



# Update on time variable gravity models

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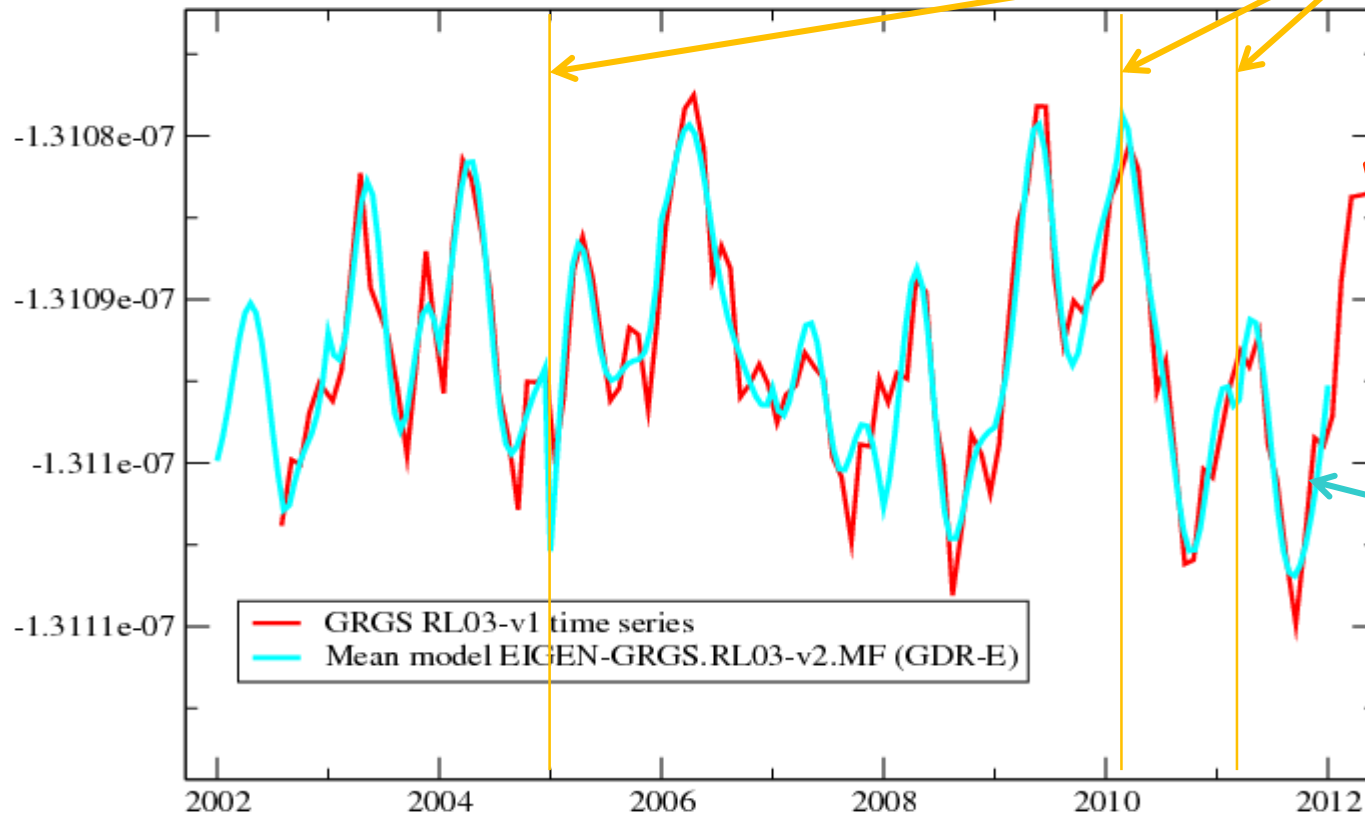
- 1) CNES/GRGS, Toulouse, France
- 2) Stellar Space Studies, Toulouse, France

**IDS AWG meeting, Munich 4 April 2019**

- ❖ The new **EIGEN-GRGS.RL04.MEAN-FIELD** is available for download:
  - <https://grace.obs-mip.fr/variable-models-grace-lageos/mean-fields/release-04/>
- ❖ We propose to use it for the computation of the future **ITRF2020**.
- ❖ It is based on 14 years of GRACE data (2002/08 – 2016/06), 3 years of GOCE data and 26 years of SLR data (1993/01 – 2019/02).
- ❖ It contains a time-variable gravity (TVG) part until degree and order 90, and a static part coming from the model **GOCE-DIR5** up to degree and order 300.
- ❖ The TVG part model is based on the CNES/GRGS **RL04** series of monthly GRACE solutions
  - A description of the **RL04** monthly solution is given here: <https://grace.obs-mip.fr/variable-models-grace-lageos/grace-solutions-release-04/rl04-products-description>
  - A detailed description of **EIGEN-GRGS.RL04.MEAN-FIELD** was presented at the last IDS Workshop: [https://ids-doris.org/images/documents/report/ids\\_workshop\\_2018/IDS18\\_s3\\_LemoineJM\\_NewtimeVariableGravityFieldModelForPOD.pdf](https://ids-doris.org/images/documents/report/ids_workshop_2018/IDS18_s3_LemoineJM_NewtimeVariableGravityFieldModelForPOD.pdf)
- ❖ The TVG part is modeled for each year as an annual bias + slope + annual and semi-annual periodic components ➔ 6 parameters / year \* 14 years \* 91x91 spherical harmonics = ~800 000 coefficients

➤ Example for one spherical harmonic coefficient:

Normalized S (10,01) coefficient



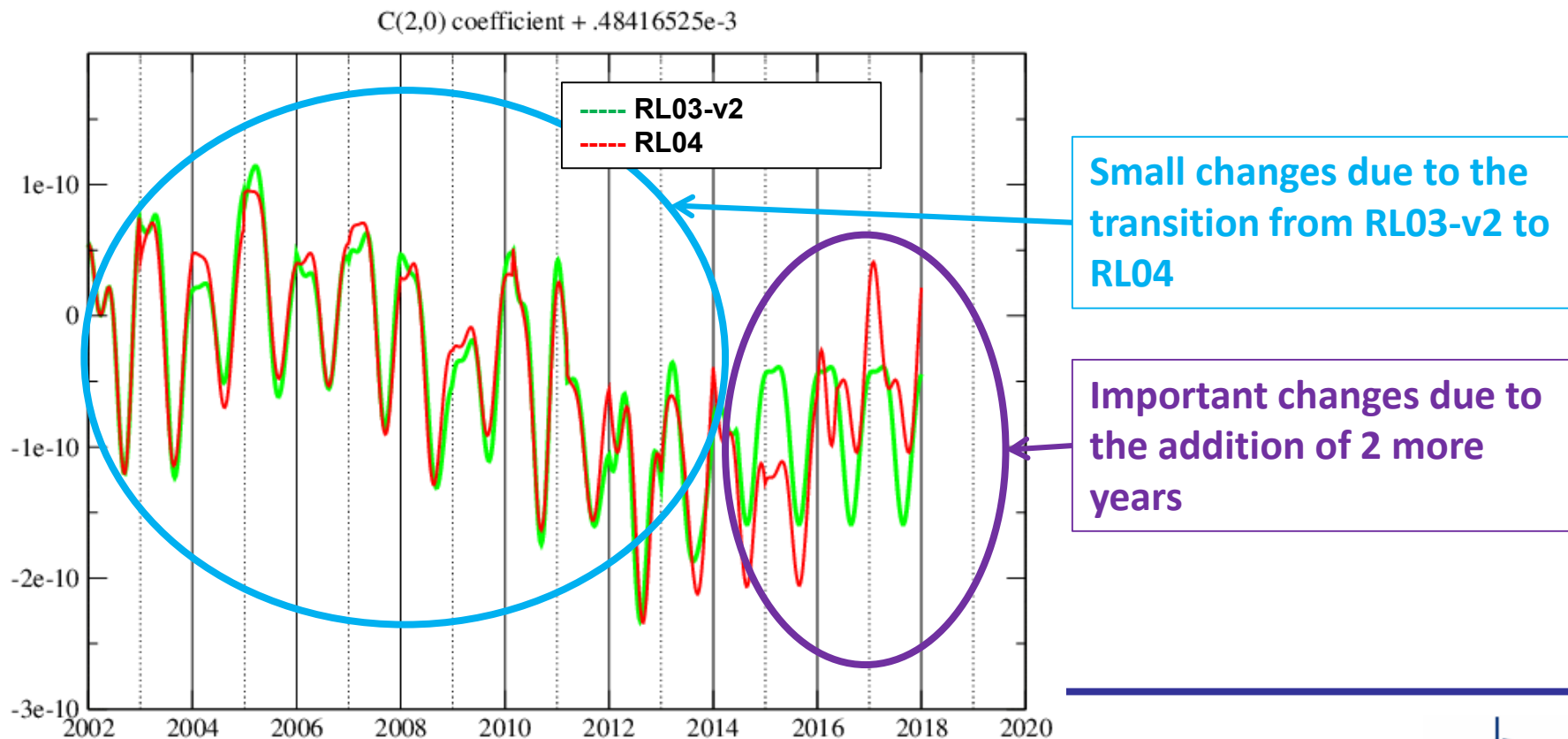
Large Earthquake events

GRACE monthly time series

Mean model with bias, drift per year, annual and semi-annual periodic terms per year

