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A global empirical GIA model based on GRACE data

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Introduction

- GRACE does not distinguish between signals from the solid earth (GIA) and the water layer (PD).

- PD geoid fingerprints can be accurately pre-computed (while GIA fingerprints depend on modelling choices).

- PD and GIA fingerprints have very different spectra and temporal evolution, hence:

=> They can be simultaneously constrained by GRACE timeseries.

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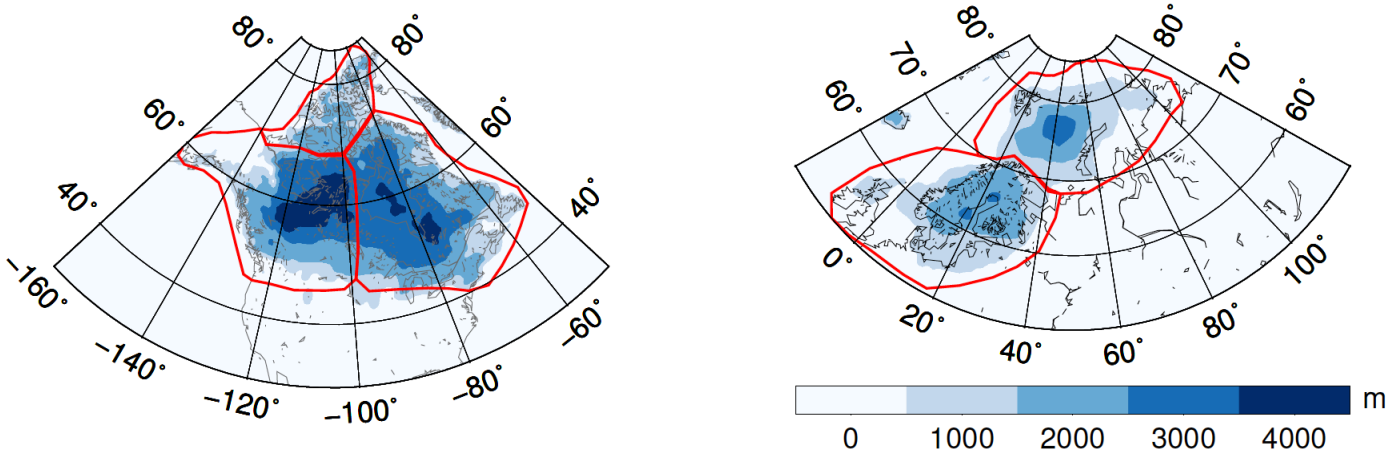
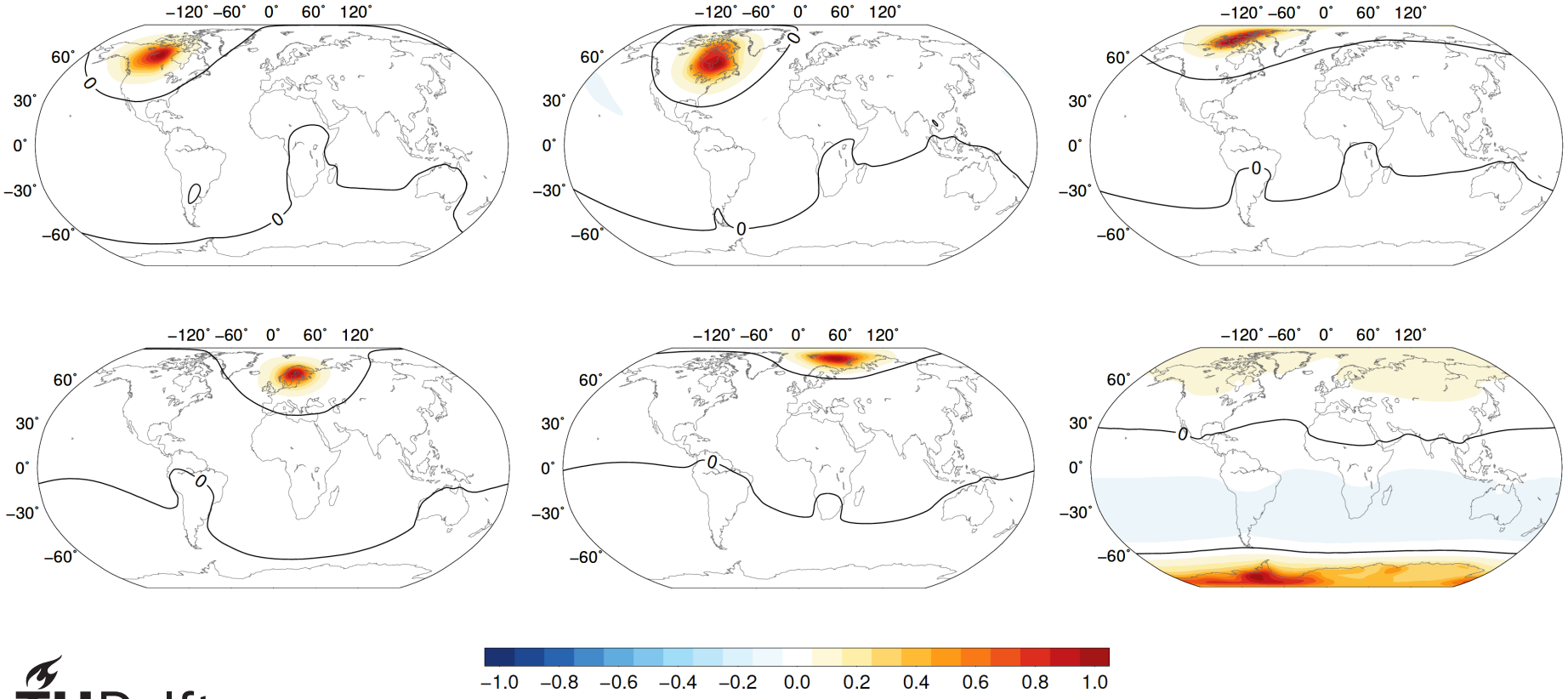
GIA fingerprints

