Spatio-temporal evolution of 20th century regional mean sea level rise

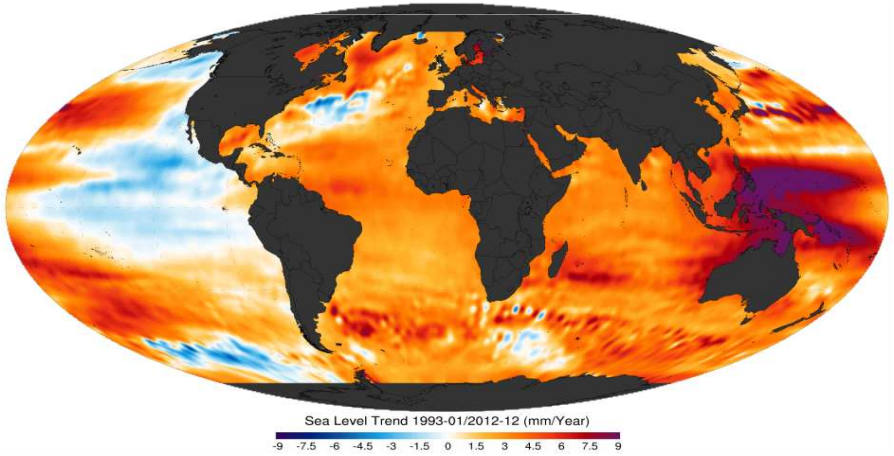
Sönke Dangendorf, Marta Marcos, Chris Piecuch, Gabriel Jorda, Jürgen Jensen

email: *soenke.dangendorf@uni-siegen.de*

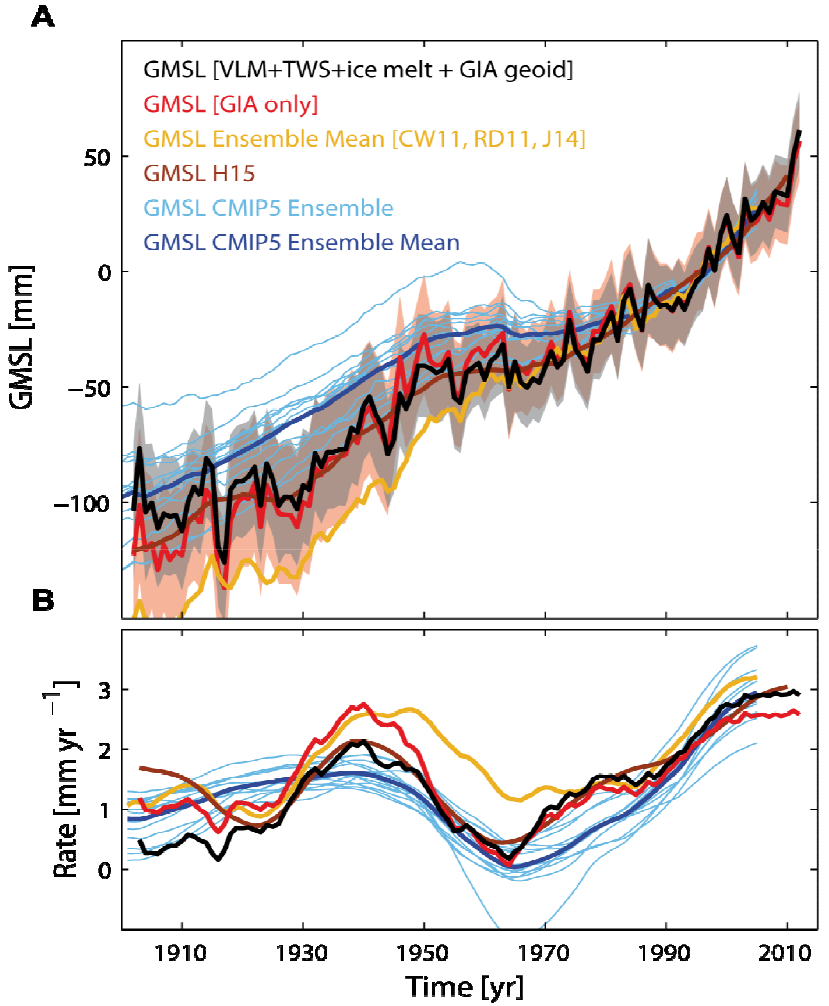
UNIVERSITÄT SIEGEN

GMSL vs. RMSL

- GMSL has risen by ~14-22 cm since 1900
- The non-linearity of GMSL change and its physical origin is unsure
- An essential key is the understanding of RMSL change and its influence on GMSL



https://upload.wikimedia.org/wikipedia/commons/6/69/NOAA_sea_level_trend_1993_2010.png



