Update of the EIGEN time variable gravity model for precise orbit determination

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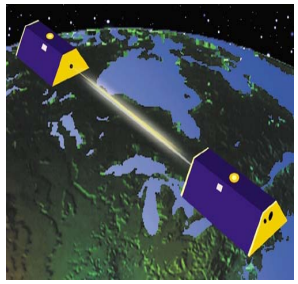
Data processing

GRACE (L-1B "Version2" data)

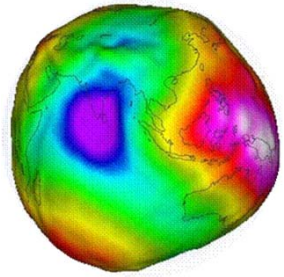


- **K-Band Range-Rate** data ($\sigma_{apriori}$ = .1 µm)
- Accelerometer / attitude
- **GPS** data (1-day arcs, σ_{code} = .8 m, **σ_{phase} = 20 mm / 30s resolution**)
  (previously: $\sigma_{2002\text{-}2003}$= 8 mm/30 s , $\sigma_{2003\text{-}2013}$= 20 mm/300 s, $\sigma_{2013\text{-}2016}$= 8 mm/30 s)

SLR

- **Lageos1/2** data (10-day arcs, $\sigma_{apriori}$ = 6 mm)
- **Starlette/Stella** data (5-day arcs, $\sigma_{apriori}$ = 10 mm)

Physical parameters present in the normal equations



- Gravity spherical harmonic coefficients complete to **degree and order 80** (truncated to **30 for LAGEOS** and **40 for GPS** data)
- Ocean tides s. h. coefficients for 14 tidal waves with maximum degree/order ≤ 30 (not used yet)

Models used : v2 → v3

Dynamical models

Gravity	*EIGEN-6S2* → *EIGEN-GRGS.RL03-v2.MEAN-FIELD*
Ocean tide	*FES2012 (Legos)* → *FES2014 (Legos)*
Atmosphere	*3-D ECMWF ERA-interim pressure grids / 3hrs*
Ocean mass model	*TUGO (Legos) / 3hrs*
Atmospheric tides	→ *Not necessary because of the 3hrs dealiasing time sampling*
3rd body	*Sun, Moon, 6 planets (DE405)*
Solid Earth tides	*IERS Conventions 2010*
Pole tides	*IERS Conventions 2010*
Non gravitational	*Accelerometer data (+biases and scale factors)*

Geometrical models

SLR stations	*ITRF2008 coordinates* → *ITRF2014 coordinates*
GPS	*IGS Repro-1 orbits & clocks* → *IGS Repro-2 orbits & clocks*

Other models

Hydrology	Taken into account by the a priori gravity field
Glacial Isostatic Adjustment	