- 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:

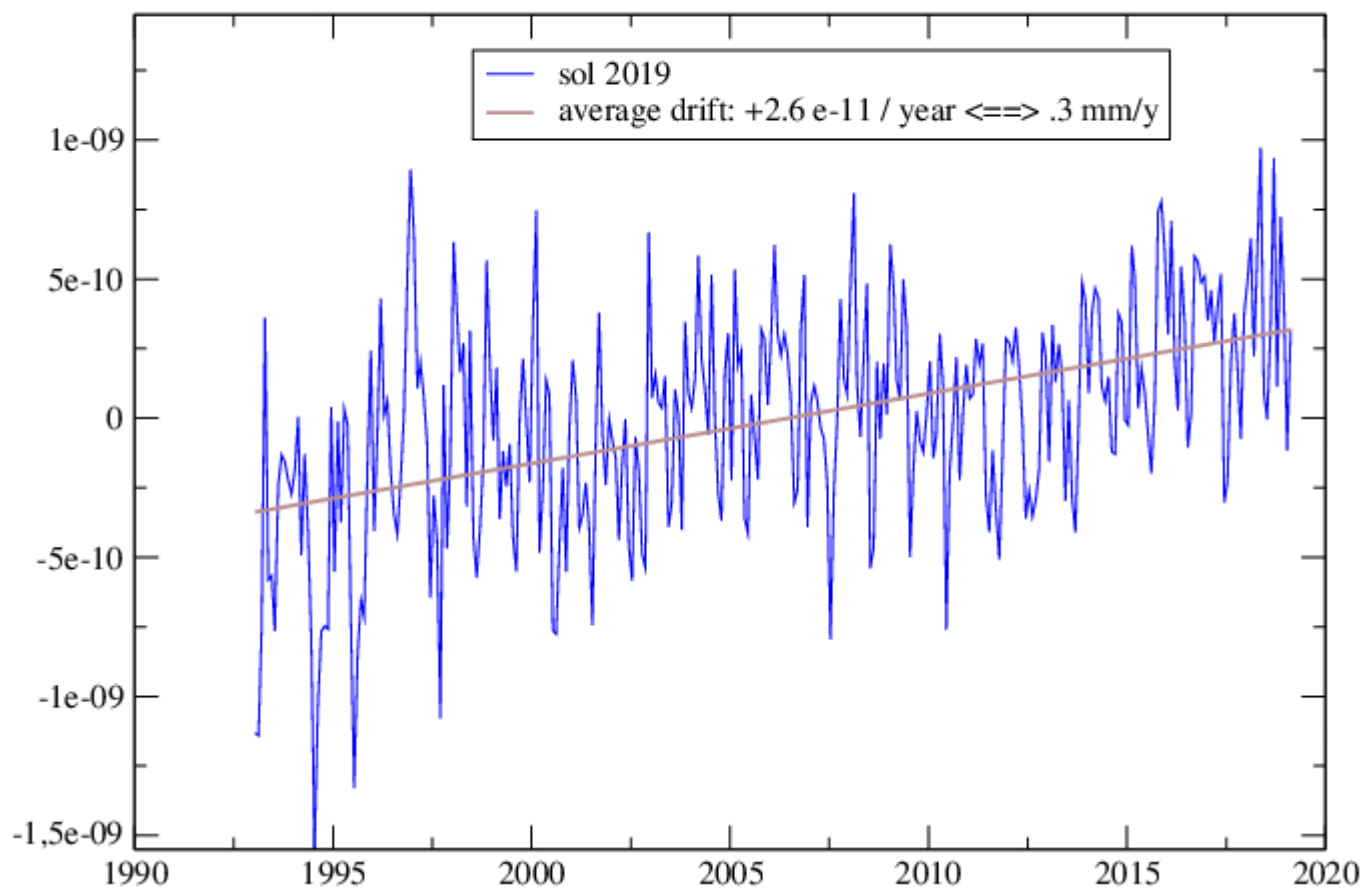


# Low degrees

- ❖ For POD it is important that the low degrees of the gravity model be very accurate.
- ❖ A complete reprocessing of the SLR data from 5 satellites (Lageos, Lageos-2, Starlette, Stella, Ajisai) has been done from 1993/01 to 2019/02 using the latest standards.
- ❖ SLR data contribution to EIGEN-GRGS.RL04.MEAN-FIELD:
  - provides the degree 1 solution,
  - contributes to the degree 2 solution.
- ❖ **Degree 1:**
  - This new solution, based on a long time span, lets appear a **small drift** of the  $C(1,0)$  coefficient:  $+2.6 \text{ e-}11 / \text{y} \Leftrightarrow \mathbf{0.3 \text{ mm/y in } Z_{\text{Earth}}}$
  - And a small offset of the  $S(1,1)$  coefficient of  $1.0 \text{ e-}10 \Leftrightarrow \mathbf{1.1 \text{ mm on } Y_{\text{Earth}}}$
  - The main period present in the solution is annual with a peak at **2.6 mm in Z, 1.0 mm in X and 2.5 mm in Y**
  - There is a second peak in Z at 0.318 y: 1.9 mm