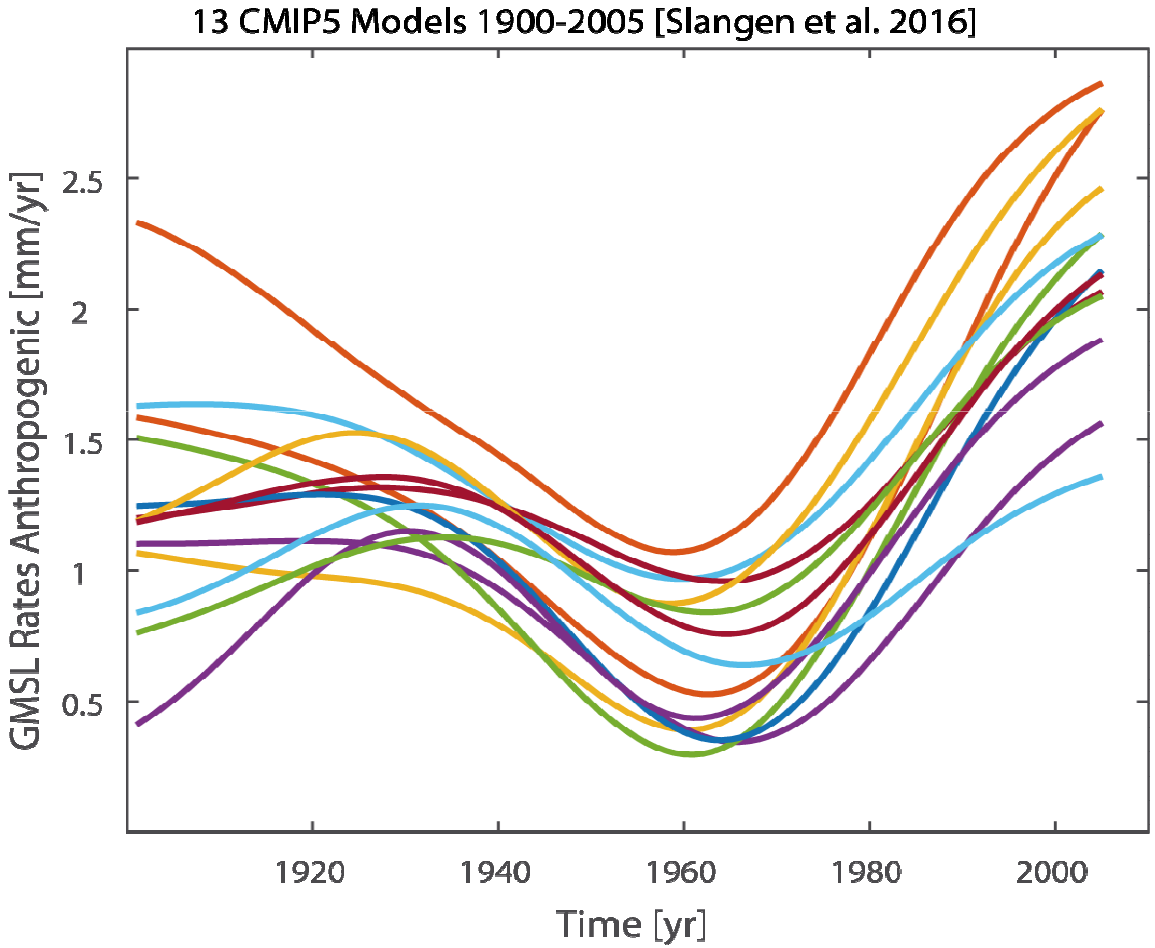
Dangendorf et al., under review

fwu

UNIVERSITÄT SIEGEN

Nat. vs. Anthropogenic

- Anthropogenic forcing is rela-tively smooth (long timescales)
- Natural forcing is relatively noisy (shorter timescales)
- But where is the transition and what is the right filter?



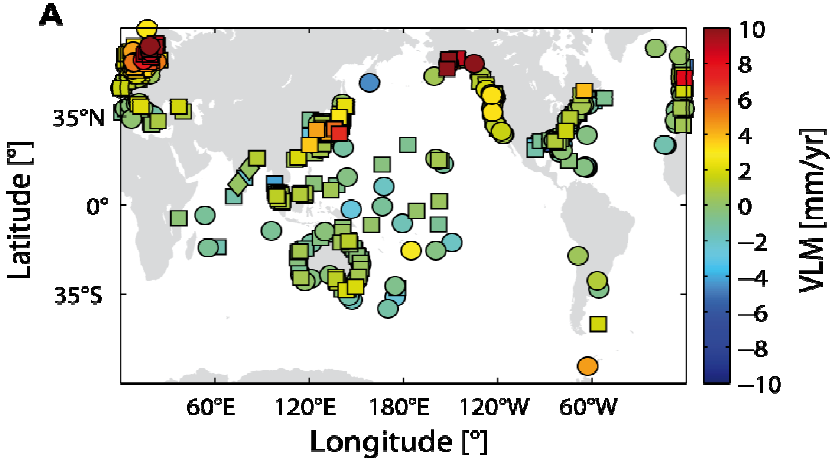
fwu

1.) Is there a more objective way to define the smoothing window for a non-linear trend?

