2020

Mean Sea Level Changes in the Southwestern Baltic Sea Over the Last 190 Years

Jessica Kelln

Sönke Dangendorf
Old Dominion University, sdangendorf1@tulane.edu

Ulf Gräwe

Holger Steffen

Justus Patzke

See next page for additional authors

Original Publication Citation

Kell, J., Dangendorf, S., Gräwe, U., Steffen, H., Patzke, J., & Jensen, J. (2020). Mean sea level changes in the southwestern Baltic Sea over the last 190 years. 3rd Baltic Earth Conference: Earth System Changes and Baltic Sea Coasts, Virtual, June 2-3, 2020.

Mean sea level changes in the southwestern Baltic Sea over the last 190 years

Jessica Kelln[1], Sönke Dangendorf[2], Ulf Gräwe[3], Holger Steffen[4], Justus Patzke[5] and Jürgen Jensen[1]

[1]Research Institute for Water and Environment, University of Siegen, Siegen, Germany (jessica.kelln@uni-siegen.de)
[2] Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, Virginia, USA
[3] Leibniz Institute for Baltic Sea Research Warnemünde, Warnemünde, Germany
[4] Lantmäteriet, Gävle, Sweden
[5] Technical University of Hamburg-Harburg, Hamburg, Germany

1. Introduction

Over the 20th century a global mean sea level (GMSL) rise of about 1.3 to 2 mm/yr could be observed and it is projected to further accelerate throughout the 21st century (Church and White 2006, Hay et al., 2015; Dangendorf et al., 2017). However, GMSL rise is neither temporally nor spatially uniform. Because of a number of different factors (e.g. mass changes and gravitational effects due to melting ice sheets/glaciers, expanding/contracting volume due to temperature and salinity fluctuations, ocean circulation changes, atmospheric forcing), regional mean sea level (MSL) trends can vary significantly from the global average. In order to develop sustainable coastal protection strategies, local/regional sea level studies are necessary.

In the Baltic Sea the availability of observations with some of the longest tide gauge time series in the world is excellent, but especially in the southwestern Baltic Sea MSL time series have until now only been made available and investigated at a few locations (e.g. PSMSL). This is mainly because so far only handwritten charts have been available for historic measurement periods especially before 1975. Now, after extensive digitization works, the Federal Waterways and Shipping Administration (WSV) have provided electronic high-resolution data (hourly) since about 1950 for a larger number of tide gauge stations at the German Baltic coastline. In the context of the BMBF research project AMSeL_Ostsee these high-resolution data were the first time compiled and assembled with other available data to generate a novel long and high quality monthly MSL dataset (Kelln et al. 2019). In this contribution, we present detailed analysis of MSL changes with a special focus on the southwestern Baltic coastline.

2. Methods and results

We analyze MSL records with a temporal availability of more than 19 years (to take the nodal cycle into account) and (1) calculate relative mean sea level (RMSL) trends, (2) examine interannual variations around the long-term trend, (3) assess potential changes in the rate of rise (i.e. accelerations), and (4) investigate the link to GMSL considering the influencing physical processes.

The analyses in the southwestern Baltic Sea show linear trends of the RMSL over the 20th century (1900 to 2015) from 0.93 mm/yr (Marienleuchte) to 1.67 mm/yr (Travemuende). The differences between the individual tide gauge locations are based on data gaps, local effects (e.g. wind effects, sea level pressure, baroclinic response) (Gräwe et al. 2019) and vertical land movements (VLM). RMSL changes in the Baltic Sea are dominated by VLM due to glacial isostatic adjustment (GIA) and broadly consistent with known patterns of RMSL rates-of-change due to GIA. We corrected our MSL time series for GIA by using the VLM Modell NKG2016LU of the Nordic Geodetic Commission (NKG) (Vestøl et al. 2019). The uncertainties in the estimates of RMSL changes due to GIA are still large, especially for the southwestern Baltic coastline, since it is located in the transition area between land uplift and subsidence due to GIA. Furthermore, monthly MSL changes are characterized by considerable interannual variability with distinct differences to the neighboring stations from the North and Baltic Seas. The long-term GIA corrected mean sea level trend for 1900 to 2015 is estimated to be 1.2 ± 0.1 mm/yr for the southwestern Baltic coastline and lies at the lower limit of current GMSL trend estimators (1.3 to 2 mm/yr) due to regional effects. Mainly responsible are the dominant westerly winds redistributing the water from the southwestern to the northeastern Baltic coast, but at the same time leading to balancing water inflows from the North Sea (see also Gräwe et al. 2019). Furthermore, the investigations show acceleration tendencies in the rates of increase since the end of the 19th century with slight interruptions in the middle of the 20th century.

References

Church, White (2006) A 20th century acceleration in global sea-level rise. In: Geophysical Research Letters, Jg. 33, 1, n/a. doi: 10.1029/2005GL024826.

Dangendorf et al. (2017) Reassessment of 20th century global mean sea level rise. In: Proceedings of the National Academy of Sciences of the United States of America, Jg. 114, 23, 5946-5951. doi: 10.1073/pnas.1616007114.

Gräwe, Klingbeil, Kelln, Dangendorf (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.

Hay et al. (2015) Probabilistic reanalysis of twentieth-century sea-level rise. In: Nature, Jg. 517, 7535, 481-484. doi: 10.1038/nature14093.

Kelln, Dangendorf, Jensen, Patzke, Fröhle (2019) Monthly sea level from tide gauge stations at the German Baltic coastline (AMSeL_Baltic Sea). PANGAEA, https://doi.pangaea.de/10.1594/PANGAEA.904737

PSMSL (2016) Tide Gauge Data. Retrieved 26 Feb 2016 from. http://www.psmsl.org/data/obtaining/

Vestøl, Ågren, Steffen, Kierulf, Tarasov (2019) NKG2016LU: a new land uplift model for Fennoscandia and the Baltic Region. In: Journal of Geodesy, Jg. 93, 9, 1759-1779, doi: 10.1007/s00190-019-01280-8.