Analysing Mean Sea Level trends and variability in the southwestern Baltic Sea

***Jessica Kelln*[1], *Sönke Dangendorf*[1], *Justus Patzke*[2], *Ulf Gräwe*[3] *and Jürgen Jensen*[1]**

[1]University of Siegen | Germany | Contact: jessica.kelln@uni-siegen.de [2]Hamburg University of Technology | Germany [3]Leibniz Institute for Baltic Sea Research (IOW) | Germany

SPONSORED BY THE Federal Ministry of Education and Research

This presentation participates in OSPP

Outstanding Student Poster & PICO Contest

Background

Within the BMBF Project AMSeL Baltic Sea high quality relative mean sea level (RMSL) time series from tide gauge records were calculated for the Baltic Sea with a particular focus on the German coasts in the southwestern part.

Here we present final results of the trend and variability analysis of the new MSL dataset. We have the following objectives:

- **To estimate long-term changes and variability.**
- **To investigate physical processes.**
- **To investigate the link to global mean sea level (GMSL).**

Exchange & redistribution processes

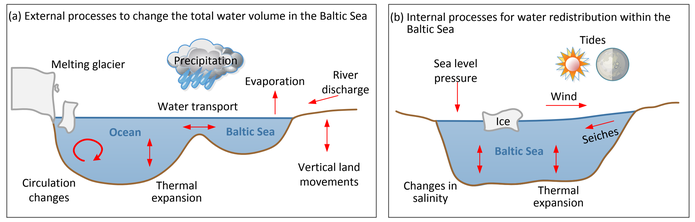


Fig. 1: *a) Processes involved in the change of the total amount of water in the Baltic Sea. b) Internal processes for the redistribution of water within the basin. Reproduced and supplemented according to Johansson (2014).*

Data

- 139 tide gauges in the Baltic Sea (96 from PSMSL, Holgate et al. 2013)
- 72 tide gauges in the southwestern Baltic Sea
- Corrections: seasonal cycle and GIA (global isostatic adjustment) from NKG2016LU (Vestøl et al. 2016)
- Barotropic and baroclinic model runs from a 3D ocean model (Gräwe et al. 2019)
- Sea level anomaly data from the AVISO satellite altimetry multi-mission product (Corrections: seasonal cycle and recorrection of the dynamic atmospheric correction)

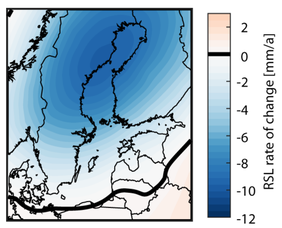


Fig. 2: *RSL rate-of-change from GIA in the Baltic Sea (*Vestøl et al. 2016).

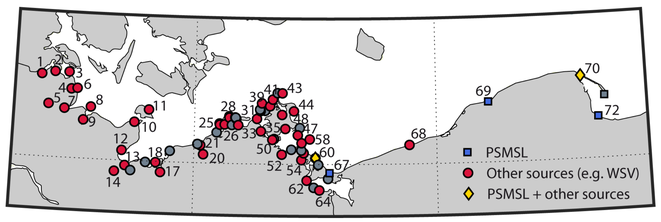


Fig. 3: *Tide gauge stations in the southwestern Baltic Sea: Grey stations were not used for the analysis, because the temporal availability of these stations is < 19 years.*

Results 1: Linear MSL trends

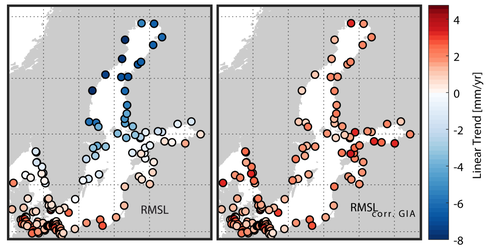


Fig. 4: *Linear trends of all 139 RMSL and GIA corrected $RMSL_{corr.GIA}$ time series. Please note that the available period for the trend estimation varies between sites from 19 to 185 years.*

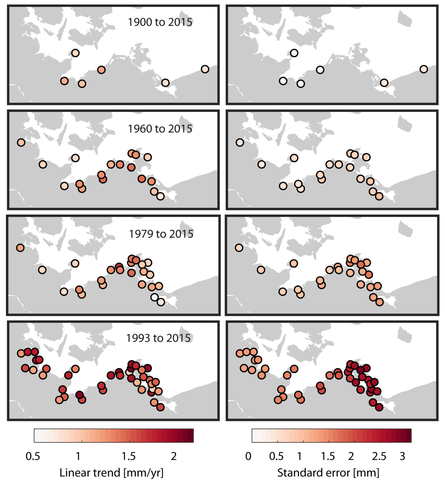


Fig. 5: *Comparison of the linear trends and 1-σ standard error (68-% confidence interval) over common periods. Please note that trends have only been fitted if at least 75% of data are available over the respective period.*

Results 2: Forcing factors at different time scales

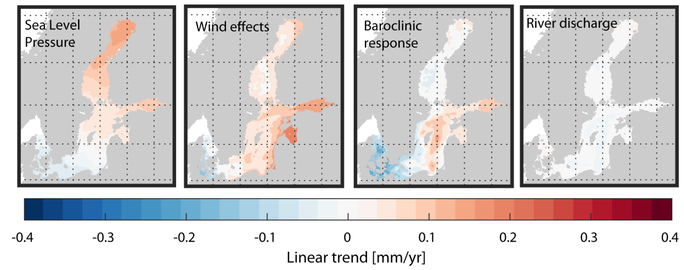
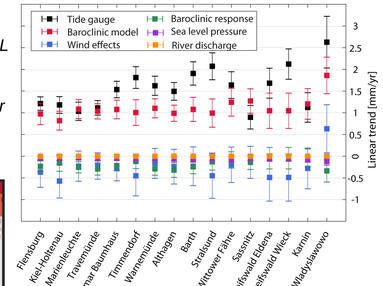
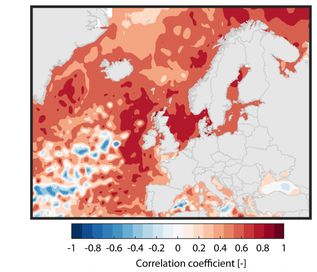