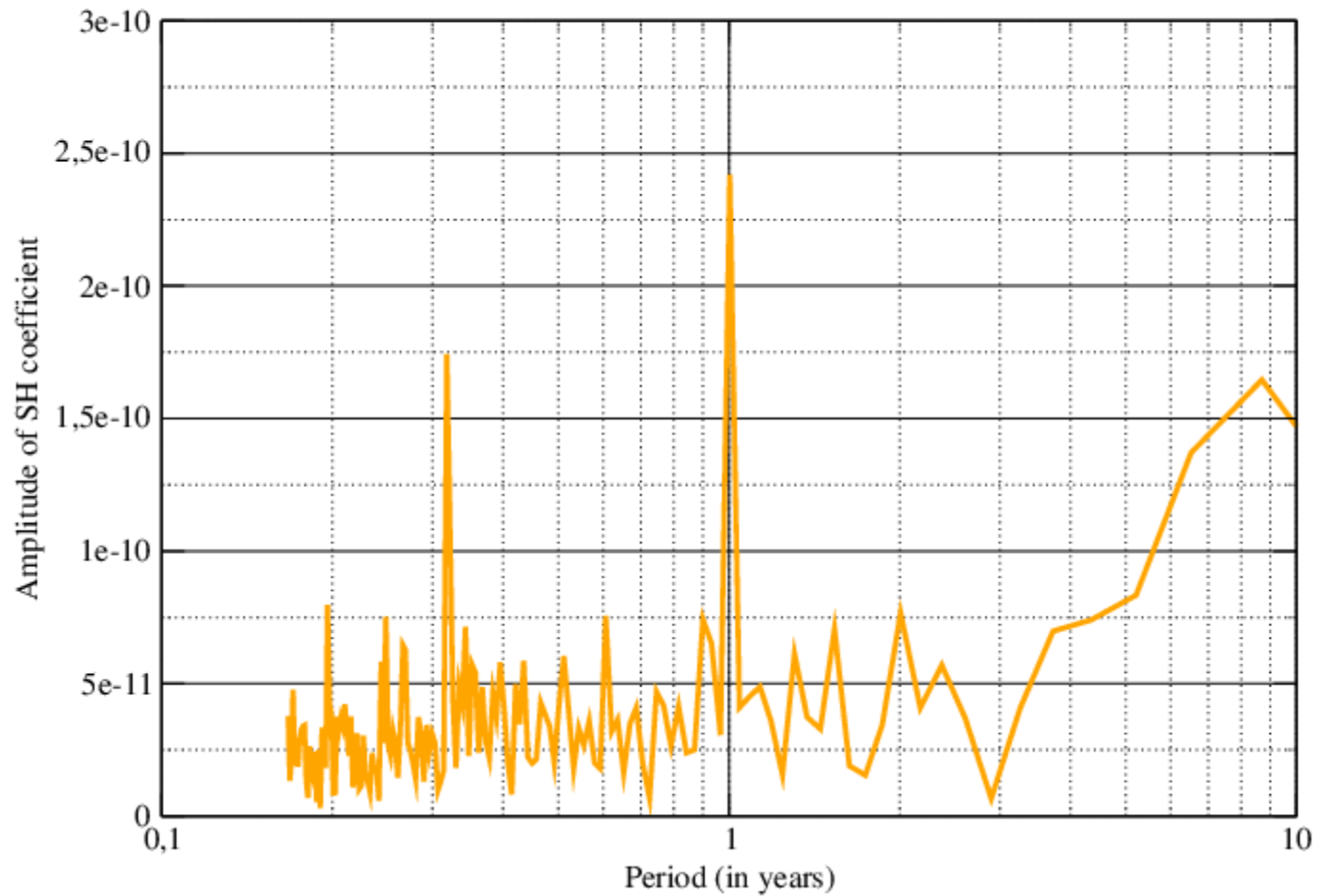
# Time series

C(1,0)



