High-resolution grids of GOCE-only gravitational gradients for geophysics

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Motivation and Background

- Working on GRACE/GOCE data regionally within STSE ⇒ why not globally?
- GOCE data: GRF and TRF GGs, geopotential models (combi. & only), grids (combi. by DGFI+UWB) ⇒ no GOCE-only grids (SPW grids?)?
- 2 (Dirichlet-problem) siblings: **spherical harmonics** and **Poisson integral** equation ⇒ should provide equal results
- ⇒ Feedback on TRF data.
- Useful or not? ⇒ users will answer.

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On the approach applied

Input: GOCE L2 TRF gradients for 2009-2013 (Oct19)

1. Real orbit → mean orbital sphere (MOS) - **Gradient approach**
   - A priori model used for $\frac{\mathrm{d}V_{ij}}{\mathrm{d}r}$ (TIMr4)
   - GOCE data position varies ± 15/30 km (before/after descends in 2012-13)
   - On a constant sphere gridding is "easy" (number of software)
2. MOS → downward - **Iterative approach equipped with Poisson integral equation**
   - No a priori gravity information (starts with given data)
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   - The approach provides error estimate in the spatial domain ⇒ wash your data!

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Note on L2 TRF data

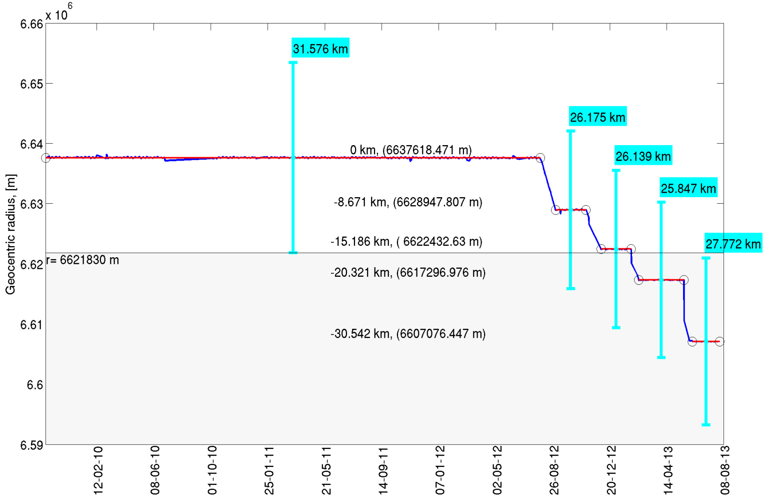
See GOCE L2 Product Data Handbook (p. 49):

"The EGG_TRF_2_ gravity gradients should be used for local applications. Because of the use of (external) gravity field models to compute the long wavelength part of these gravity gradients, they should not be used for global gravity field analysis. Or at least the results from such an analysis should be interpreted with care."

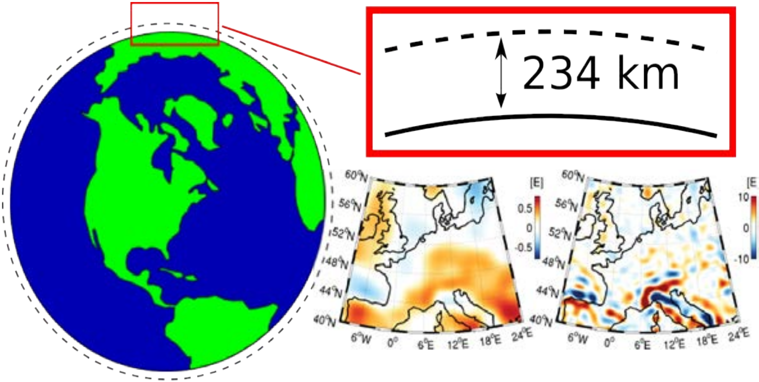
$\Rightarrow$ applies also to our GOCE-only grids!

