DSO DORIS Analysis Software Intermediate Outcomes

G. Serelis[1] D. Anastasiou[1] X. Papanikolaou[1] M. Tsakiri[1] V. Zacharis[1] V. Krey[1]

[1]Dionysos Satellite Observatory
School of Rural, Surveying & Geoinformatics Engineering
National Technical University of Athens

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Software Testing

Testing is hard . . .

- hundreds of thousands of LOC,
- different modules, performing different tasks, in different repositories,
- different kinds of errors: programming, bugs, implementation, models,
- different magnitudes and effects,
- writing and devising (new) test, checking corner cases

Software Testing

We strive to embed testing in our development process through Continuous Integration (CI); in essence, testing is tied to the development & building chain.

- Unit testing; automated for every module/library; try for maximum code coverage.
- Testing against IAU Standards of Fundamental Astronomy (SOFA) tools[1]
- Testing against IERS-provided software tools (usually FORTRAN).
- How to test for the force model ?

[1] Software Routines from the IAU SOFA Collection were used. Copyright International Astronomical Union Standards of Fundamental Astronomy (http://www.iausofa.org).

COST-G Benchmark Test

COST-G

In the framework of the COST-G (Jäggi et al. (2022)) gravity field solutions from different analysis centres (ACs) are combined to offer a consolidated solution of improved quality, robustness and reliability to the user.

The COST-G initiative was formally established in 2019 and operationally provides state-of-the-art monthly global gravity models from the Gravity Recovery And Climate Experiment (GRACE, Tapley et al. (2004)), GRACE Follow-On (Landerer et al. (2020)) and Swarm (Friis-Christensen et al. (2008)).

COST-G Benchmark Test

In the framework of COST-G, Lasser et al. (2020) published data and reference results for a benchmark test of various commonly used forces in orbit. The corresponding accelerations are evaluated along a one day orbit arc of GRACE.

"This data set is intended to be used as a reference data set and provides the opportunity to test the implementation of these models in various software packages." The benchmark data set was compiled at the Institute of Geodesy (IfG) at Graz University of Technology.

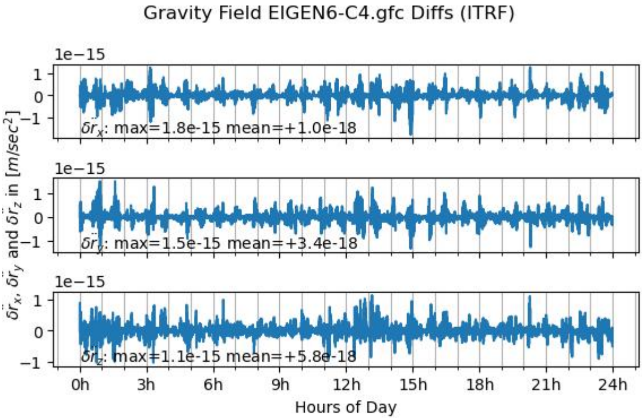
Expected Results & Differences

"It is very unlikely to obtain zero differences. Unless large systematic differences emerge, oscillating patterns around zero will usually be observed due to the orbital revolution", Lasser et al. (2020)

"We consider differences in the force modelling for GRACE which are one order of magnitude smaller than the accelerometer noise of about $10^{-10} ms^{-2}$ to be negligible"

Earth's Gravity Field

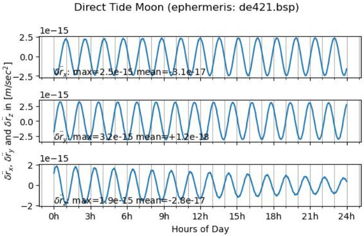
Model: EIGEN-6C4, Förste et al. (2014)



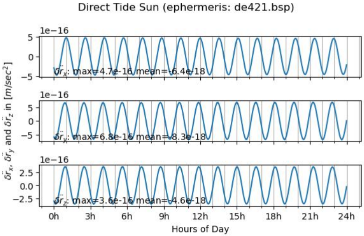
(a) DSO vs COST-G: Discrepancies between implementations for Earth's gravity field (one day of GRACE orbit).

