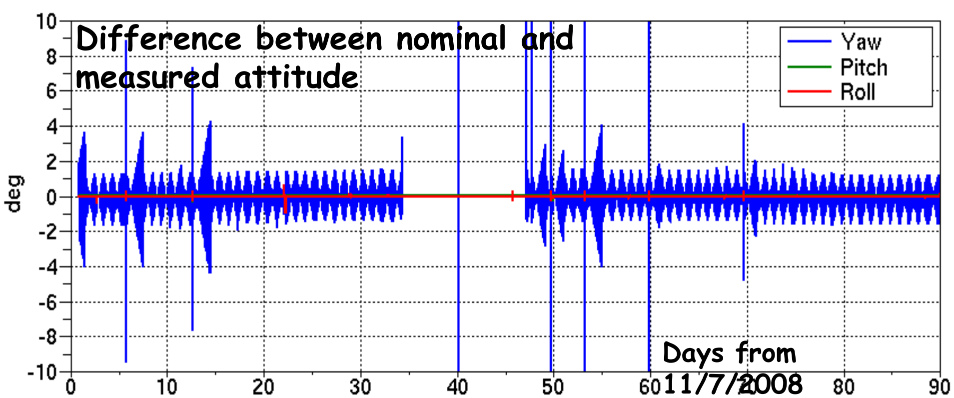
Evidence of SLR station bias / position error, the LPOD2005 solution, and effect on the Jason-1 orbit.

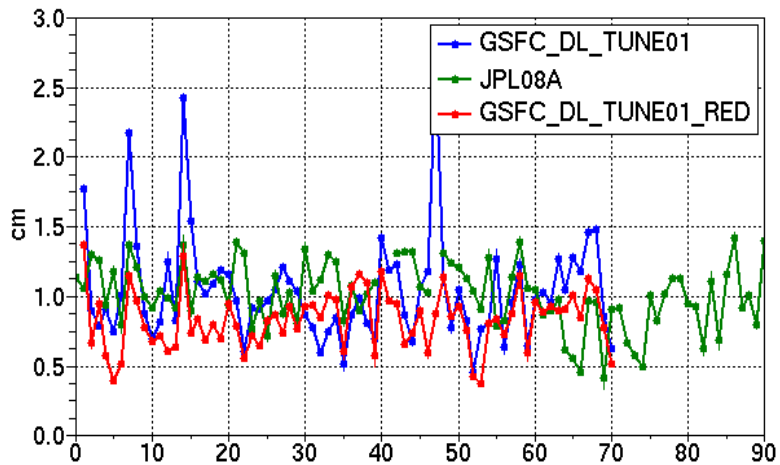
External comparisons 1/3

- CNES orbit compares to the cm level with JPL and GSFC
- Few exceptions mainly on GSFC dynamic orbit (attitude events?)
- Excellent agreement with GSFC reduced dynamic orbits (mean radial RMS=0.83 cm)