STEP 1 - ro2mos

Nominal accuracy of gradient mapping: RMS=0.01 mE



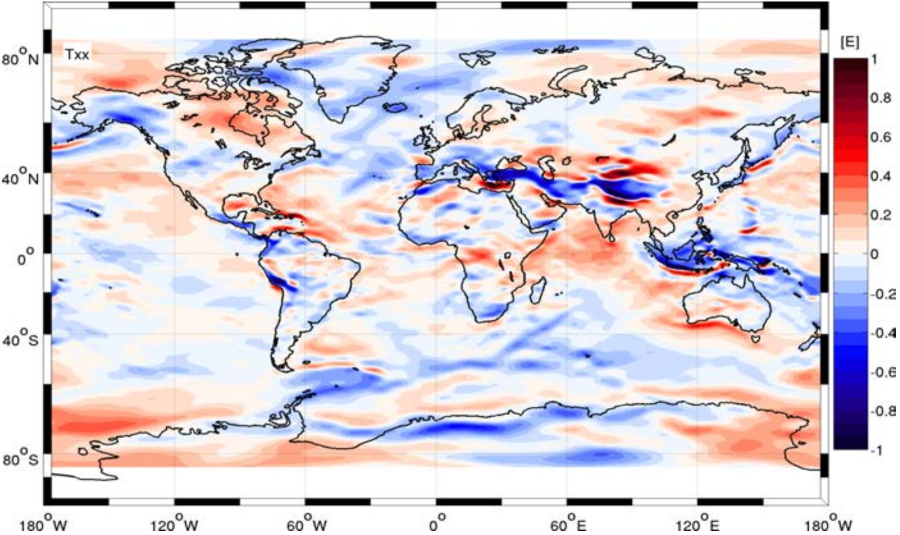
STEP 2 - mos2down



- Integral equation: $V(\mathbf{r}) = \frac{R(r^2 - R^2)}{4\pi} \int_{\lambda=0}^{2\pi} \int_{\theta=0}^{\pi} \frac{1}{l^3} V(\mathbf{R}) \sin\theta' \mathrm{d}\theta' \mathrm{d}\lambda$
- Algorithm: $\mathbf{f}_i = \mathbf{f}_{i-1} + p \cdot (\mathbf{g} - \mathbf{K} \cdot \mathbf{f}_{i-1})$ with $\mathbf{f}_1 = \mathbf{g} + p \cdot (\mathbf{g} - \mathbf{K} \cdot \mathbf{g})$

Results at satellite altitude

Txx



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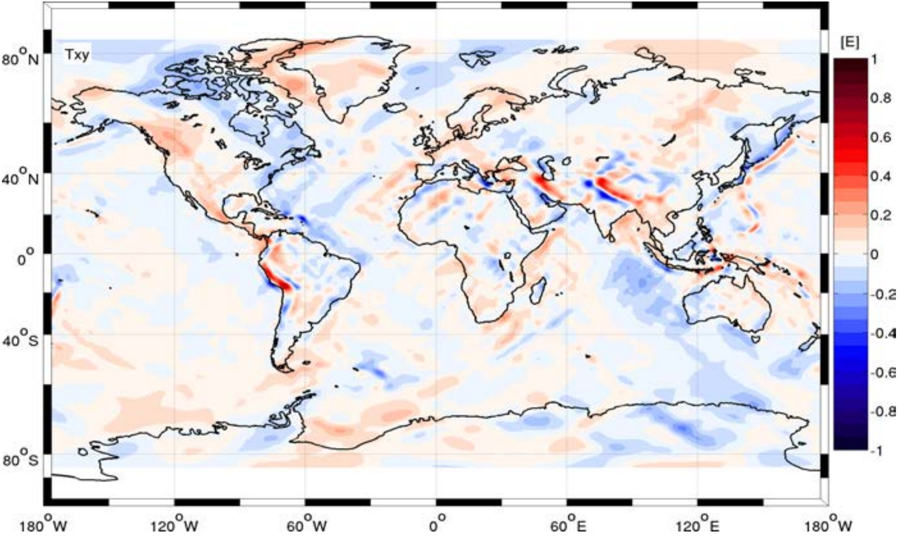
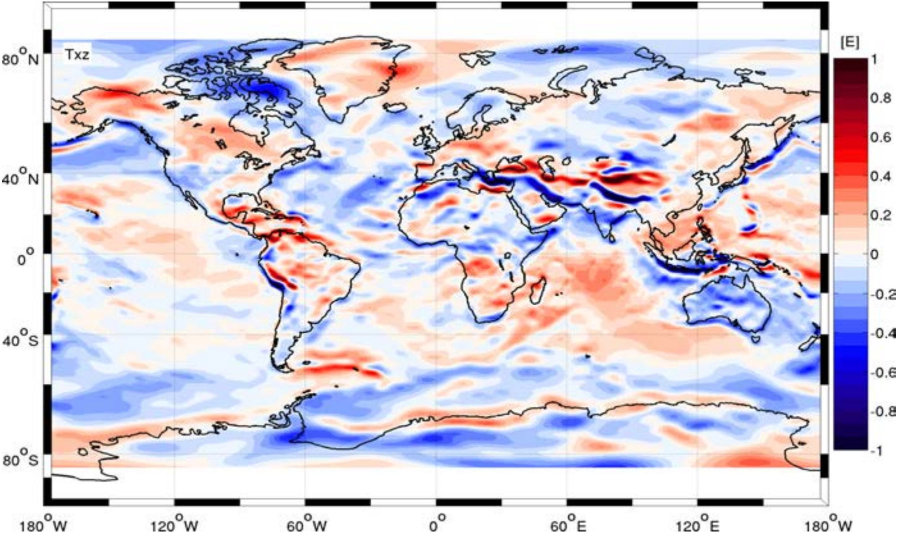
Txy