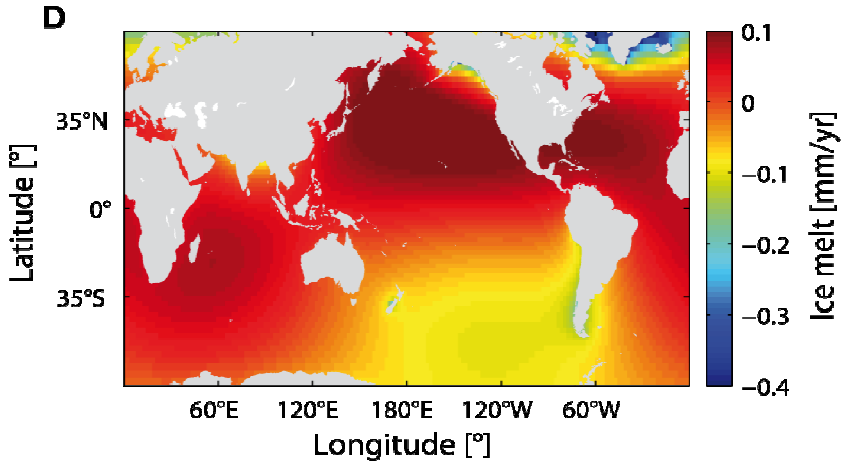
2.) What is the role of regional phenomena (atmospheric forcing, vertical land motion), which contaminate the tide gauge measurements with respect to GMSL?

Datasets

- 167 tide gauges corrected for vertical land motion (VLM) (Wöppelmann & Marcos, 2016) with an **VLM error < 0.7 mm/yr** and providing at least **75% of data** since 1900
- GIA corrections from ICE6G (Peltier et al., 2015)
- Two global barotropic models kindly provided by C. Piecuch and G. Jorda
- Ice melt fingerprints from glaciers (Marzeion et al., 2012) and the Greenland ice sheet (Kjeldsen et al., 2015) kindly provided by T. Frederikse



Dangendorf et al., under review

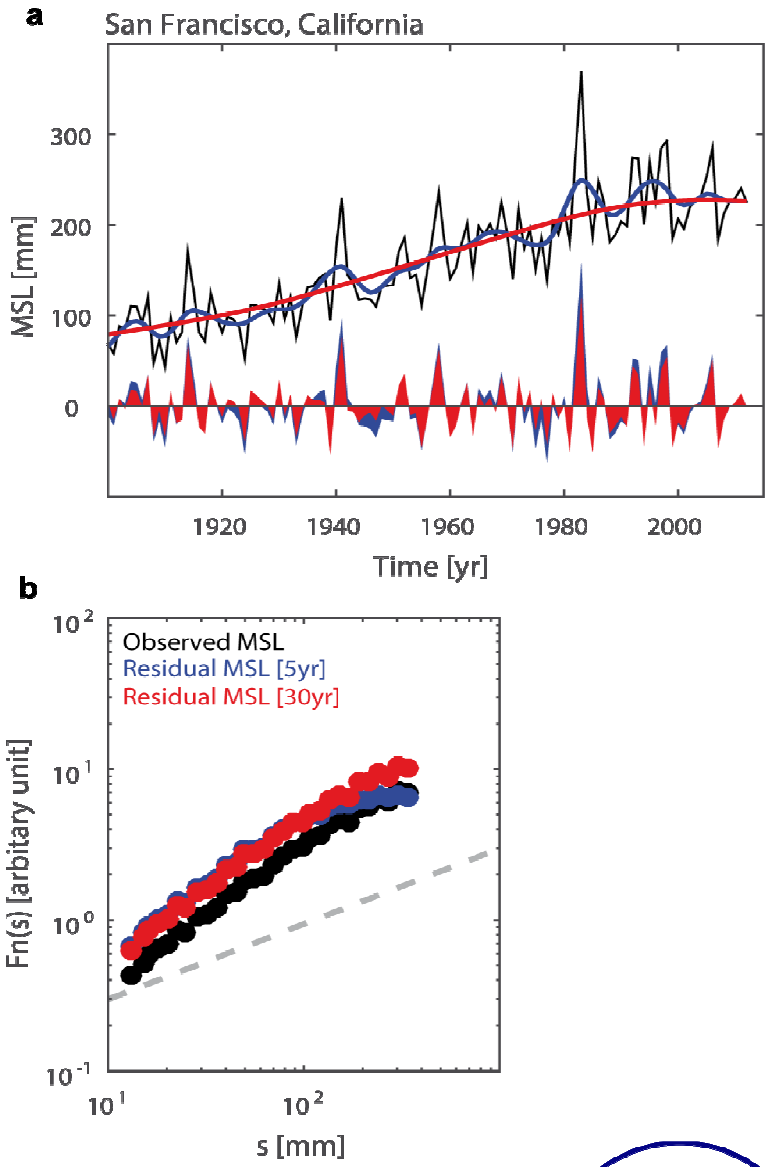


Detrended Fluctuation Analysis

- **Hypothesis:**

The nonlinear (external) signal is well determined, if the noise structure (i.e. natural variability) in the residuals remains unaffected by the trend removal (here SSA)