The main control on GIA patterns comes from the ice load at LGM (for past ice sheets).

- Northern hemisphere: 5 fingerprints from ICE-5G (no Greenland).
- Southern hemisphere: Antarctica only (IJ05).



GIA fingerprints (LM viscosity 10^{22} Pa s)



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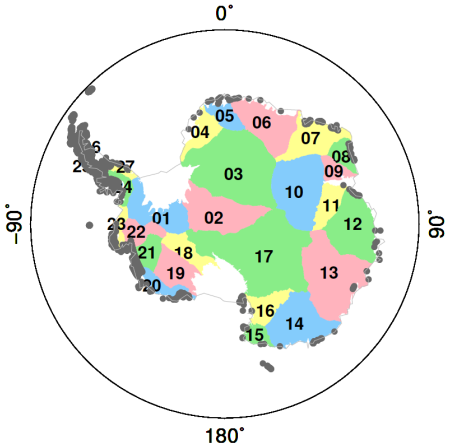
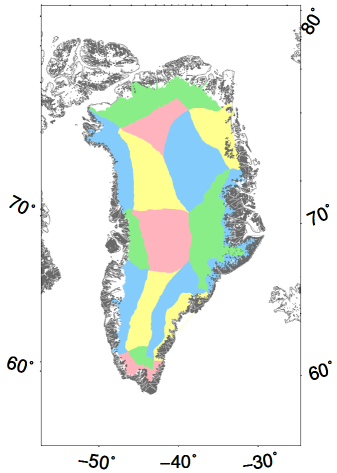
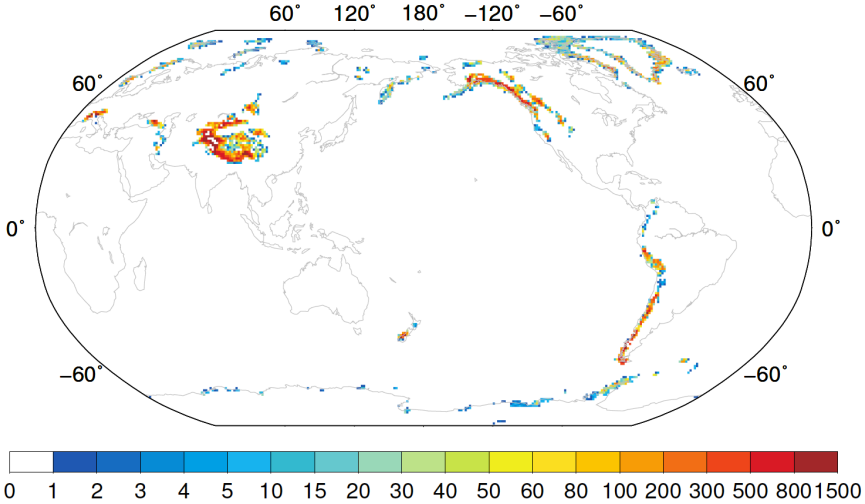
Land ice fingerprints

Antarctica and Greenland ISs: one fingerprint per main drainage basin.
Glaciers: GLIMPS database (including IS perpherals).