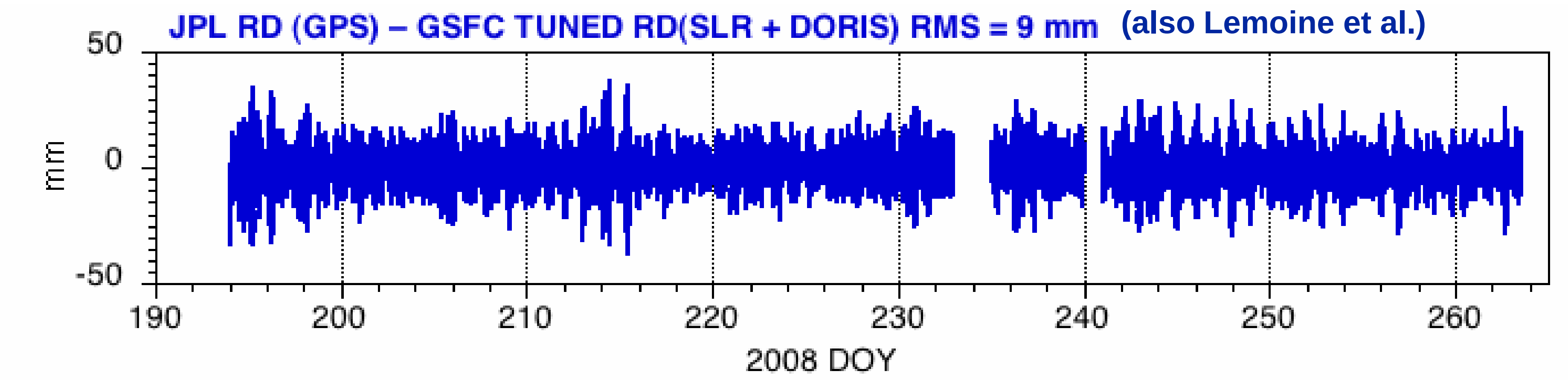


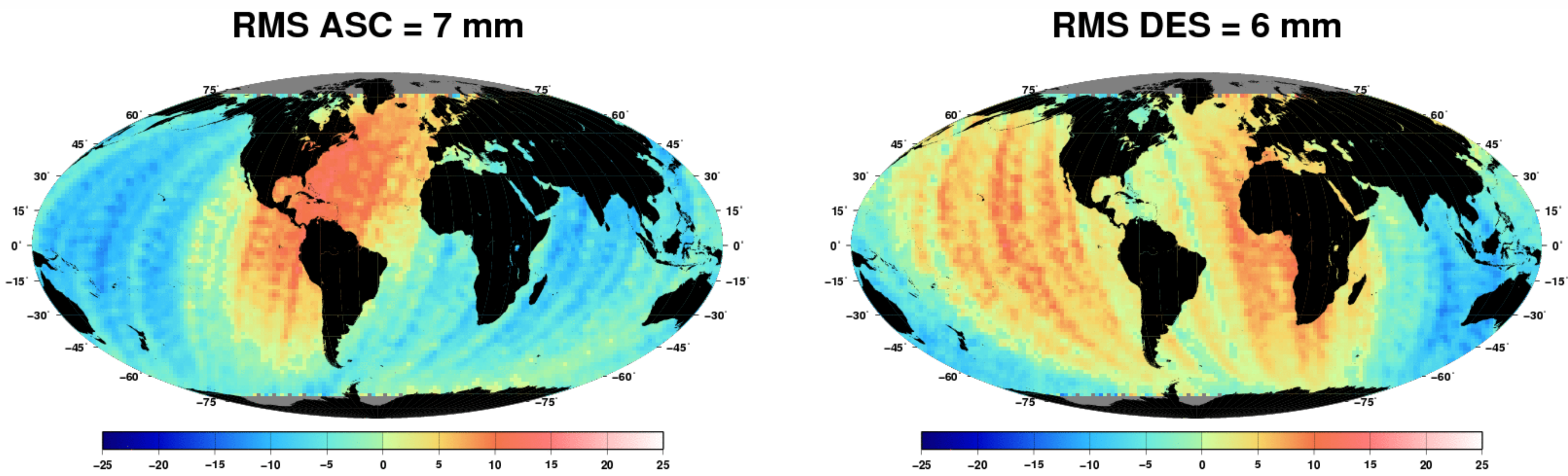






Jason-2 Radial Orbit Accuracy:
External Measure Yields <1 cm Agreement





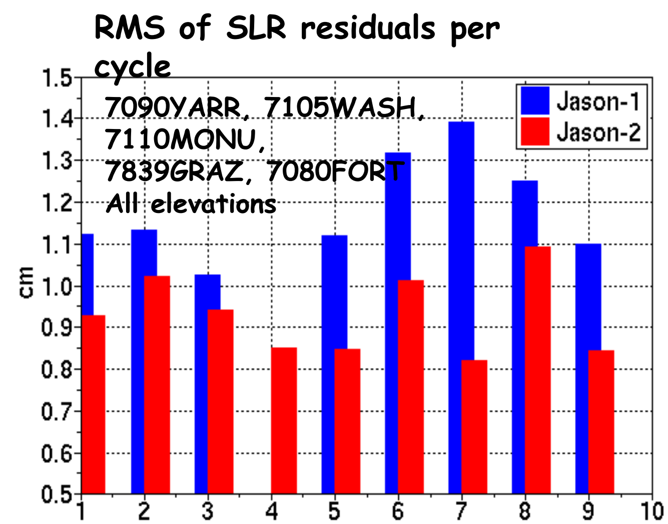
High Elevation SLR Range Biases: RMS = 15 mm, with 7 mm repeatability at both Yaragadee (N = 66) and Graz (N = 35)

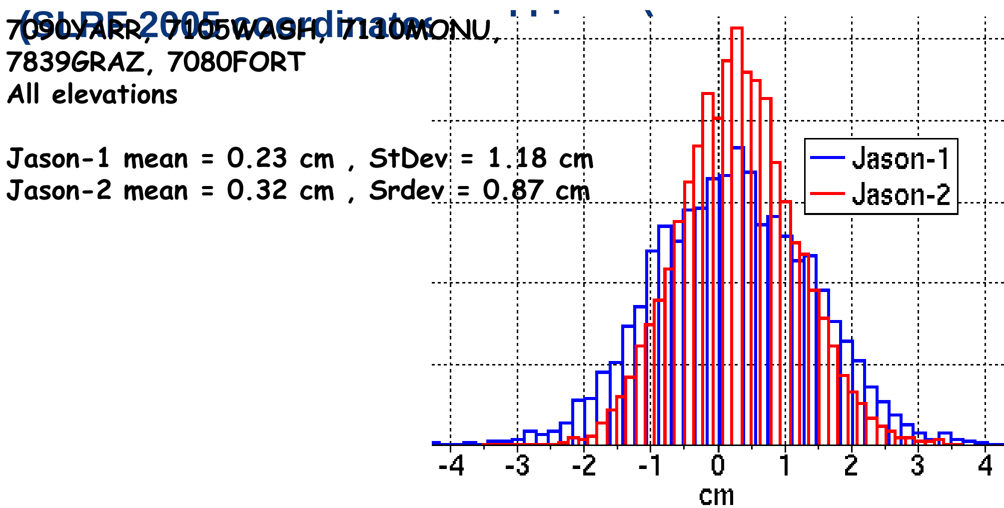
Post-fit SLR Residuals

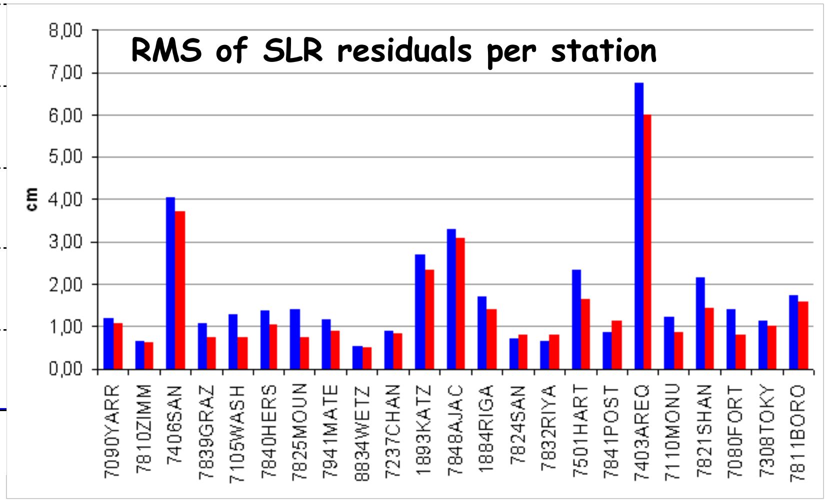
- Better fit for Jason-2: possible causes
  - Radial accuracy probably increased by higher

    number of empirical forces (12 hr 1/rev thanks to GPS)
  - SAA effect degrades Jason-1 orbit

