Monthly gravity fields from SLR and DORIS using tailored base functions: final improvements

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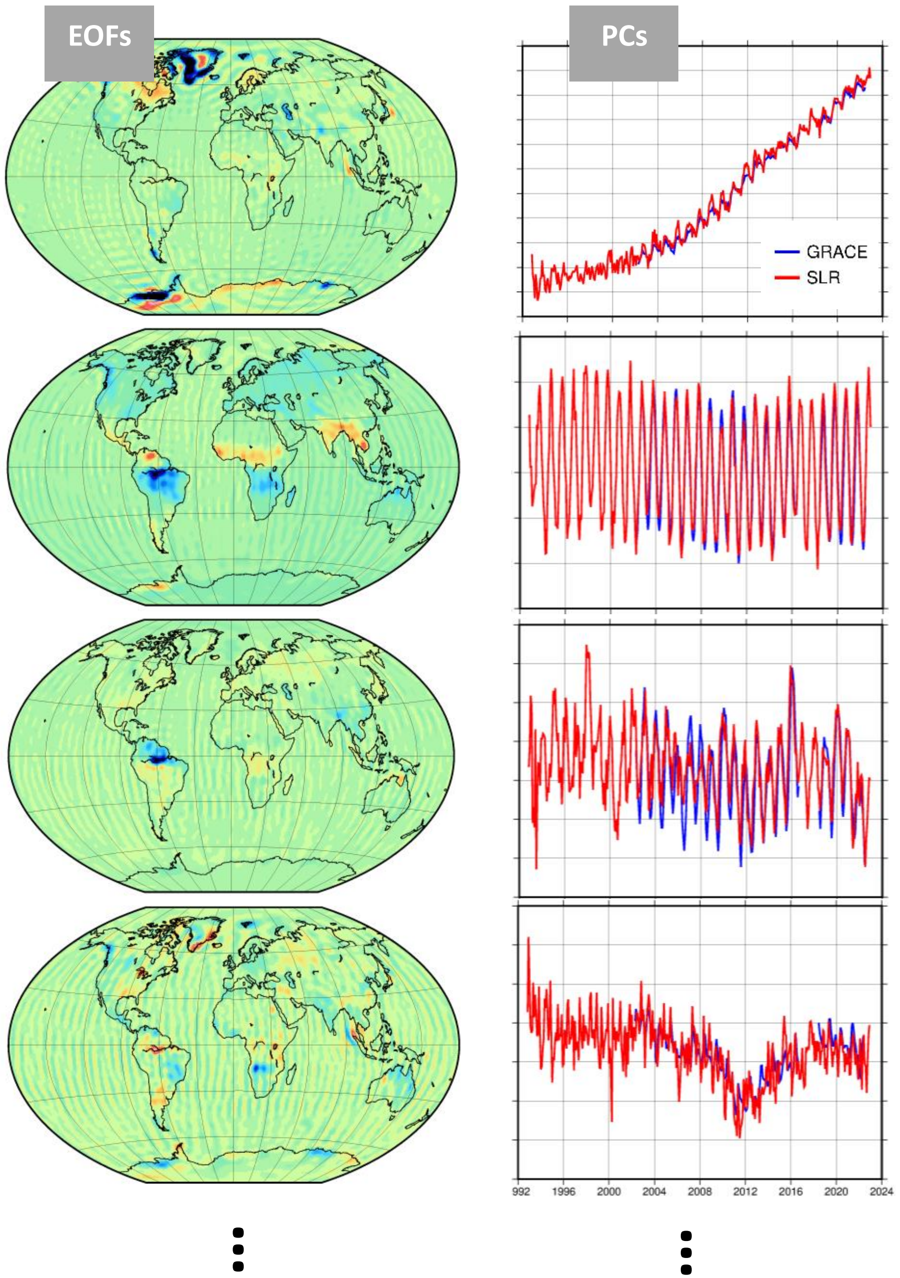
Time-variable gravity at IGG

- Monthly gravity field solutions from non-dedicated missions
- Objectives: Extending the GRACE time series backward + filling the GRACE gap
- **Time-variable gravity field represented by GRACE EOFs** in terms of spherical harmonics. **PCs are solved**.

→ Change of base functions from individual SHs to linear combinations of SHs.



