

Pushing the limits of gravity field recovery from high-low satellite-to-satellite tracking – a combination of 10 years of data of the satellite pseudo-constellation CHAMP, GRACE and GOCE



Matthias Weigelt, Tonie van Dam



Oliver Baur



Holger Steffen



Adrian Jäggi, Lars Prange,
Uli Meyer, Heike Bock



Torsten Mayer-Gürr
Norbert Zehentner

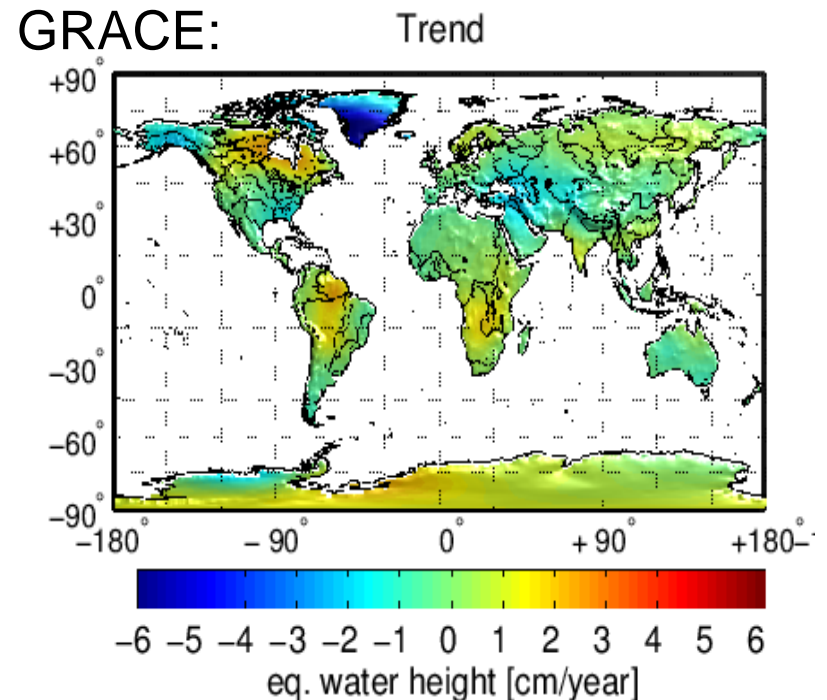
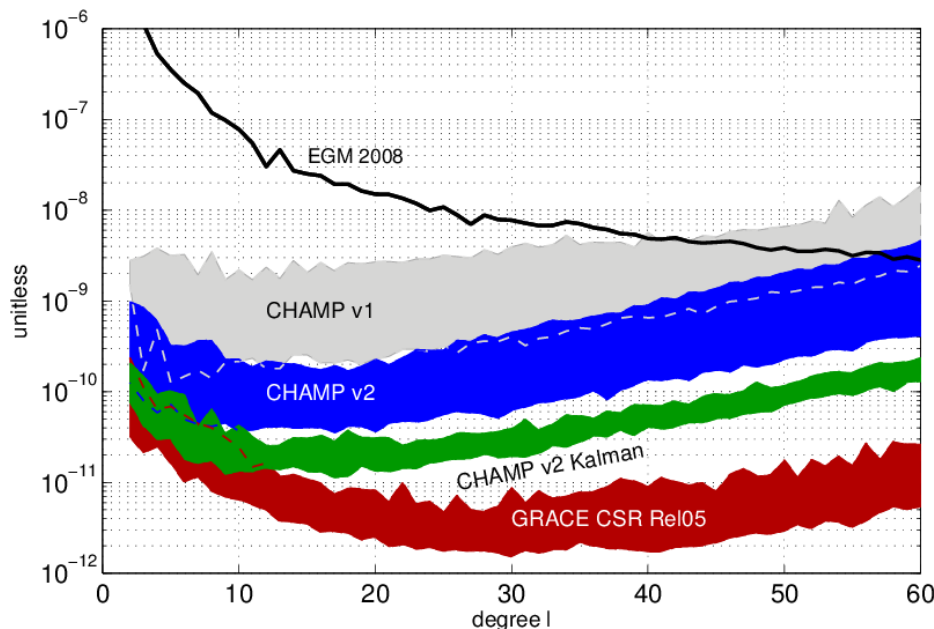
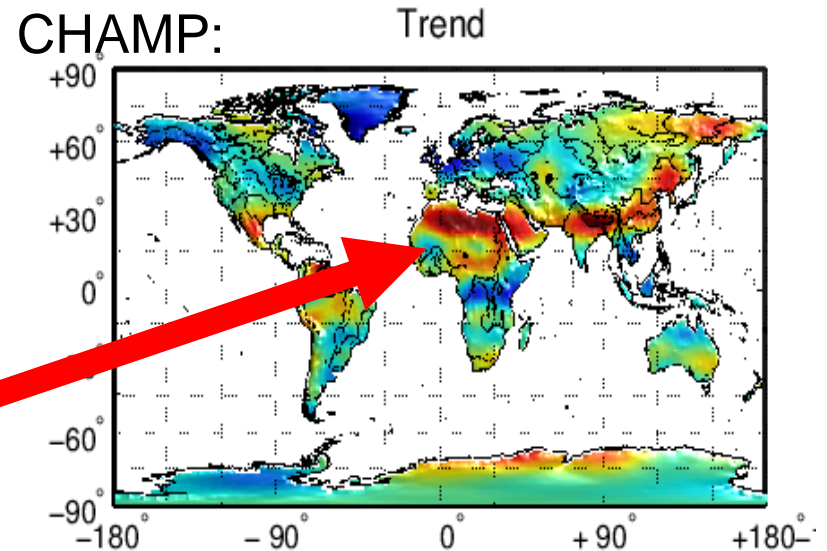