(SLRF2005 coordinate







Conclusions (1)

- **GDR-C standards are close to the state of the art**
  - transition from SLRF2005 (with adjusted biases) to LPOD2005 would further improve long term performance; this transition will be implemented without impact on users (no reprocessing)
  - modeling of long term changes in the gravity field due to hydrology and ice melting is not mature enough to enter the standard; impact of long term drifts will be monitored using GRACE monthly solutions, and mitigation techniques involving empirical parametrizations will be investigated

- **Jason-2 POE orbits already have a precision comparable with those of Jason-1**
  - minor modeling issues need to be analyzed (surface force models, instrument phase center corrections, etc.)
  - these orbits already meet GDR precision requirements

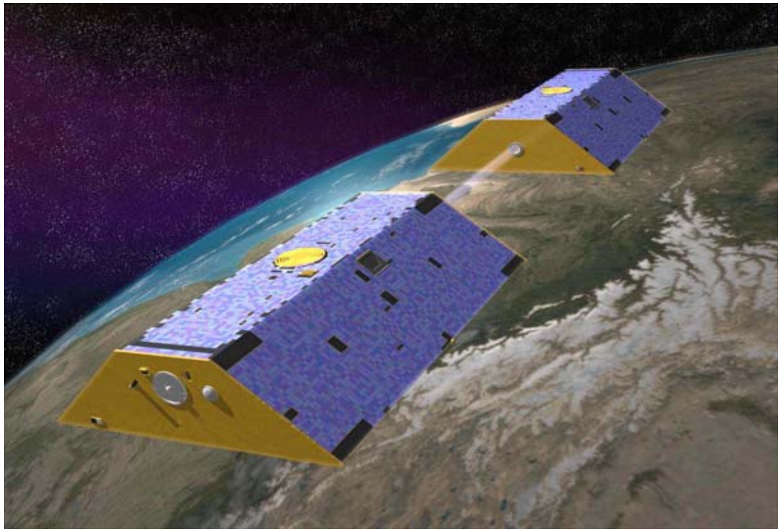
Conclusions (2)

- **Parametrizations for Jason-1 and Jason-2 are slightly different to optimize orbit precision given the available tracking data**
  - these differences in parametrization induce small differences in orbit error signatures that might affect tandem mission intercalibration
  - GSFC has produced a set of orbits for Jason-1 and Jason-2 which are designed to be as consistent as possible
  - current Jason-1 IGDR orbits (MOE) are not suitable for intercalibration work (they do not use the DORIS SAA model)

- **POD is not sensitive to the Jason-1 / Jason-2 relative geometry**
  - no recommendation is issued by the POD group regarding where and when to move Jason-1
  - SAA model adjustment to the new ground track will require time; during that time orbit precision will likely be degraded

Geoid Summary

GRACE Mission Status: Still Good



NASA 2007 Senior Review and DLR approved mission extension and funding through 2009

- Extension to 2011 approved by NASA “in-principle”; discussions underway at DLR
- Predicted mission lifetime at least 2013