- **Approach:**
  1. Estimate natural variability in original data
  2. Estimate/remove nonlinear trend
  3. Estimate natural variability in residuals
  4. Difference between 3. and 1. should be close to zero

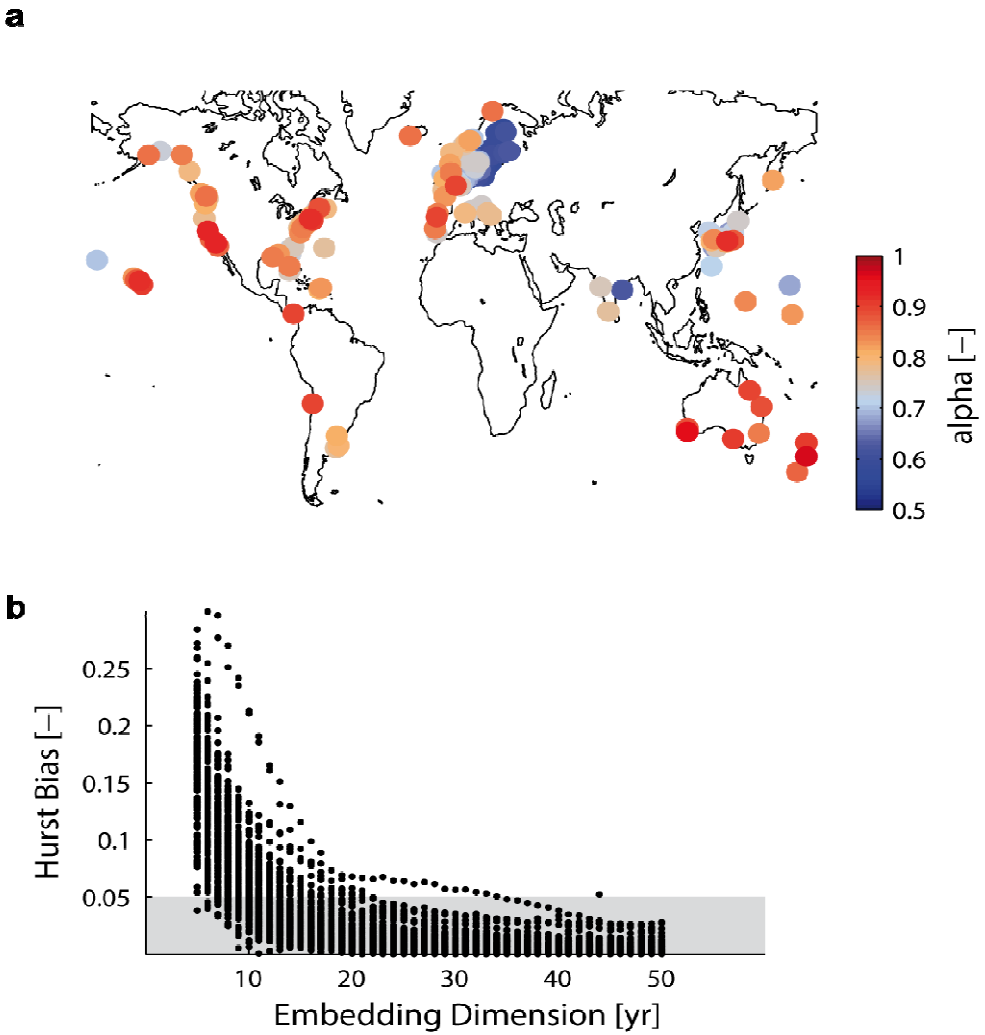


UNIVERSITÄT SIEGEN

Smoothing window

- Characteristic of natural variability varies by region
- No major differences in Hurst coefficients (alpha) if the smoothing window is > ~25-30yr
- This is independent from the chosen locations

