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

Jessica Kelln¹, Sönke Dangendorf², Justus Patzke², Ulf Gräwe³ and Jürgen Jensen¹

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

1.7 (0.1 mm/yr) to 1.8 ± 0.1 mm/yr (Dangendorf et al. under review)

Results 1: Linear MSL trends

Results 2: Forcing factors at different time scales

Conclusions

• Long-term trends are dominated by GIA. The southwestern Baltic coastline lies in the transition zone between 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.

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

Data

• 1.39 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 NKG2016ULV (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-product (Corrections: seasonal cycle and re-creation of the dynamic atmospheric correction)

Results 3: Relationship to the global ocean

Results 4: Linear MSL trends

Results 5: Comparison of the linear trends and 1σ standard error (±1σ 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.

Fig. 4: Linear trends of all 139 MSL and GIA corrected RMSL 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 1σ standard error (±1σ 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.

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.

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 (VS-BS), North Sea (RS-NS), Northeast Atlantic (RS-NEA) and global (RS-Global).

 mientras que la congelación de hielo induce redistribución de procesos en la cuenca del Báltico. En el mar inferior ( Palestinians is located in the red-colored zone), el clima se encuentra en un estado de cambio seco, con un incremento en la temperatura y la humedad, lo que puede afectar tanto a la vegetación como a la fauna. En el mar superior ( Palestinians is located in the blue-colored zone), la situación es más fría, con una disminución en la temperatura y la humedad, lo que puede favorecer el crecimiento de plantas y animales acuáticos. En resumen, la congelación de hielo puede tener un efecto perjudicial en el equilibrio ecológico del mar, pero también puede desempeñar un papel positivo en el manejo de los recursos marinos y la conservación del ambiente acuático.