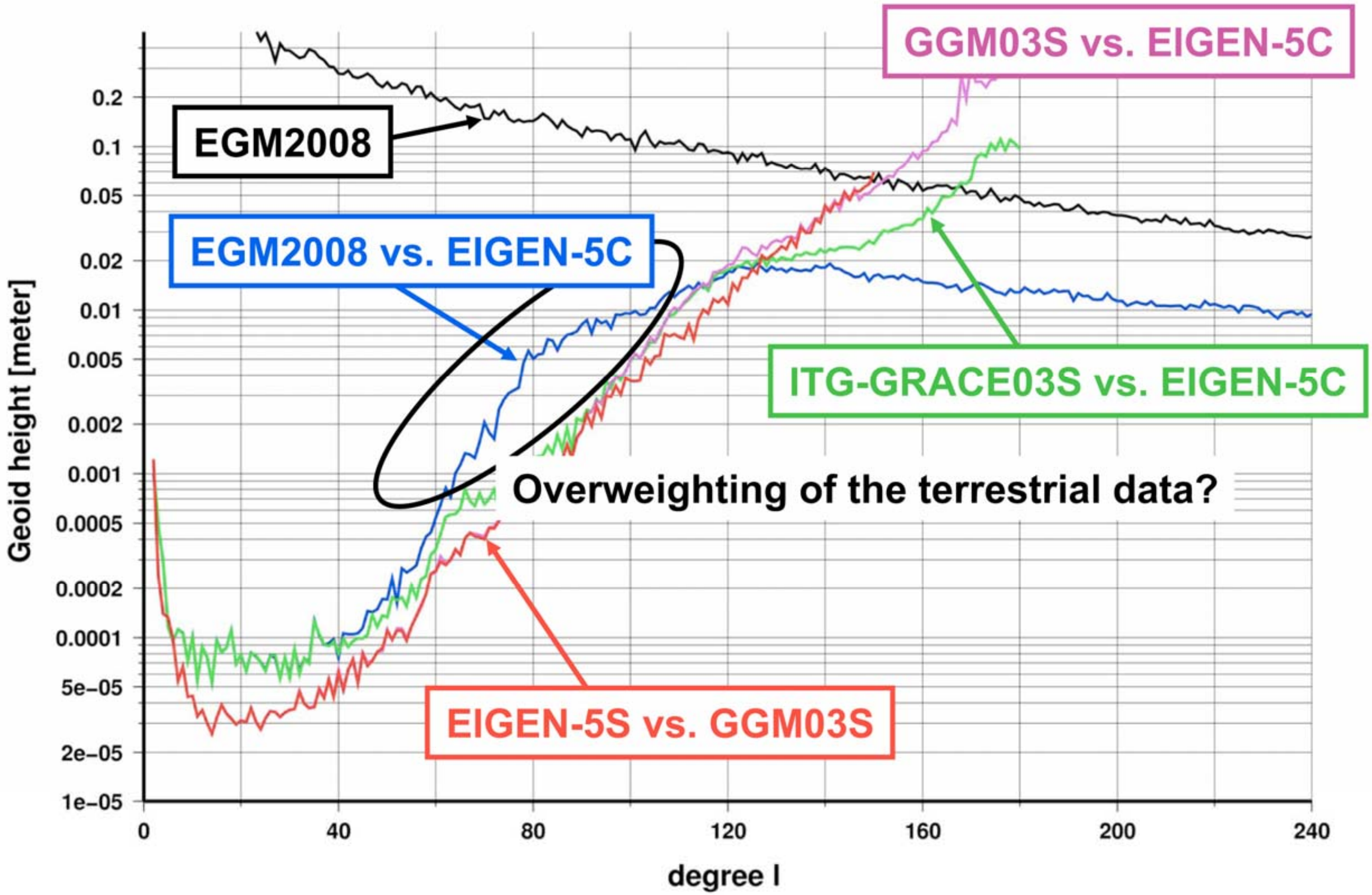
Flight Segment

- Almost 100 % of scientific measurements for nearly seven years have been collected and analyzed
- Instrument performance continues to meet mission requirements

New mean gravity models

- GGM03S, EIGEN-GL05S&C, ITG-GRACE03S → EGM2008

Improved Next-Generation Geoid Models (EIGEN-GL05C, EGM2008)



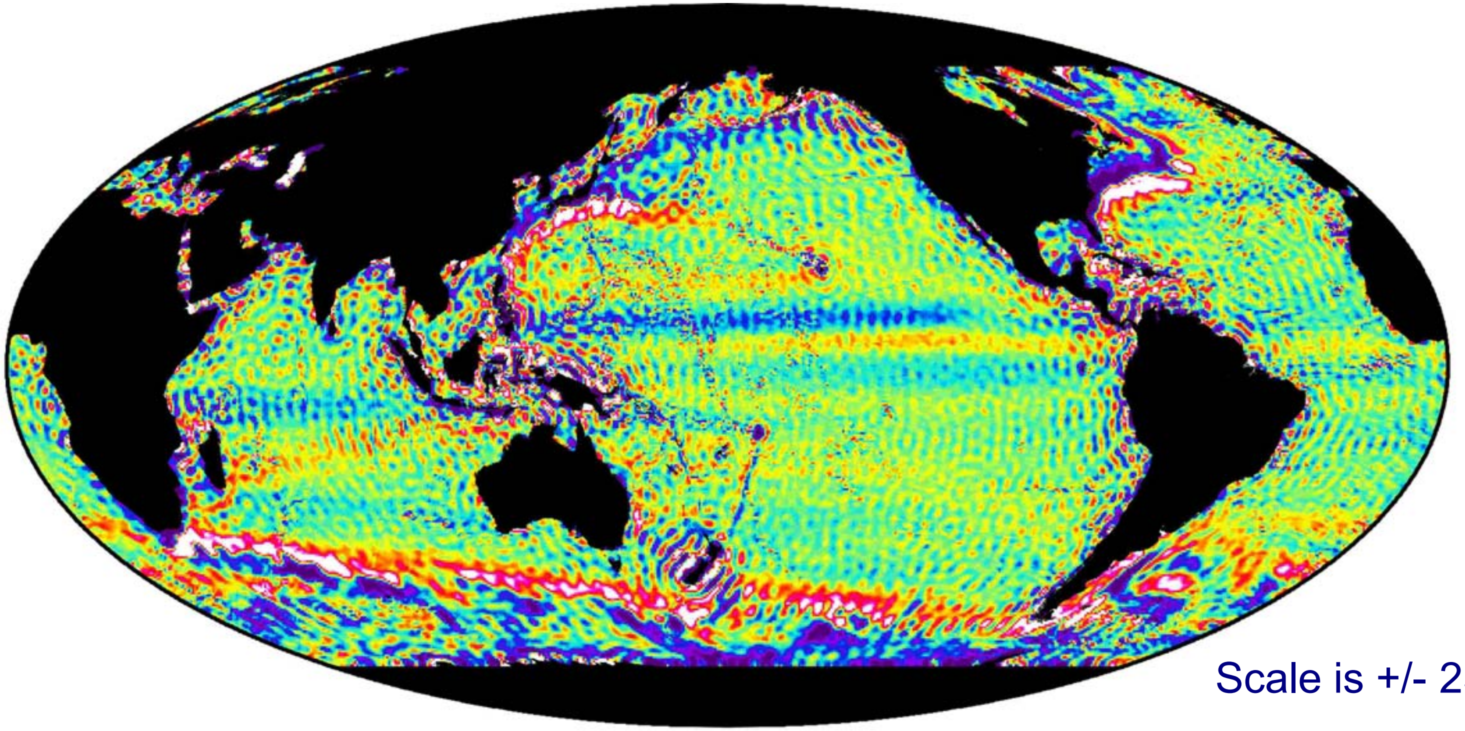
EIGEN-5C: Degree variances (in terms of geoid heights) in comparison to other current models including EGM2008