Differences in alpha values →

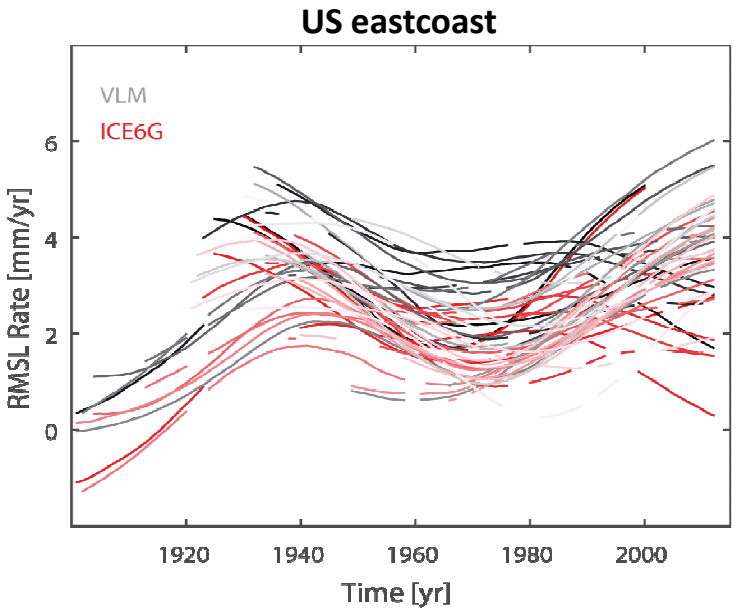


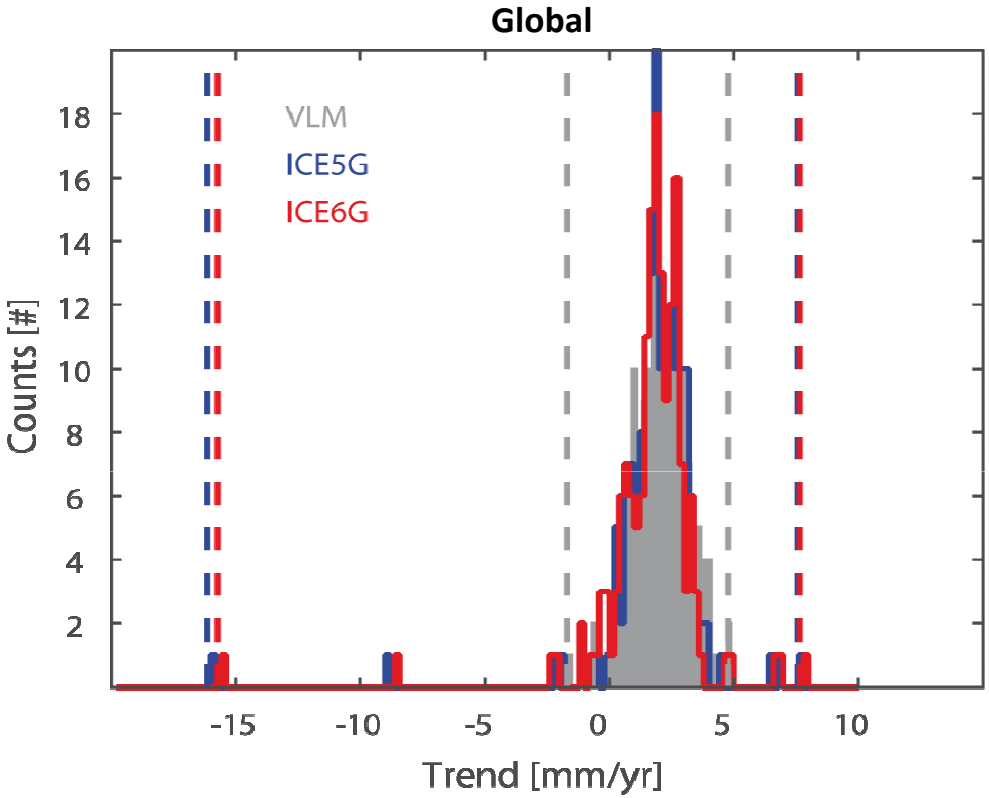
fwu

UNIVERSITÄT SIEGEN

Impact of VLM

- Consistent with previous studies VLM correction significantly reduces the regional variability in trends
- However: Some regions (e.g. US east-coast) show a slightly better regional agreement when corrected for GIA only