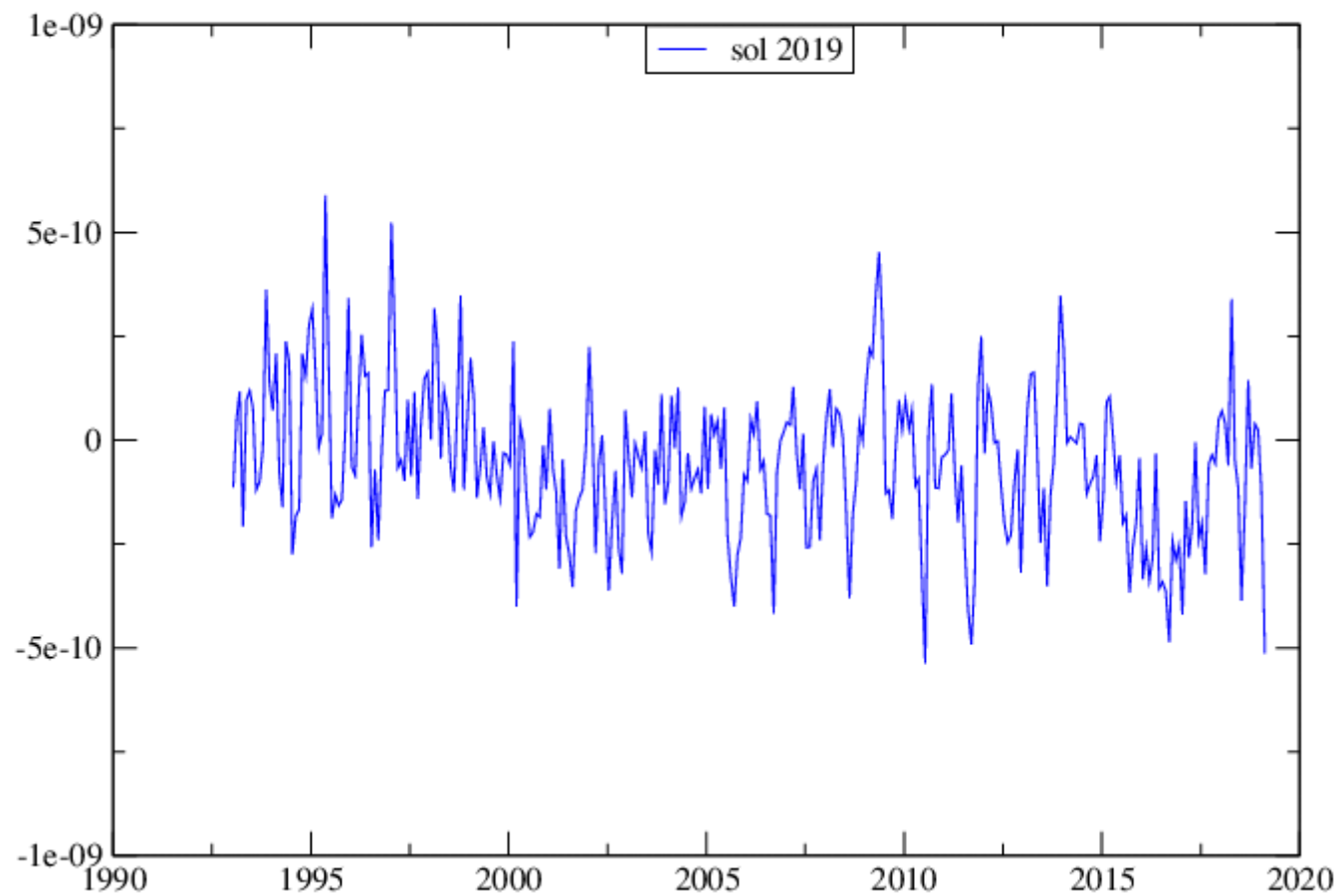
# Periodogram

$C(1,0)$



# Time series

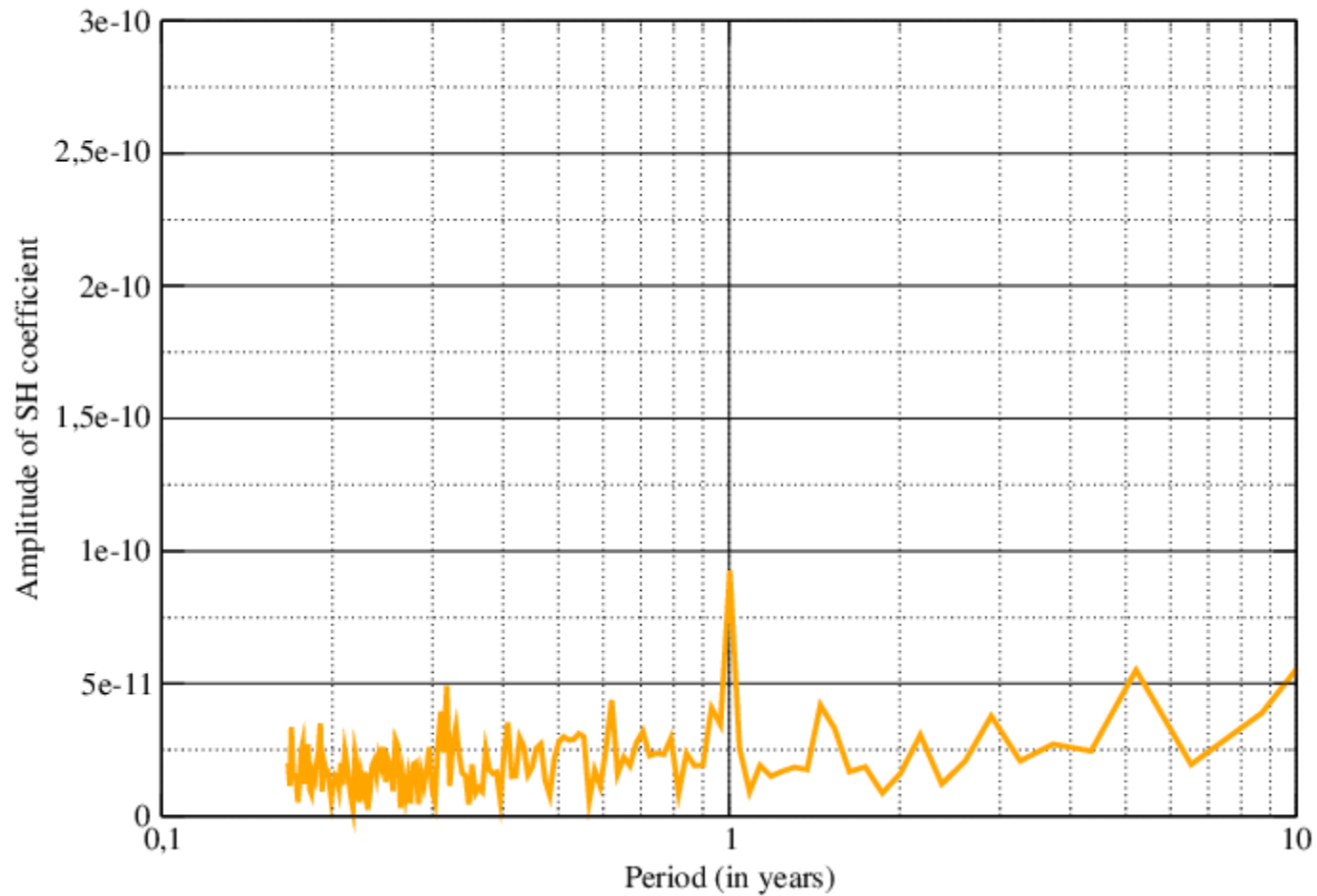
$C(1,1)$





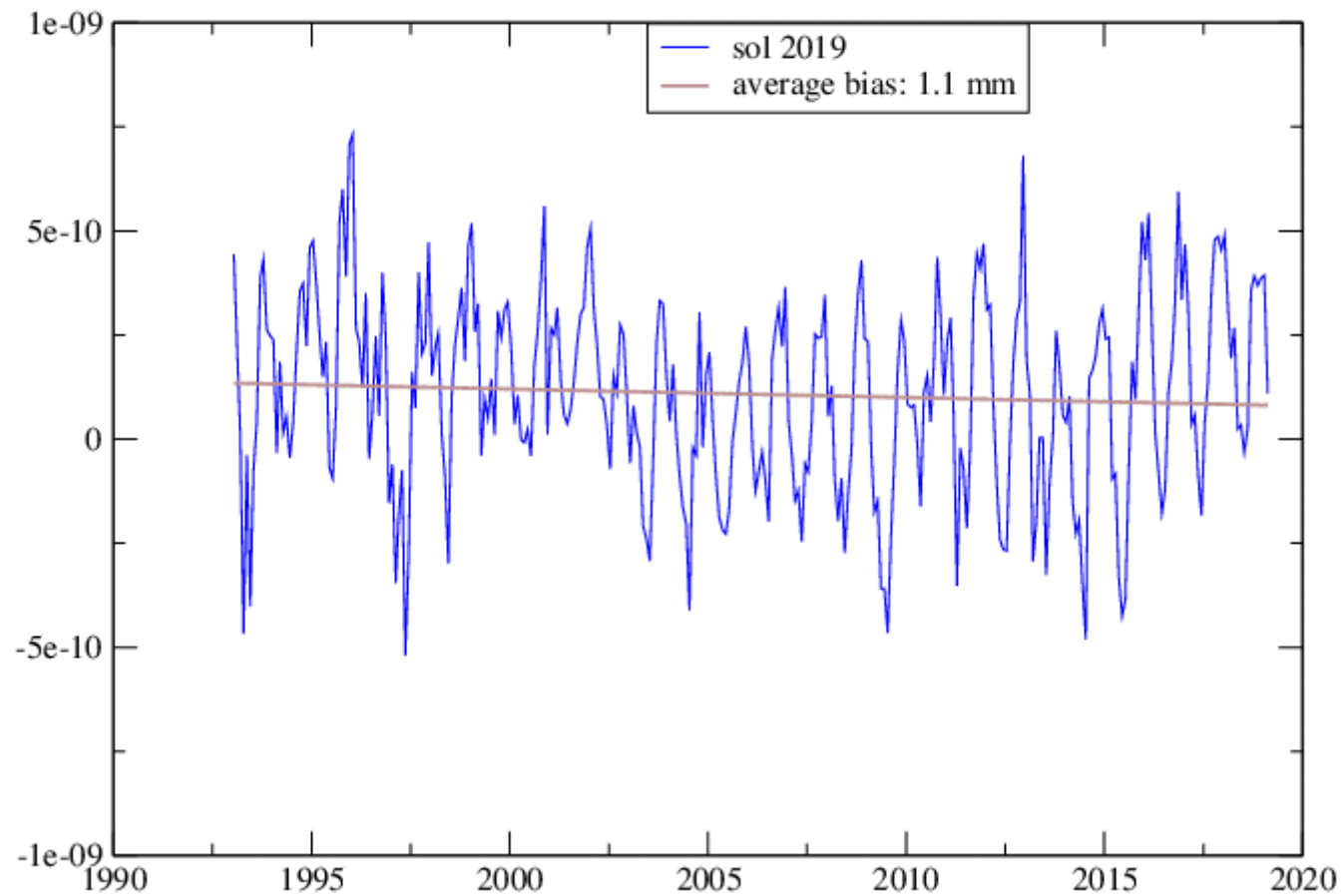
# Periodogram

$C(1,1)$



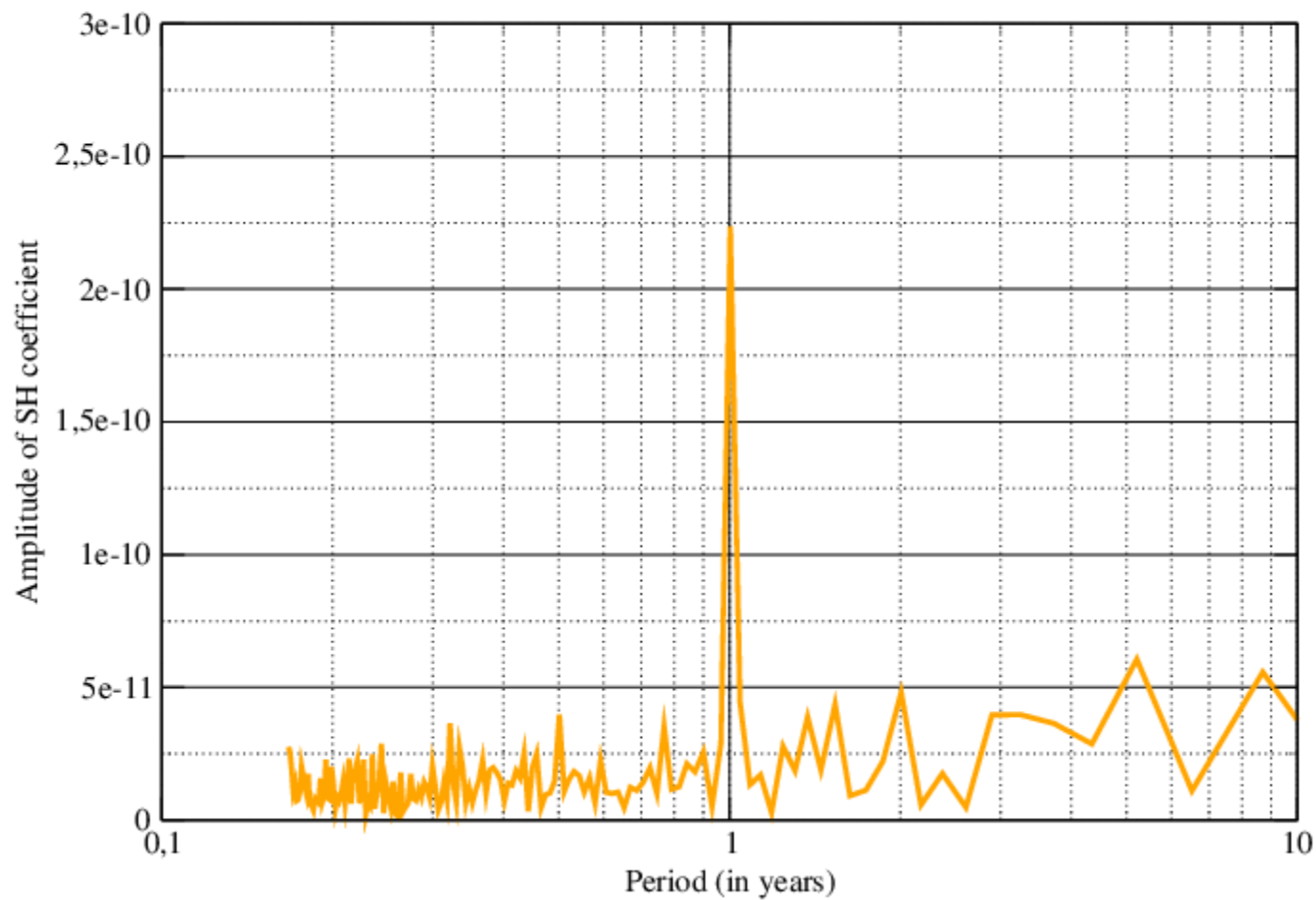
# Time series

$S(1,1)$



# Periodogram

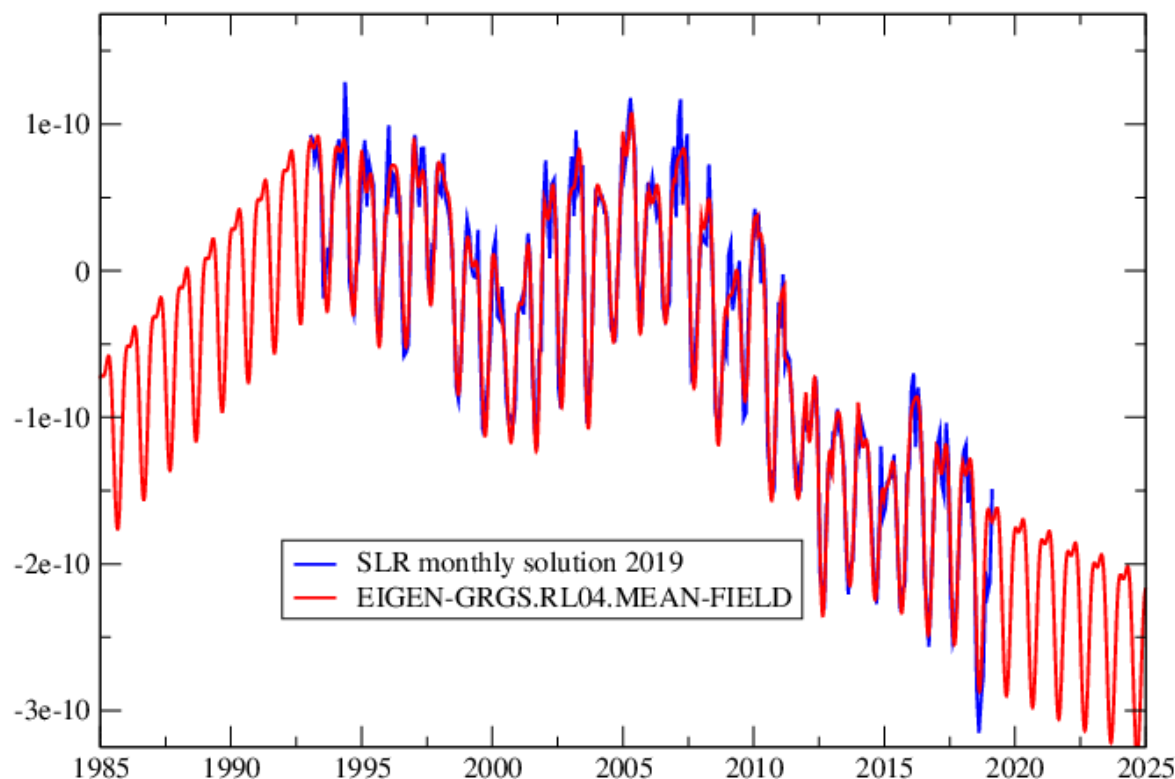