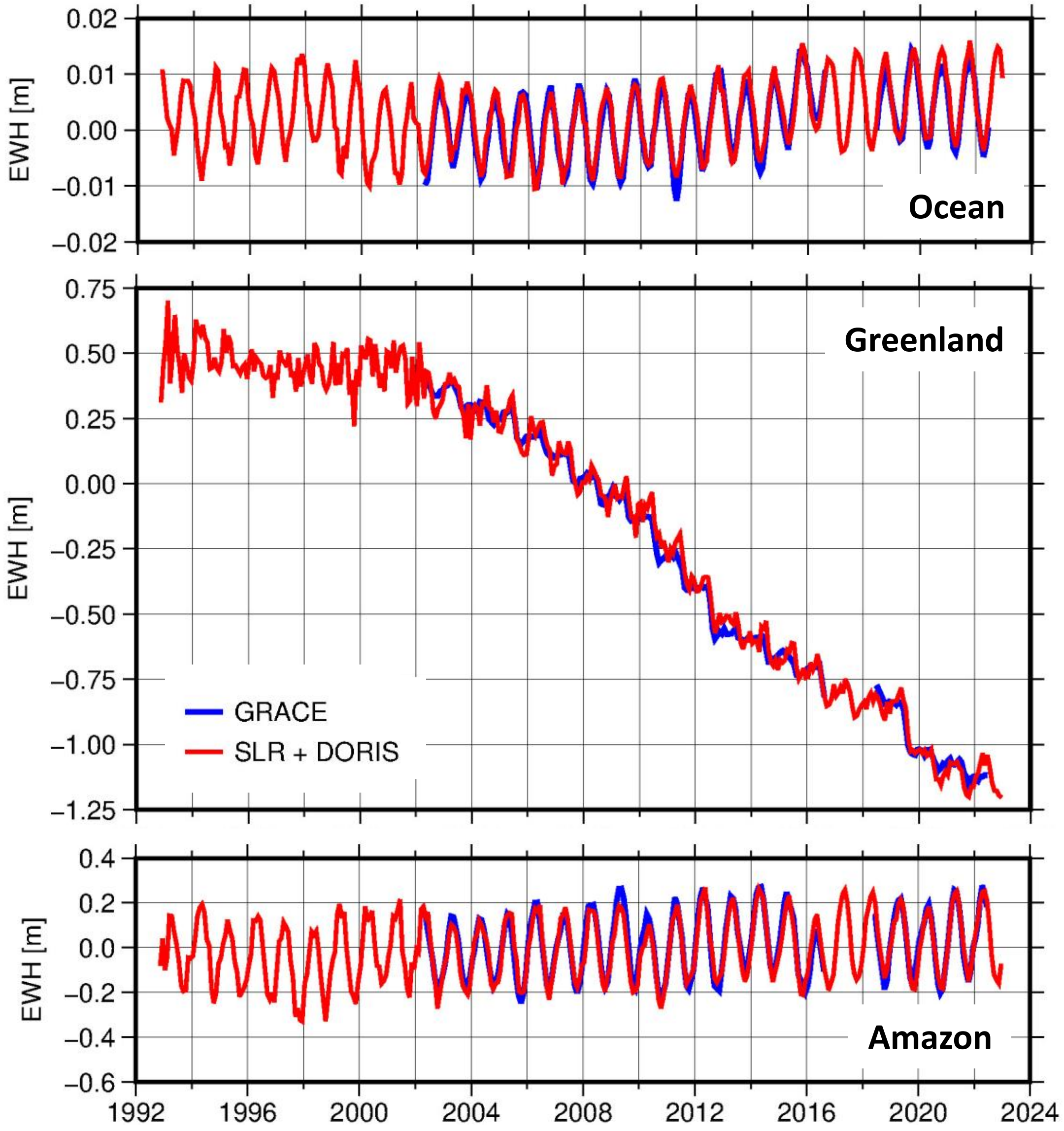
Time-variable gravity at IGG

SLR IGG-HYBRID series published at ICGEM, paper„A hybrid approach…“, JoG 95/1 (2021)

- Five satellites: Lageos 1/2, Stella, Starlette, Ajisai

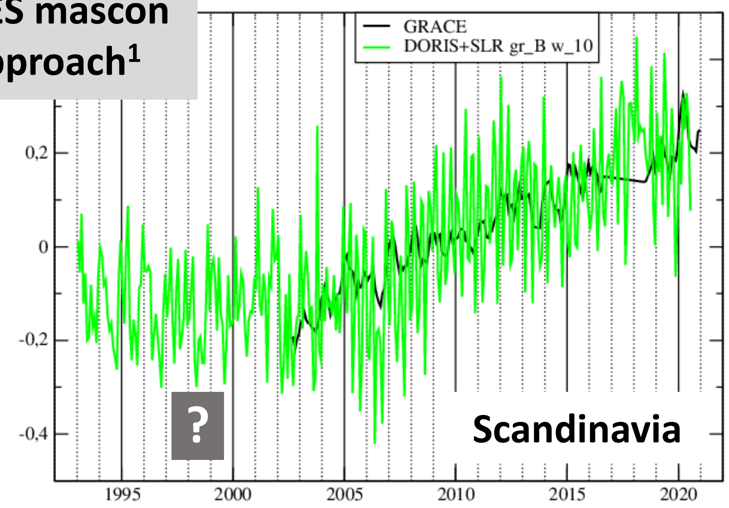
SLR + DORIS presented in Venice 2022 and at EGU 2023

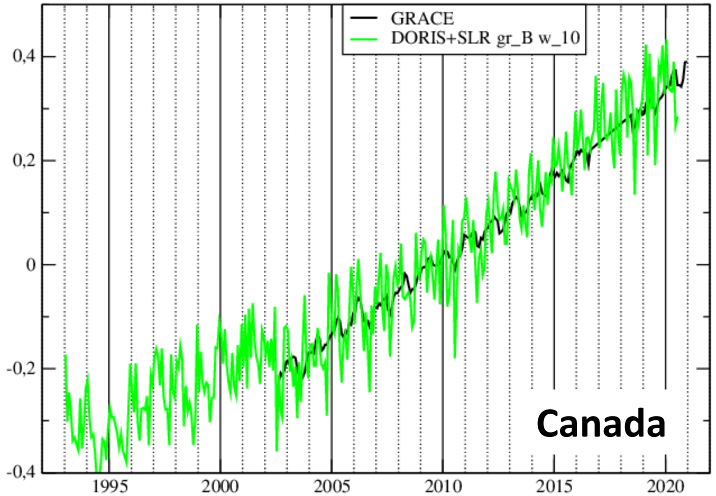
- Six SLR satellites plus ten DORIS satellites: Spot-2/3/4/5, Envisat, Cryosat-2, HY-2A, Saral, Sentinel-3A/B
- 10-day arcs for Lageos, 3-day arcs for other SLR satellites, daily arcs for DORIS



