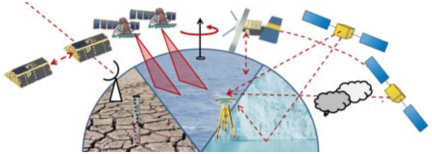

Long-term Trend Estimation of Climate Related Mass Transport in Satellite Gravity Simulations

Marius Schlaak, Matthias Graf, Roland Pail

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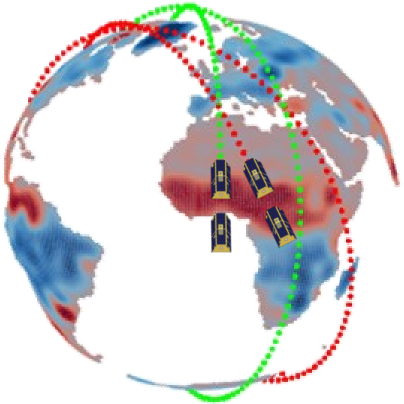
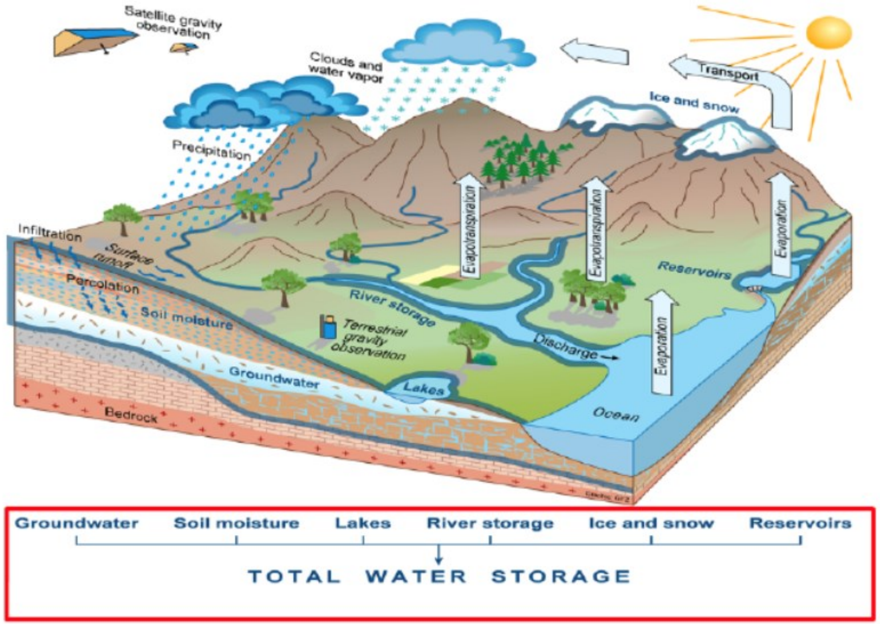