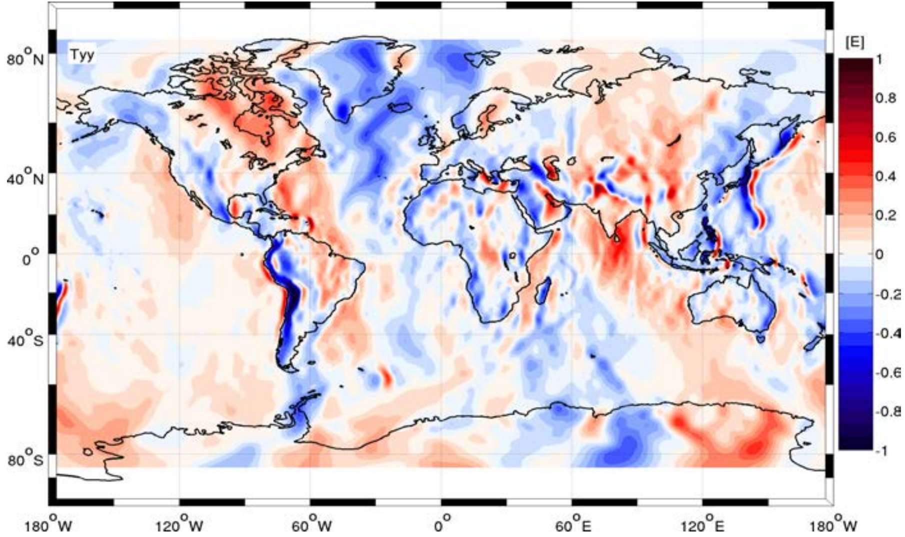
Results at satellite altitude

Txz



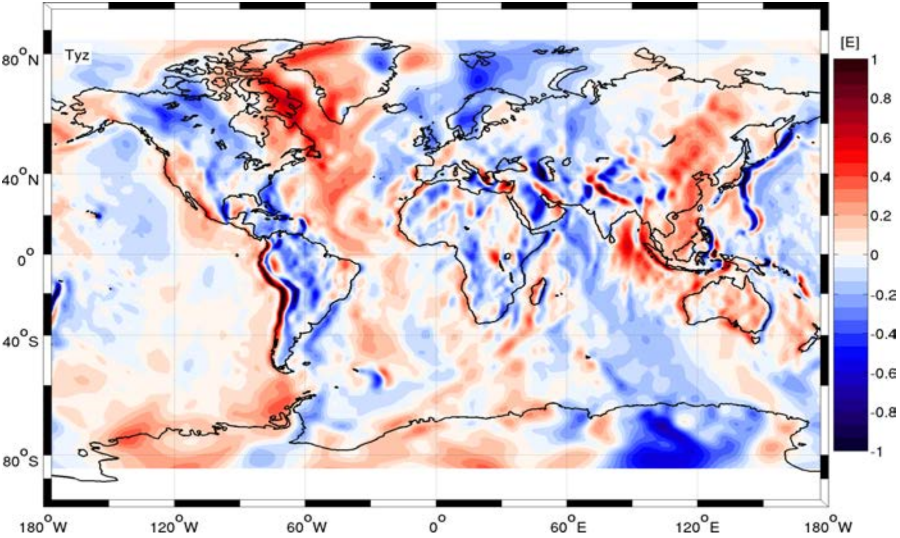
Results at satellite altitude

Tyy



Results at satellite altitude

