

# 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



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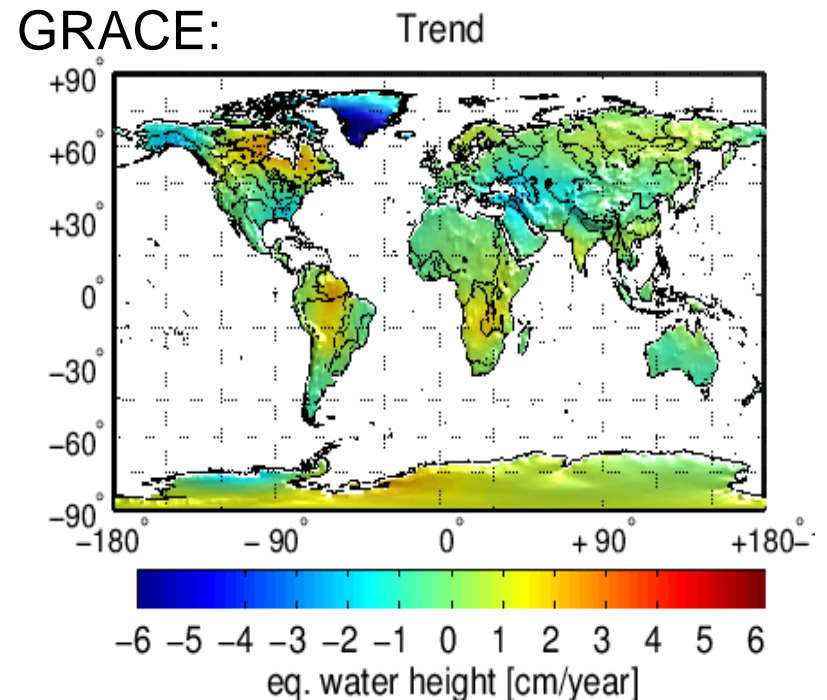
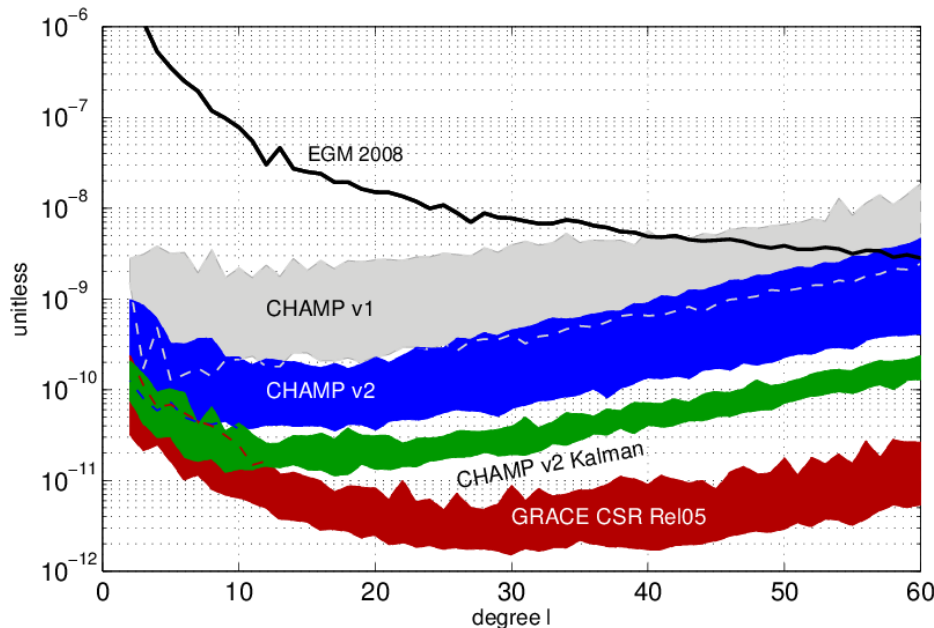
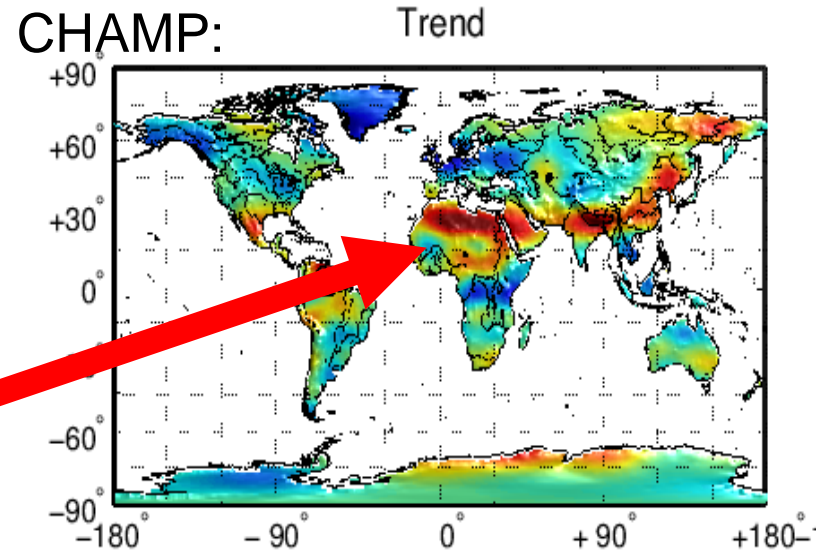