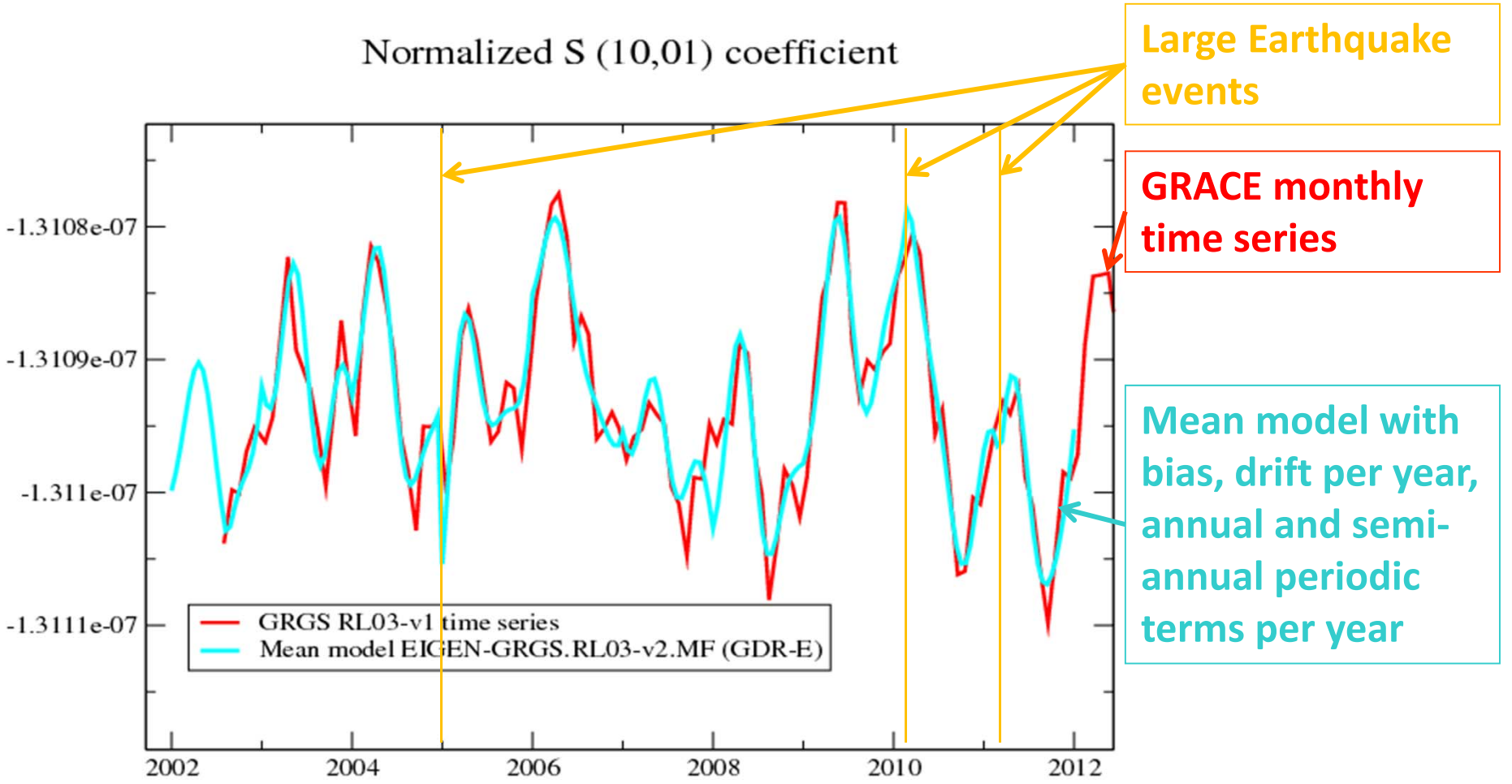
Mean model generation

❖ Mean models are now generated from time series

- Fitting each series of monthly spherical harmonic coefficients by a set of 6 parameters :
  - Yearly bias and slope : piecewise linear function except in case of …
  - Jumps caused by big earthquakes (so far : Sumatra/2005.0, Concepcion/2010.2 and Tohoku/2011.2)
  - Annual and semi-annual sine/cosine functions (with continuity constraints at hinge epochs)
- It means 600 000 coefficients for a 80x80 spherical harmonic model which better match with GRACE monthly models
- Used for operational computation (i.e. altimetric orbit processing) or TRF processing (i.e. ITRF2014)