Tyz



Results at satellite altitude

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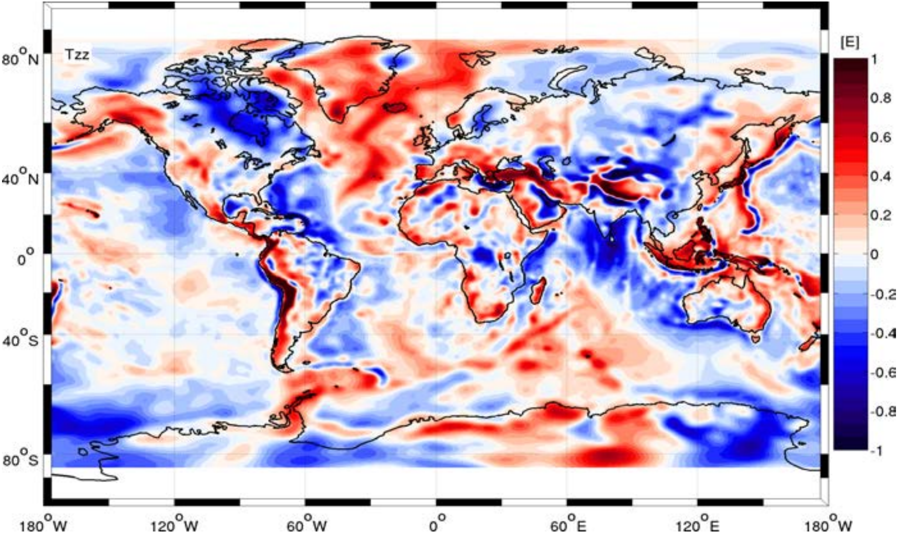
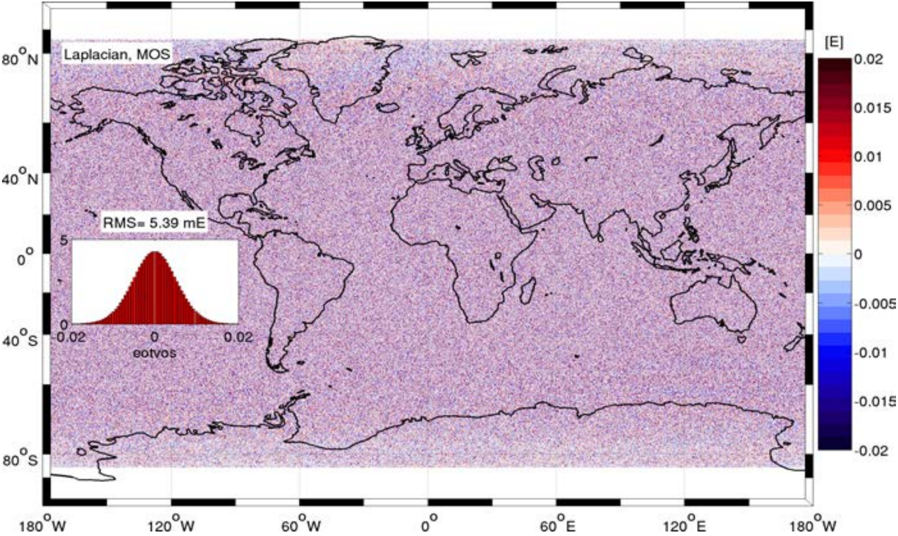