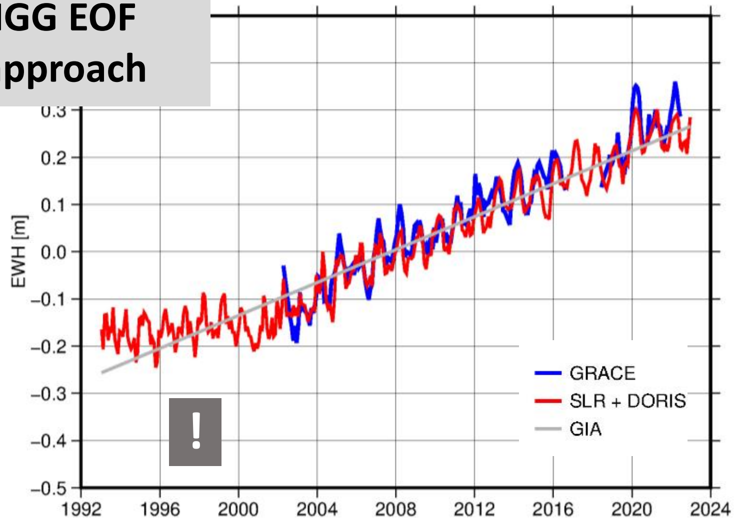
A question from CNES…

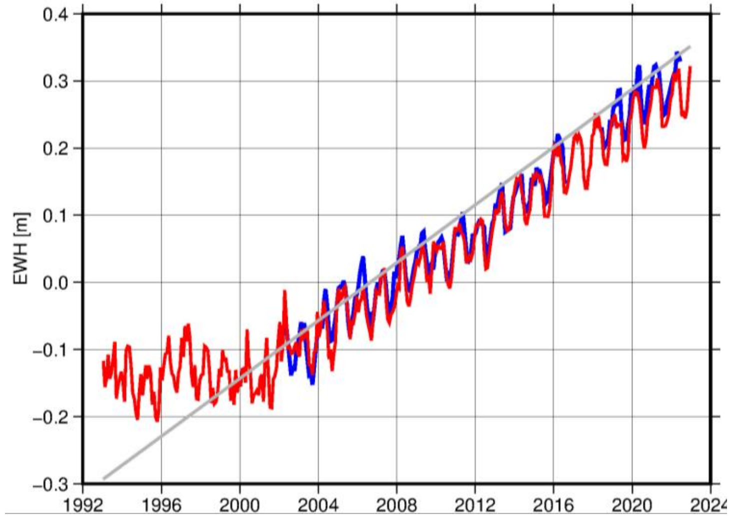
CNES mascon approach[1]