Fig. 6: *Linear MSL trends based on the sensitivity experiment outputs of a 3D baroclinic ocean model (Gräwe et al., 2019). Shown are sea level pressure effects, wind effects, baroclinic response and changes in river discharge for the period 1949 to 2014.*

Fig. 7: *Comparison of the linear MSL trends from tide gauges (at least 75 % data availability) and the sensitivity experiment outputs of the 3D model for the period 1949 to 2014.*





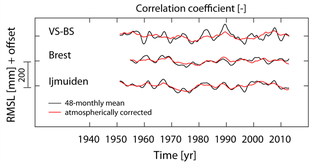


Fig. 8: *Top: Correlation coefficients between the 48-months moving averages of VS-BS with the AVISO data for the common period 1993 to 2014. Bottom: The respective time series together with exemplary selected time series of Brest and Ijmuiden.*

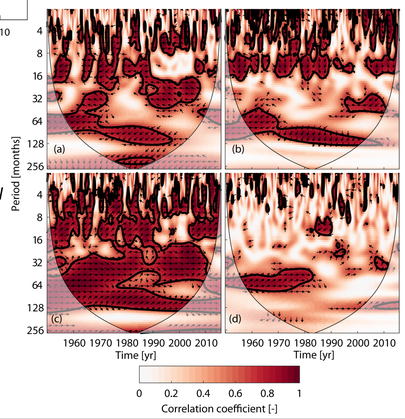
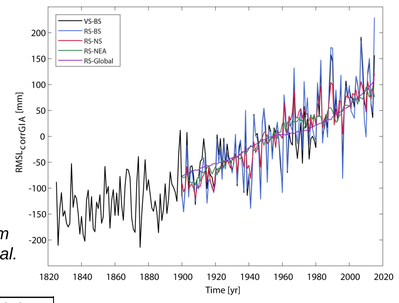


Fig. 9: *Wavelet coherence (colours) and phase relationship (arrows) between the RMSL time series Warnemünde with the individual components (a) sea level pressure, (b) baroclinic response, (c) wind effects and (d) river discharge. The thick black lines indicate the 95 % confidence interval. Areas influenced by boundary effects are brighter and separated by a thin black line.*

Results 3: Relationship to the global ocean

Fig. 10: *Comparison of the average Baltic Sea time series (calculated from 121 tide gauge records) VS-BS with the basin averages from the spatial and temporal reconstruction from Dangendorf et al. (under review) for the Baltic Sea (RS-BS), North Sea (RS-NS), Northeast Atlantic (RS-NEA) and global (RS-Global).*



Tab. 1: *Comparison of the linear trends over the 20th century (1900 to 2015) for the average southwestern Baltic Sea time series (calculated from 31 tide gauge records) VS-SWBS, VS-BS, RS-NS, RS-NEA and RS-Global.*

VS-SWBS	VS-BS	VS-NS	VS-NEA	RS-Global
1.2 ± 0.1 mm/yr	**1.7 ± 0.1 mm/yr**	**1.8 ± 0.1 mm/yr** (Dangendorf et al. under review)	**1.5 ± 0.1 mm/yr** (Dangendorf et al. under review)	**1.4 ± 0.1 mm/yr** (Dangendorf et al. under review)

Conclusions

- **Long-term trends are dominated by GIA. The southwestern Baltic coastline lies in the transition zone between land uplift and subsidence (largest uncertainties).**
- **MSL changes are characterized by considerable interannual to decadal variability.**
- **Interannual variability is dominated by barotropic atmospheric forcing (wind & pressure). On decadal time scales external processes (e.g. steric variations in the deep NEA) control the MSL variability.**
- **Basin internal dynamics (atmospheric forcing & steric variations) induce redistribution processes leading to spatially varying trends at multiple time scales (the German coastline has experienced lower trends than the entire basin).**
- **Basin-wide MSL trends over the entire 20th century are within the range of available GMSL estimates.**

EGU2019-12953

References

- Dangendorf et al. (under review.): Persistent acceleration in global sea-level rise since the 1970s.
- Gräwe et al. (2019): Decomposing mean sea level rise in a semi-enclosed basin, the Baltic Sea. In: Journal of Climate, doi: 10.1175/JCLI-D-18-0174.1.
- Holgate et al. (2013): New Data Systems and Products at the Permanent Service for Mean Sea Level. In: Journal of Coastal Research, Jg. 288, 493-504. doi: 10.2112/JCOASTRES-D-12-00175.1.
- Johansson (2014): Sea level changes on the Finnish coast and their relationship to atmospheric factors. Dissertation. University of Helsinki, Helsinki, Finnland, Finnish Meteorological Institute.
- Vestøl et al. (2016): NKG2016LU, an improved postglacial land uplift model over the Nordic-Baltic region. Vortrag, Presentation at Nordic Geodetic Commission Working Group of Geoid and Height Systems meeting, Tallinn.

Scan this code for a PDF of this poster