Mohamad J. Tourian,
Nico Sneeuw



Recall van Dam et al. EGU 2013

- Long wavelength features can be recovered from CHAMP/hl-SST, e.g. the trend in Greenland
- Strong spatial error pattern, e.g. in Africa and Asia



COMBINING CHAMP, GRACE A/B AND GOCE



RUES

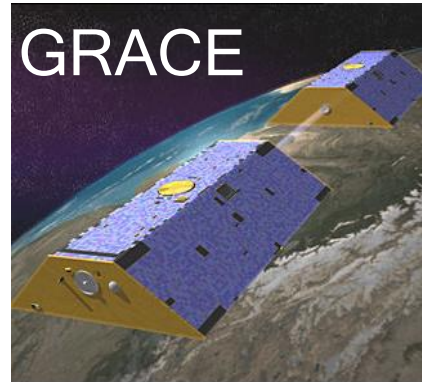
RESEARCH UNIT
IN ENGINEERING
SCIENCES



Data availability for period 2003 to 2012



© GFZ-Potsdam

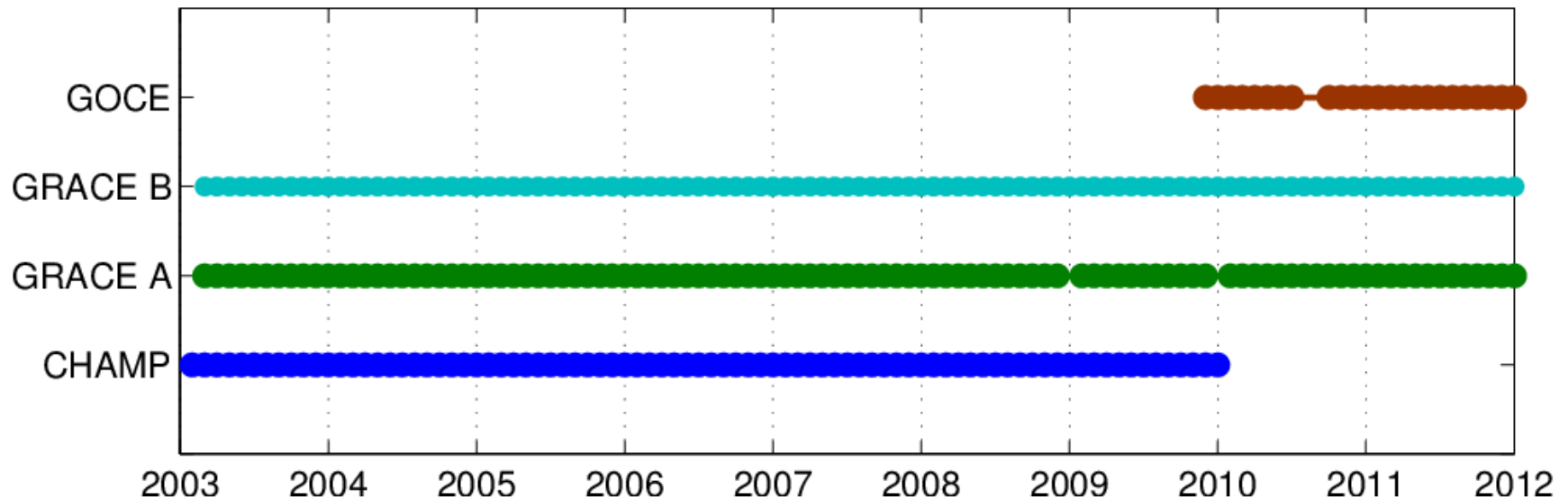


© CSR Texas



© ESA

Data availability



Data processing

GPS positions for CHAMP:

- Prange 2010
- 10 s sampling
- empirical absolute antenna phase center model

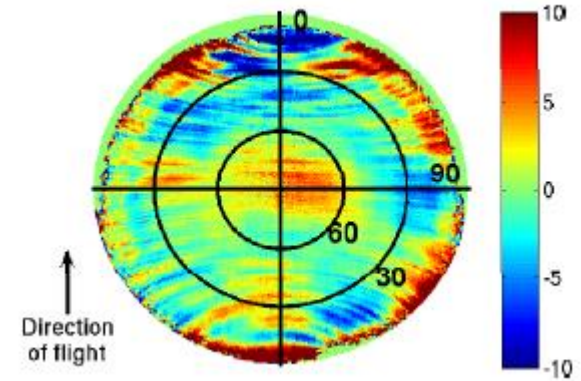
GPS positions for GRACE A/B and GOCE:

- Zehentner et al. 2014 (subsequent talk)
- 10 s sampling
- direct use of code and phase observations
- empirical absolute antenna phase center model

Approach:

- acceleration approach
- no accelerometer data used
- no regularization and no *a priori* model / information