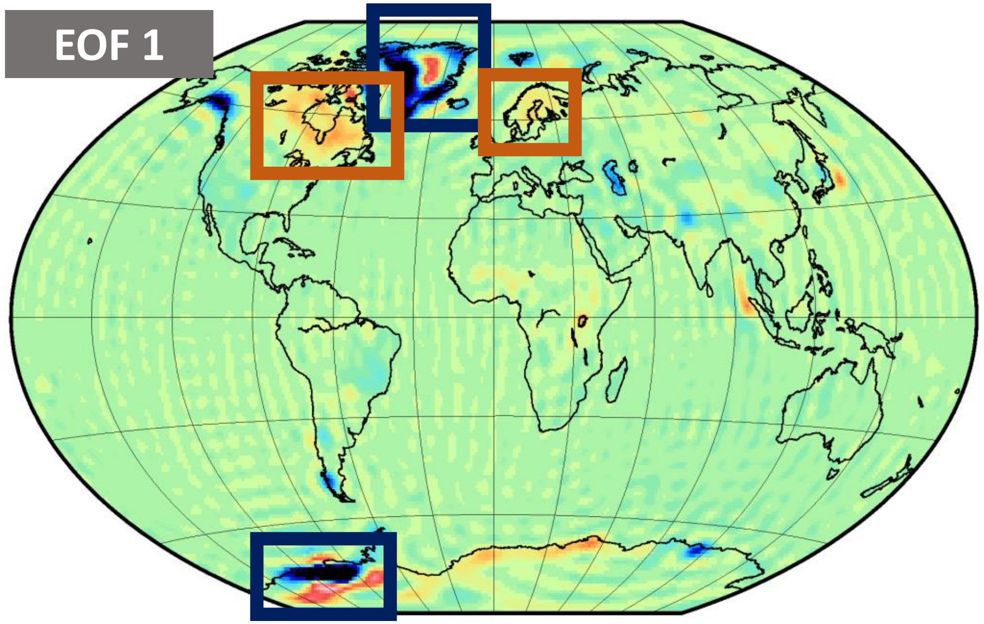
IGG EOF approach

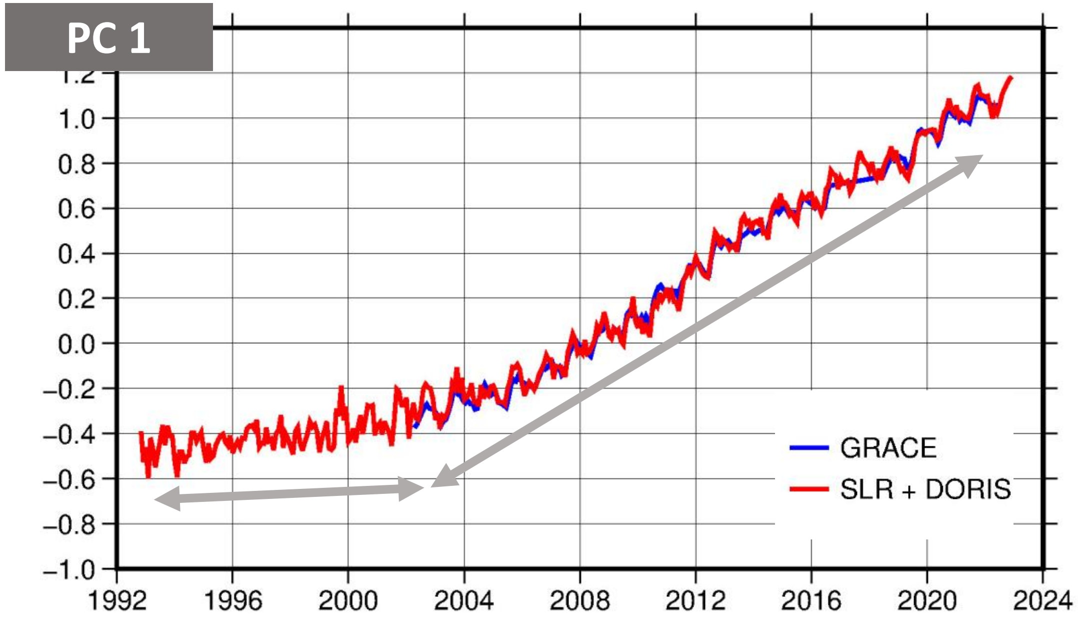




1 Lemoine et al., New mean gravity field model CNES_GRGS.RL05MF_combined_ GRACE_SLR_DORIS, DORIS AWG Meeting, 18 April 2023

The culprit





- Ice mass loss in Greenland and Antarctica starting around GRACE launch
- Mass gain by GIA starting some 10.000s of years ago

GIA downscaled in pre-GRACE years due to coupling with ice mass loss!

Fixing the issue

Option 1: Coestimate unmodelled GIA signal by adding GIA signature to existing EOFs

Option 2: Take GIA from a model (remove/restore approach)

Remove GIA from GRACE solutions

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EOF decomposition

↓

Compute observation/normal equations with new EOFs, GIA reduced as “background” model

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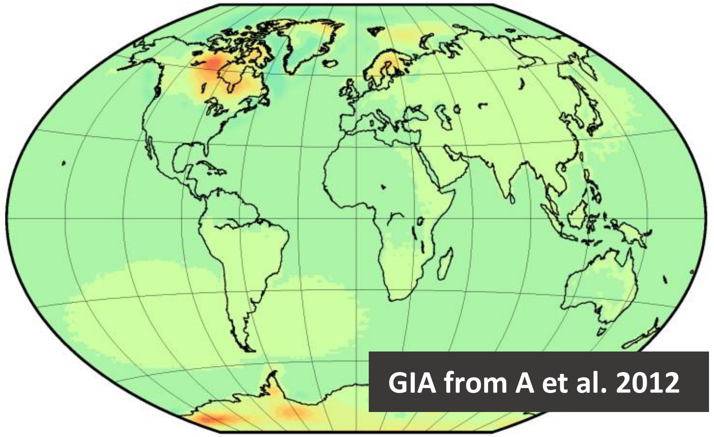
GIA-free monthly solutions