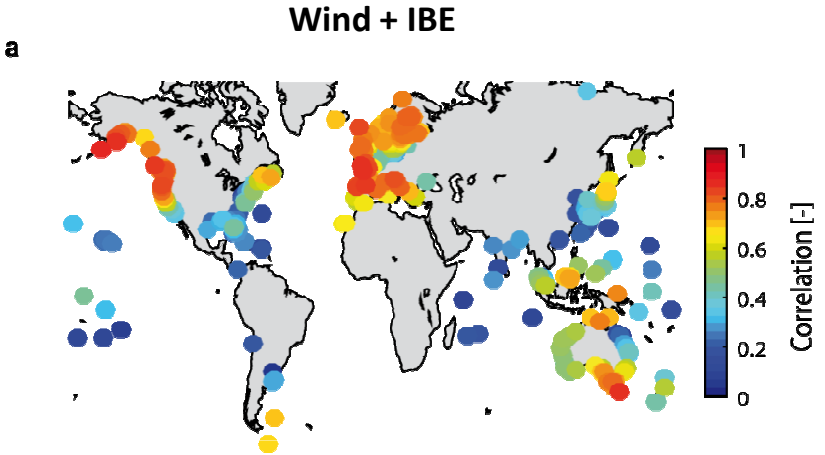


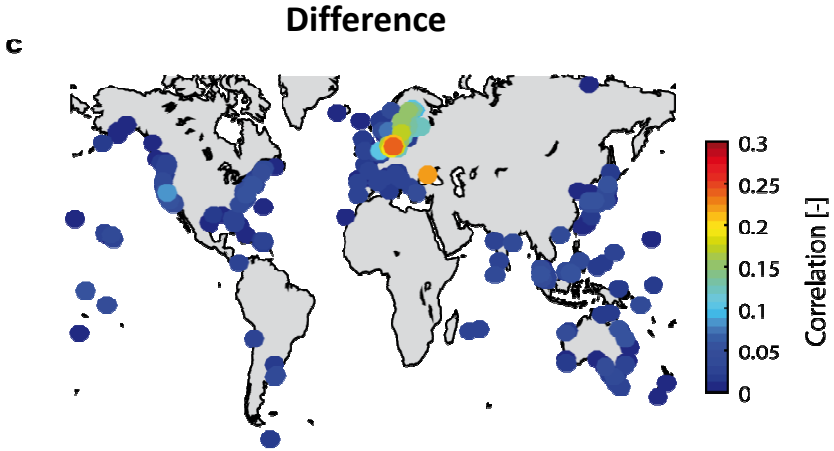


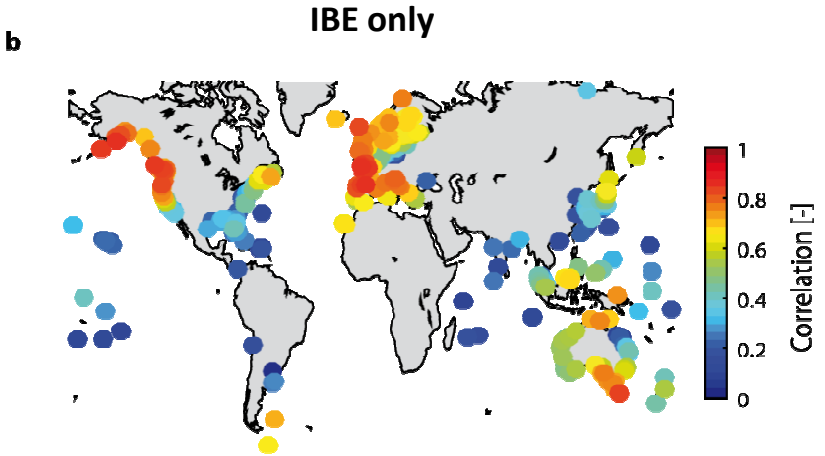
fwu

Impact of atmospheric forcing

- Atmospheric forcing explains a significant portion of the interannual variability (especially in mid-latitudes)
- However: The current generation of (coarse resolution) global models does not significantly improve the classical IB correction (→ neglect wind forcing)