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Nico Sneeuw



# 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



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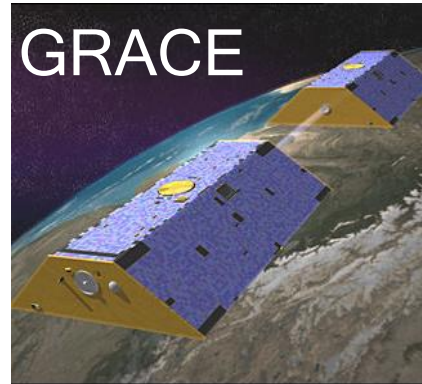


# Data availability for period 2003 to 2012



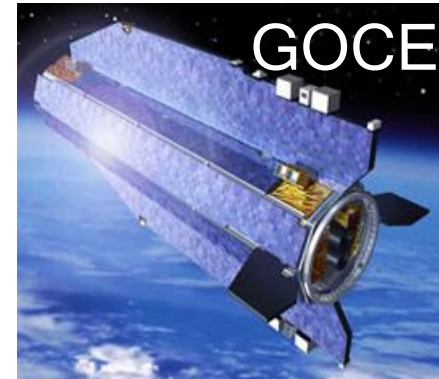
CHAMP

© GFZ-Potsdam



GRACE

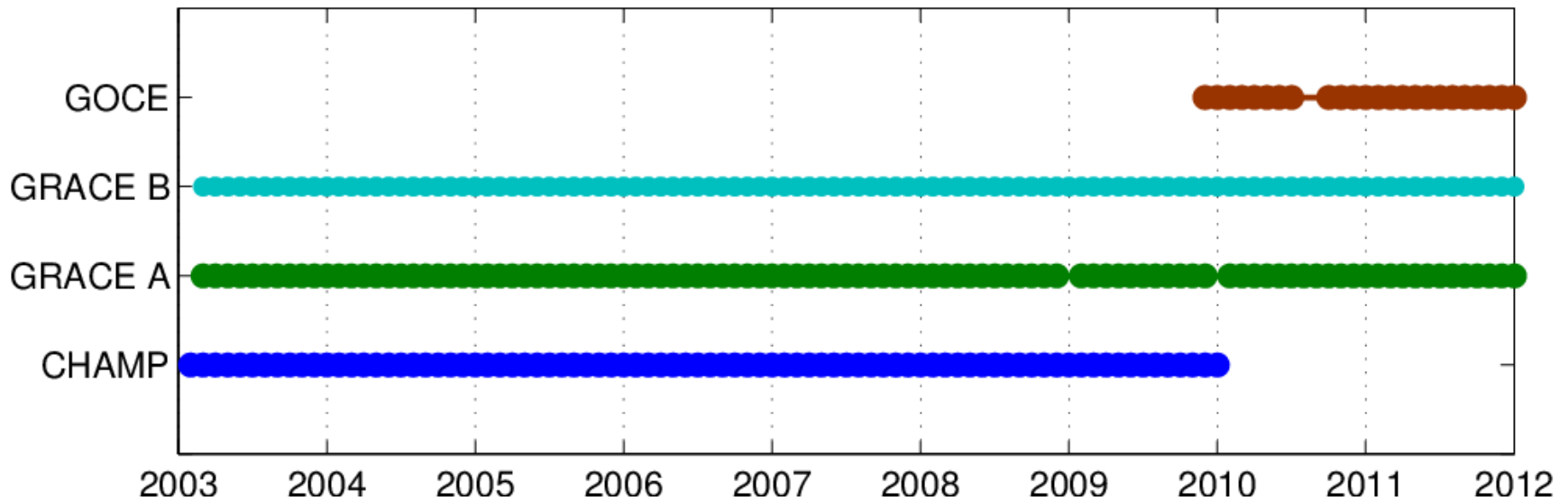
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GOCE