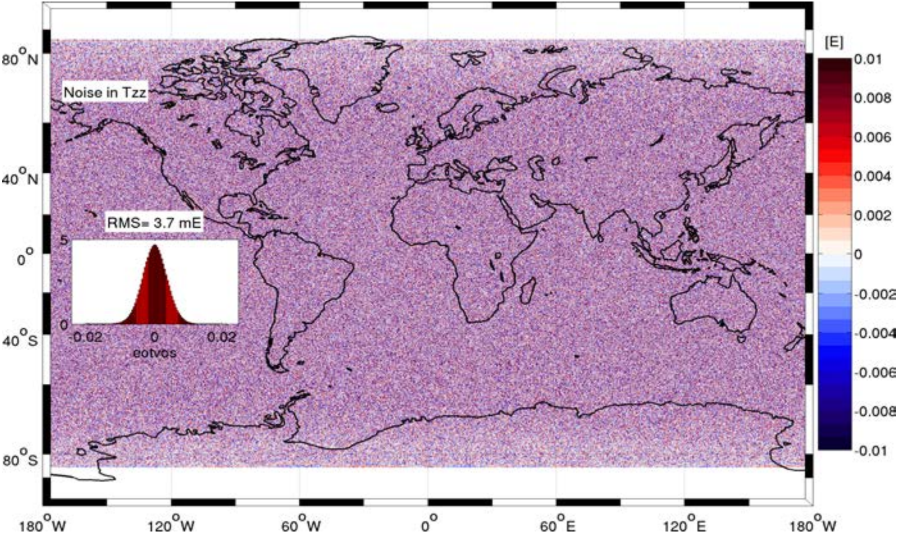
Results at satellite altitude

Laplacian before washing



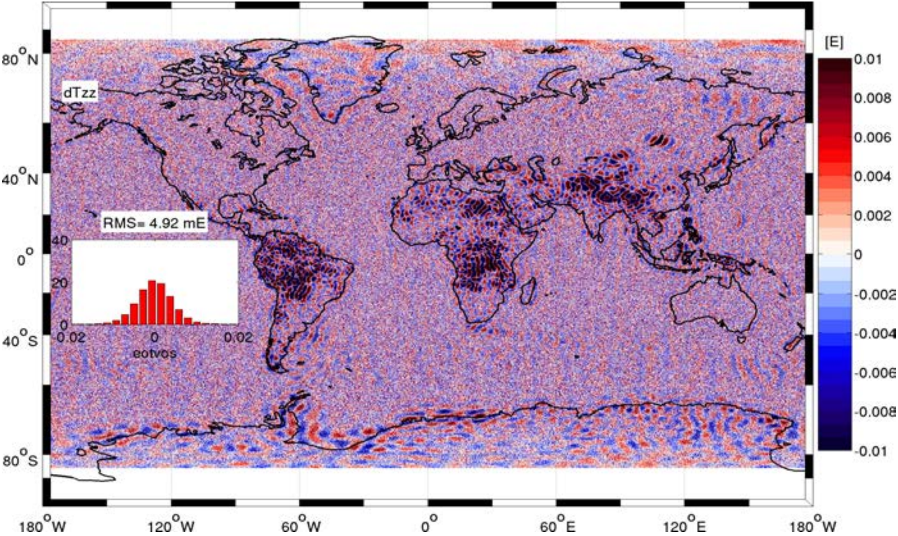
Results at satellite altitude

Noise estimate from iteration



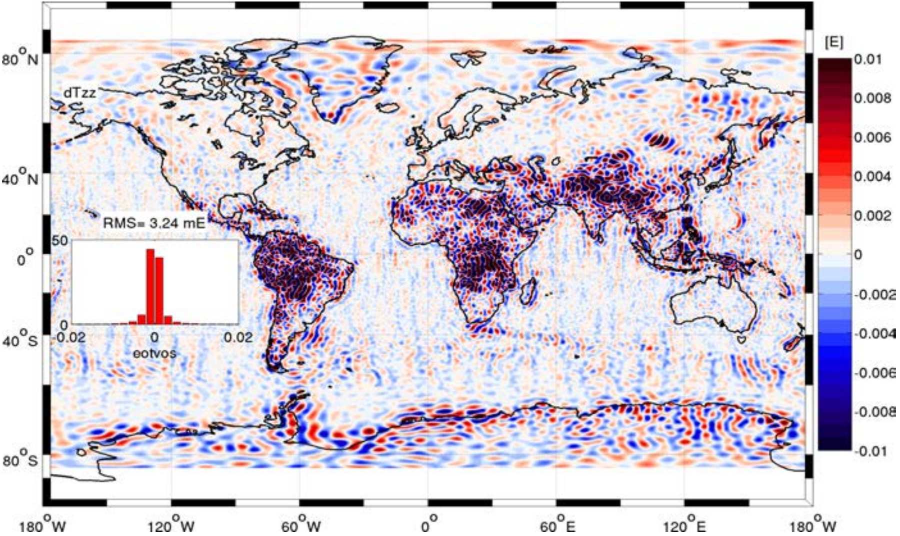
Results at satellite altitude

T_{zz} difference with EGM2008 (300) with noise