2nd ICCC Workshop, Geodesy for Climate Research,

March 28-29.2023, Online

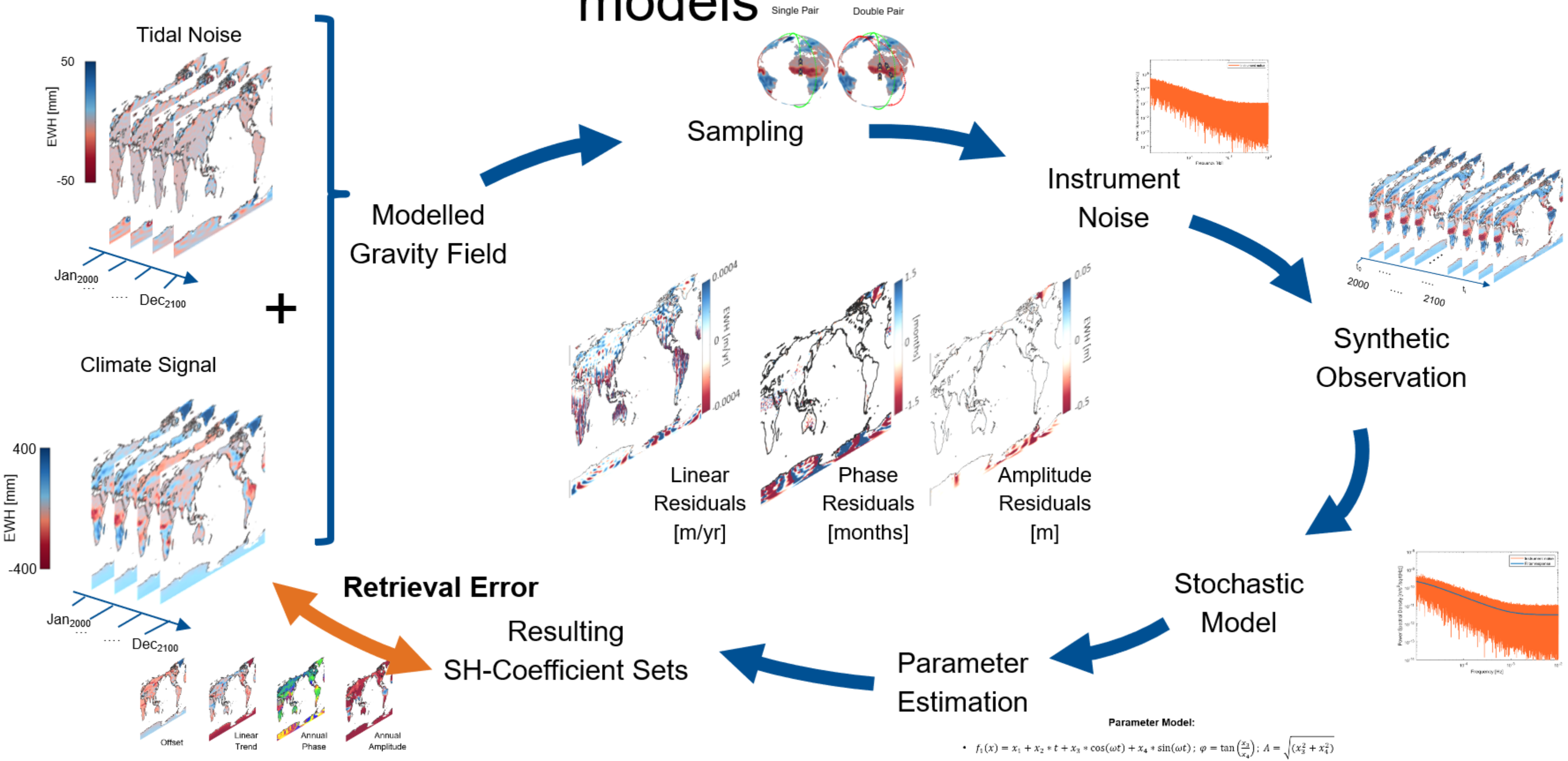
IAPG

Variations in terrestrial water storage represent continental climate related mass transports



- Climate model projections from the CMIP6 include components of the Terrestrial Water Storage (TWS):
  - soil moisture
  - snow
  - ice
- Changes in TWS are directly measured by satellite gravimetry and quantify climate effects

Simulations can evaluate the performance of parameter models



Parameter Model:

- $f_1(x) = x_1 + x_2 * t + x_3 * \cos(\omega t) + x_4 * \sin(\omega t)$; $\varphi = \tan\left(\frac{x_3}{x_4}\right)$; $A = \sqrt{(x_3^2 + x_4^2)}$
- $f_2(x) = x_1 + x_2 * t + \sum_{j=1}^{\#months} x_{(2+j)}$
- $f_3(x) = x_1 + x_2 * t + (x_3 + x_4 * t) * \cos(\omega t - (a x_5 + b x_6 * t))$

The right choice for a parameter model depends on the properties of the globally heterogenic climate system