Result: time series of monthly gravity field solutions for each satellite



Prange 2010

REFINED KALMAN-FILTER APPROACH



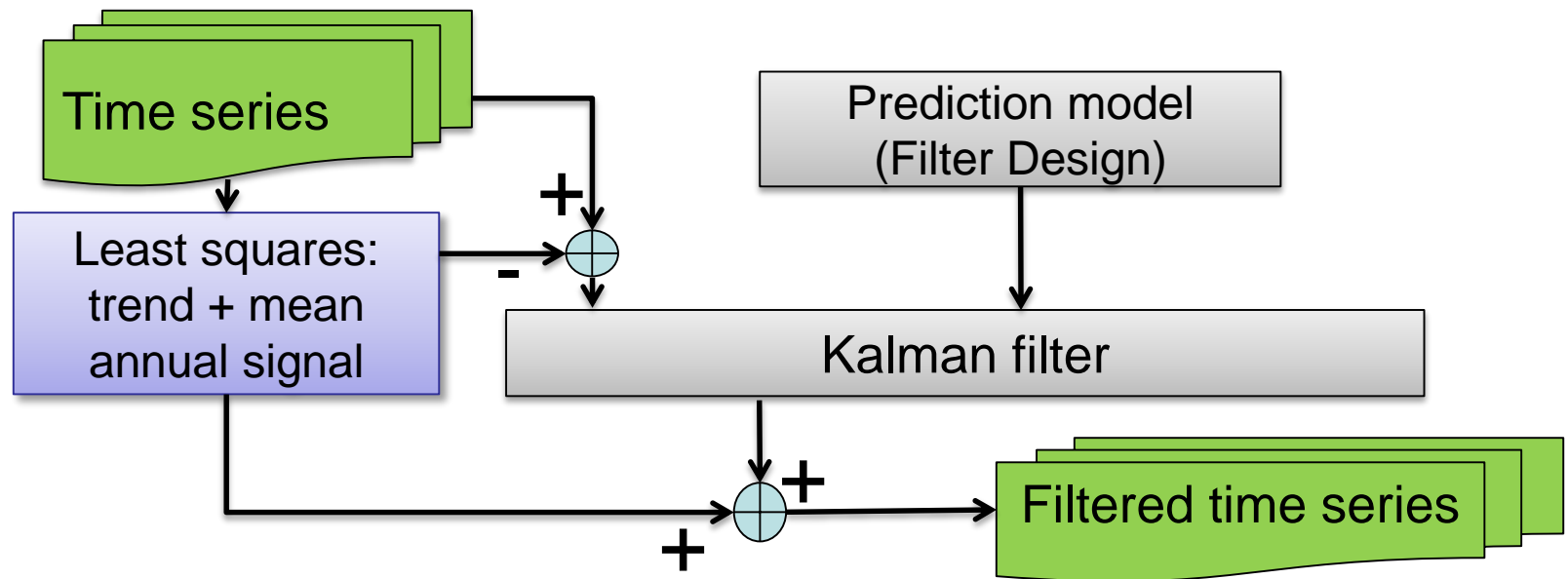
RUES

RESEARCH UNIT
IN ENGINEERING
SCIENCES



Kalman-Filter

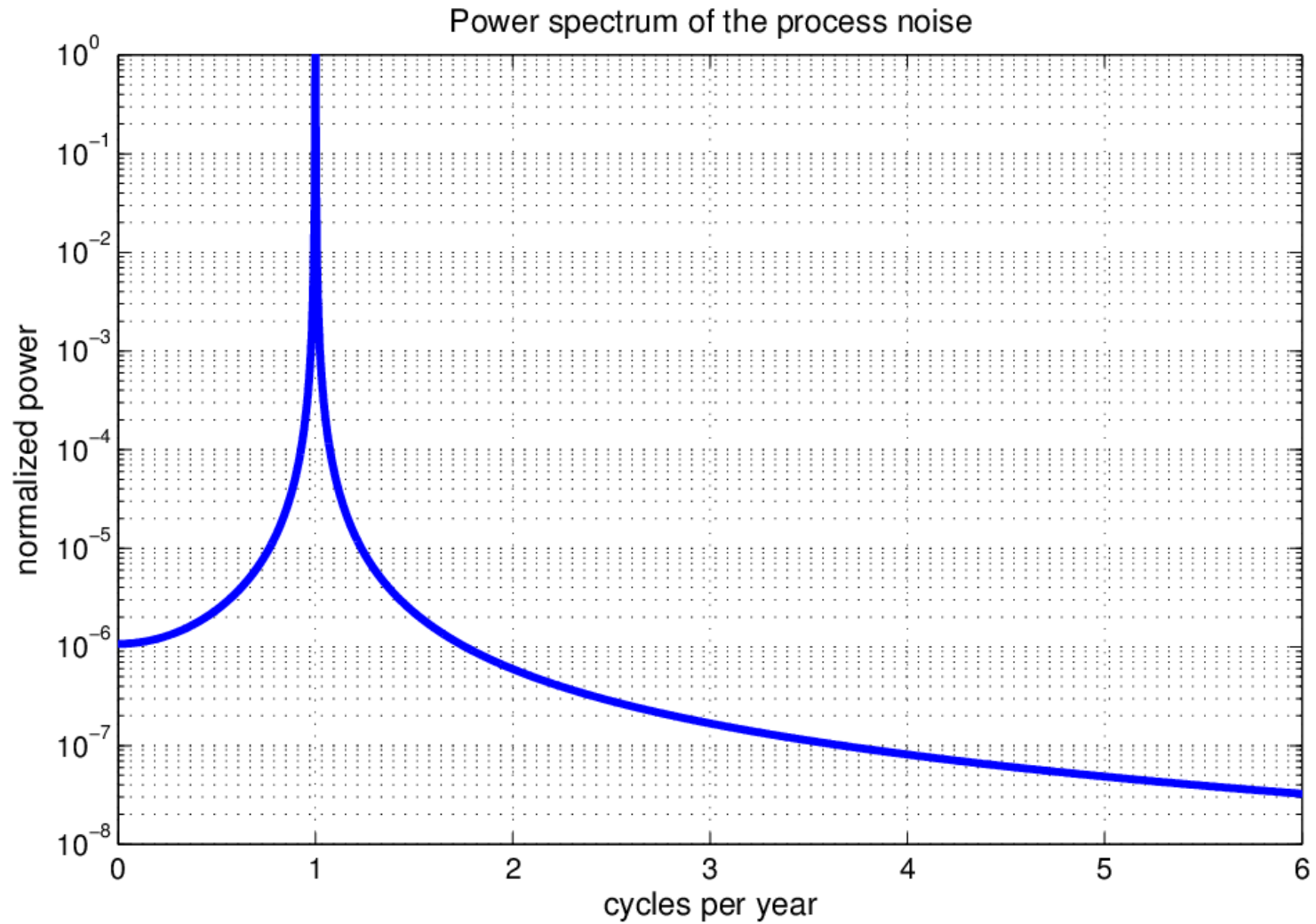
- formerly using the approach of Davis et al. 2012
- changing to Kurtenbach et al. (2009)
- advantage: the process noise is implicitly defined
- processing scheme:



Kalman-Filter: prediction model

- Kalman-Filter: concept of least-squares prediction
 - assuming a stochastic process
 - description by auto- and cross-correlation functions
 - prediction model
- in Kurtenbach et al. (2009) correlation functions empirically derived from hydrological models
- Here: no usage of a priori information
- Instead: filter design can be converted to a correlation function
- Filter: only variations around the annual signal

Kalman-Filter: prediction model



RESULTS

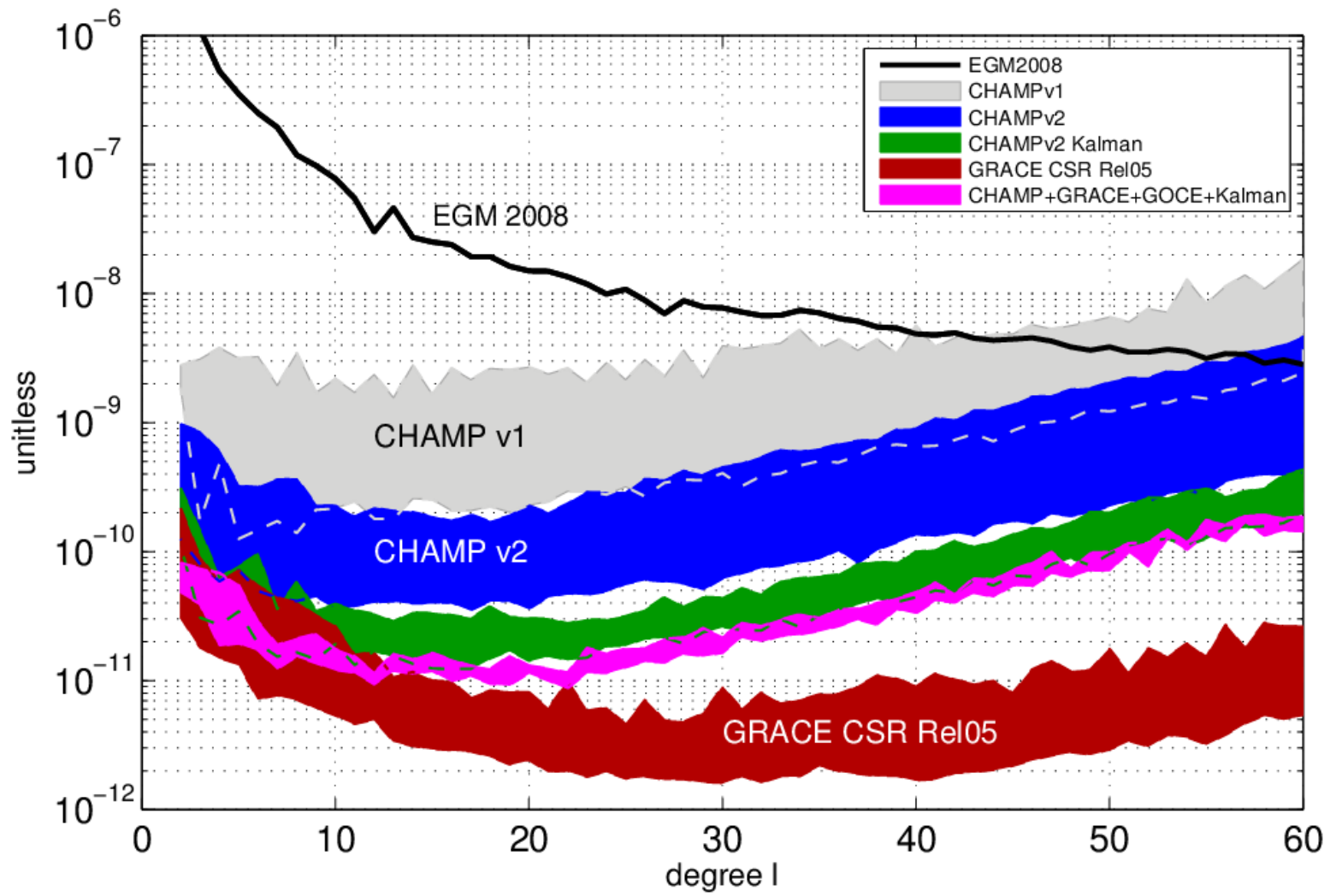


RUES

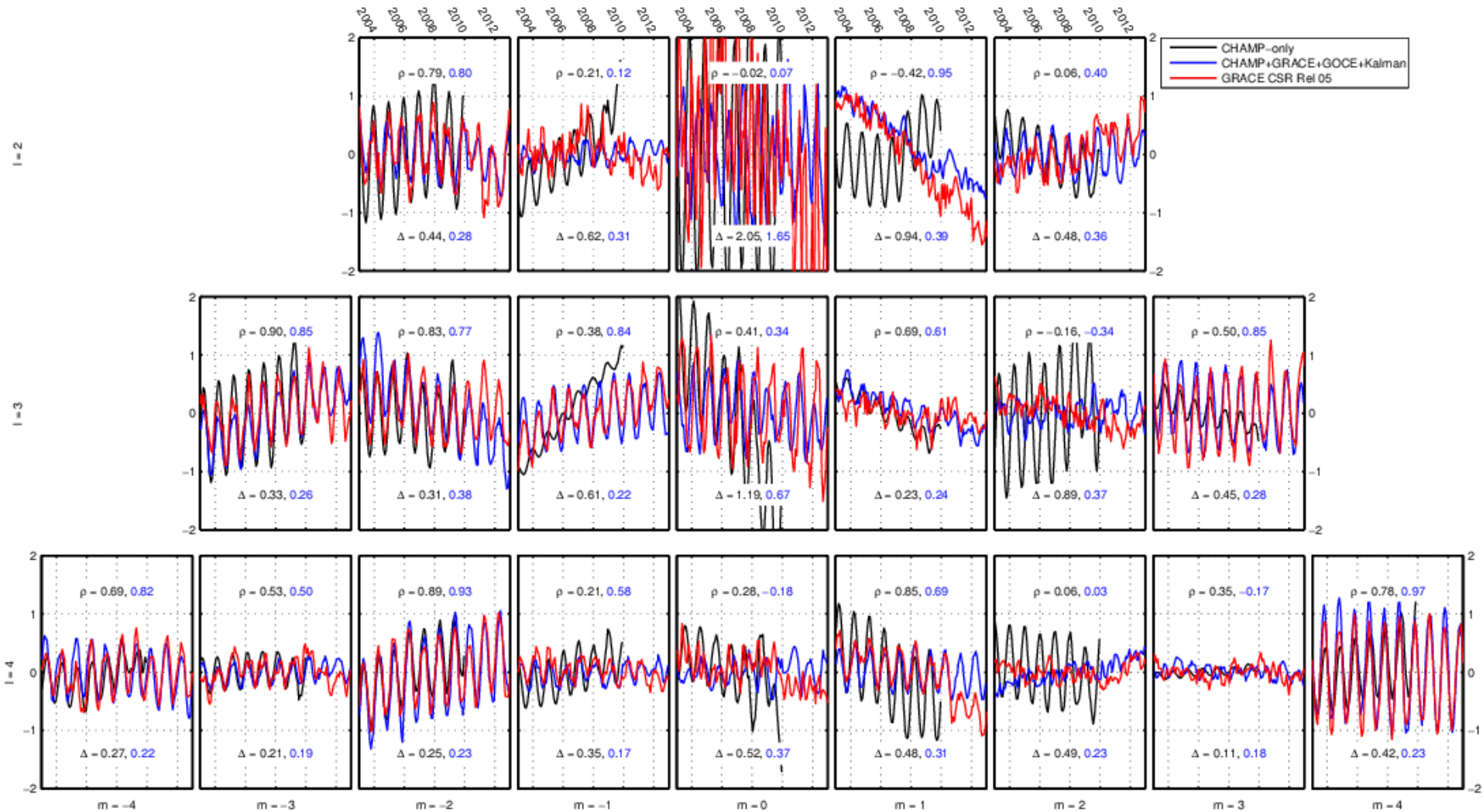
RESEARCH UNIT
IN ENGINEERING
SCIENCES



Degree RMS



Time series of coefficients



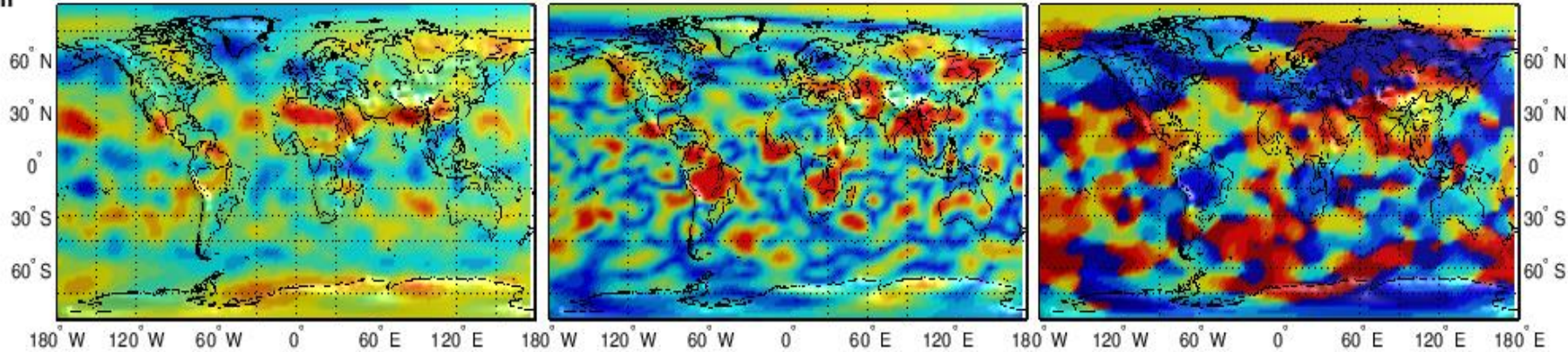