S(1,1)



## ❖ Degree 2:

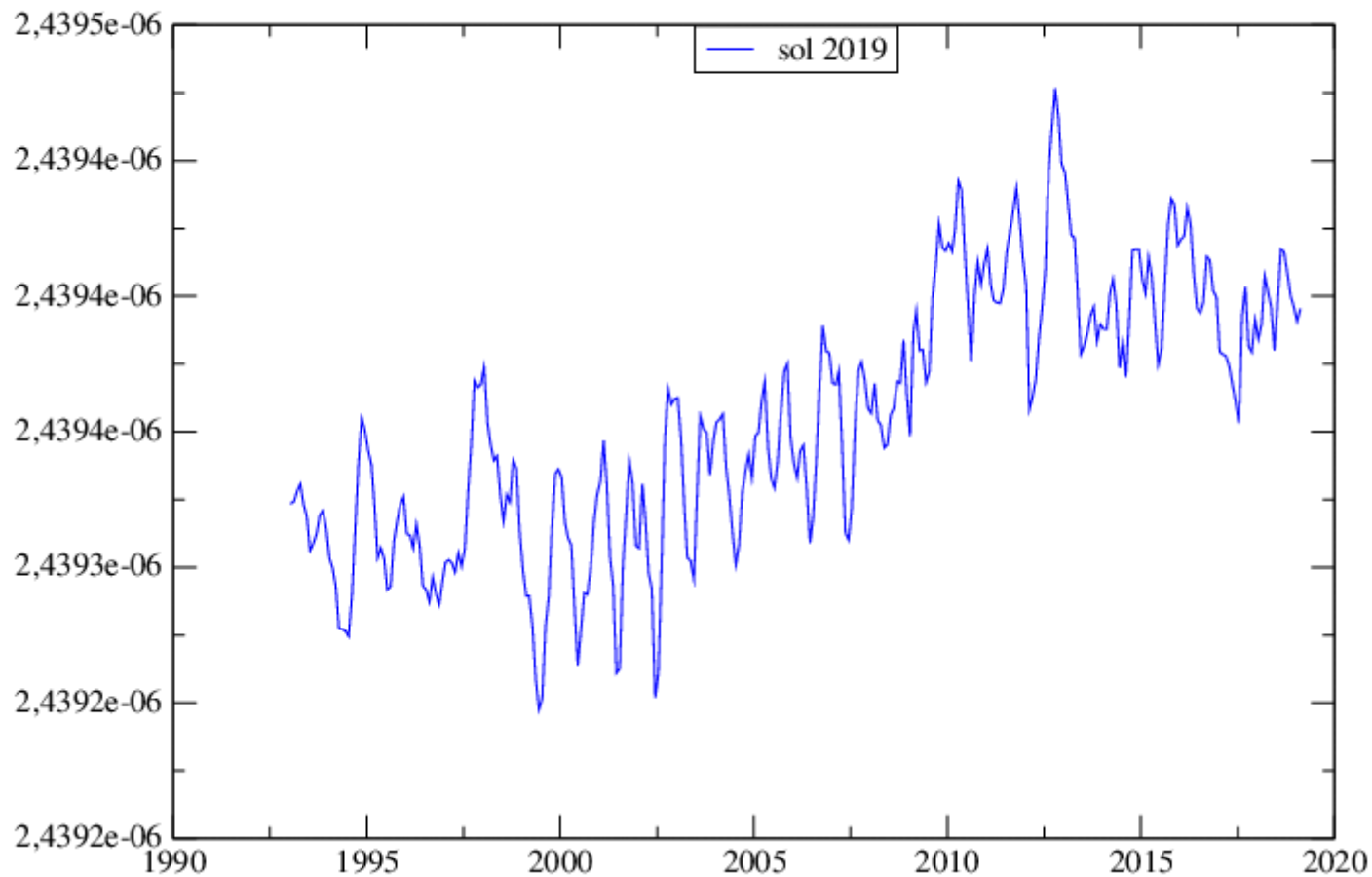
- The **slope** of the C(2,0) coefficient **before 1993** is based on earlier determinations of C(2,0)
- The **slope** of the C(2,0) coefficient **after 2019** is based on the average slope over the recent years: 2012-2019