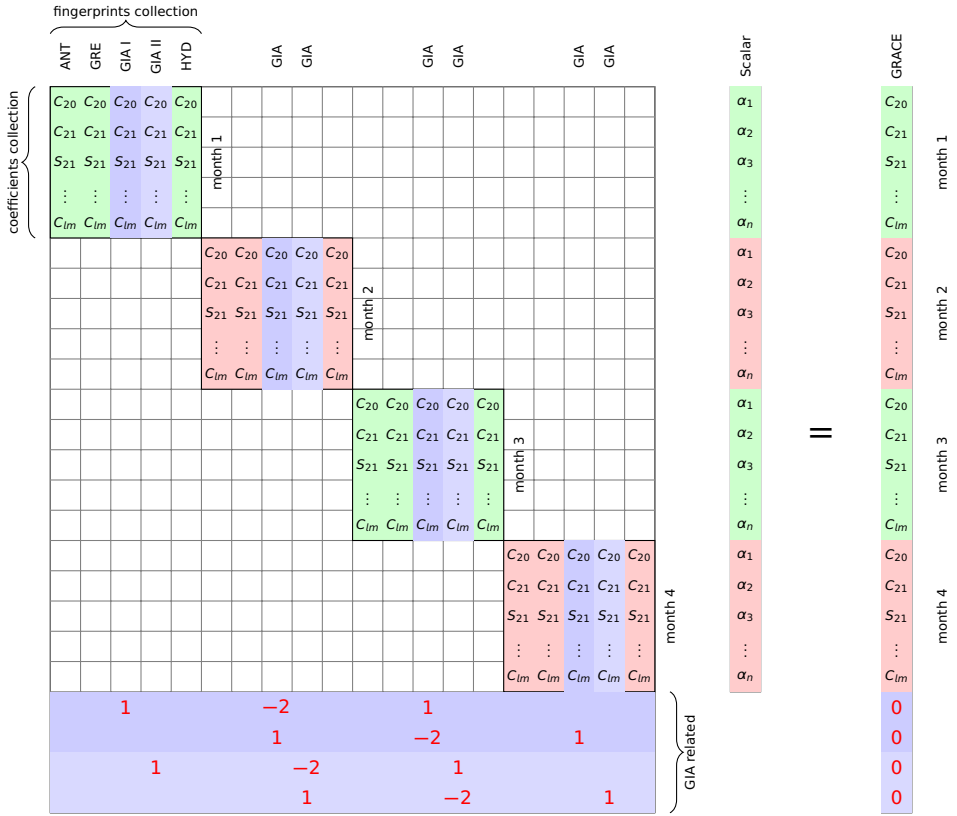






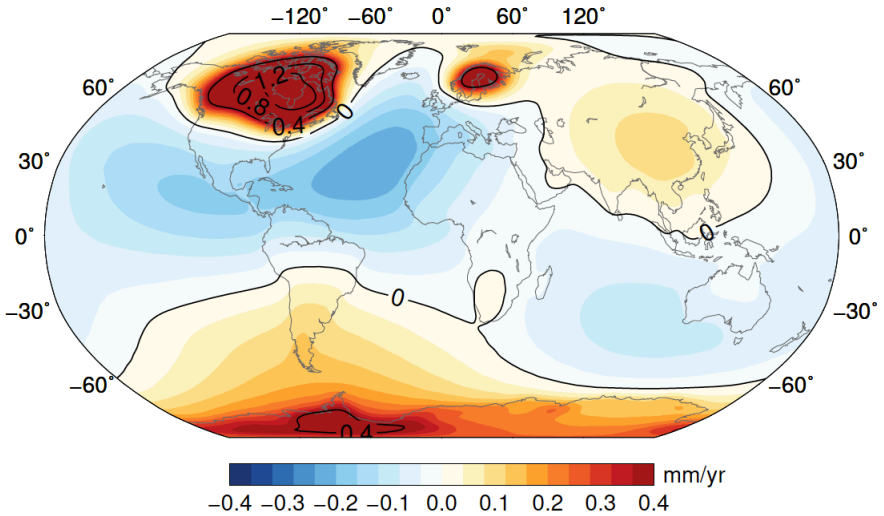
Constraining fingerprints by GRACE monthly solutions

- GRACE: CSR RL05, 2002.6 – 2014.9, no pole tide correction.
- Land hydrology: 60 EOFs from WGHM (Rietbroek et al., 2016).
- Additional pole tide trend.
- Passive ocean.
- GIA extra constraint: only linear trend allowed.
- Solution by least squares.