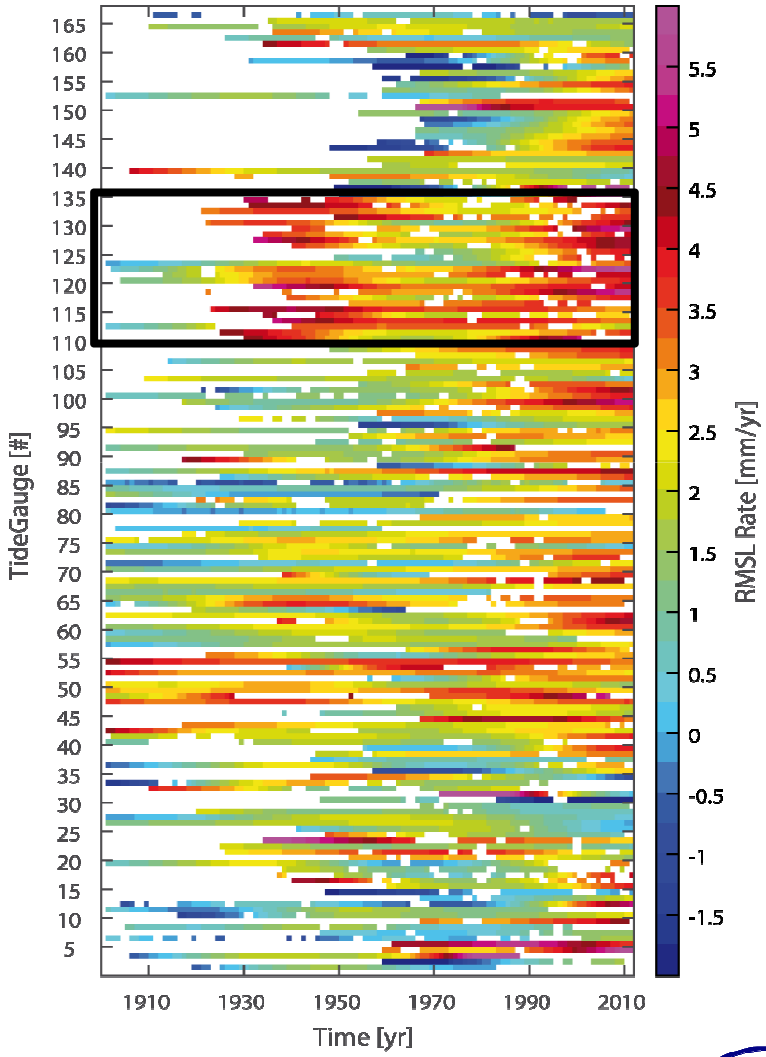




UNIVERSITÄT SIEGEN

Trend rates in tide gauges

- Spatio-temporal plotting of the rates allows identifying regional patterns
- So far (with the grouping in use) there is a relatively large scatter
- However, there are some hotspots emerging (e.g. US eastcoast)
- Interestingly, the US eastcoast hotspot shows comparable ups and downs as GMSL!