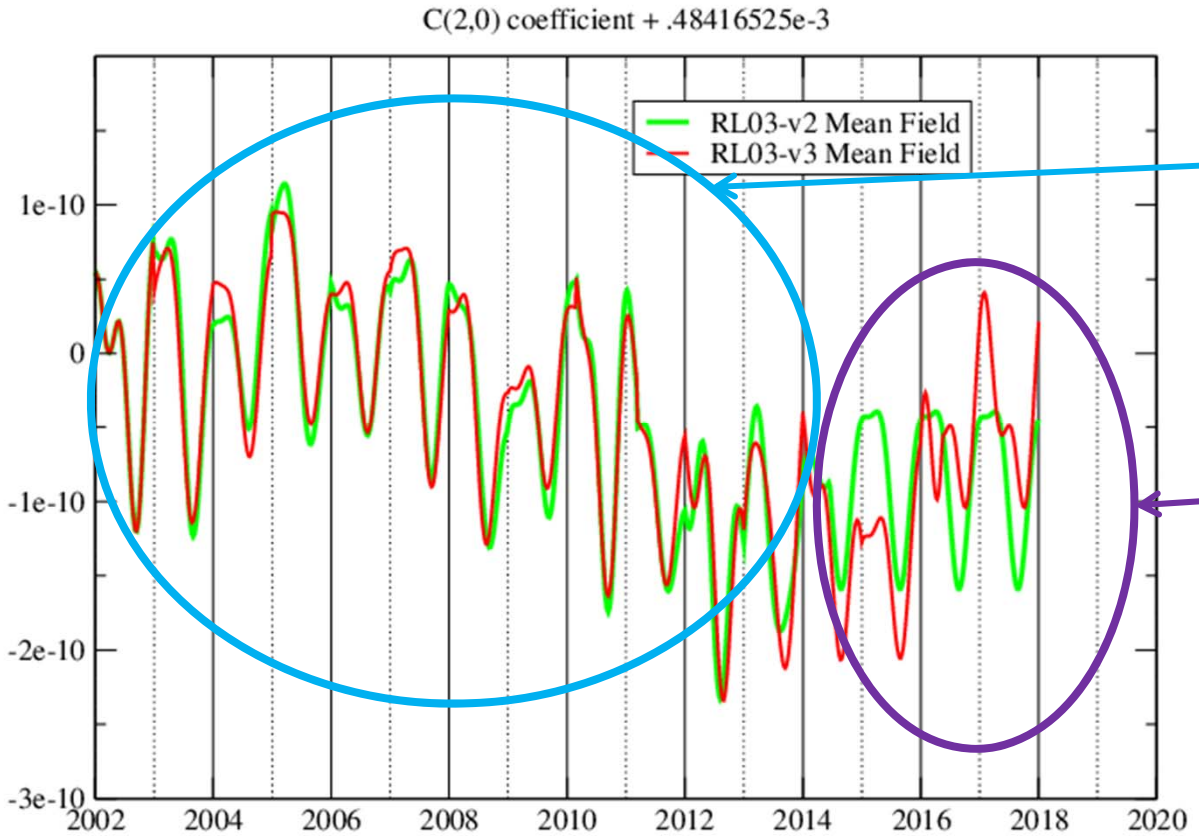
RL03 mean models

- Example for one spherical harmonic coefficient:



Update of the mean model from -v2 to -v3

- The new mean field updates the previous one over 2 years: mid-2014 to mid-2016.
- Example for the C(2,0) spherical harmonic coefficient:

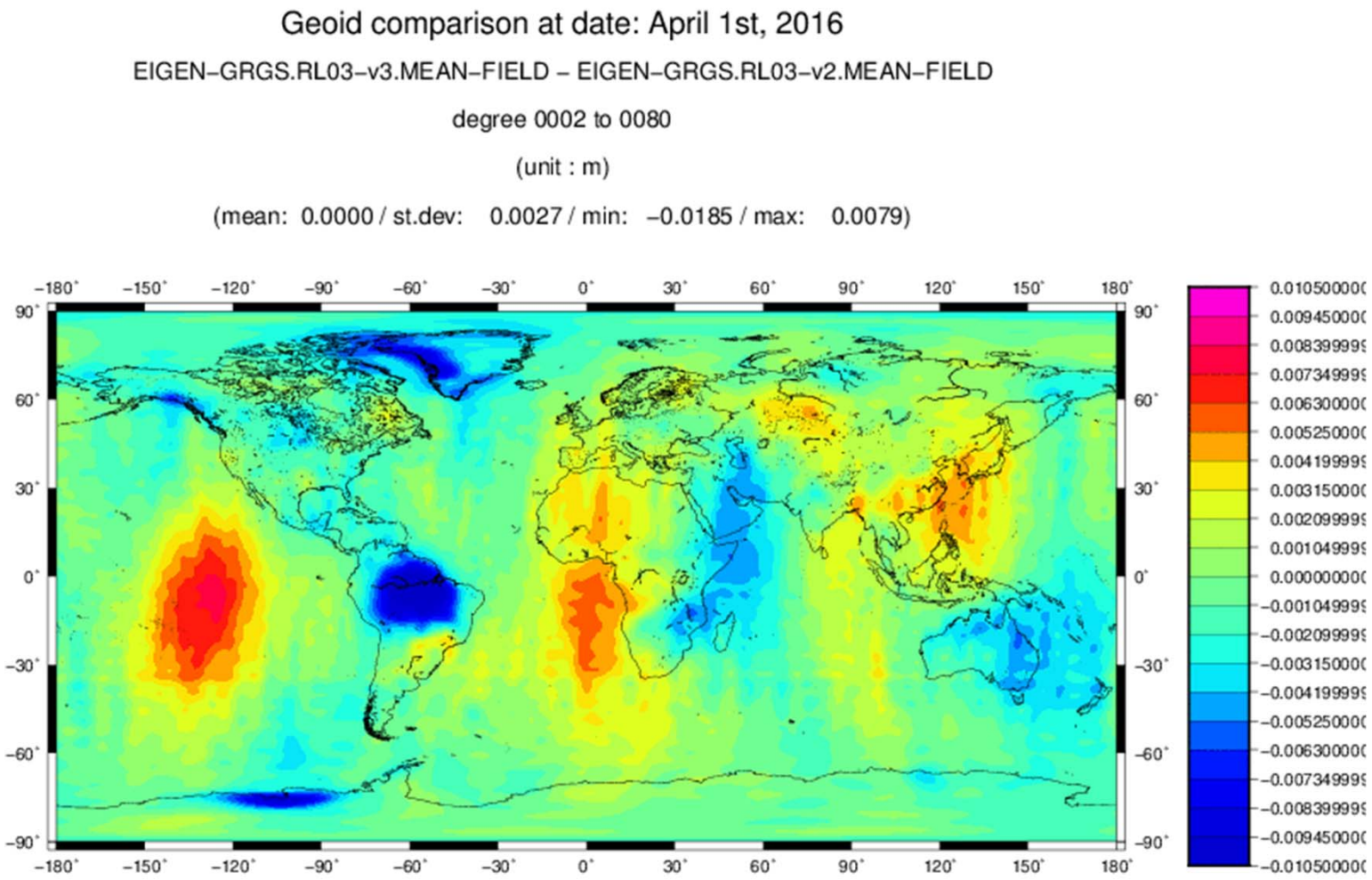


Small changes due to the transition from RL03-v2 to RL03-v3

Important changes due to the addition of 2 more years

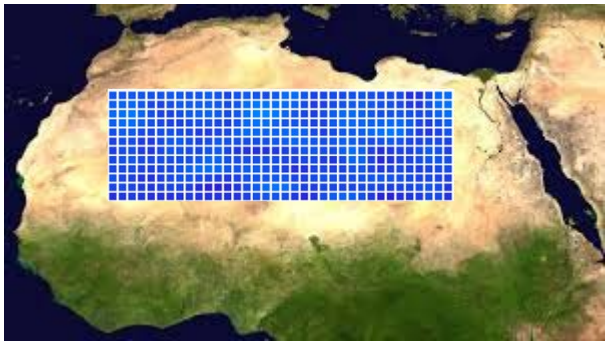
Update of the mean model from -v2 to -v3

- Extrapolation vs. real data after 2 years: difference between mean-field –v2 and mean field –v3 at mid-2016