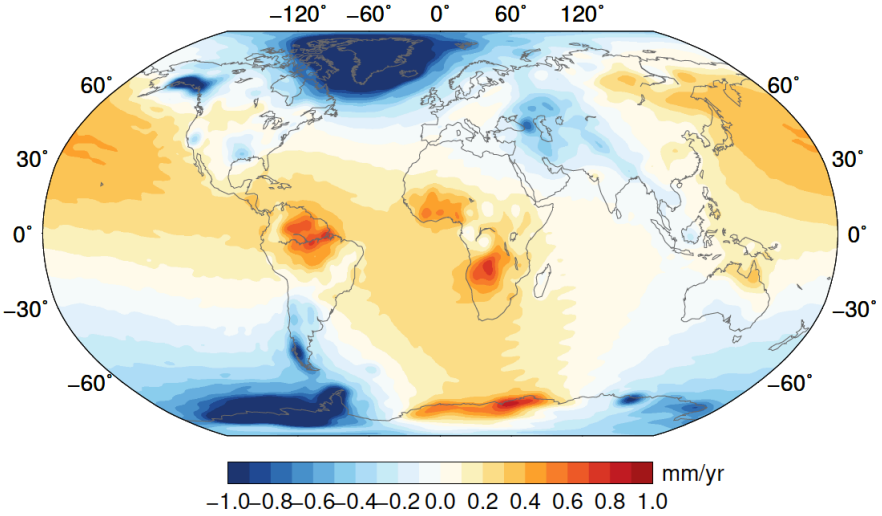


Geoid changes (LM viscosity 10^{22} Pa s)

GIA



Land ice and waters (PD)



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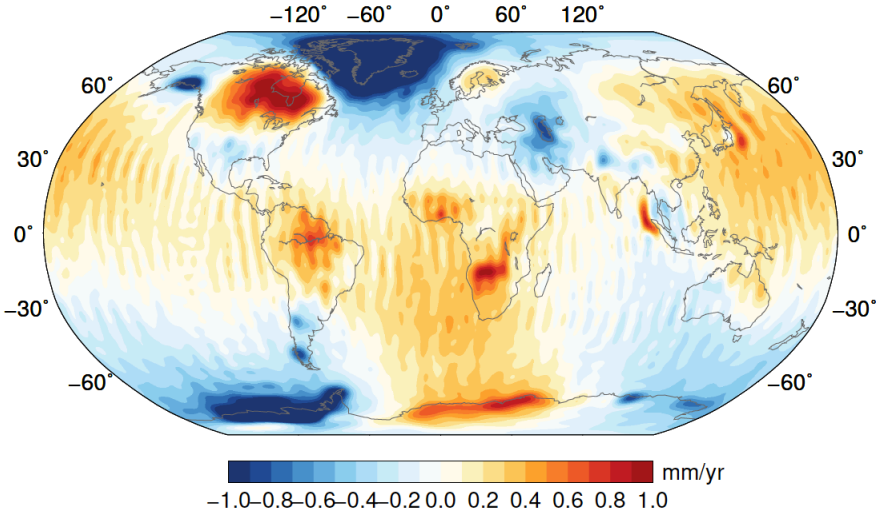
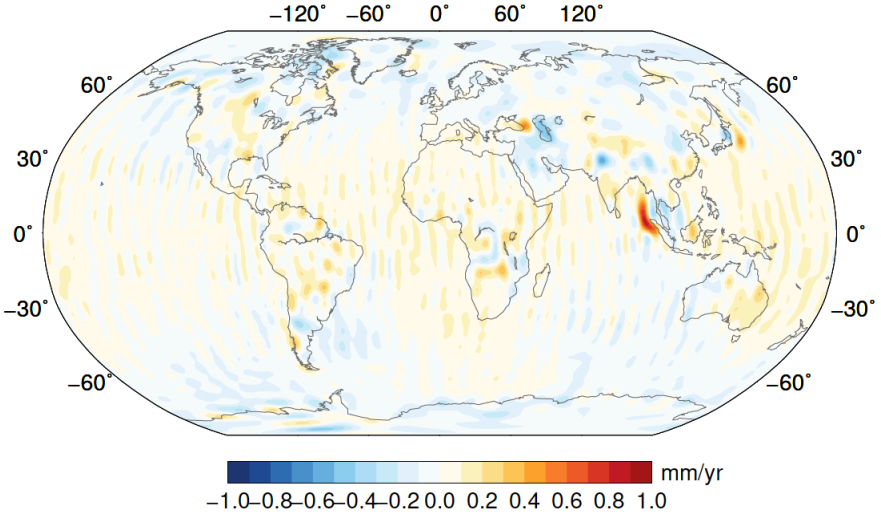
Geoid changes (LM viscosity 10^{22} Pa s)