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## Data availability



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# Data processing

## GPS positions for CHAMP:

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

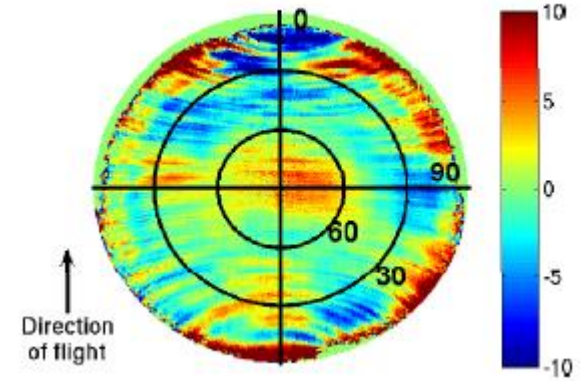
## GPS positions for GRACE A/B and GOCE:

- 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



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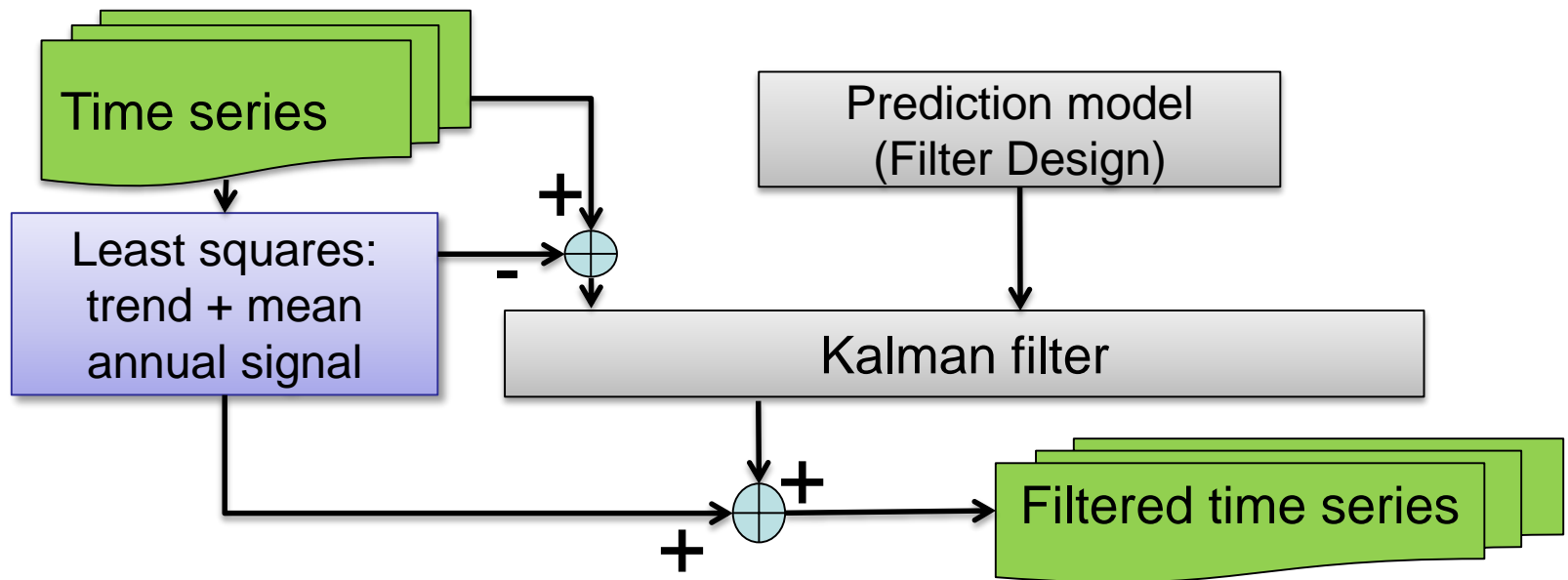
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# Kalman-Filter