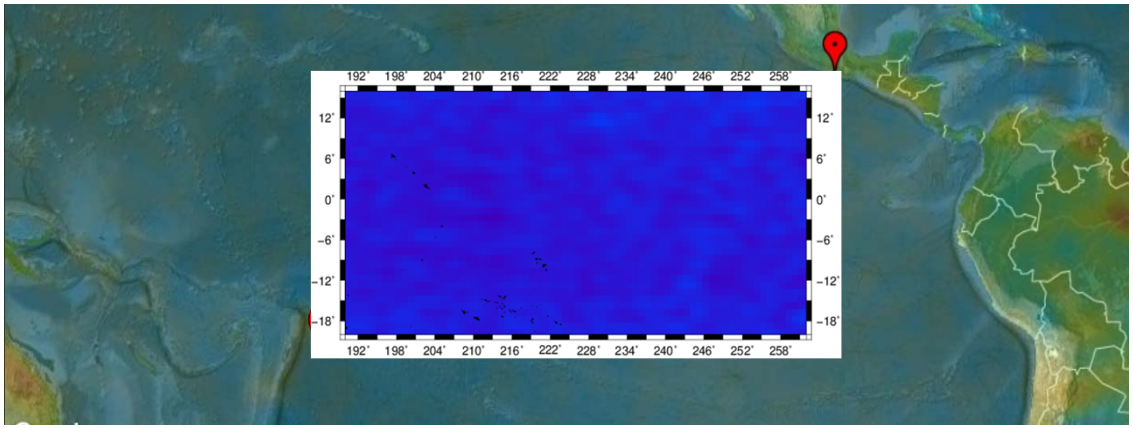


RL03/RL04 evaluation

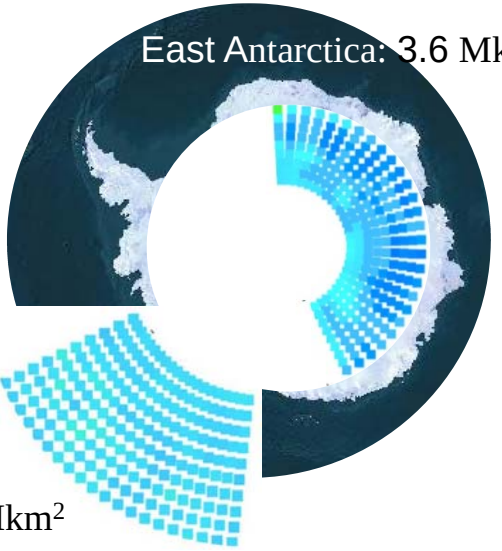
Noise assessment can be made in areas with no or very little mass variations: Sahara and Gobi deserts, East Antarctica, South and Equatorial Pacific