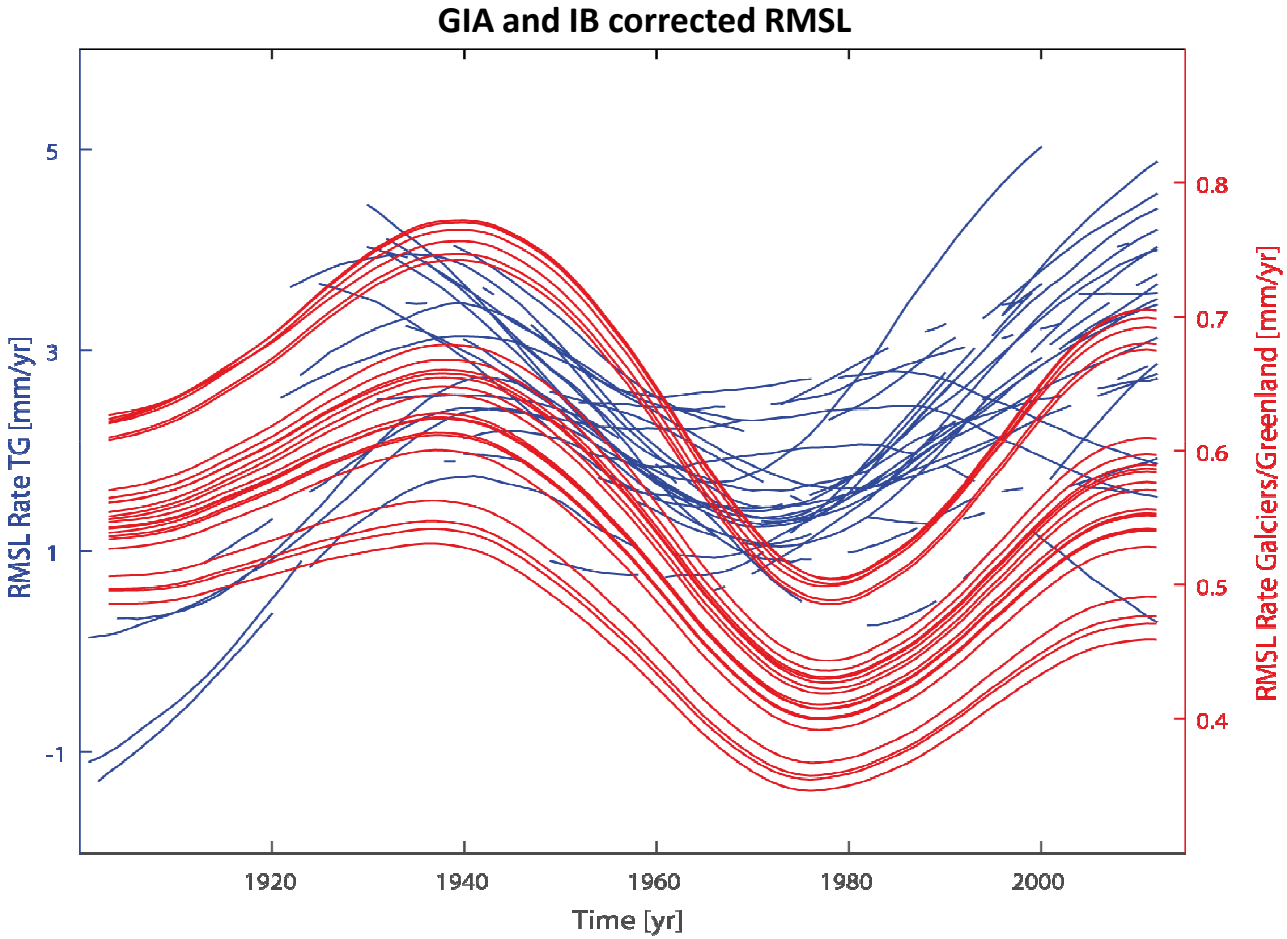


fwu

UNIVERSITÄT SIEGEN

US eastcoast

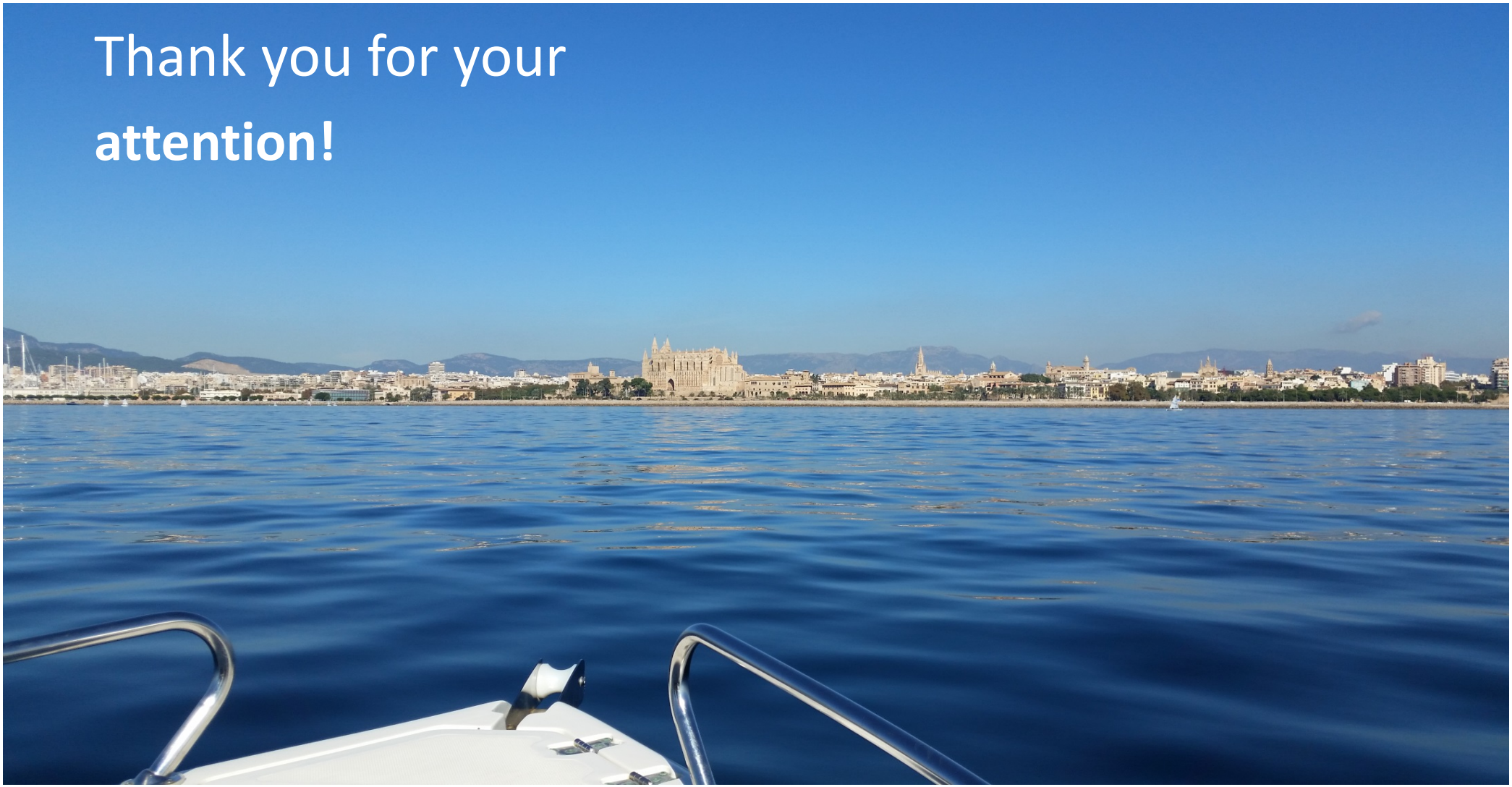
- Rates along the US eastcoast show coherent temporal patterns
- The rates shows qualitative similarities to the rates following ice melting from glaciers and the Greenland ice sheet (although with different amplitude)
- Circulation changes due to freshwater input?



fwu

Take-home messages

- We have introduced a (more) objective criteria to define the smoothing window of nonlinear trends
- The criteria suggests coherently around the world that the noise content (natural variability) remains „unaffected“ by the removal of a non-linear trend of ~25-30 yr
- Our VLM estimates reduce the scatter of non-linear trends on a global scale (with some regional differences)
- Current generation of barotropic models seems to underestimate the role of wind forcing due to the coarse resolution of the models (→ use IB correction)
- Spatio-temporal mapping of nonlinear trends identifies some interesting „hotspots“
- Recent updates in „fingerprinting“ offer unique insights into the processes behind non-linear trends


Thank you for your
attention!