3rd Body Attraction

Planetary Ephemeris DE421, Folkner et al. (2009)



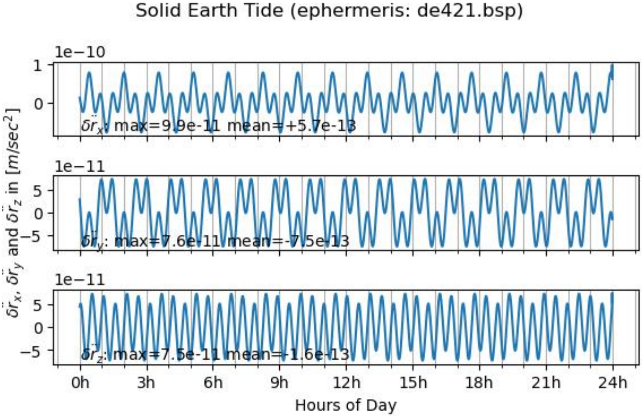
(a) DSO vs COST-G: Discrepancies between implementations for Moon's attraction (one day of GRACE orbit).



(b) DSO vs COST-G: Discrepancies between implementations for Sun's attraction (one day of GRACE orbit).

Solid Earth Tides

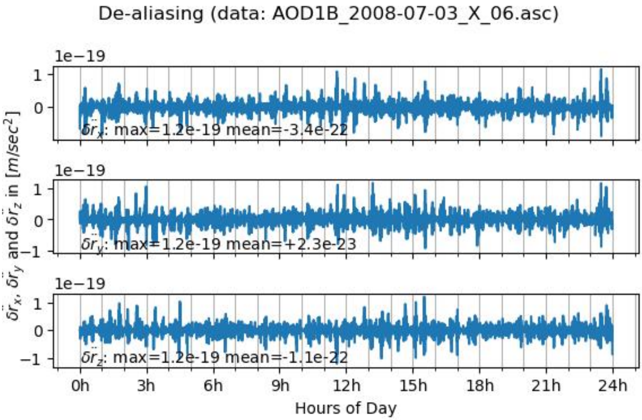
Model: IERS2010, Petit and Luzum (2010)



(a) DSO vs COST-G: Discrepancies between implementations for Solid Earth Tides on potential (one day of GRACE orbit).

Dealiasing

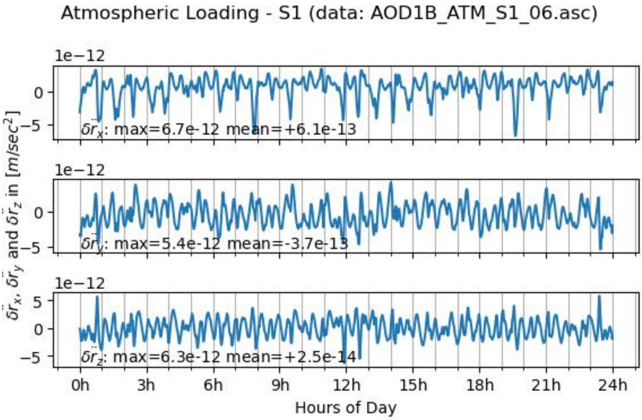
Product: AOD1B RL06, Dobslaw et al. (2017)



(a) DSO vs COST-G: Discrepancies between implementations for Dealiasin; atmospheric and oceanic contribution gon potential (one day of GRACE orbit).