$$C(2,0) + .00048416525$$

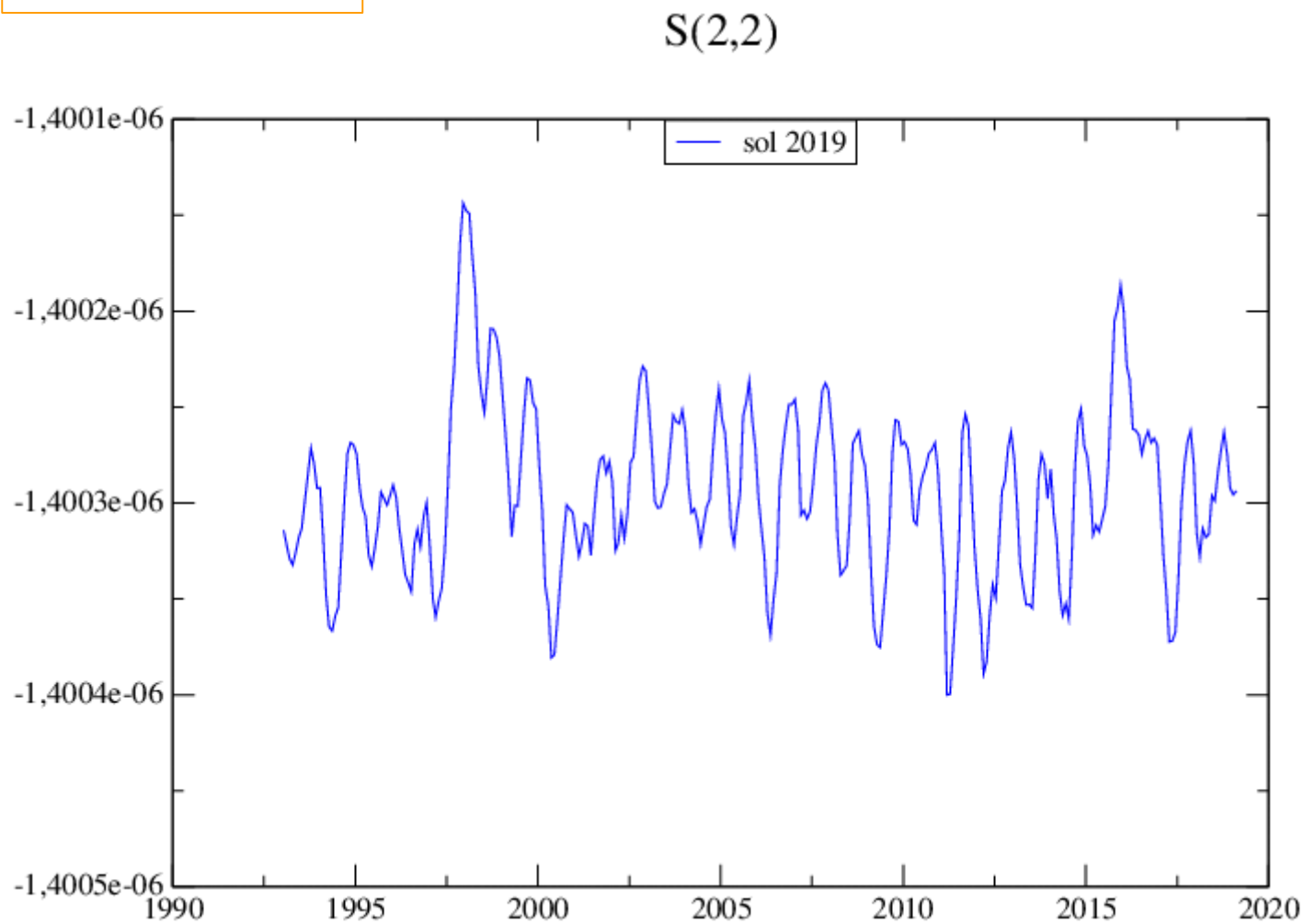


# Time series

$C(2,2)$



## Time series



- ❖ Specific case of the **C(2,1) / S(2,1)** coefficients: on Feb 1st, 2018, the IERS convention for the mean pole motion changed from “quadratic” (old IERS2010 conventions) to linear (updated IERS2010 conventions). The change of IERS conventions on the mean pole implies that the CNES/GRGS RL04 solutions (monthly RL04 solutions, as well as mean gravity field model) are **provided in both conventions**.

- ❖ **Remarks:**

- There **has to be** a coherence between the mean pole convention that is adopted (quadratic or linear) and the gravity field that is used.
- In the CNES/GRGS gravity field models a comment in the header indicates which convention is used:

**CMMNT Mean pole convention: quadratic**

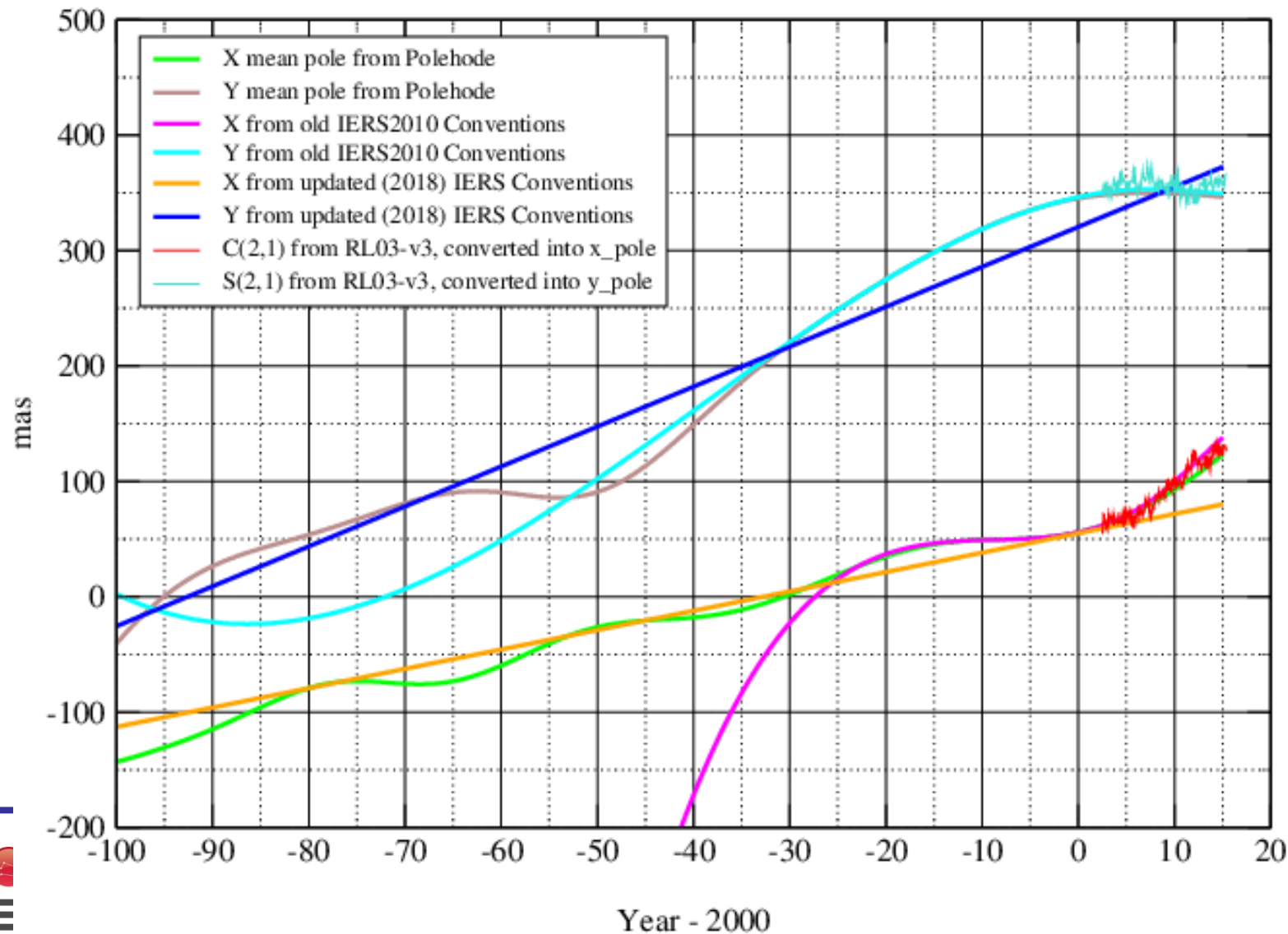
or

**CMMNT Mean pole convention: linear**

# “IERS2010 mean pole”

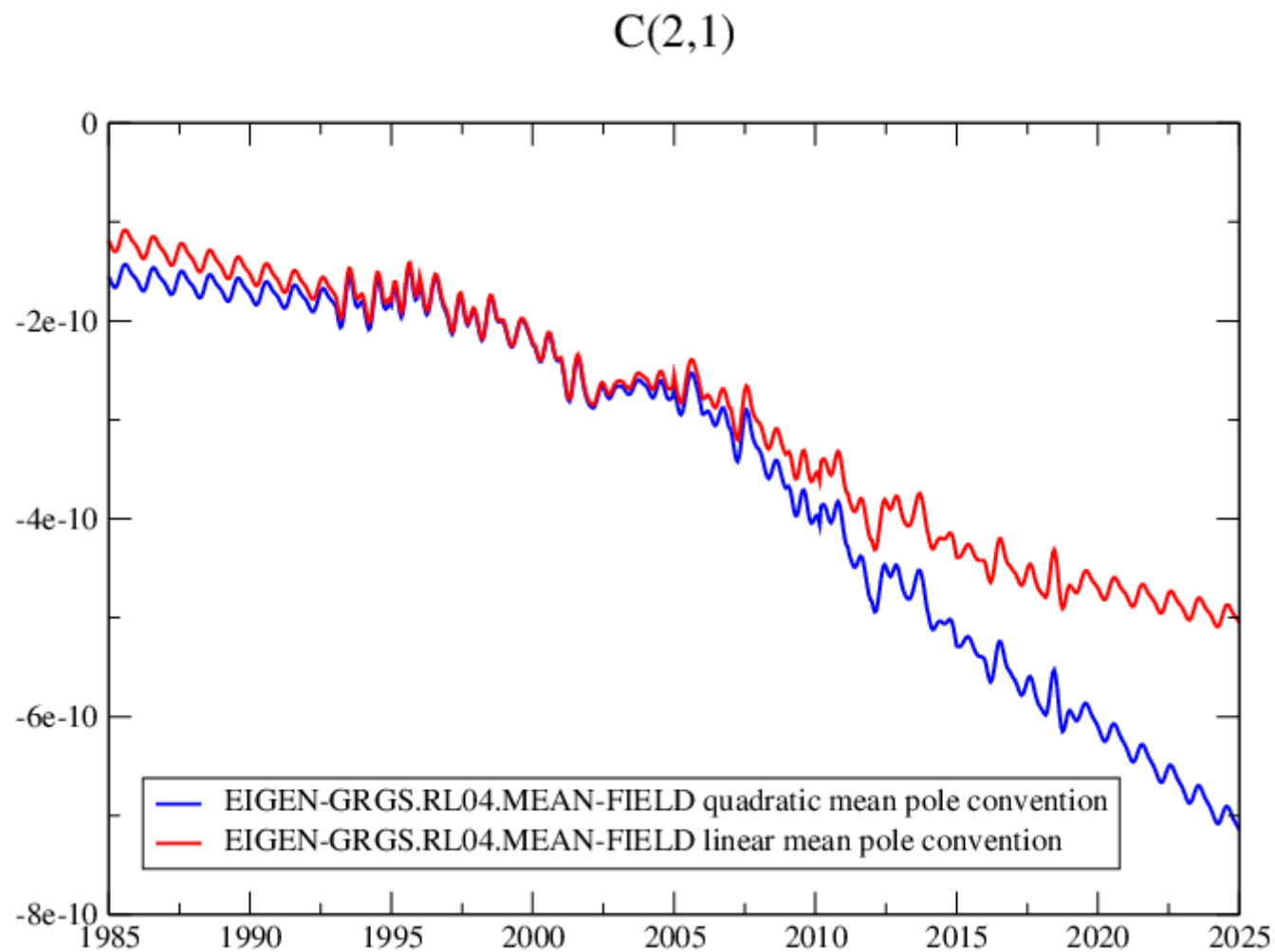
## Pole coordinates

IERS Conv. 2010 (Eq. 6.5):  $x_p \sim -2.46e11 * C(2,1)$  ;  $y_p \sim +2.46e11 * S(2,1)$  with  $x_p, y_p$  in mas, CS normalized