GFZ POTSDAM

GRGS Groupe de Recherches de Géodésie Spatiale

Short Wavelength Geoid Residuals
EIGEN-GL04C

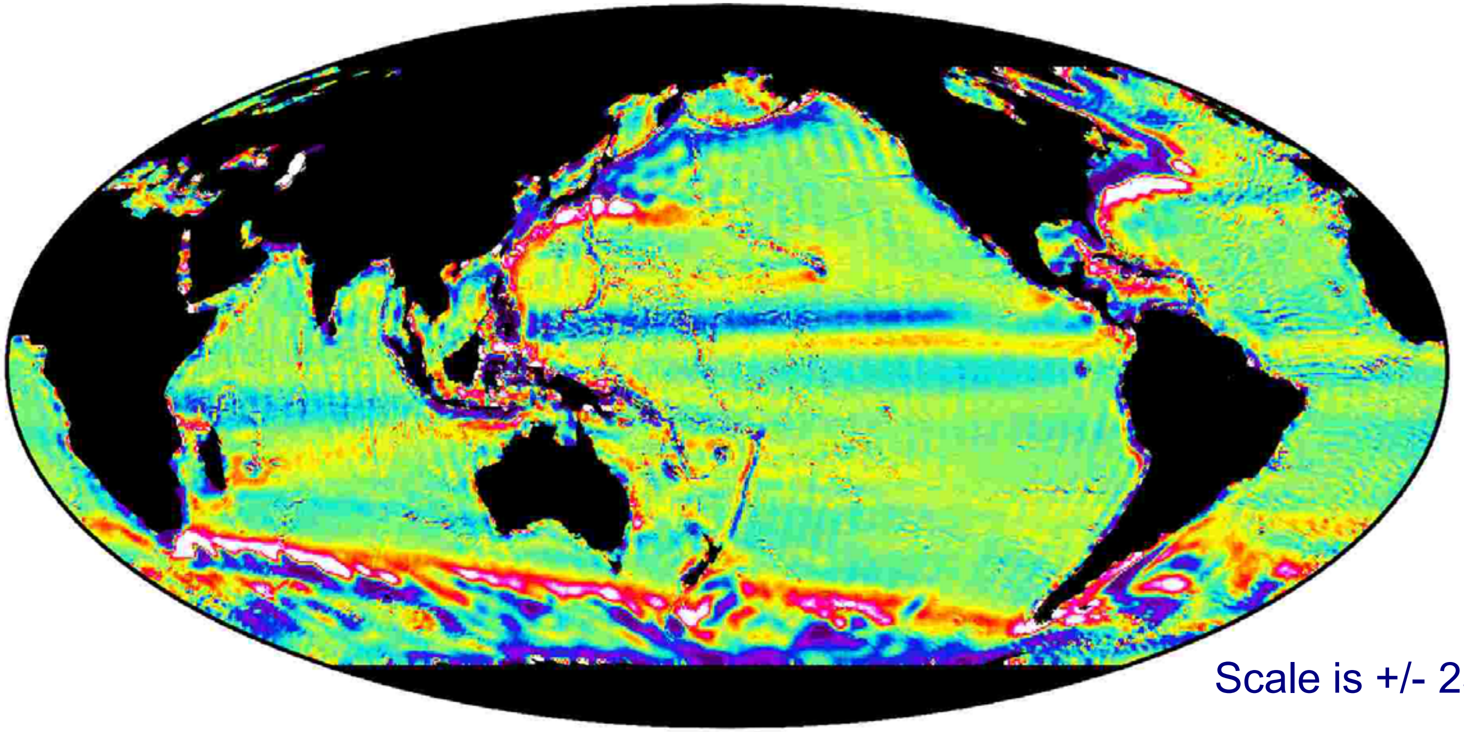
The residuals are the difference between a ‘high-frequency DOT’ defined as (GSFCMSS00 – geoid) and the same DOT smoothed to ~900 km



Scale is +/- 25 cm.