- $f_1(x) = x_1 + x_2 * t + x_3 * \cos(\omega t) + x_4 * \sin(\omega t)\,;\ \varphi = \tan\left(\frac{x_3}{x_4}\right);\ A = \sqrt{(x_3^2 + x_4^2)}$
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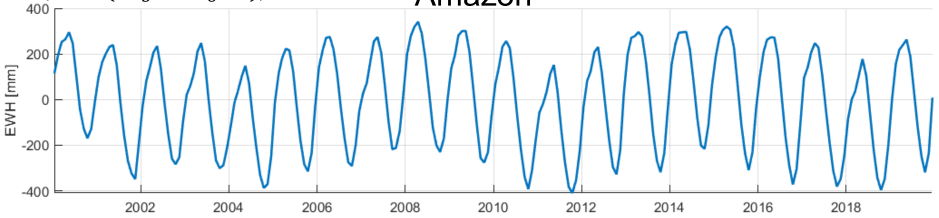
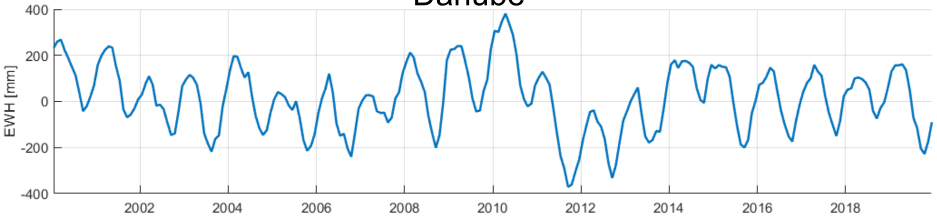
Strong annual amplitudes