Spatial pattern

CHAMP
Kalman

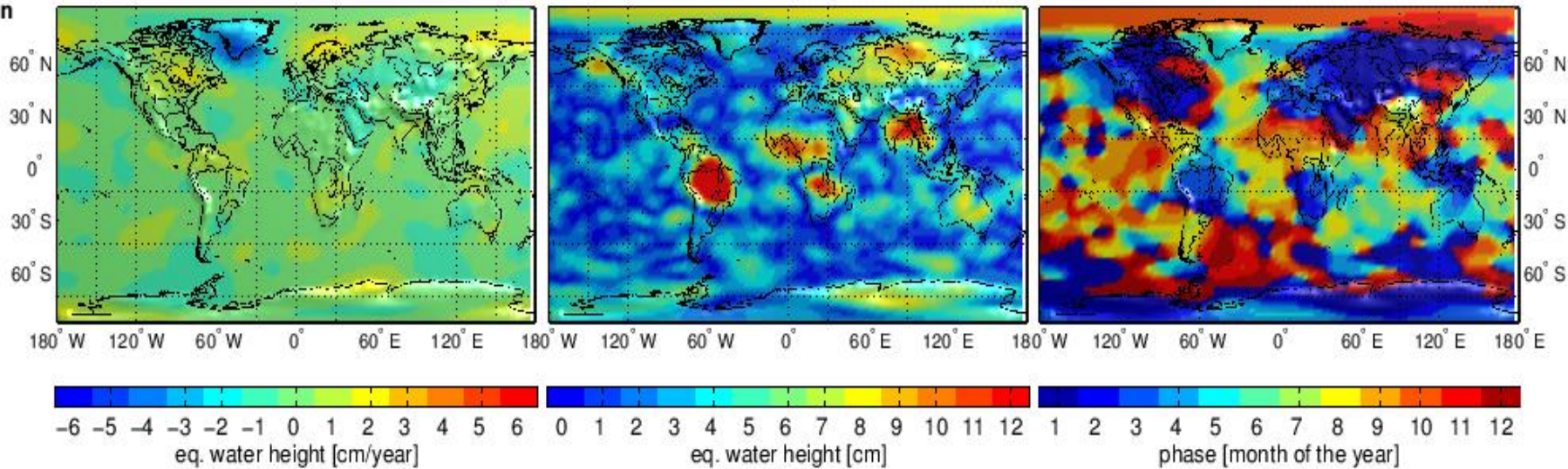
Trend

Amplitude

Phase



Combined
Kalman

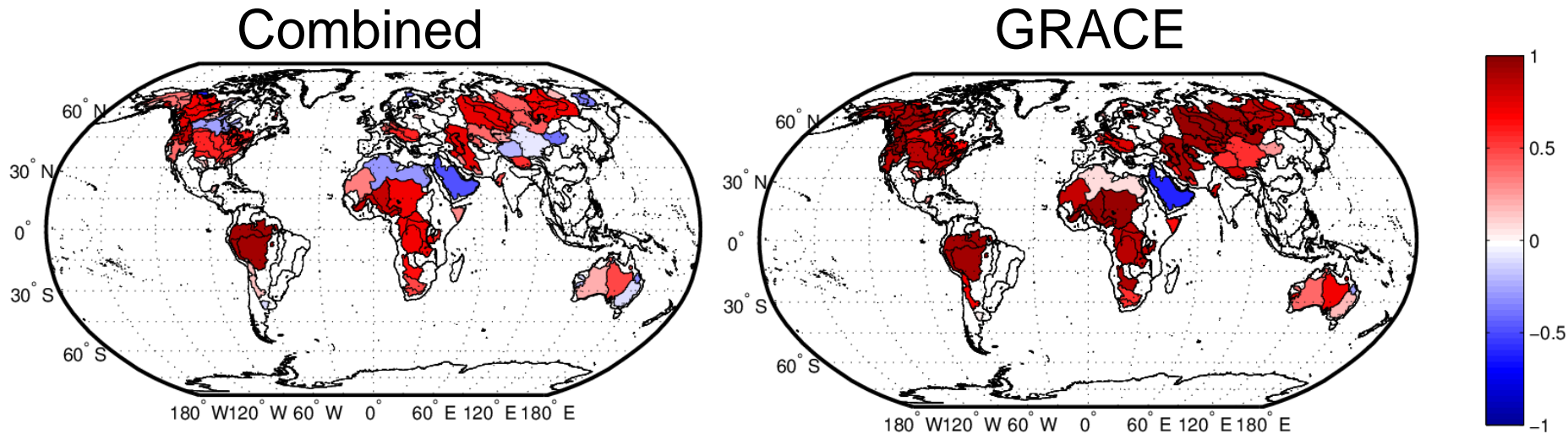


VALIDATION AND APPLICATIONS



Comparison with hydro-meteorological data

- Comparison with the difference of vertical integrated moisture flux divergences (ERA-INTERIM) and river discharge (GPCC)