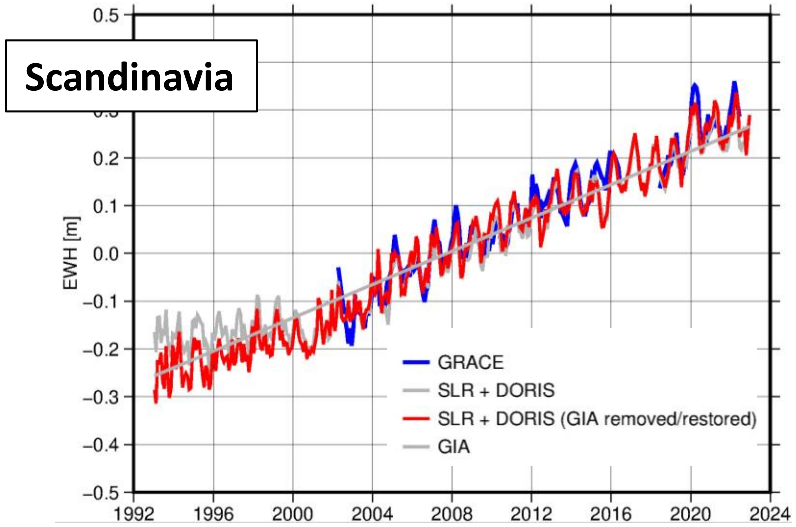
↓

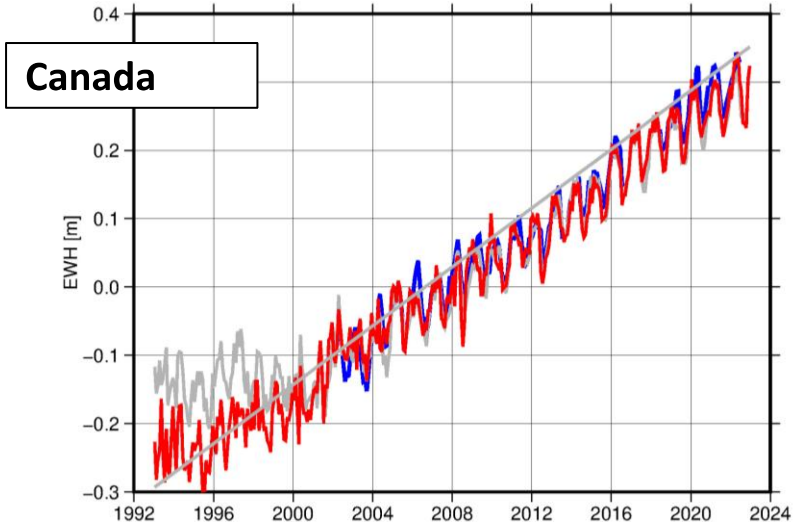
Resubstitute GIA model

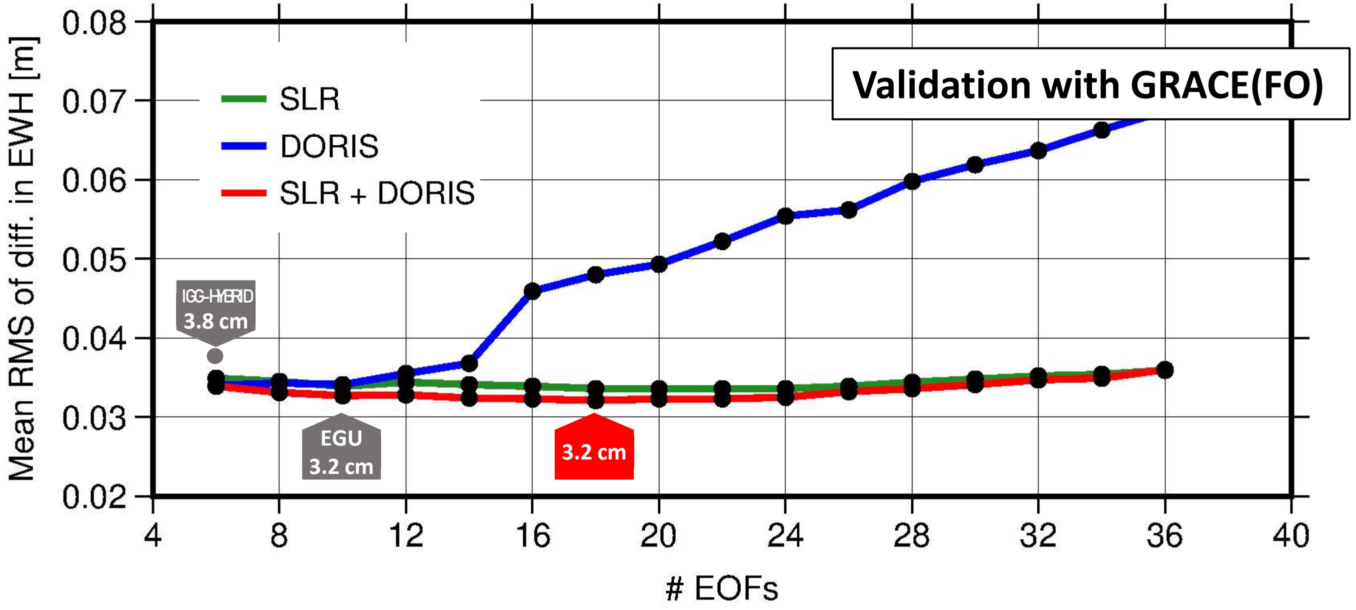


GIA from A et al. 2012

Results



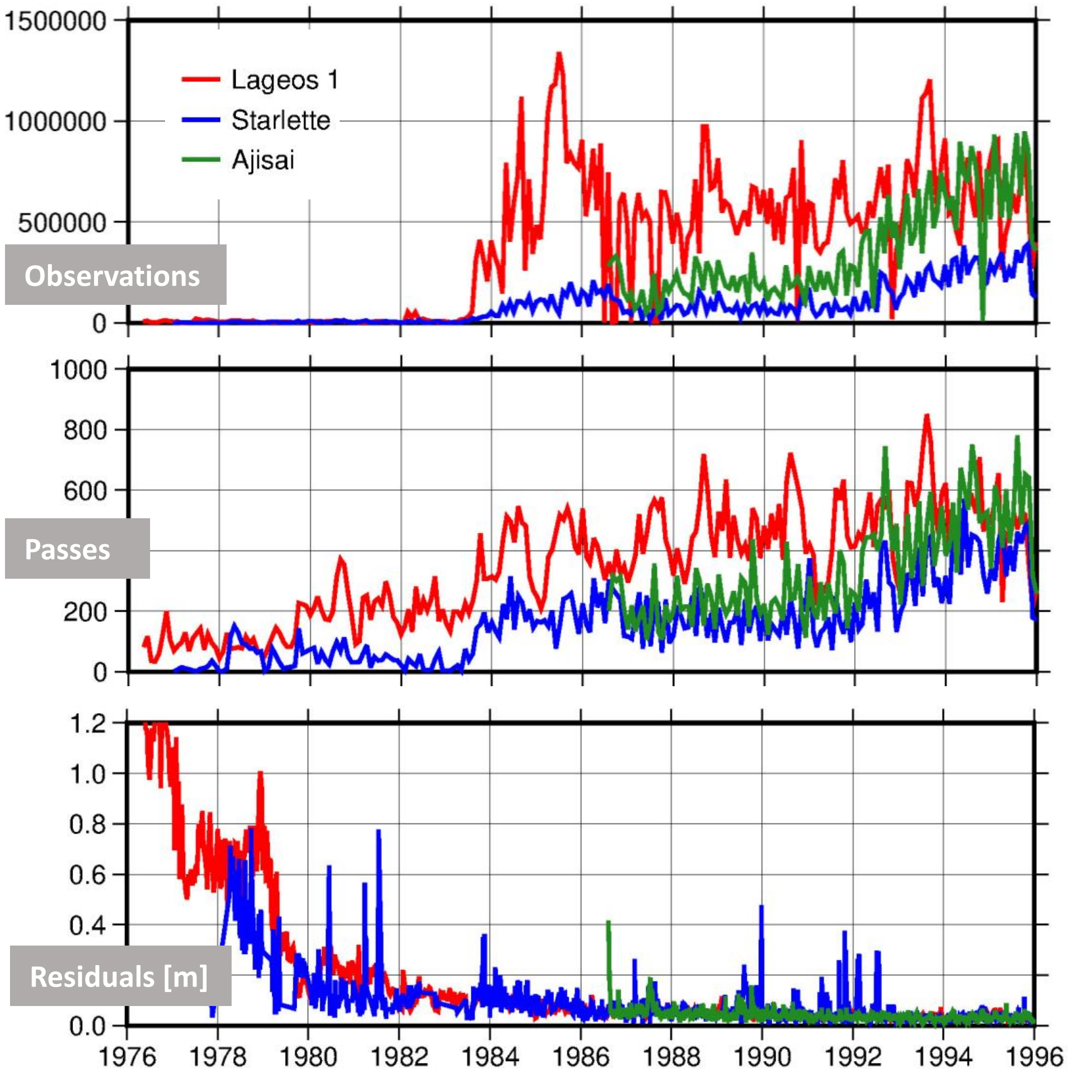




Taking GIA from a model leads to an overall improvement, even in the GRACE period!

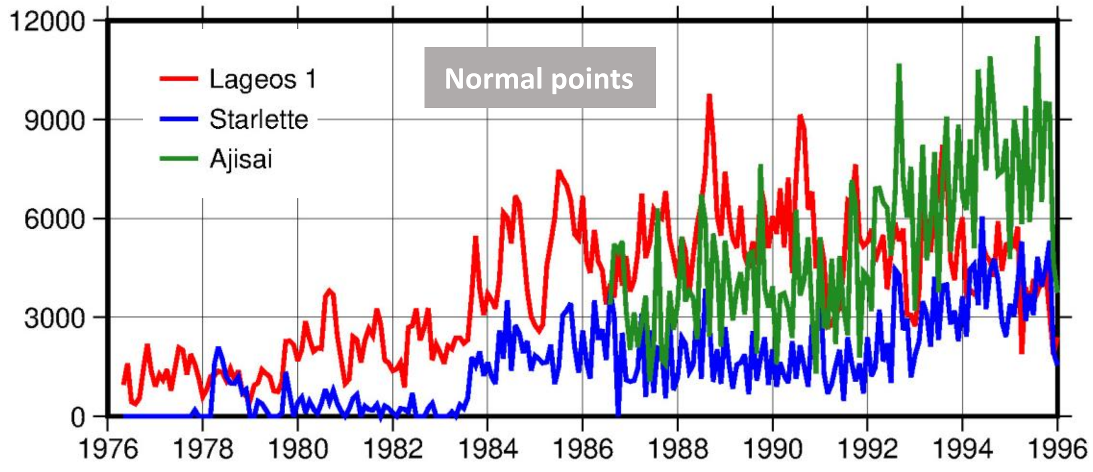
For some years more: SLR full-rate data

- Three satellites only : Lageos-1, Starlette, Ajisai (Beacon-C not considered)
- Very sparse data until 1984, sparsest for Starlette
- Errors at m-level in the very first years, approx. 3 cm reached in 1992



Full-rate data processing

- Normal points computed following ILRS recommendation, bin size Lageos 120 s, Starlette and Ajisai 30 s
- Same arc lengths as for later years (Lageos 10 days, LEOs 3 days), but simplified observation model:
  - Nominal values for SRP scale factors (not estimated)
  - Range biases only for Ajisai
  - Only 6 EOFS applied
- Variance components per satellite and station (not per pass)