Short Wavelength Geoid Residuals
EIGEN-GL05C

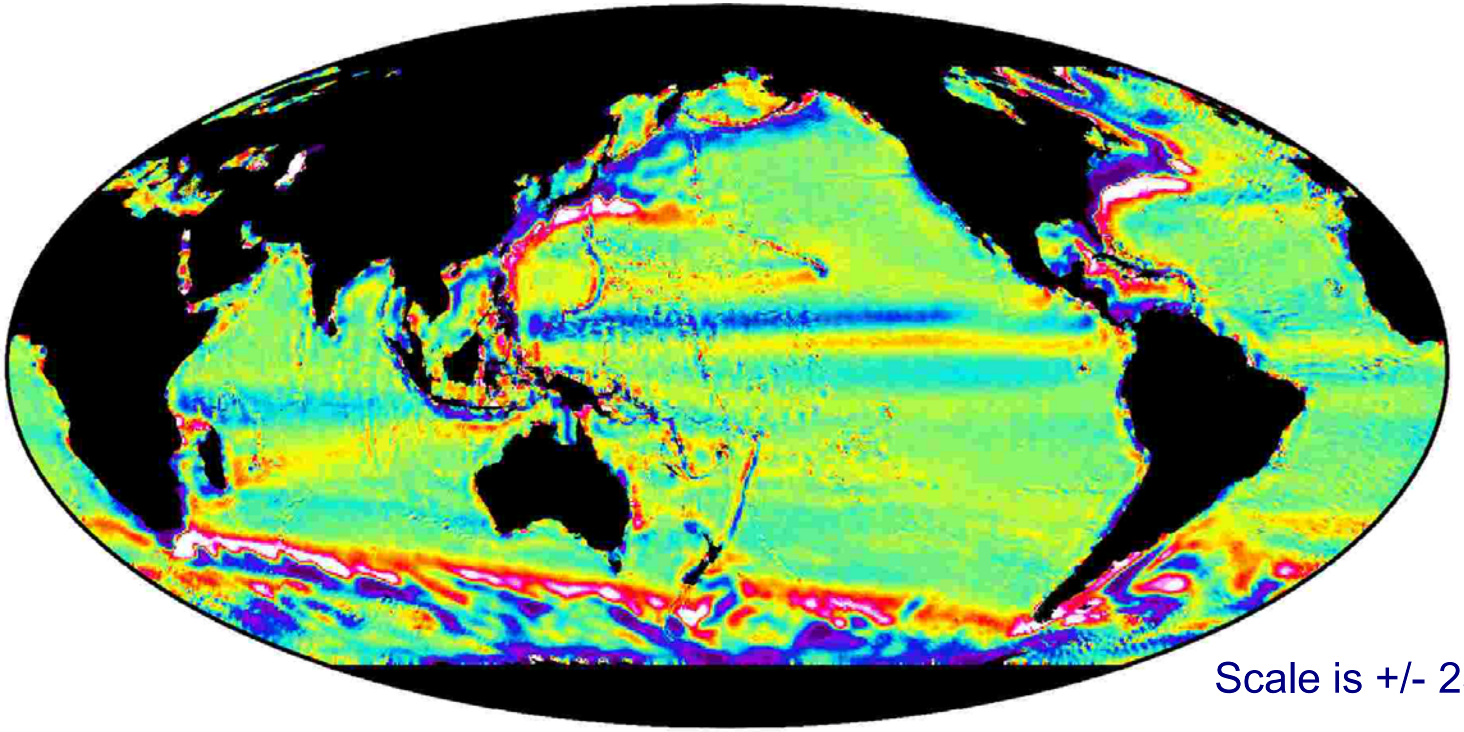
The residuals are the difference between a ‘high-frequency DOT’ defined as (GSFCMSS00 – geoid) and the same DOT smoothed to ~900 km



Scale is +/- 25 cm.

Short Wavelength Geoid Residuals
EGM2008

The residuals are the difference between a ‘high-frequency DOT’ defined as (GSFCMSS00 – geoid) and the same DOT smoothed to ~900 km



Scale is +/- 25 cm.

Short Wavelength Geoid Comparison

Calculate global RMS of the residual geoid after removing a model for the mean dynamic ocean topography (i.e. MSS - WOA01 DOT - geoid) at different wavelength filtering (shorter and longer than 300 km [$\lambda/2$]).

Model	**> 300 km**	**< 300 km**
EGM96	9.3	12.7
GGM02C (+EGM96)	8.2	12.7
EIGEN-GL04C	8.7	13.1
EIGEN-GL05C	7.8	12.6
EGM08	7.6	11.7

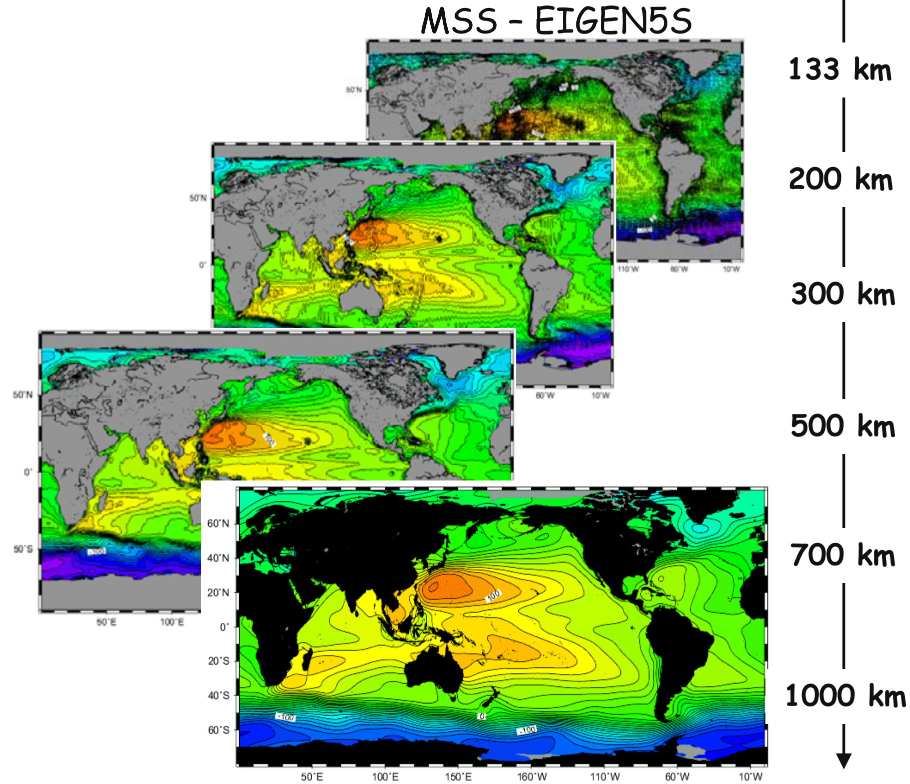
Units are cm

Computed along new T/P groundtrack to provide independent assessment.
Mean removed along each altimeter pass before computing the RMS.