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

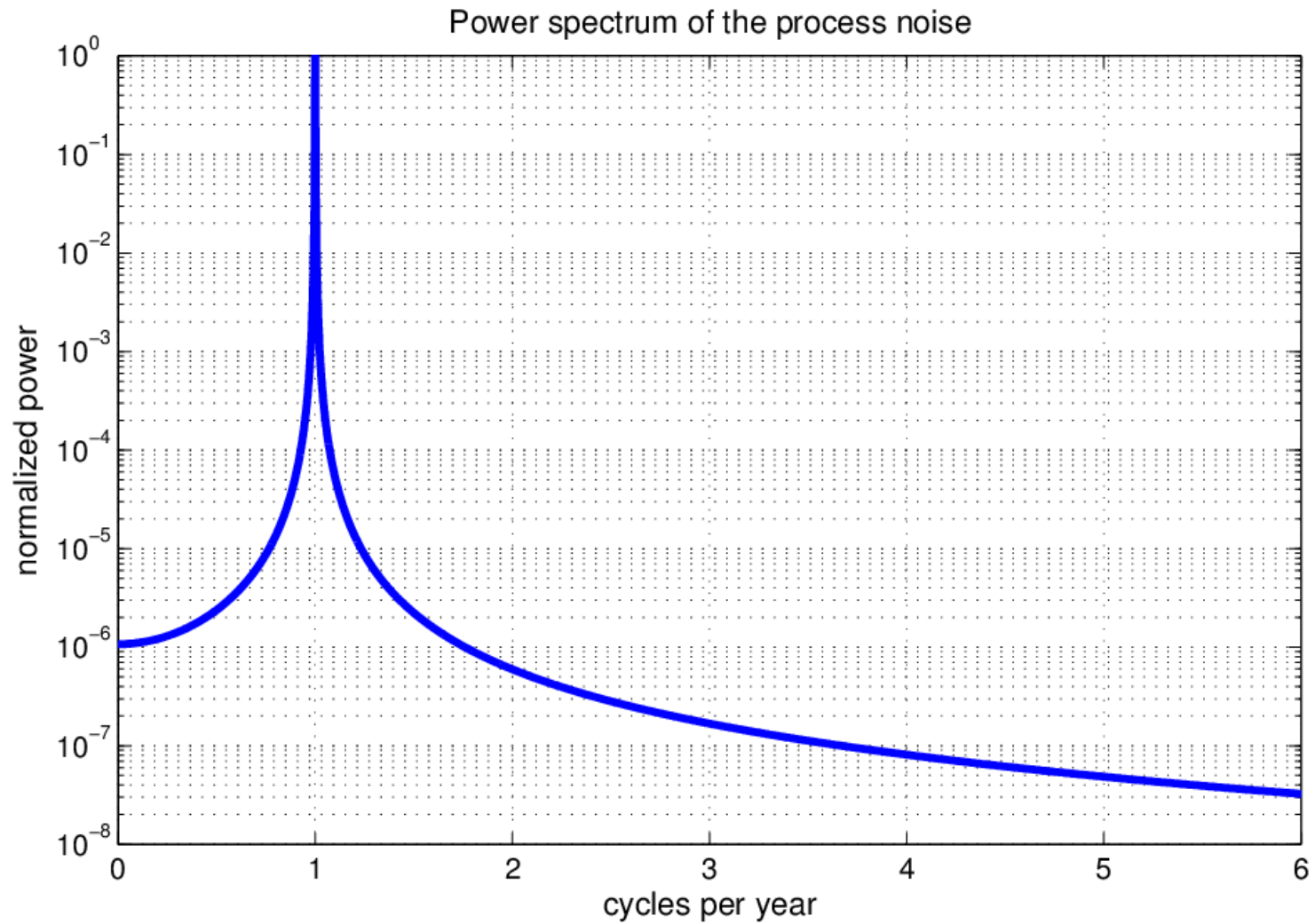


# Kalman-Filter: prediction model

- 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