GRACE trend



Residual



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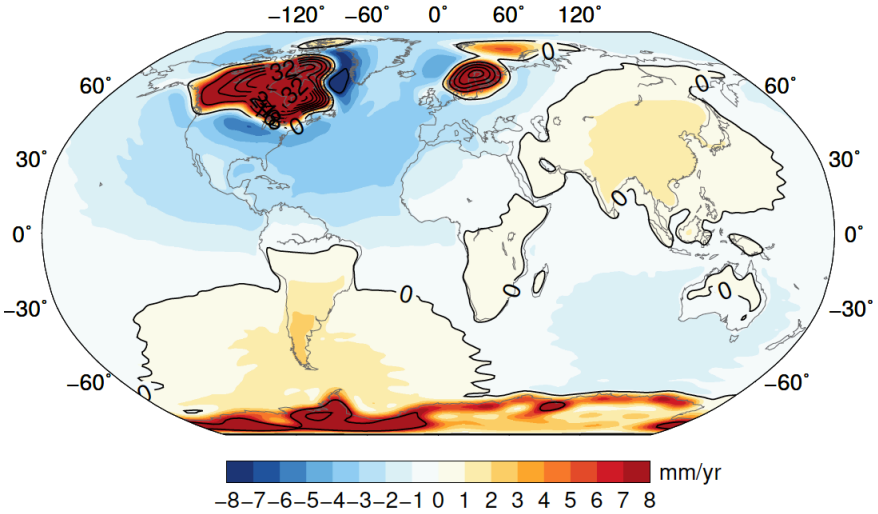
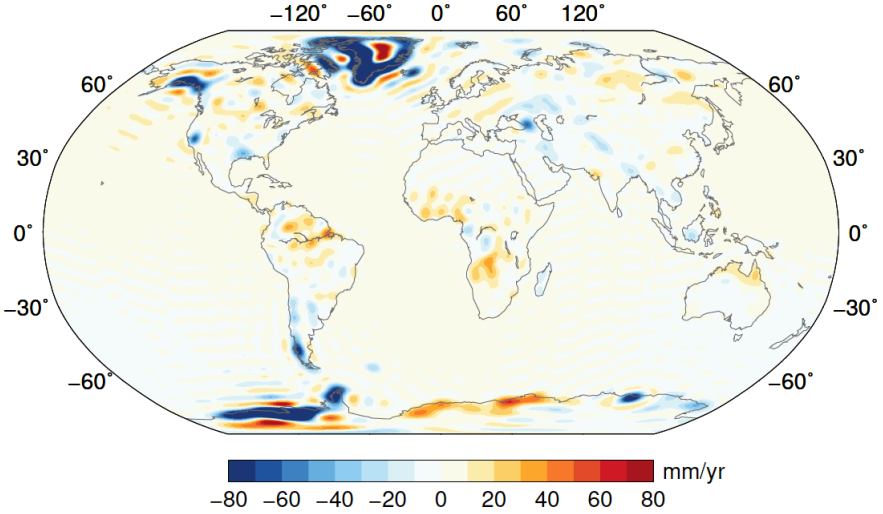
Surface mass changes (LM viscosity 10^{22} Pa s)

GIA



Land ice and waters (PD)



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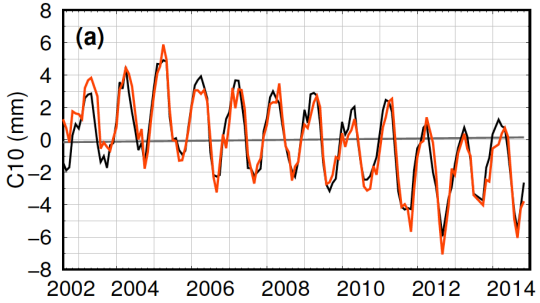
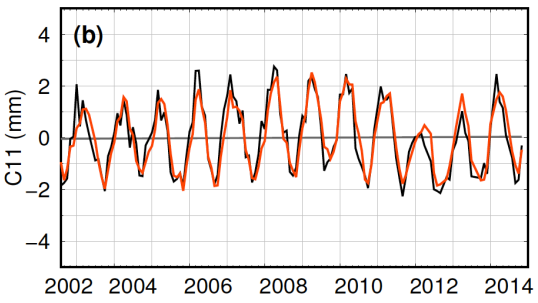
Geocentre motion and earth rotation trends