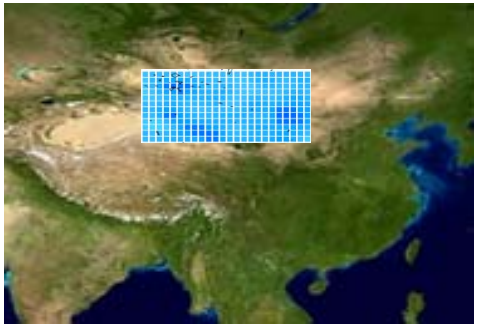
Sahara desert: 2.2 Mkm^2



Equatorial Pacific: 31.6 Mkm^2



South Pacific 6.7 Mkm^2



Gobi desert: 1.6 Mkm^2

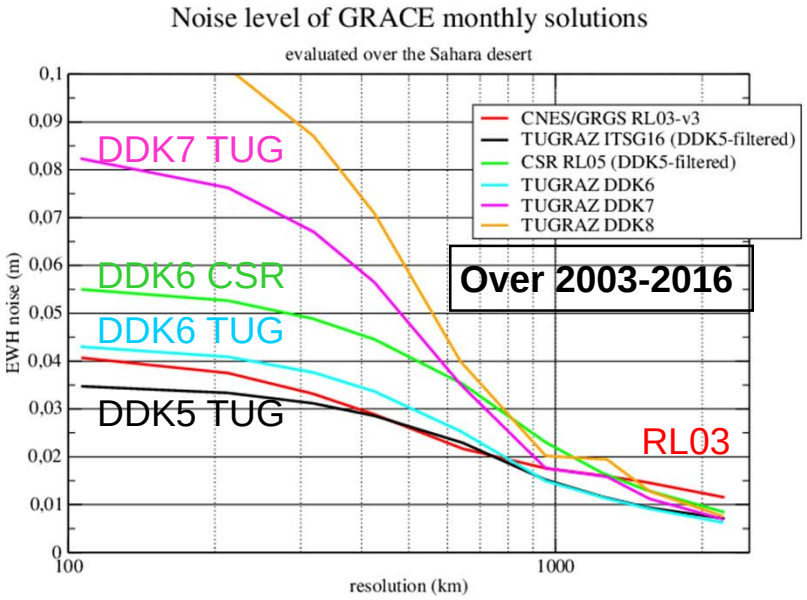
Noise assessment over the Sahara

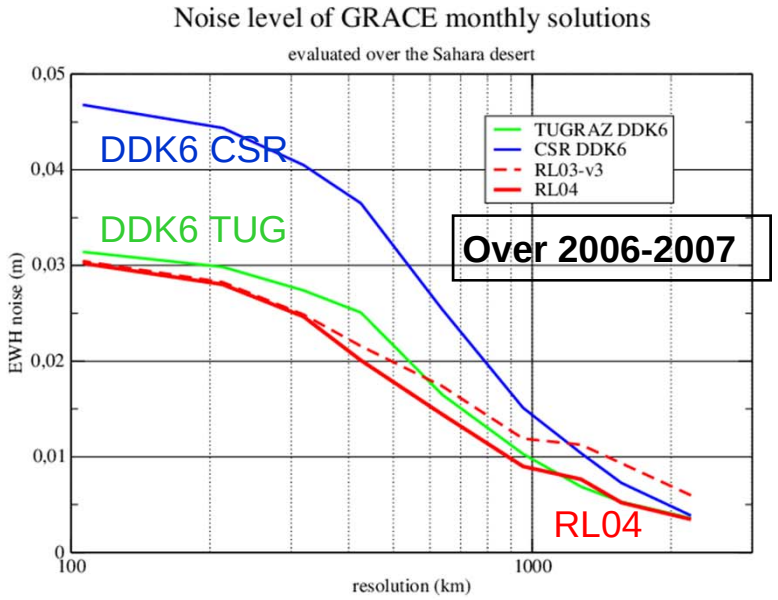
The Sahara desert shows very little hydrological variations. We have delimited a rectangular zone of 2.2 Mkm^2 where almost no gravity variation is suspected. (except a small depletion of 1.3 mm/yr in South Libya).

It is hence well dedicated to control the quality of gravity field variation models.

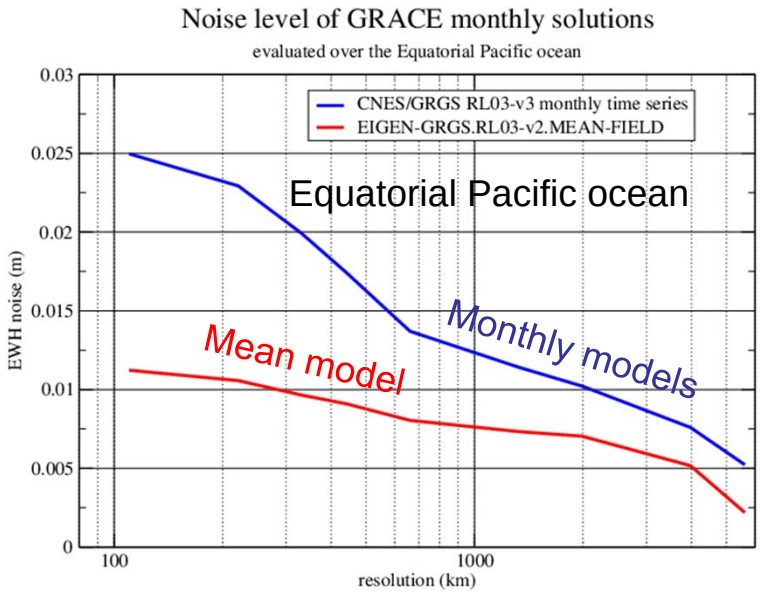
The surface is first divided in 2 deg.*2 deg. blocs (⇔ degree/order 90), then averaged in blocs of larger size up to 20 deg.*20 deg. Drift and annual/semi-annual variations are fitted a priori.

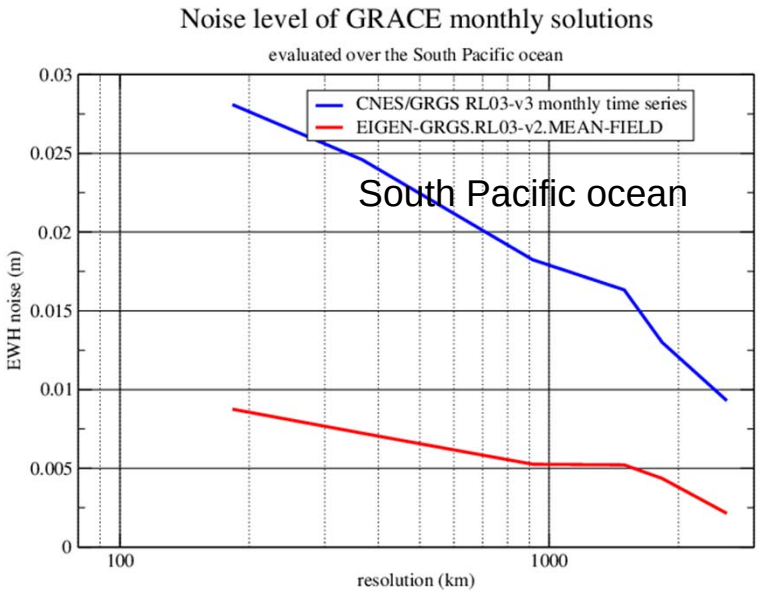
Different time-varying gravity models with various DDK filters (Kusche et al.) are compared spectrally in this way from 100 km to 2200 km.