(GGM02C extended above 200x200 by EGM96)

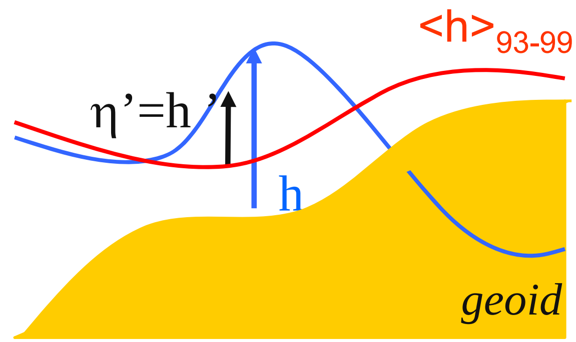
Use of oceanographic in-situ measurements and altimetry to assess the accuracy of the latest geoid models

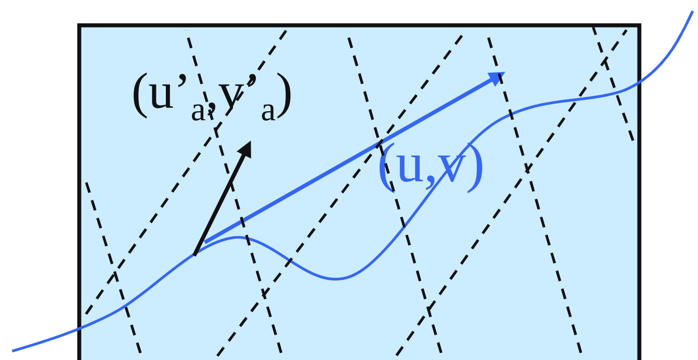
Computation of the ocean Mean Dynamic Topography from filtered altimetric MSS – Geoid (**direct MDT**)



+ geostrophic mean surface currents

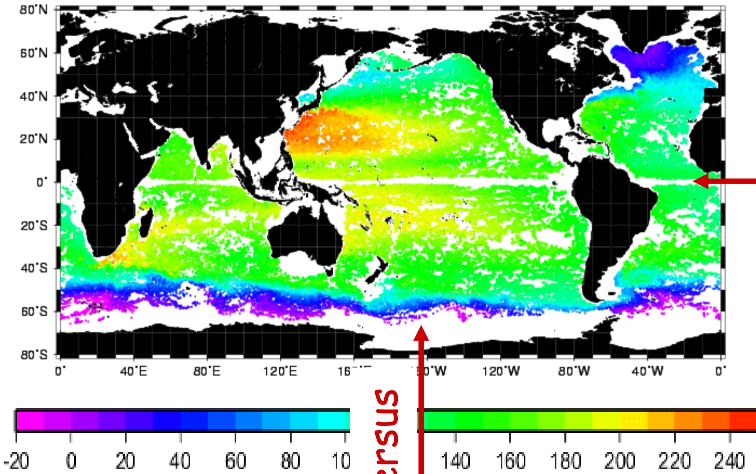
Use of in-situ oceanographic measurements and altimetry to compute **synthetic estimates of the MDT (and mean velocities)**