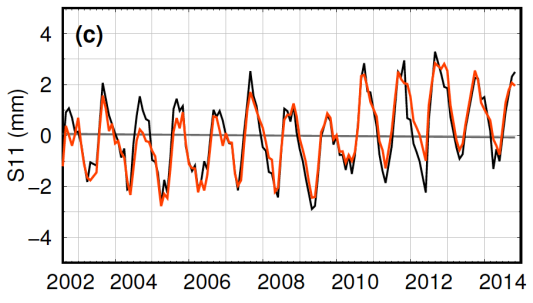
Z (PD): -0.41 mm/yr



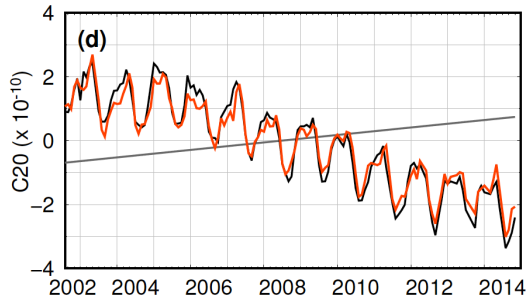
X (PD): 0.02 mm/yr



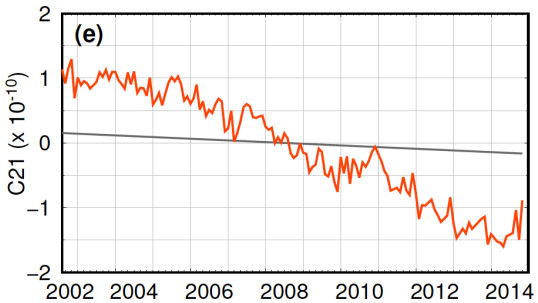
Y (PD): 0.17 mm/yr



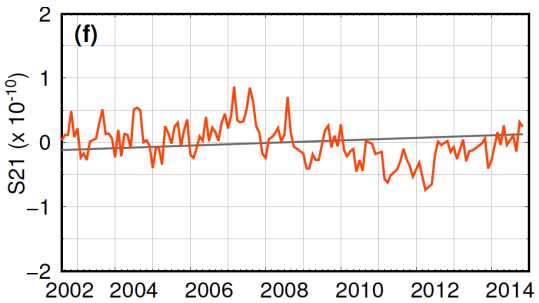
J_2(PD; GIA): (6.9; -2.7) 10^{-11} 1/yr



m_1(PD; GIA): (-14; -2) marcsec/yr



m_2(PD; GIA): (-2; 1) marcsec/yr



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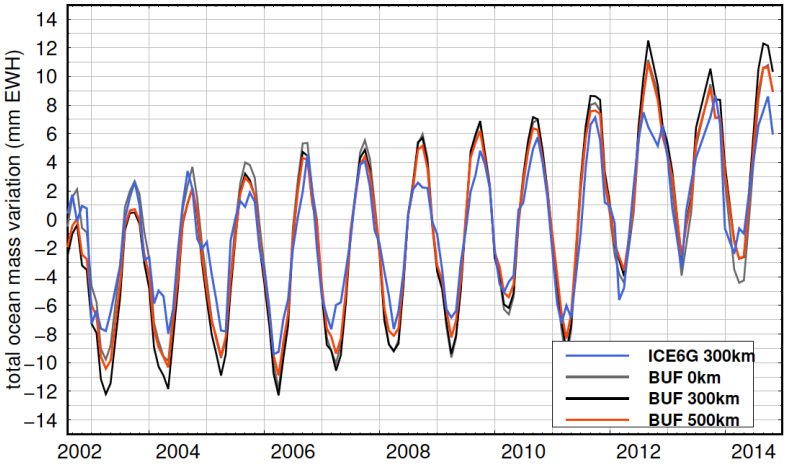
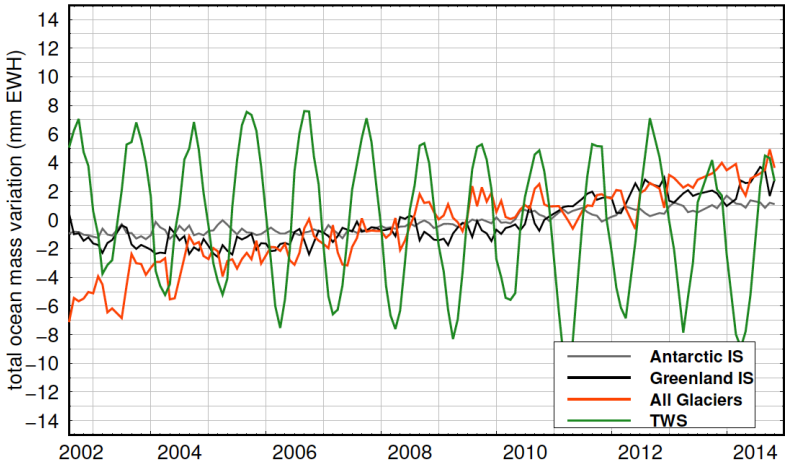
Ice and water contribution to ocean mass changes





Global ocean:	0.96 mm/yr
Residual:	0.03 mm/yr
GRACE-ICE6G:	0.52 mm/yr

Greenland:	0.63 mm/yr	(-229 Gt/yr)
Antarctica:	0.29 mm/yr	(-106 Gt/yr)
Glaciers:	0.30 mm/yr	(-109 Gt/yr)
Land waters:	-0.27 mm/yr	(+98 Gt/yr)