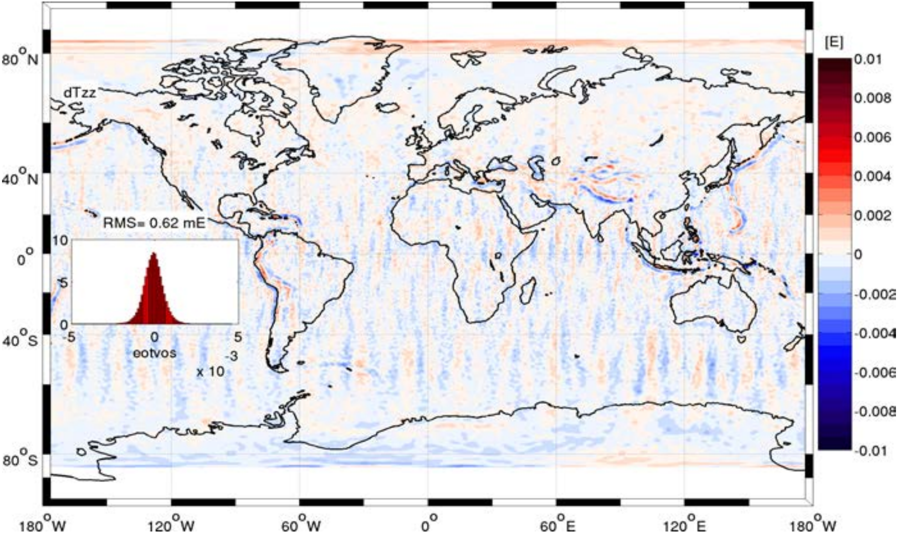
Results at satellite altitude

T_{zz} difference with EGM2008 (300) w/o noise



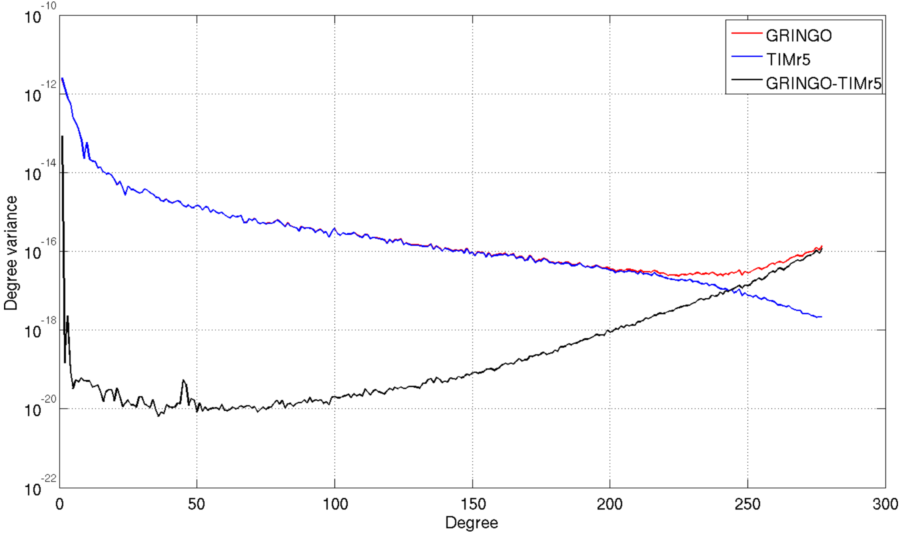
Results at satellite altitude

T_{zz} difference with TIM-r5 (280) w/o noise (0.4 mE for TIMr3 before repro, R. Pail)