Amazon



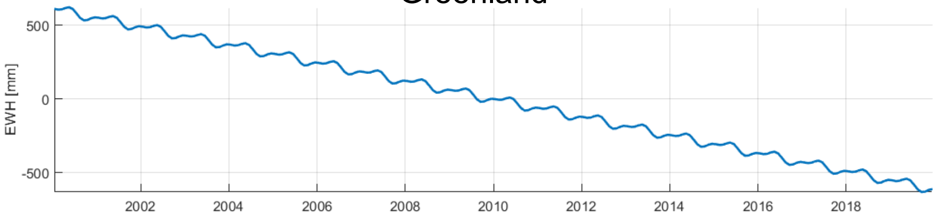
Danube



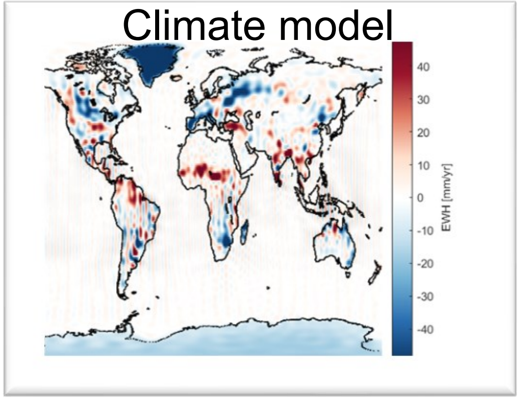
Significant interannual variability

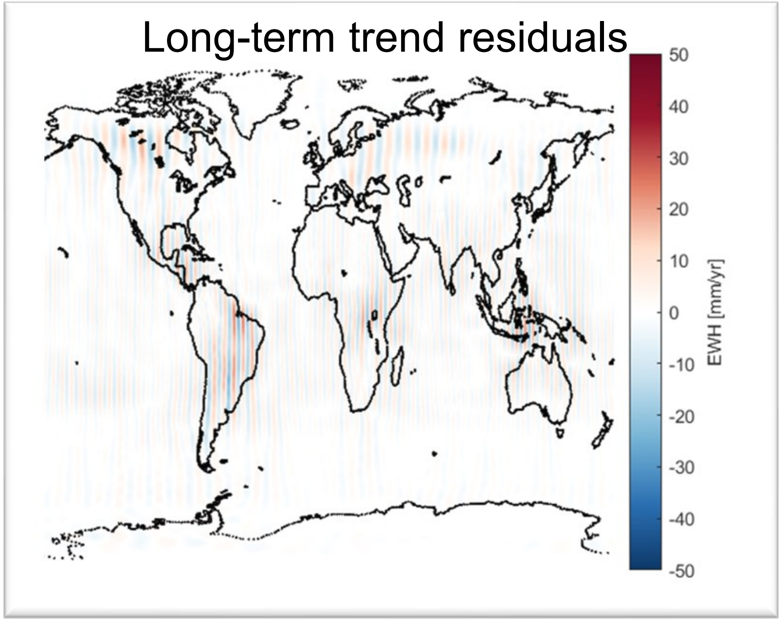
Dominating linear trend

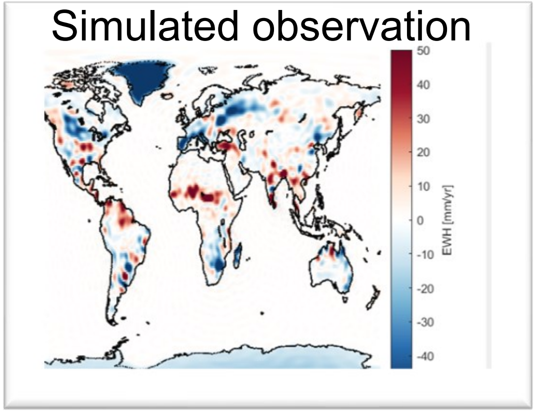
Greenland



Co-estimation of linear trend and annual signal yield stable solutions for the long-term trend



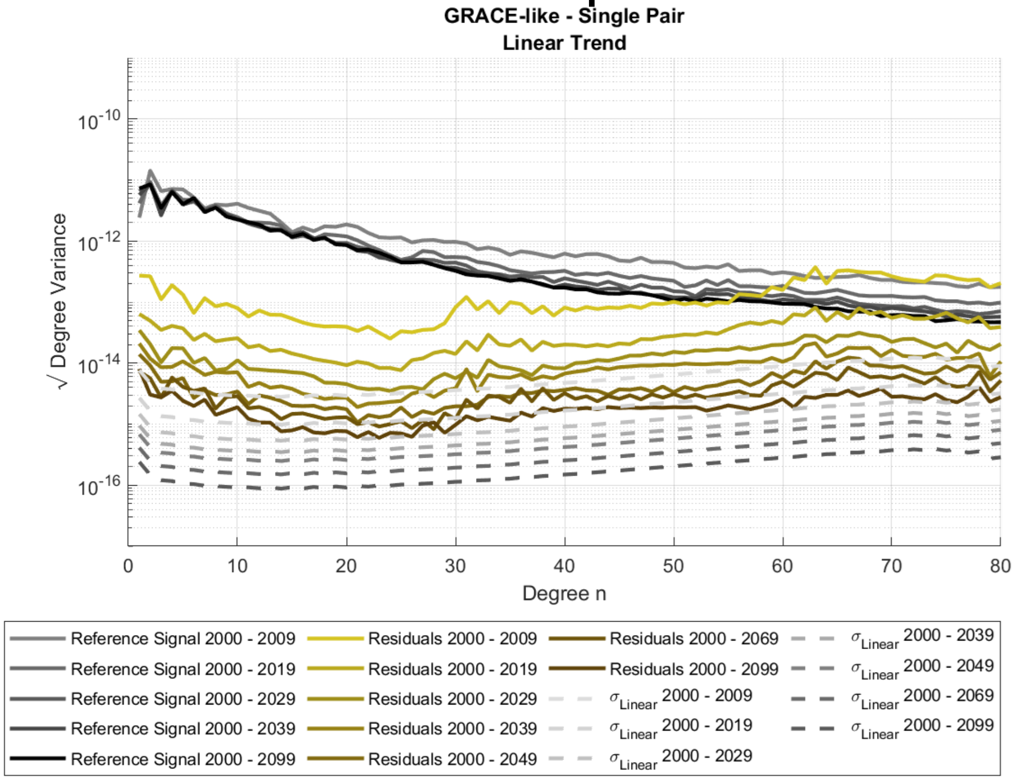




Parameter Model:

$$f_1(x) = x_1 + x_2 * t + x_3 * \cos(\omega t) + x_4 * \sin(\omega t)\,;\ \varphi = \tan\left(\frac{x_3}{x_4}\right);\ A = \sqrt{(x_3^2 + x_4^2)}$$

The resolvability of long-term trends depends on strongly on observation period and the observation system



- Residuals compared to reference signal of same retrieval period.
- Residuals decrease with:
  - increased observation interval