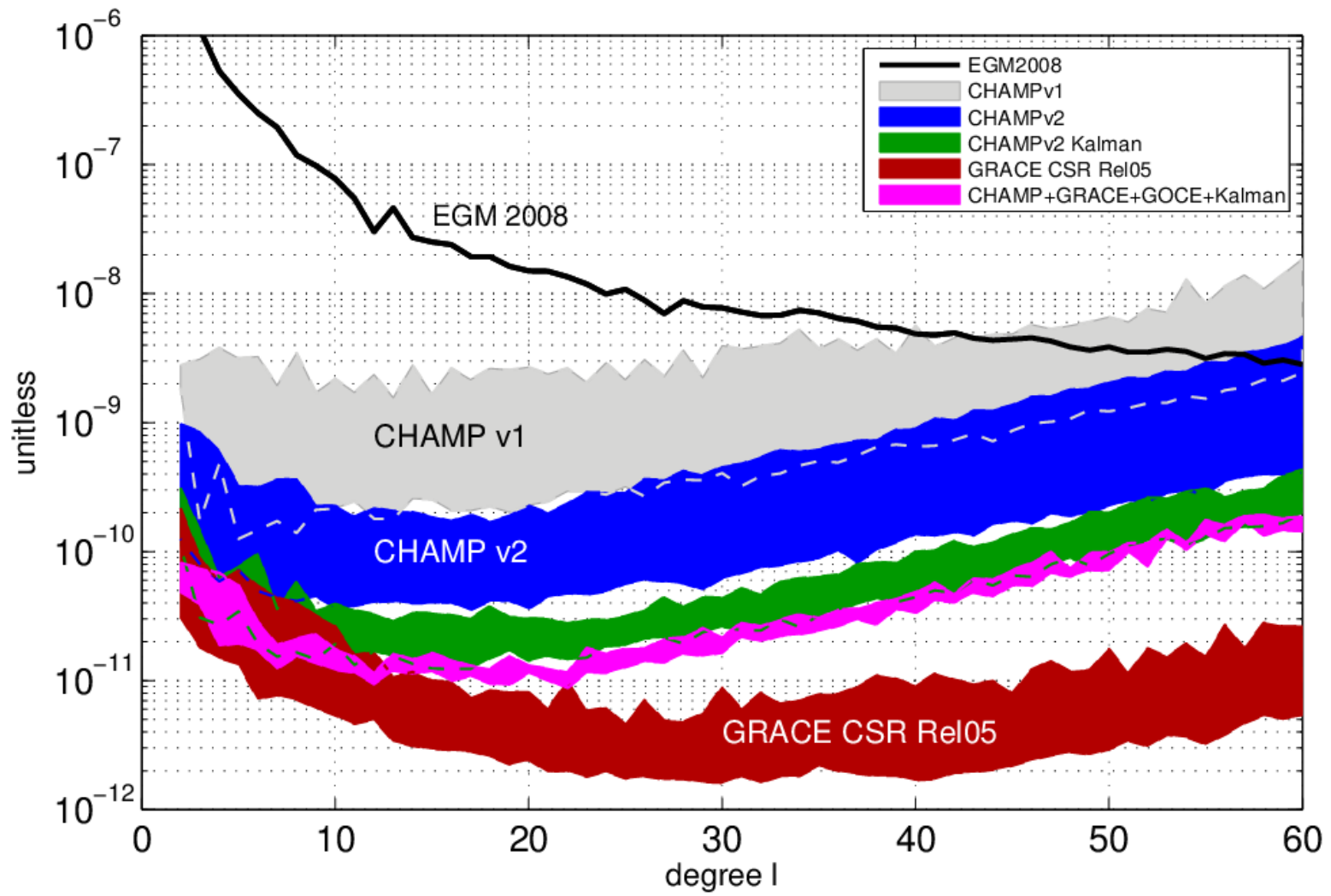
# RESULTS



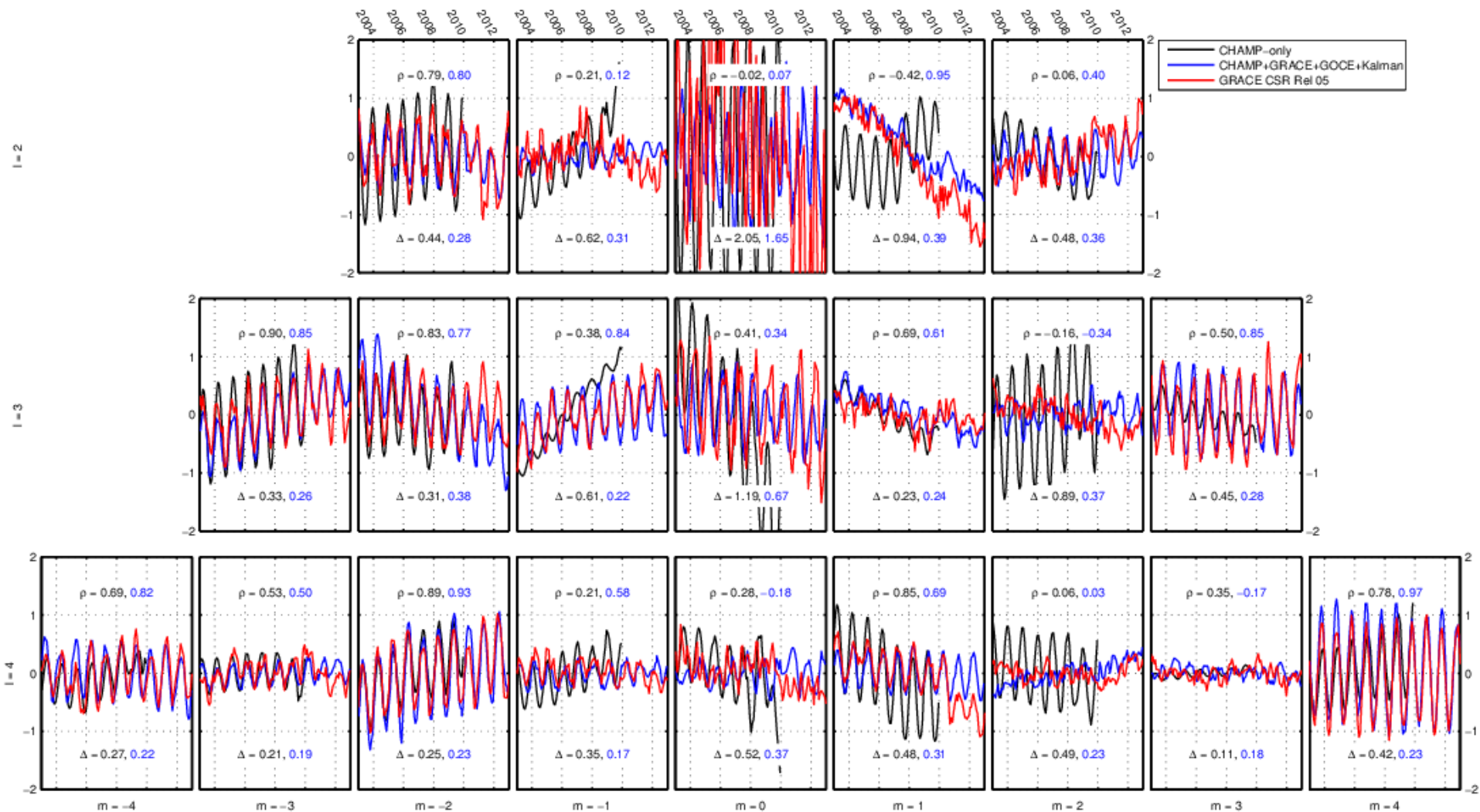
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# Degree RMS