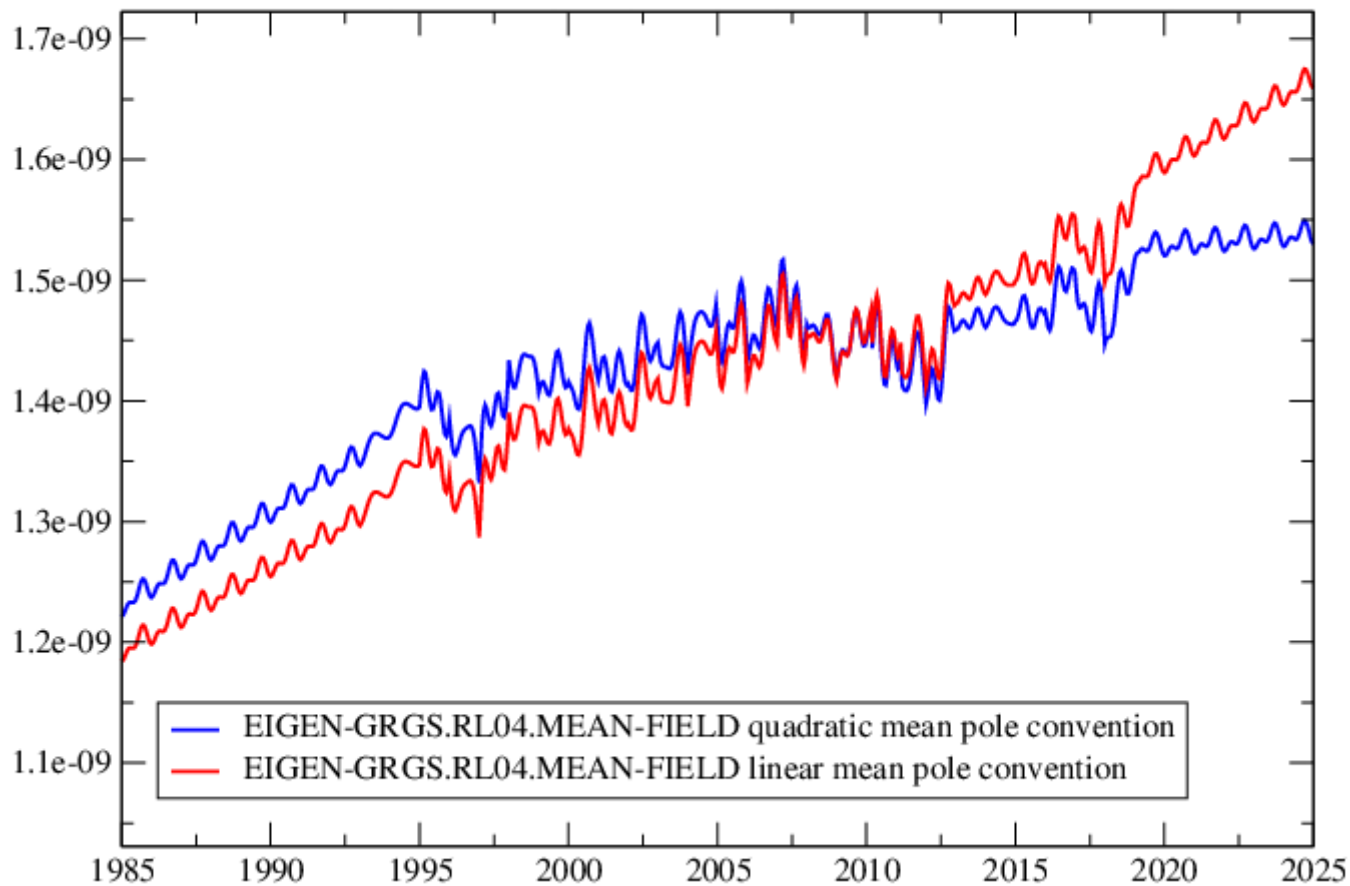


# Time series of the models



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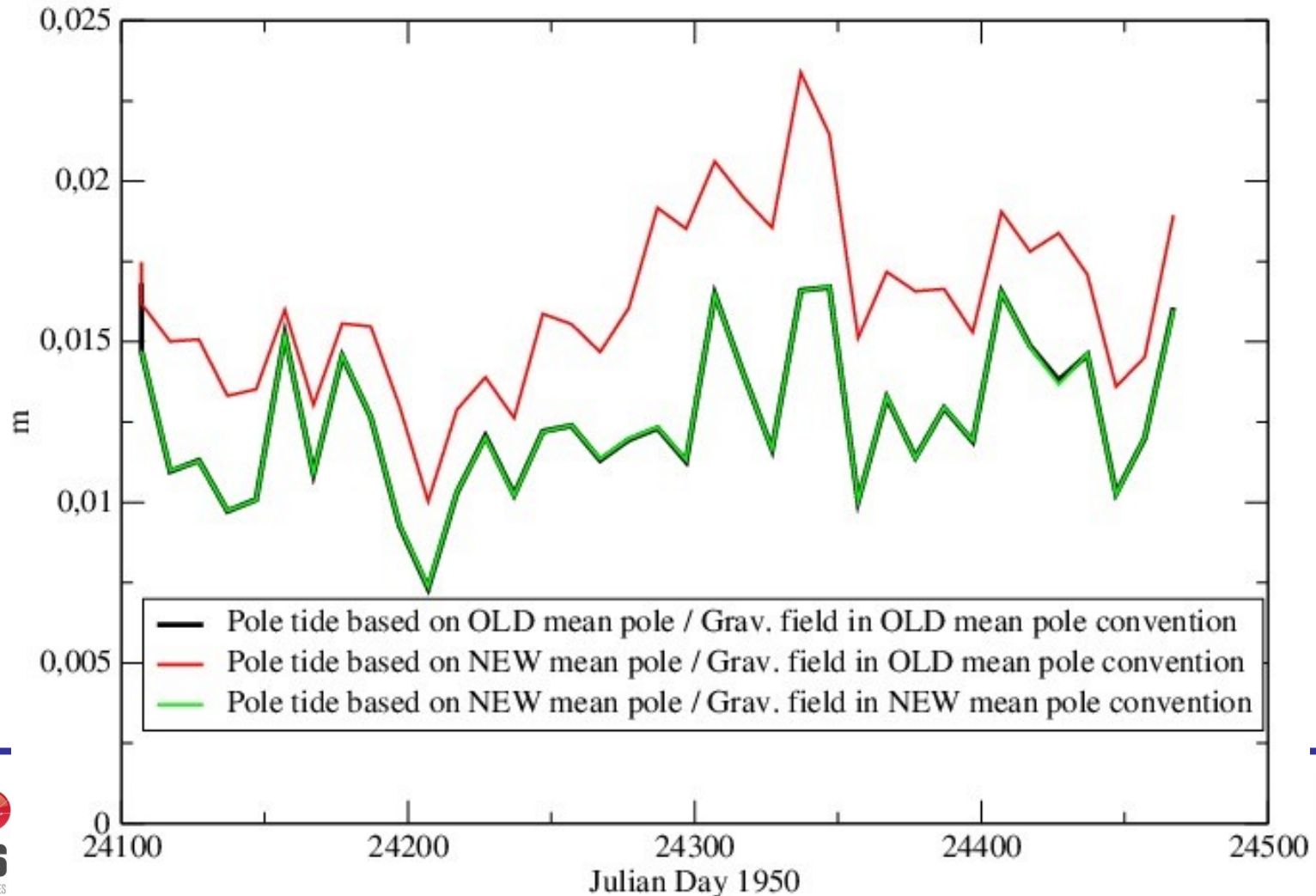
$S(2,1)$



# Impact of a non-compatibility between the mean pole and the gravity field model

## STARLETTE residuals, year 2016

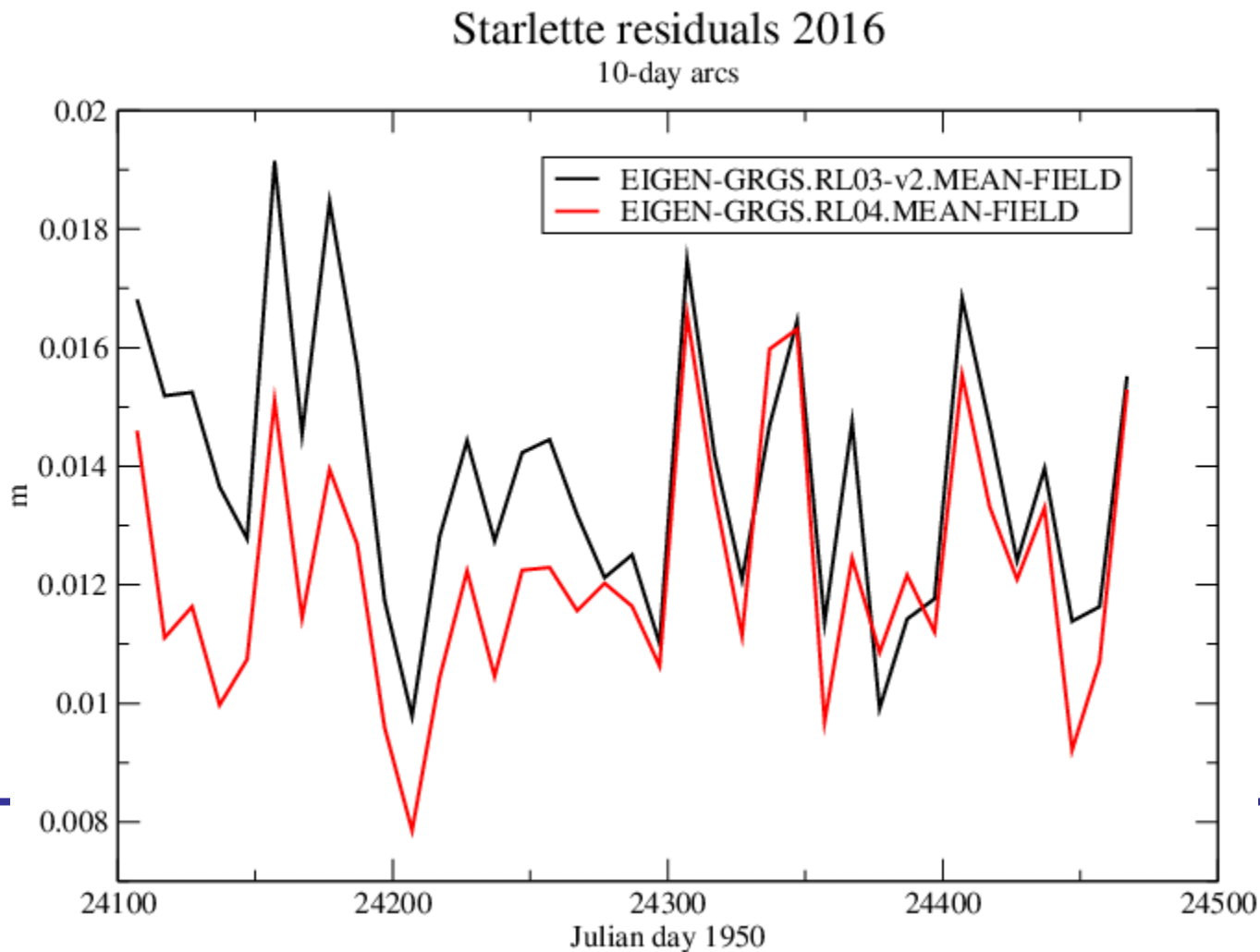
(24100 = 26/12/2015 - 24500 = 29/01/2017)



# Quality control on RL04

A- RL04 monthly time series: see [http://gravitegrace.get.obs-mip.fr/costg/meetings/COSTGM1\\_CNES\\_external\\_validation.pdf](http://gravitegrace.get.obs-mip.fr/costg/meetings/COSTGM1_CNES_external_validation.pdf)

B- POD with **new mean field**: Example of the SLR residuals on Starlette in 2016



# Conclusions and perspectives

## A. 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. Therefore this information ought to be delivered together with the gravity field model by the makers of the models.

B. The new mean gravity field model is available at: <https://grace.obs-mip.fr/variable-models-grace-lageos/mean-fields/release-04/>

C. The first tests indicate that **EIGEN-GRGS.RL04.MEAN-FIELD** allows to obtain smaller POD residuals than the previous model EIGEN-GRGS.RL03-v2.MEAN-FIELD.

D. There is also a **new version of FES2014**: FES2014c