Parameter Model:

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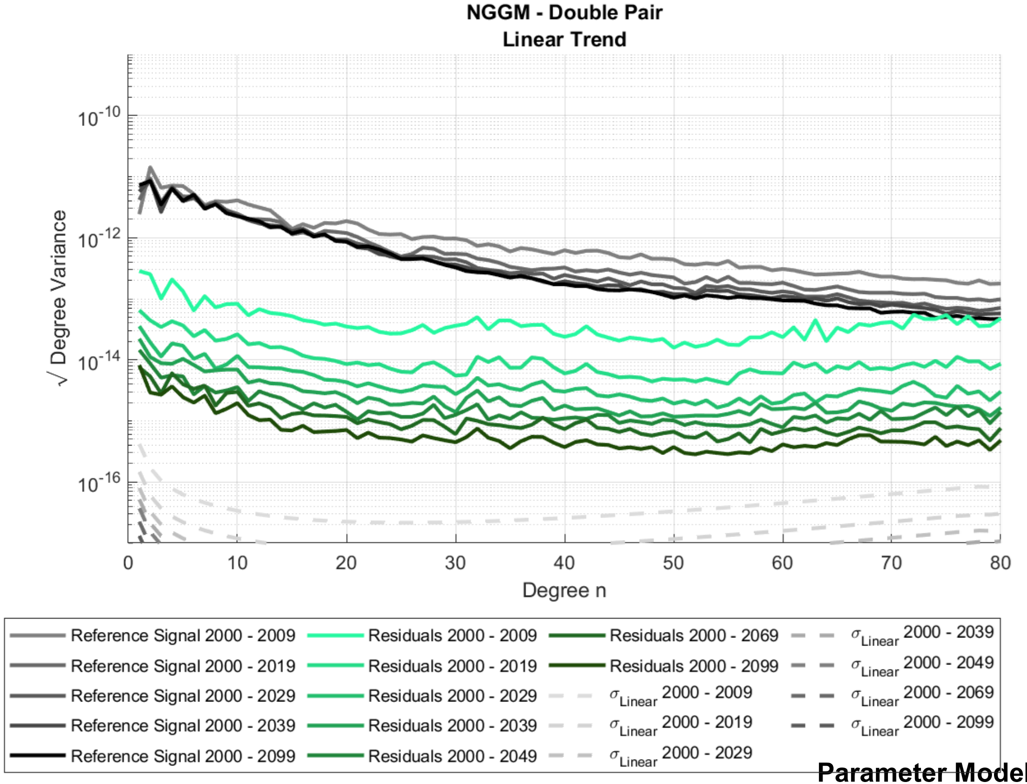
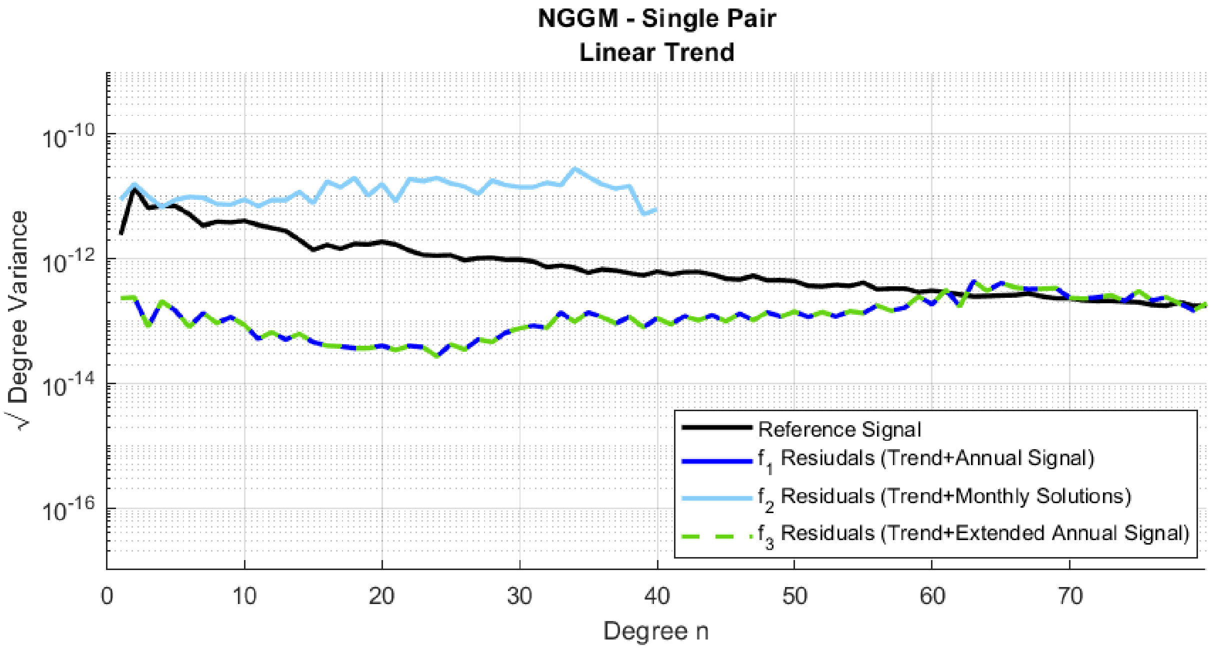