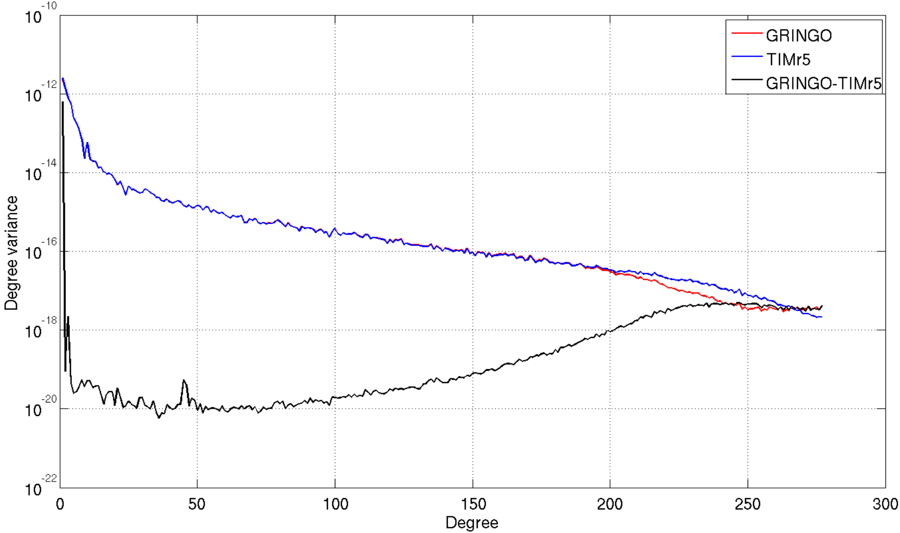
Results at satellite altitude

Degree variance with noise (before washing)



Results at satellite altitude

Degree variance without noise (after washing)



High degrees in TIM-r5 and DIR-r5

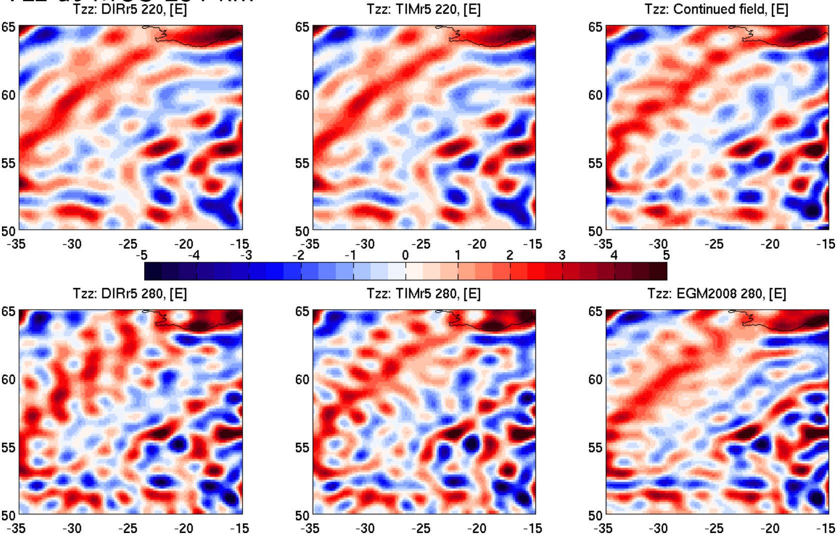
Difference	Tzz (MOS) in mE	Tzz (MOS-234 km)
TIMr5(280) - TIMr5(220)	0.262 mE	1.447 E
DIRr5(280) - DIRr5(220)	0.263 mE	1.462 E
DIRr5(220) - TIMr5(220)	0.337 mE	**0.151** E
DIRr5(280) - TIMr5(280)	0.342 mE	**0.531** E

The same proportions for other components!