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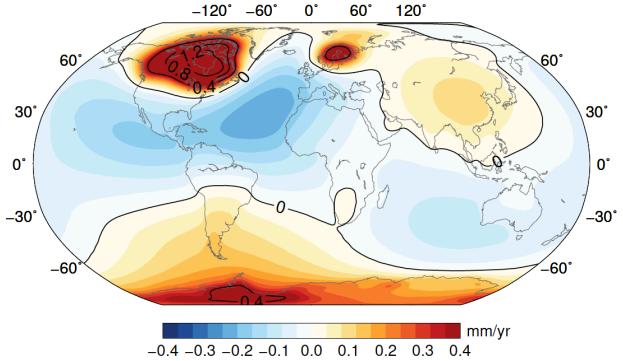
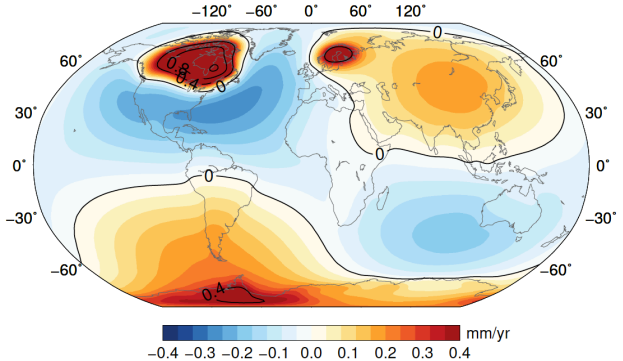
Sensitivity to lower mantle viscosity

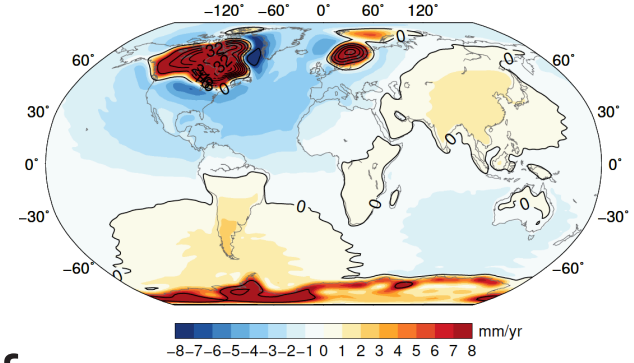
Geoid (LM22)



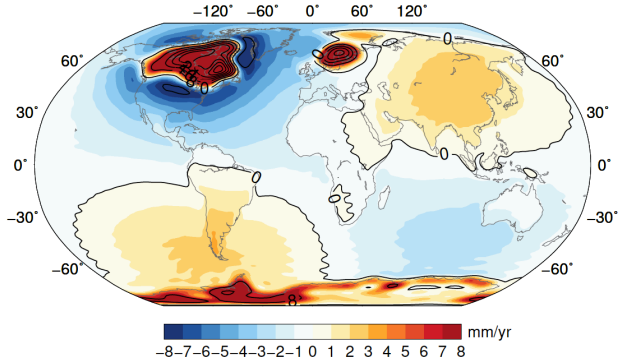
Geoid (VM2)



Surface mass (LM22)



Surface mass (VM2)



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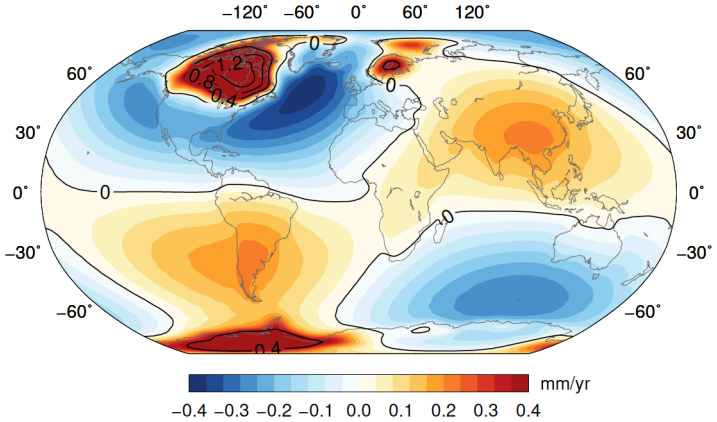
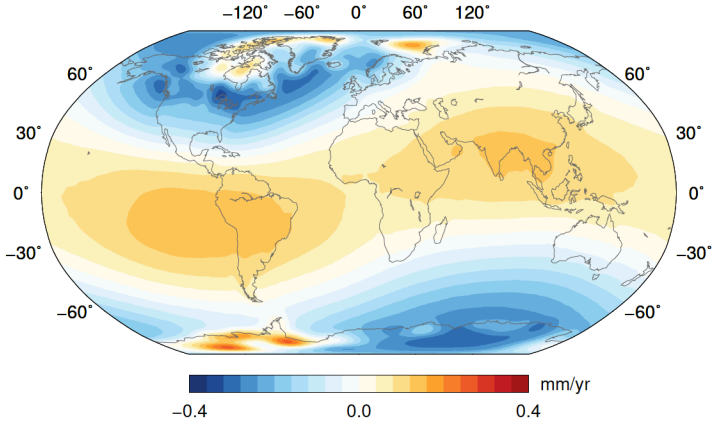
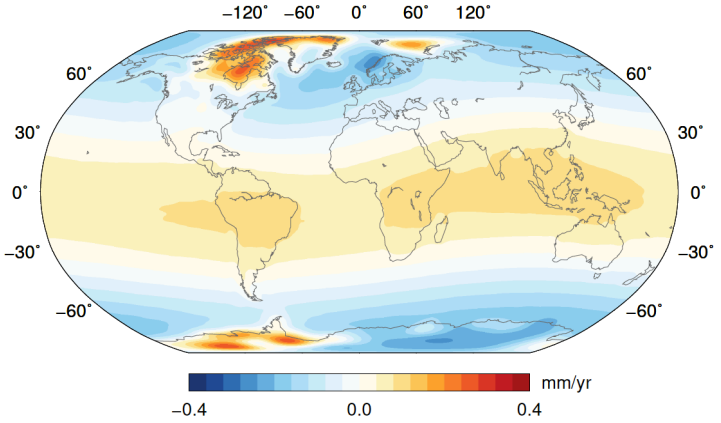
Comparison against ICE-6G_C (VM5a) geoid