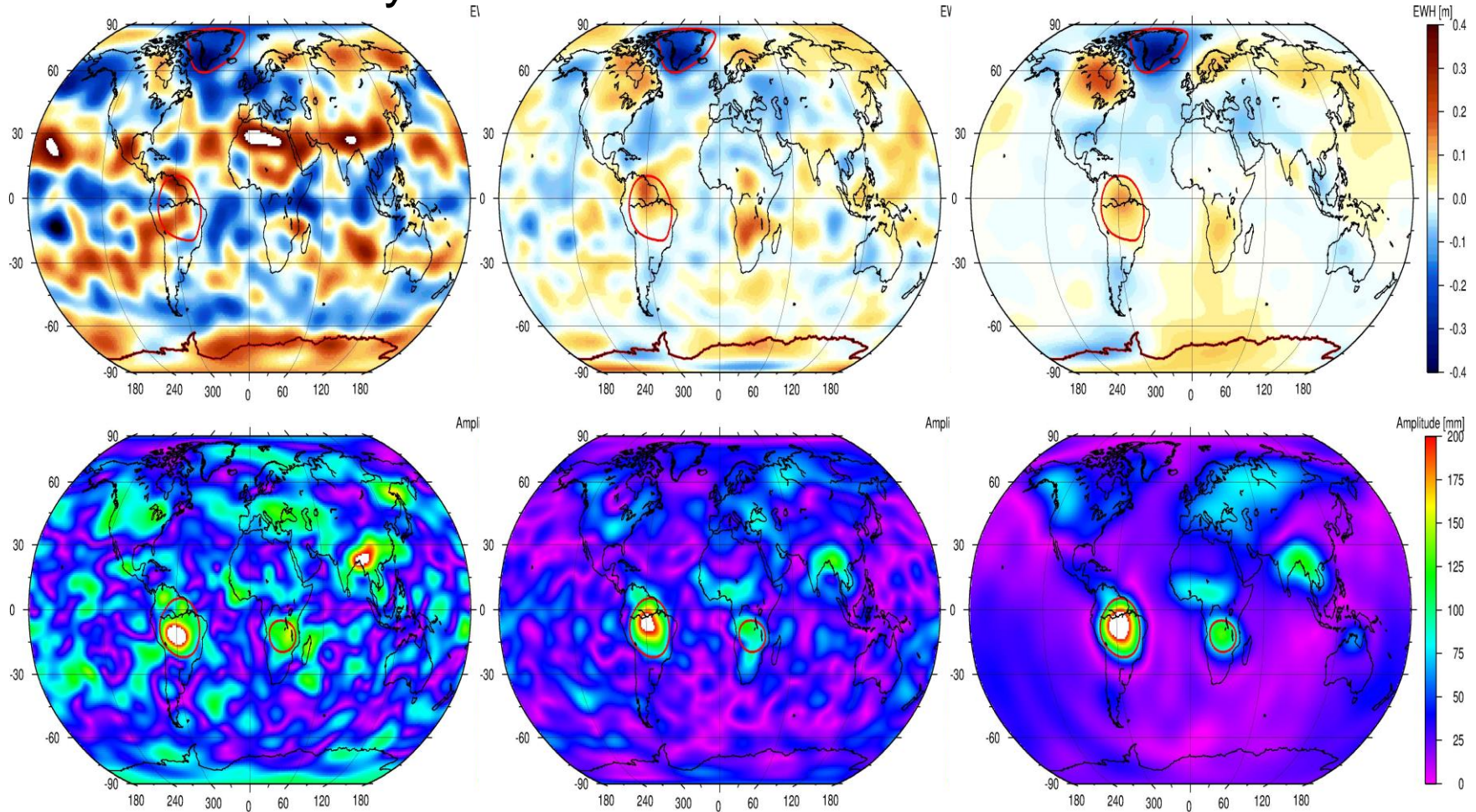


Mass trend estimates

CHAMP-only

Combined

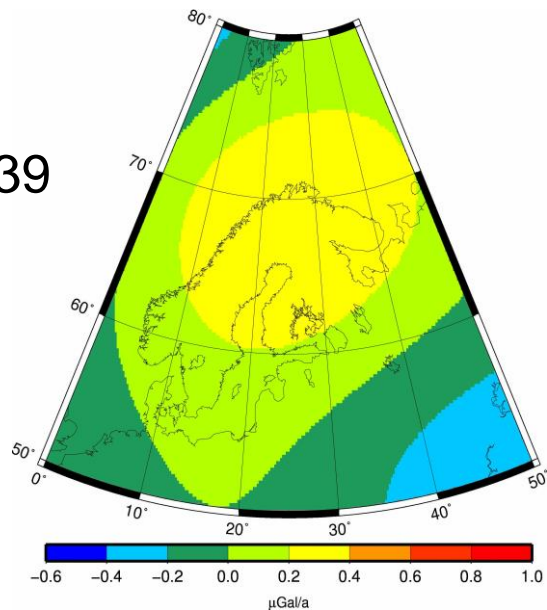
GRACE



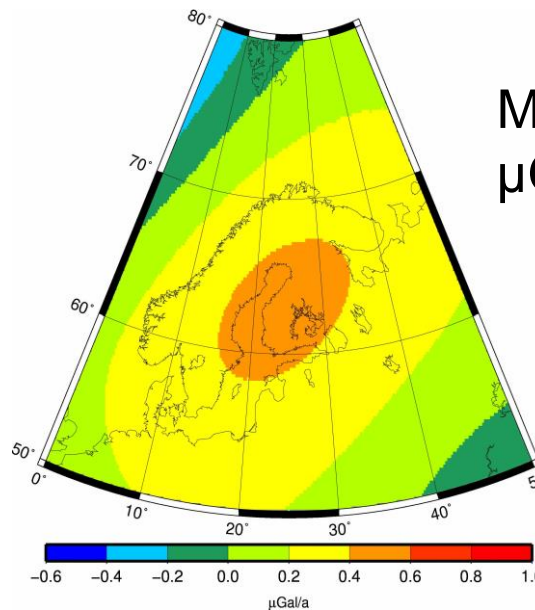
Mass trend estimates

Area	Filter radius	GRACE GT/yr	CHAMP- only GT/yr	Δ to GRACE in %	Combined GT/yr	Δ to GRACE in %
Greenland	1000 km	-239 ± 9	-261 ± 8	7	-208 ± 8	13
	750 km	-238 ± 7	-255 ± 7	9	-218 ± 7	8
Amazon	1000 km	90 ± 18	120 ± 9	33	95 ± 11	6
	750 km	92 ± 17	128 ± 9	39	96 ± 10	4
Antarctica	1000 km	52 ± 16	250 ± 21	481	42 ± 20	19
	750 km	50 ± 14	247 ± 20	494	39 ± 19	22