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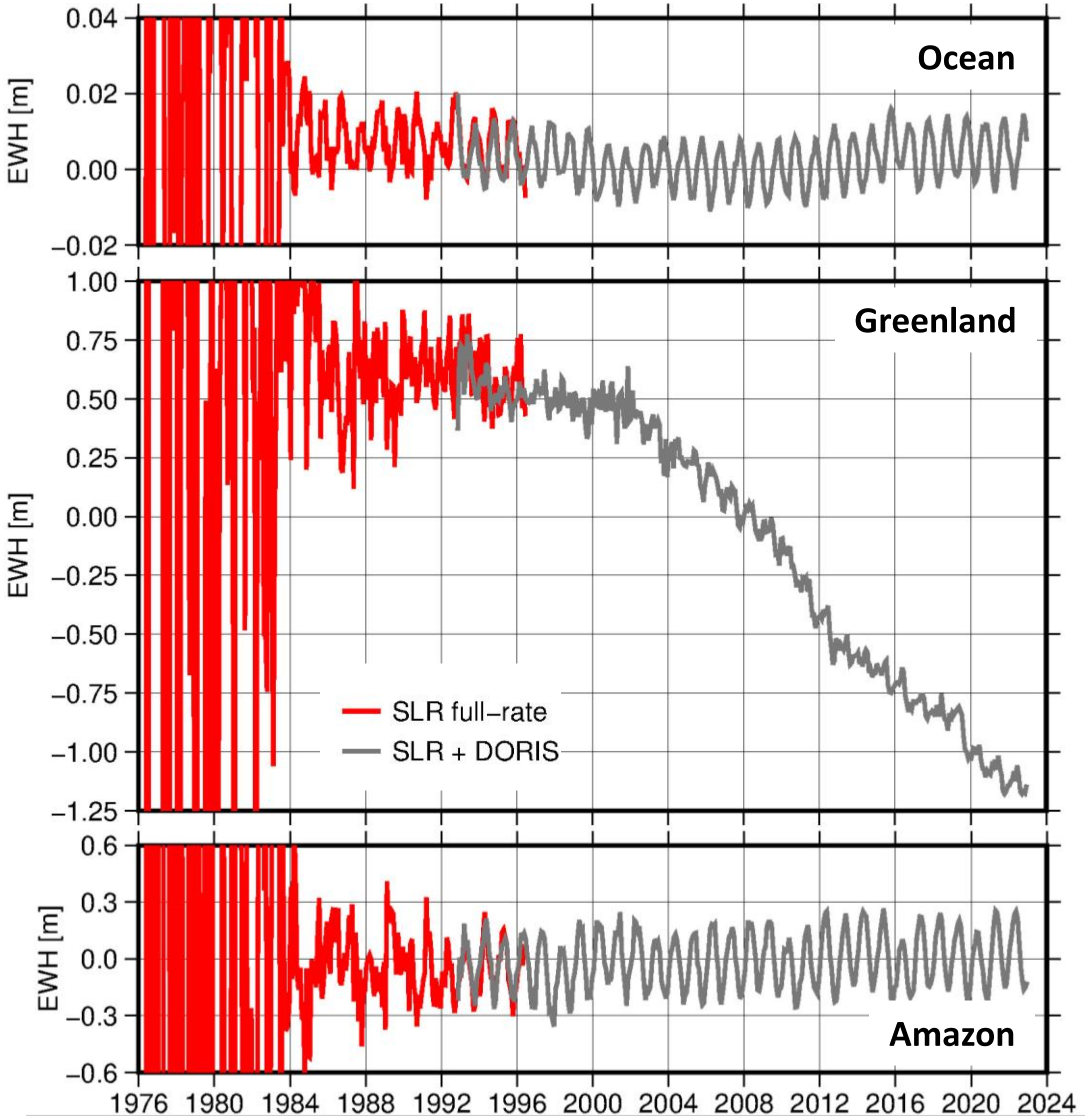


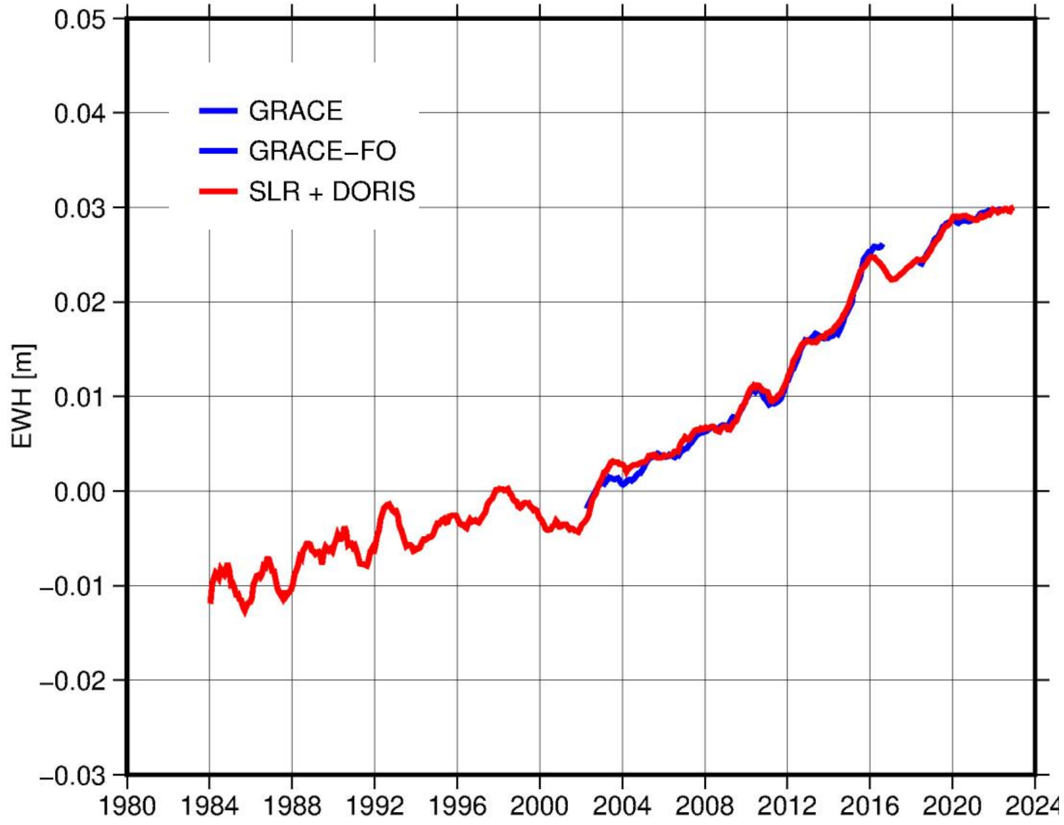
might contribute to sea level studies

confirms stable Greenland mass until late 1990s

not plausible before 1991

Ocean mass validation by altimetry (a trial)

- Postprocessing of ocean mass time series: GIA reduced, annual and semiannual signal removed, 400-day average mean, 300 km buffer zone