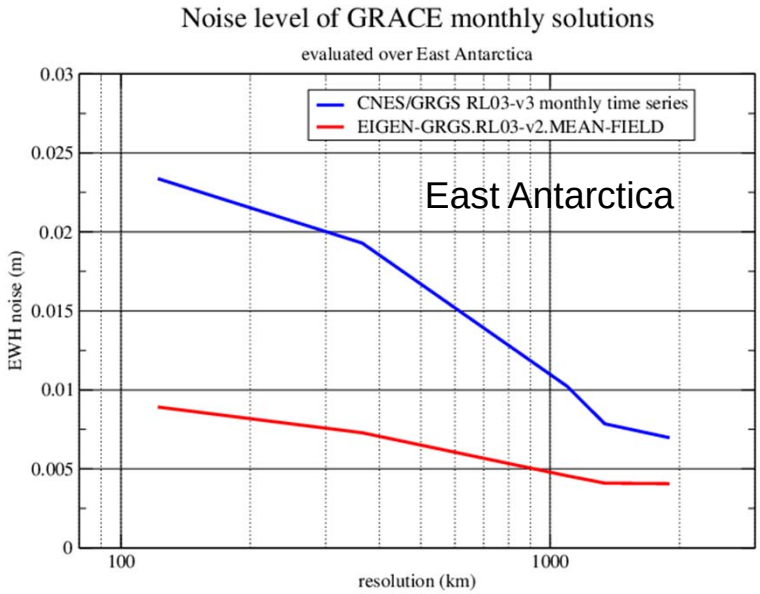


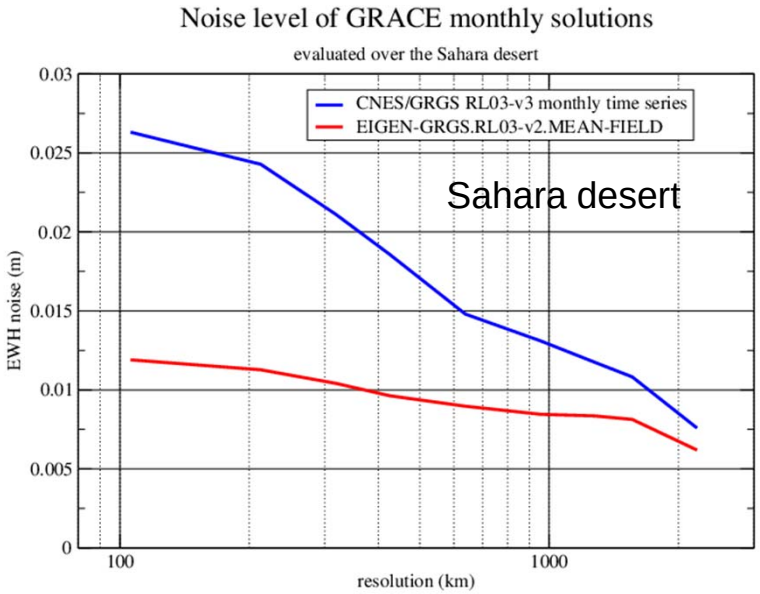


Noise assessment over “deserts”