- You can see the same in GPS levelling by T. Gruber.
- **Let's see that in the spatial domain** $\Rightarrow$

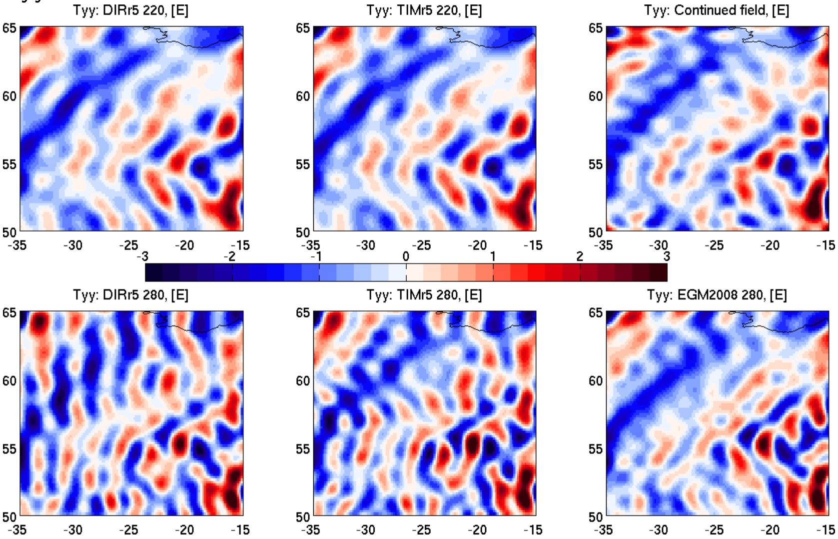
Sample results at lower altitude

Tzz at MOS-234 km



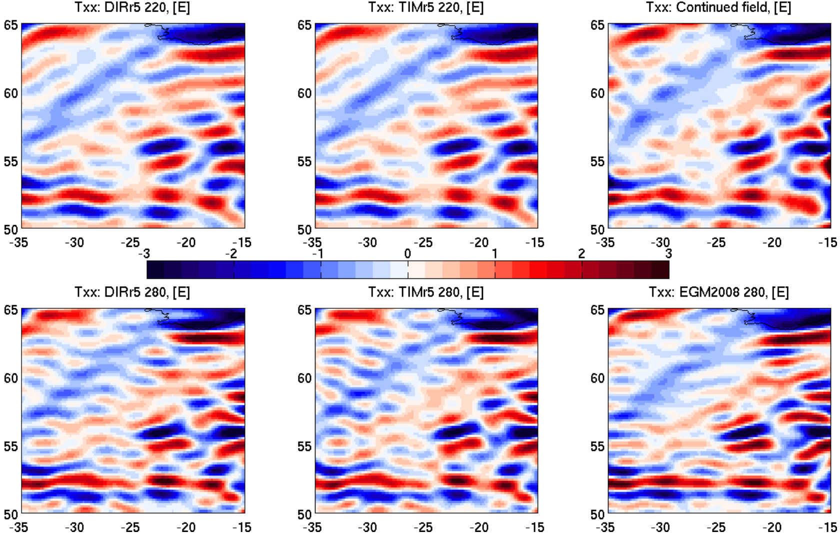
Sample results at lower altitude

Tyy at MOS-234 km



Sample results at lower altitude

Txx at MOS-234 km



Products summary (including "the kitchen")

- **@ MOS (satellite altitude)**
  - GGs along the orbit but on the MOS
  - GGs grids with noise (after interpolation)
  - GGs grids with reduced noise (after washing)
  - GGs from latest models up to d/o 220 and full resolution
- **@ MOS-234 km** (above the ground ... including "the roof")
  - DC GGs grids with reduced noise (after washing and continuation)
  - GGs from latest models up to d/o 220 and full resolution
- **Software** - Matlab script that will do (regional) downward continuation - work with GGs @ MOS on your own!

GOCE L2 Product Data Handbook: **"The EGG_TRF_2_ gravity gradients should be used for local applications. Because of the use of (external) gravity field models to compute the long wavelength part of these gravity gradients, they should not be used for global gravity field analysis. Or at least the results from such an analysis should be interpreted with care."**

Summary

- Washing ongoing! $\Rightarrow$ wait for Xmas.
- GOCE-only 10 arc-min grids from L2 TRF GGs possible
- Models and grids consistent at sat. altitude (0.6 mE for T_{zz})
- L-w effects in yy, yz, zz identified (L2 TRF?).
- Make it "easy" in application: use multiple models (TIM, DIR, GOCO, ...) and multiple grids (DGFI, ours)
- With models near the ground, carefully with a maximum degree - realistic DV vs. realistic spatial maps

http://goce.kma.zcu.cz

$$\textbf{Thank} \begin{cases} \textbf{You} \\ \textbf{ESA} \end{cases}$$