- Residuals compared to reference signal of same retrieval period.
- Residuals decrease with:
  - increased observation interval
  - advancing observation systems
- 30 years mark breaking point, where robust trend estimation becomes possible.

Parameter Model:

$$f_1(x) = x_1 + x_2 * t + x_3 * \cos(\omega t) + x_4 * \sin(\omega t)\,;\ \varphi = \tan\left(\frac{x_3}{x_4}\right);\ A = \sqrt{(x_3^2 + x_4^2)}$$

Not all parameter models are suitable to recover global long-term trends



Parameter Model:

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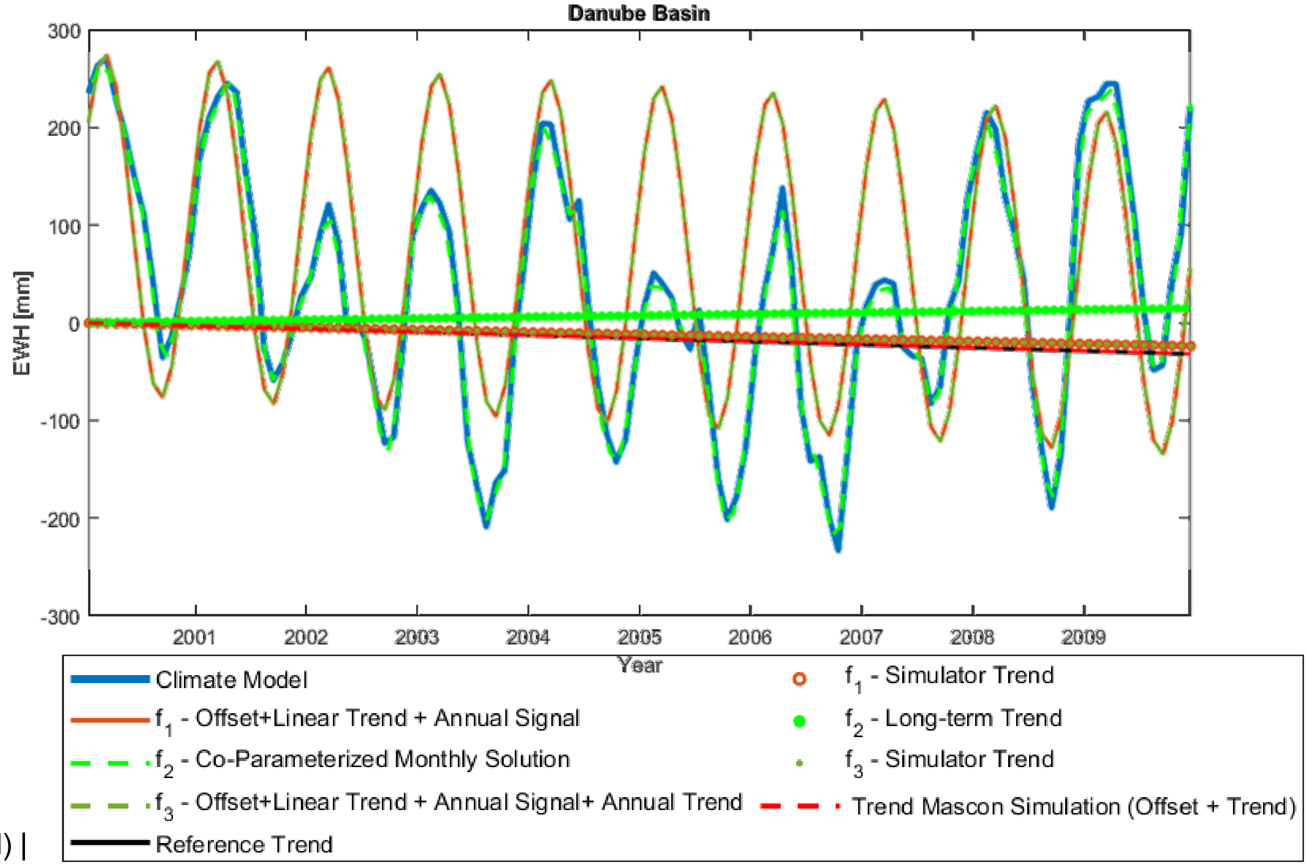
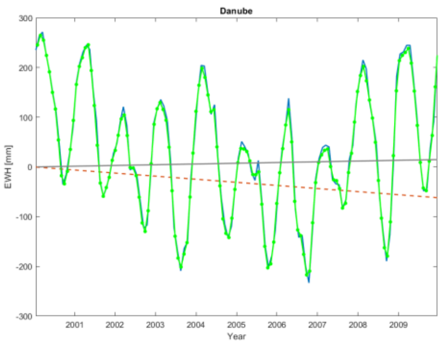
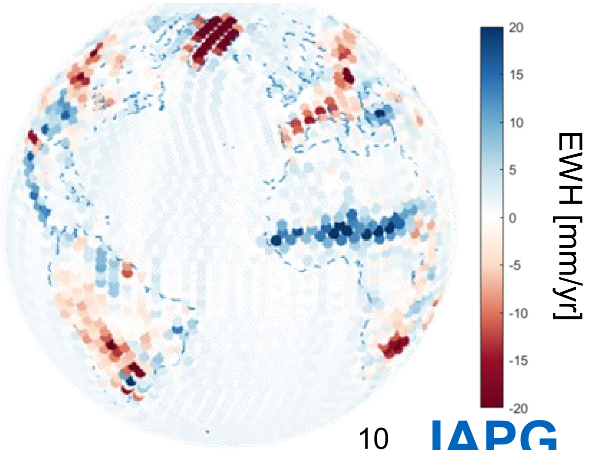
Local long-term trends can be recovered from different parameter models, but not from all



Several parameter models can retrieve long-term trends globally, but tailored solutions to local climate are a promising new development

- Monthly co-estimation yields no benefit for long-term trend estimation
- Considering amplitude and phase trends achieve a stable long-term trend, but they do not show any improvement in the signal representation either.
- Local basis functions are currently investigated. First results show a robust trend estimation using mascon approach globally.
- By densifying the mascon grid over selected target, the spatial resolution can be improved.
- **Outlook**: tailored spatial-temporal estimation considering locale climate are currently investigated.





Publications

[1] Schlaak, Marius; Pail, Roland; Jensen, Laura; Annette Eicker (2023): Closed Loop Simulations on Recoverability of Climate Trends in Next Generation Gravity Missions. In Geophys J Int. https://doi.org/10.1093/gji/ggac373

Full text on ResearchGate

[2] Jensen, L., Eicker, A., Dobslaw, H., & Pail, R. (2020). Emerging Changes in Terrestrial Water Storage Variability as a Target for Future Satellite Gravity Missions. Remote Sens., 12(23), 3898. https://doi.org/10.3390/rs12233898

[3] Guo, H., John, J. G., Blanton, C., McHugh, C., Nikonov, S., & Radhakrishnan, A., et al. (2018). *NOAA- GFDL GFDL-CM4 model output.* https://doi.org/10.22033/ESGF/CMIP6.1402