# Time series of coefficients





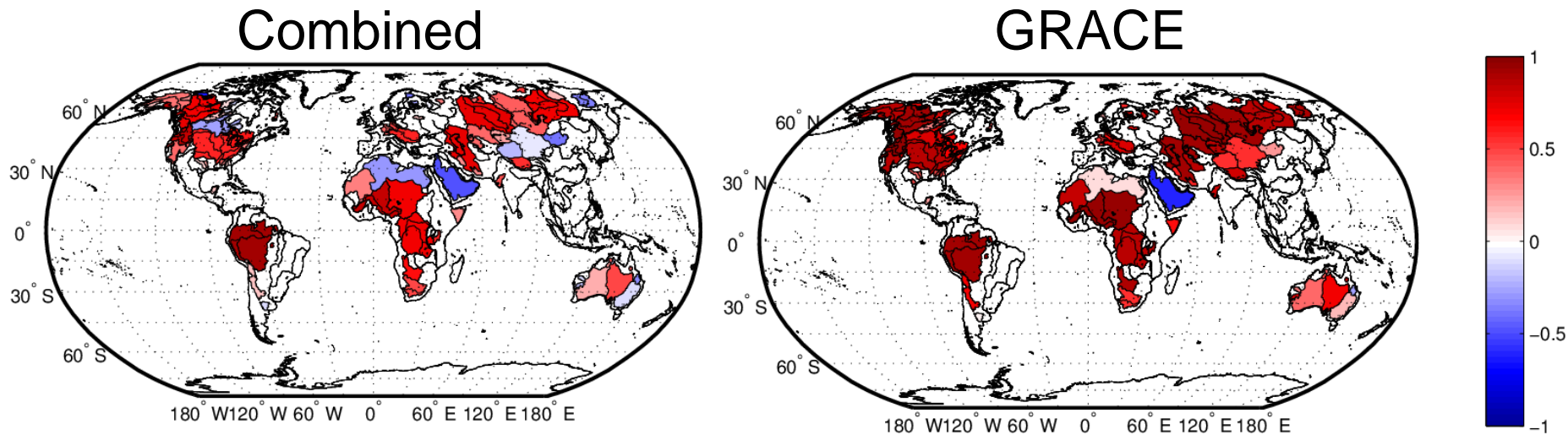


# VALIDATION AND APPLICATIONS



# Comparison with hydro-meteorological data

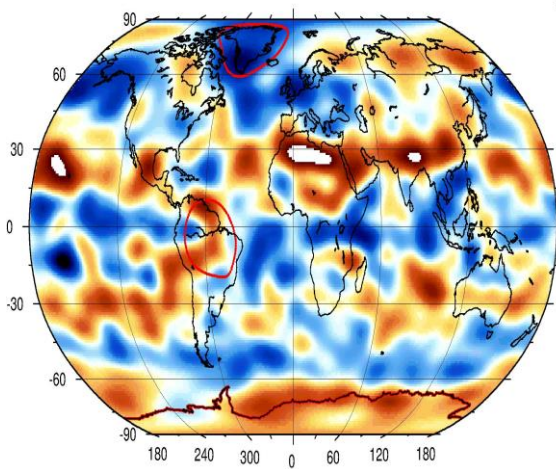
- Comparison with the difference of vertical integrated moisture flux divergences (ERA-INTERIM) and river discharge (GPCC)