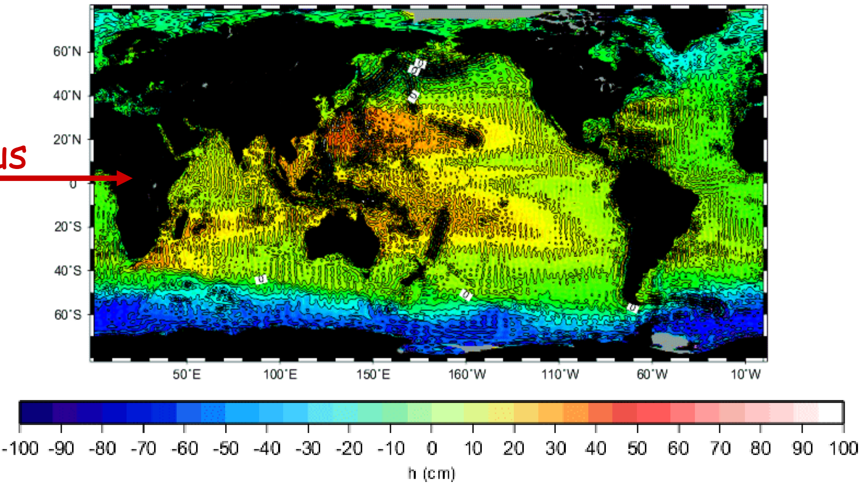
Results

MDTsynth



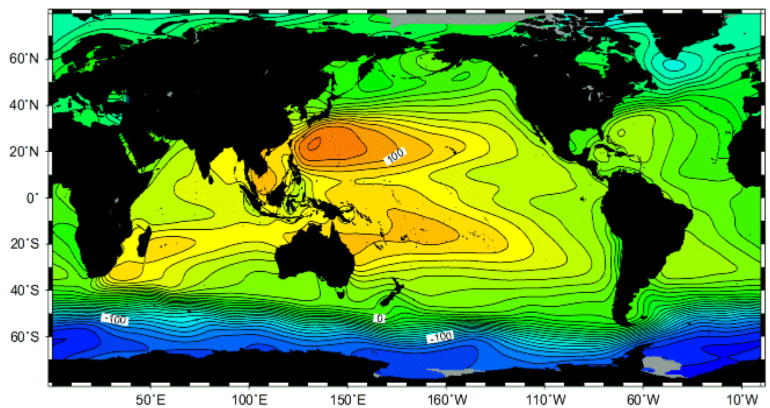
versus

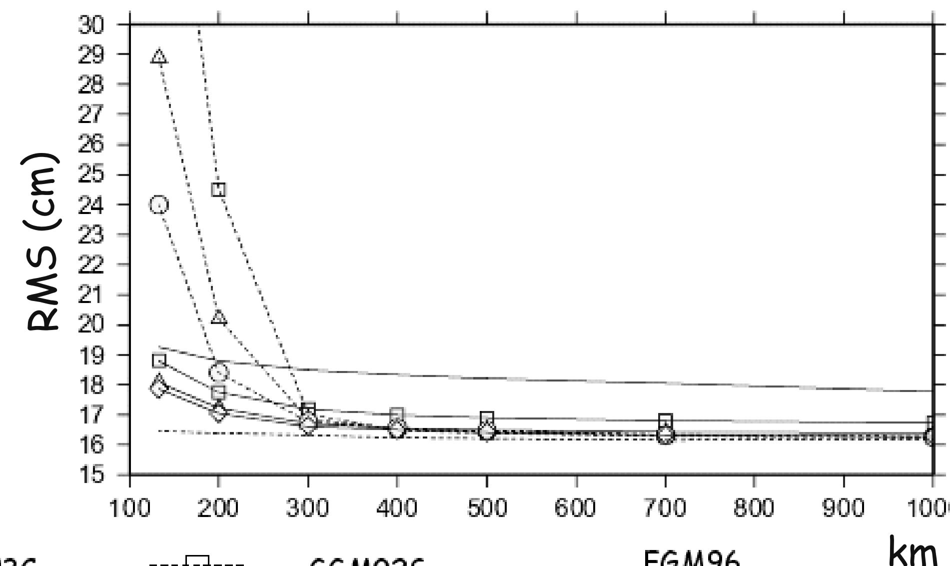
MDT 133 km (MSS-EIGEN5S)



versus

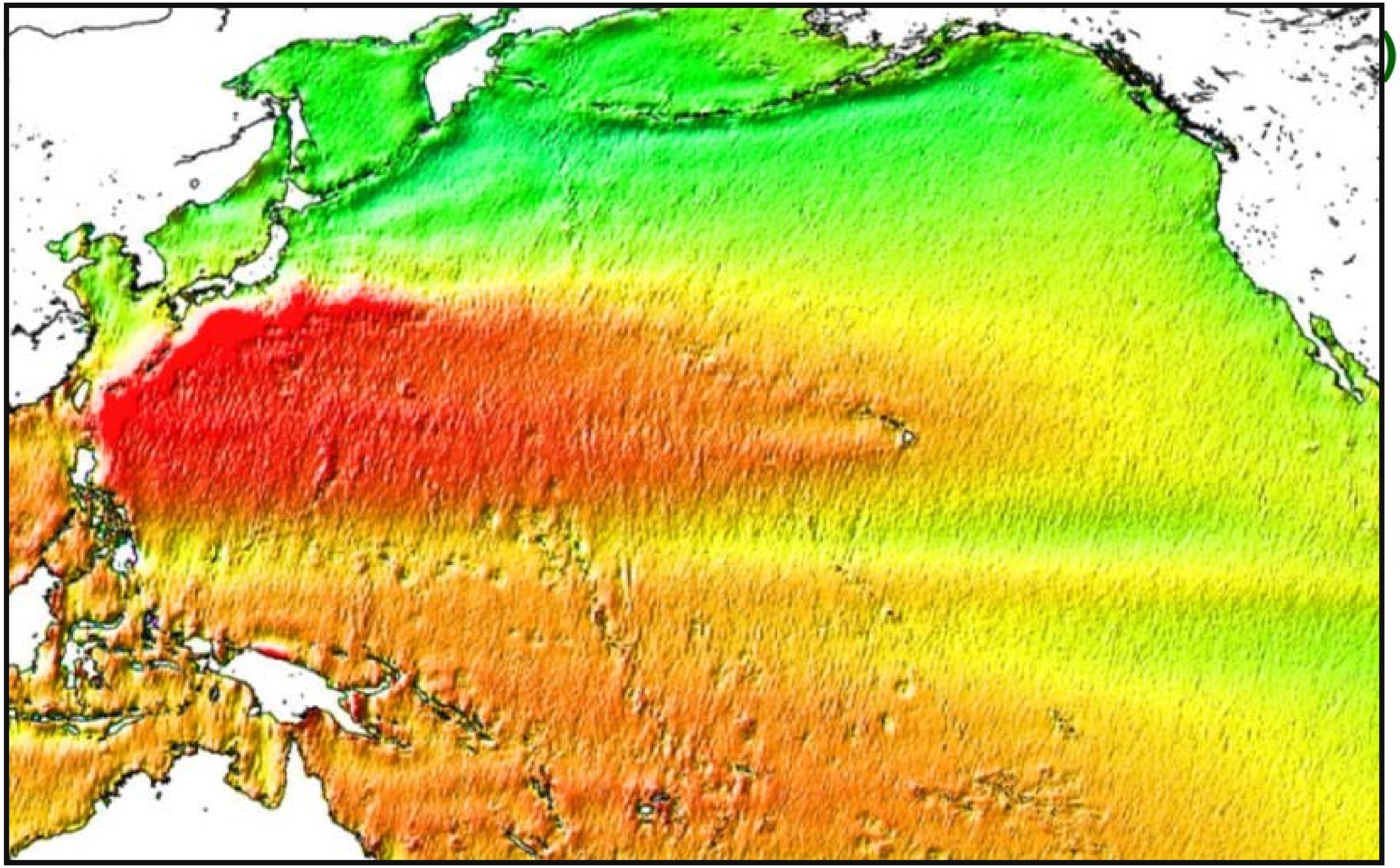
MDT 1000 km (MSS-EIGEN5S)





EIGENGL05C
EIGEN3C
GGM02S
EGM96
GGM02C
EIGENGL05S
EIGEN3S
EGM08

EGM2008 Complete to 2190x2159



(from Pavlis et al., 2008)

New generation models improve accuracy of marine geoid

- EIGEN-GL05C improvement over EIGEN-GL04C
  - Smoother marine geoid; ‘striations’ nearly eliminated
  - Best orbit determination performance
- EGM08 performs best in the short-wavelength geoid tests
  - Expansion to 2190x2159 provides considerably greater detail
- Looking forward to the contribution of GOCE to geoid accuracy