ICE-6G – LM22



ICE-6G – VM2



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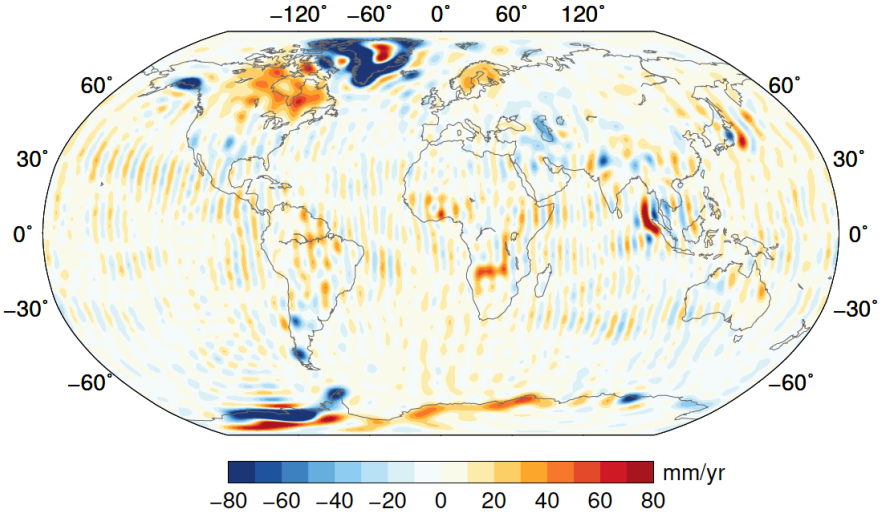
Conclusions

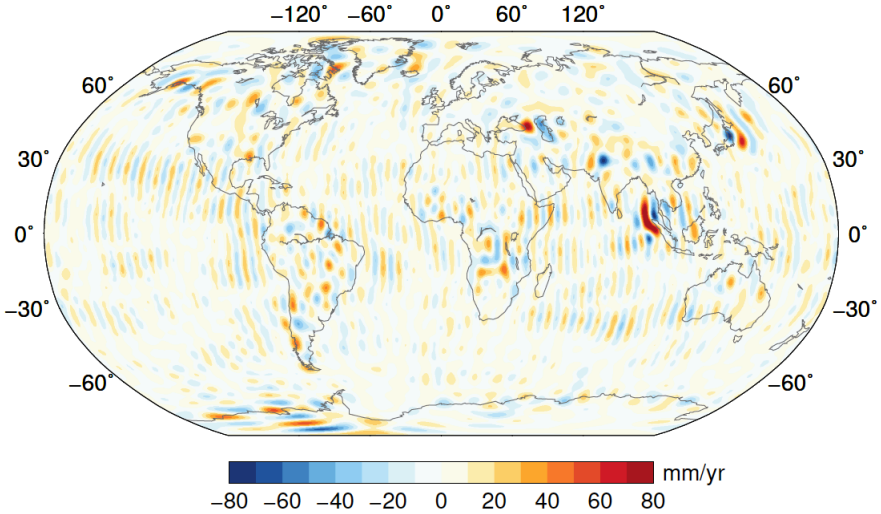
- Fingerprints are physical basis functions that allow separation of GIA from PD signals in GRACE.
- The PD trend has little sensitivity to lower mantle viscosity.
- The estimated pole tide can provide an independent estimate for modelling purposes.

Surface mass changes (LM viscosity 10^{22} Pa s)

GRACE trend



Residual



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