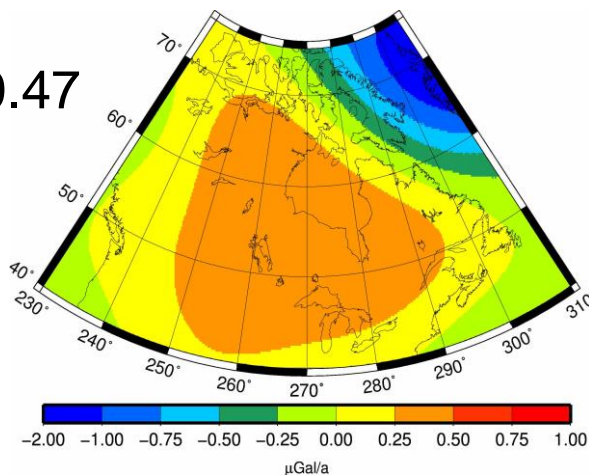
Maximum = 0.39
 $\mu\text{Gal/a}$



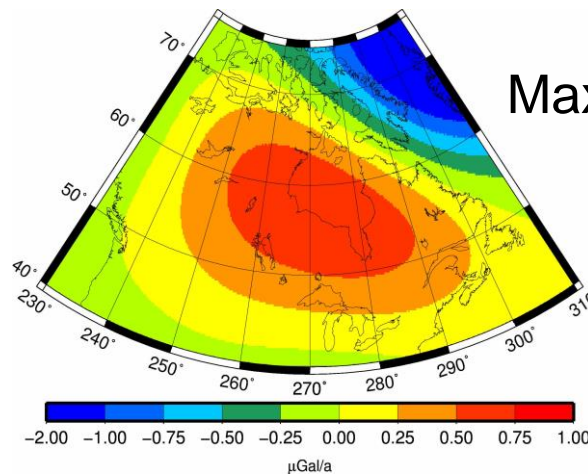
Maximum = 0.44
 $\mu\text{Gal/a}$



Maximum = 0.47
 $\mu\text{Gal/a}$



Maximum = 0.73
 $\mu\text{Gal/a}$



Conclusion:

- Combination yields improved time-variable estimates from hl-SST
- Results agree well with GRACE, hydro-meteorological data and loading from GNSS (not shown here).
- Spatial resolution improves from approximately degree 8 to 13.
- Mass estimates differ at most 22% to GRACE estimates.
- GIA estimates show first promising results but remain difficult.