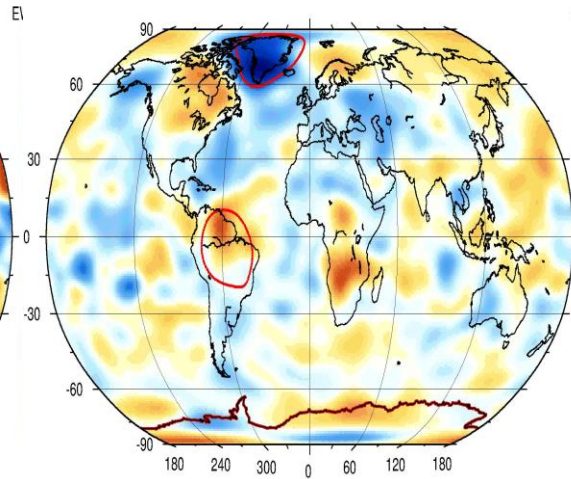


# Mass trend estimates

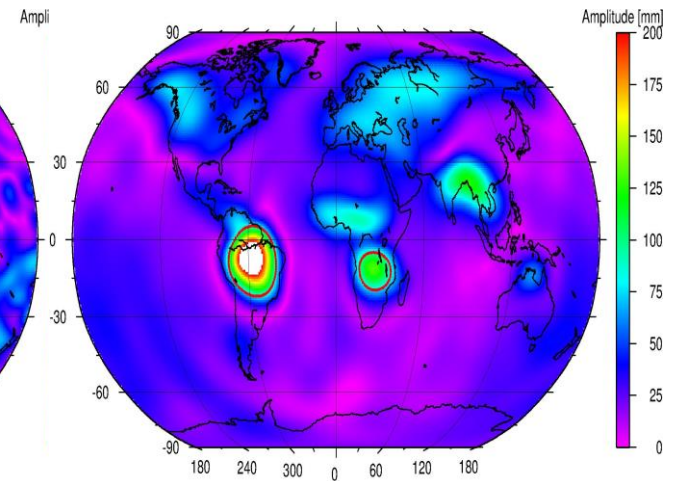
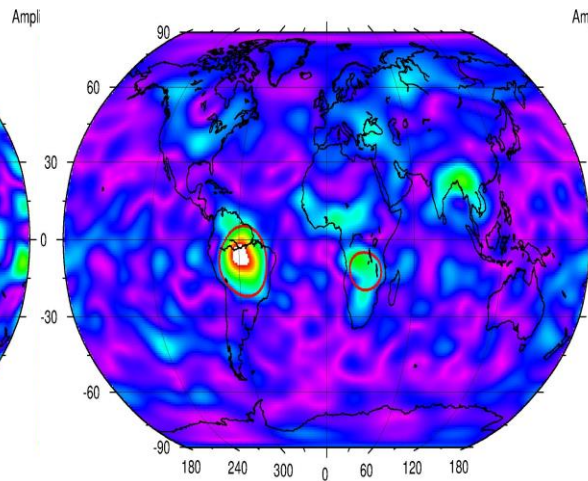
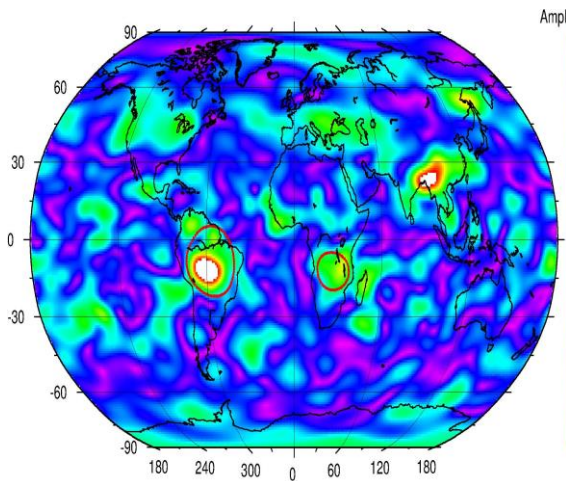
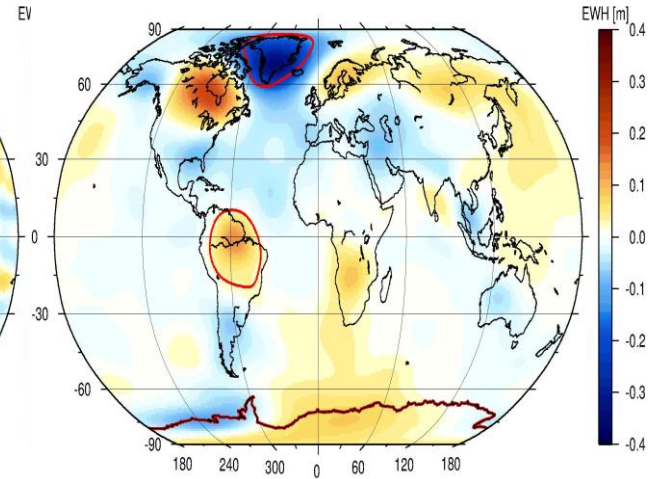
## CHAMP-only