Atmospheric Tides

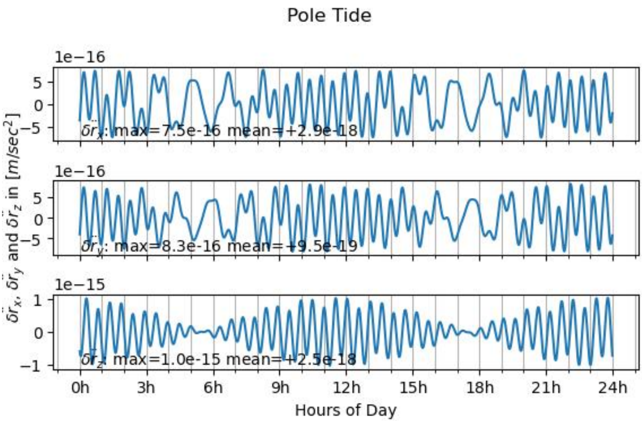
Product: AOD1B RL06, Dobslaw et al. (2017)



(a) DSO vs COST-G: Discrepancies between implementations for Atmospheric Tides on potential (one day of GRACE orbit).

Pole Tide

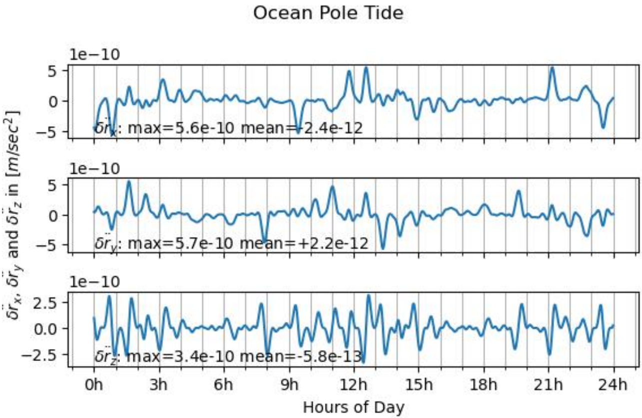
Model: IERS 2010



(a) DSO vs COST-G: Discrepancies between implementations for Pole Tides on potential (one day of GRACE orbit).

Ocean Pole Tide

Model: IERS 2010



(a) DSO vs COST-G: Discrepancies between implementations for Ocean Pole Tides on potential (one day of GRACE orbit).

Differences w.r.t COST-G Benchmark Test

Force	**Magnitude**[2] ms^{-2}	**Difference**	**Remark**
Earth's gravity	$\sim 10^{-2}$	$\sim 10^{-15}$	EIGEN-6C4, Förste et al. (2014), d/o=2 ... 180
3rd body	$\sim 10^{-6}$	$\sim 10^{-15}$	DE421, Folkner et al. (2009), Sun, Moon, Planets
Solid Earth Tides	$\sim 10^{-7}$	$\sim 10^{-10}$	IERS 2010, Petit and Luzum (2010), anelastic
Ocean Tides	$\sim 10^{-7}$	$\sim 10^{-11}$	FES2014b, Carrere et al. (2015), d/o=2 ... 180
Relativistic Corr.	$\sim 10^{-8}$	$\sim 10^{-16}$	IERS 2010
Dealiasing	$\sim 10^{-8}$	$\sim 10^{-19}$	AOD1B RL06, Dobslaw et al. (2017), d/o=2 ... 180
Pole Tide	$\sim 10^{-8}$	$\sim 10^{-16}$	IERS 2010
Atmospheric Tides	$\sim 10^{-9}$	$\sim 10^{-12}$	AOD1B RL06, d/o=2 ... 180
Ocean Pole Tide	$\sim 10^{-9}$	$\sim 10^{-10}$	IERS 2010 and Desai (2002)

Difference is maximum discrepancy, in absolute value, in any (Cartesian) component.

[2] The magnitude is a rough estimation for the GRACE orbit, as given in Lasser et al. (2020).

Concluding Remarks

Generally, the magnitude of differences is close to the numerical precision.

Take a closer look at Solid Earth and Ocean Pole Tides, with Institute of Geodesy (IfG) at Graz University of Technology.

Include admittance for minor tidal waves (ocean tides).

Enabling parsing of gfc files distributed by ifG (produced by GROOPS, Mayer-Guerr et al. (2021)).

Thank you

Thank you for your attention!

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