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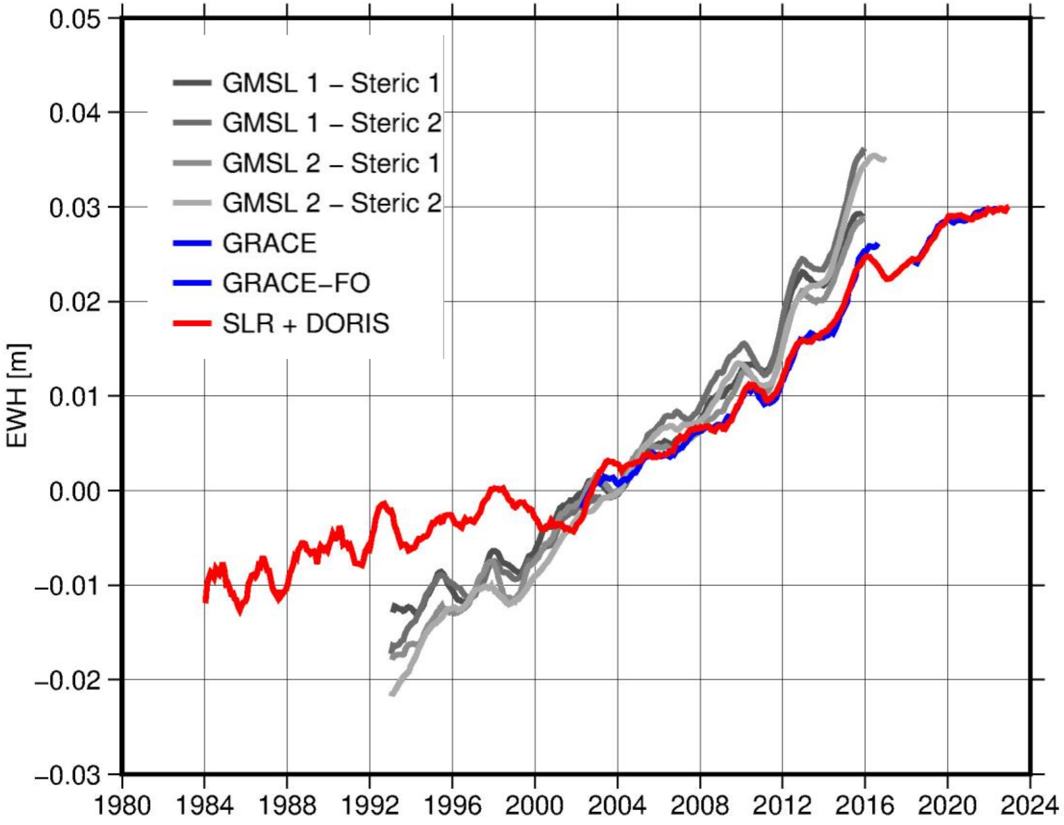
- Comparison with steric-corrected altimetry: remaining differences in trends (degree 1?)



GMSL 1: ESA CCI (ESA and NASA/CNES satellites)
GMSL 2: University of Colorado (NASA/CNES satellites)
Steric 1: Dieng et al. (2017)
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Ocean mass validation by altimetry (a trial)

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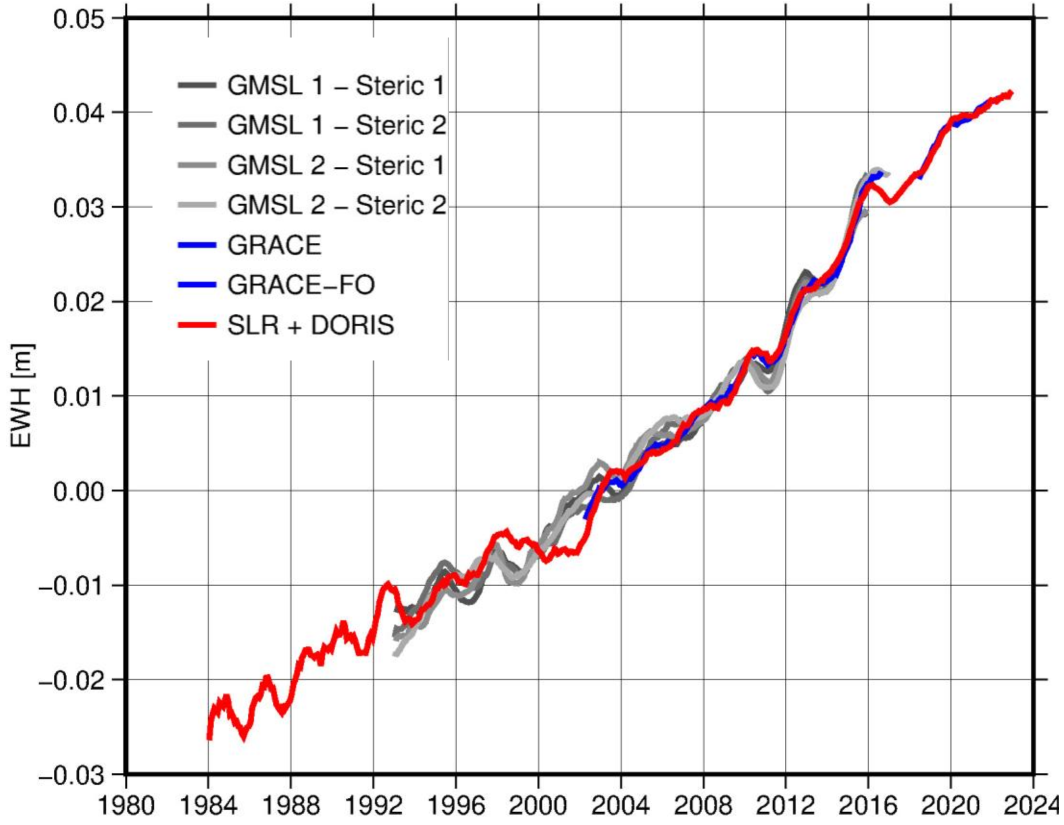
- Workaround: time series fitted to first altimetric series



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