## Combined



## GRACE



# Mass trend estimates

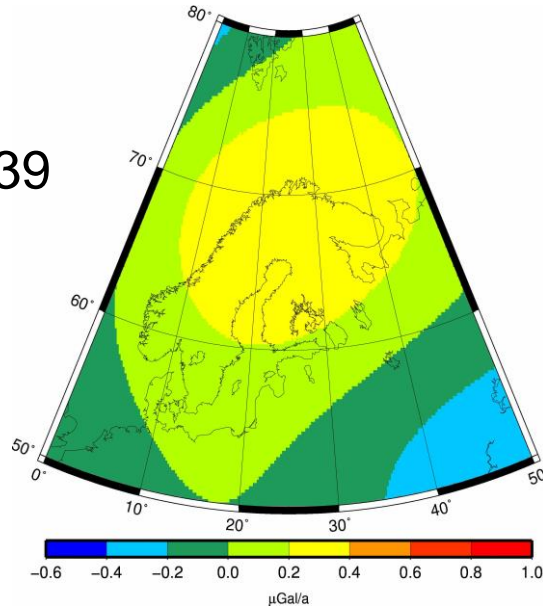
Area	Filter radius	GRACE GT/yr	CHAMP- only GT/yr	$\Delta$ to GRACE in %	Combined GT/yr	$\Delta$ to GRACE in %
Greenland	1000 km	-239 $\pm$ 9	-261 $\pm$ 8	7	-208 $\pm$ 8	13
	750 km	-238 $\pm$ 7	-255 $\pm$ 7	9	-218 $\pm$ 7	8
Amazon	1000 km	90 $\pm$ 18	120 $\pm$ 9	33	95 $\pm$ 11	6
	750 km	92 $\pm$ 17	128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

# GIA

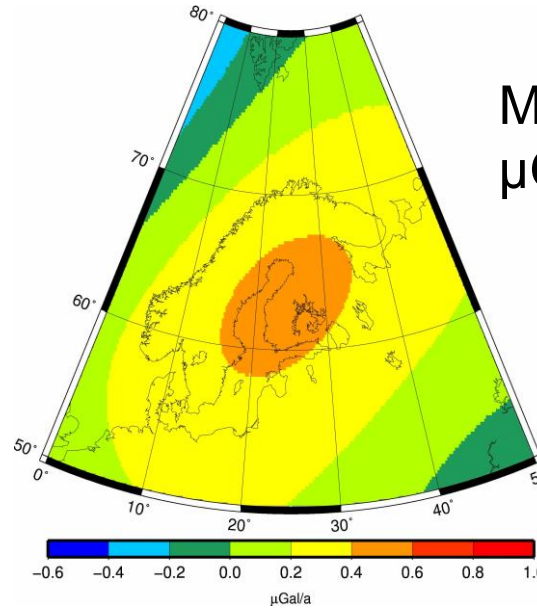
## Combined hl-SST

## GRACE GFZ Rel05

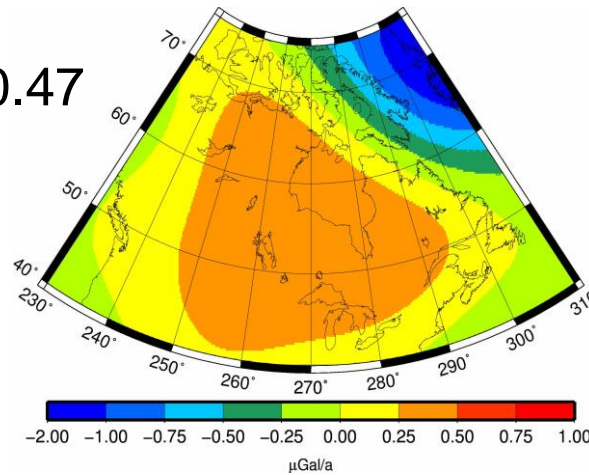
Maximum = 0.39  
 $\mu\text{Gal/a}$



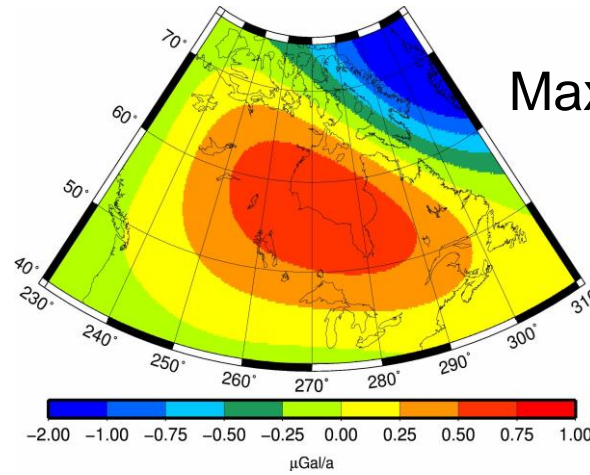
Maximum = 0.44  
 $\mu\text{Gal/a}$



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



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



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# 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.