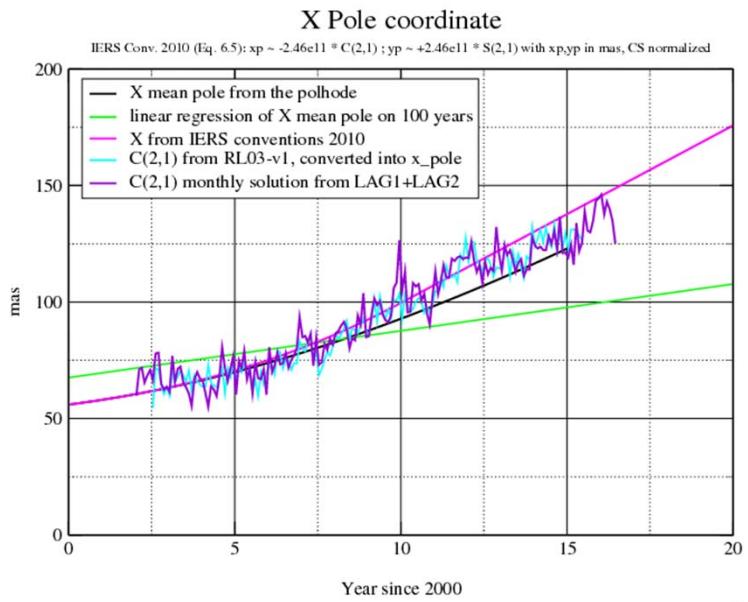


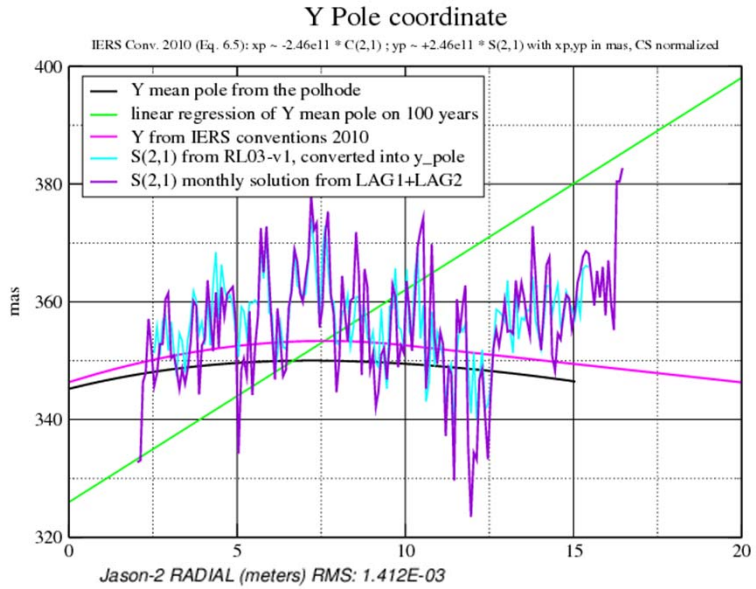


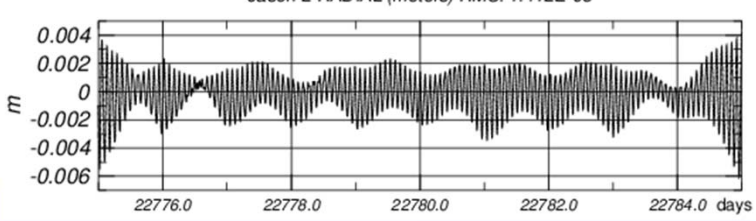
Coherence gravity / mean pole model

Very important:

- When using the C(2,1)/S(2,1) values of a gravity field model, one must adopt **the same mean pole convention** as the one used for the computation of the model.
- The same goes for the **dealiasing models**.
- CNES/GRGS is using the mean pole of the **IERS2010 conventions**. If the conventions change for a **linear mean pole**, then the C(2,1)/S(2,1) coefficients of the mean gravity model will have to be adapted to this new convention.







Radial orbit difference : 1.4 mm rms

Summary

- The new mean gravity field model based on RL03-v3 is ready to succeed RL03-v2 in the new GDR standards
- It is expanded in sets of 6 yearly coefficients (bias, slope, annual and semi-annual terms) per degree/order up to 80, and contains constant terms (from GOCE-DIR5) up to degree/order 300
- Extrapolated time-variable terms (before August 2002 and after May 2016) are based on global fits of monthly coefficients over 14 years of GRACE data
- Degree 2 time-variable terms are adjusted back to 1986 from Lageos data

Perspectives

- We are presently reprocessing all the GRACE data with new standards in order to produce the Release 04 of our time-variable gravity solutions
- We expect to have completed the reprocessing by the end of December 2017
- From this RL04, a new mean model up to degree 90 could be produced as early as January 2018