GEOCENTRIC MEAN SEA LEVEL FIELDS AT THE GERMAN NORTH SEA AND BALTIC COAST

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Global mean sea level has risen over the 20th century (Hay et al. 2015; Dangendorf et al. 2017) and under sustained greenhouse gas emissions it is projected to further accelerate throughout the 21st century (Church et al. 2013) with large spatial variations, significantly threatening coastal communities. Locally the effects of geocentric (sometimes also referred to absolute) sea level rise can further be amplified by vertical land motion (VLM) due to natural adjustments of the solid earth to the melting of the large ice-sheets during the last deglaciation (GIA) or local anthropogenic interventions such as groundwater or gas withdrawal (e.g. Santamaría-Gómez et al. 2017). Both, the observed and projected geocentric sea level rise as well as VLM are critically important for coastal planning and engineering, since only their combined effect determines the total threat of coastal flooding at specific locations. Furthermore, due large spatial variability of sea level, information is required not only at isolated tide gauge (TG) locations but also along the coastline stretches in between.

Information about geocentric sea-level rise covering the entire ocean is nowadays provided by satellite altimetry (since 1992), while beforehand measurements were limited to a few TGs at certain locations around the world, which are further affected by VLM. However, although limited in space, these TGs provide historical information reaching much farther back in time than satellites do. In this contribution, we therefore combine both measurement types in combination with the latest version of high resolution ocean reanalysis data, to calculate geocentric sea level fields along the entire German North and Baltic Sea coastline having the same spatial resolution as satellite altimetry and/or ocean reanalysis and the same temporal information as TGs.

To do so, we make use of a novel TG dataset recently collected and digitized in the BMBF projects "AMSeL North Sea" and "AMSeL Baltic Sea". This dataset consists of 70 MSL records spanning the period from 1848-2016, which significantly improves the coverage compared to the PSMSL database with currently 9 gauges in the region. The TG data is complemented with different satellite altimetry products (ESA-CCI and AVISO) covering the period 1993-2016 and a 3D ocean reanalysis (Gräwe et al., in press) covering the entire North and Baltic Sea for 1948-2015.

Before merging the different data sources, TGs need to be corrected for contaminating VLM effects, which are not measured by satellites. Here, VLM estimates from different data sources (GPS, TG minus altimetry, and different GIA models) are carefully evaluated at each TG using a novel algorithm. The algorithm assumes that the majority of the trend differences between individual locations in this region is indeed driven by VLM and the best combination of estimates is the one showing the highest correlation to the spatial variability in relative sea level trends. The application of the algorithm leads to a reduction of the observed spatial trend variability between individual stations.

To generate high resolution MSL reconstructions of similar spatial coverage as satellite or model data and the same temporal availability as TGs, we use a well-established reconstruction approach based on empirical orthogonal functions (EOFs). With a principal component analysis the sea level signal is split into temporally variable EOF modes of similar variability and ordered by the amount of variance of the total signal explained, so that the first mode explains the largest percentage of variability. TGs are then used to estimate the temporal amplitudes of these modes in a least-squares sense to project the sum of modes and therefore the full field into the period for which TGs are available.

As a result, geocentric sea level fields along the entire German North and Baltic Sea coastline with a high spatial and temporal resolution are provided. These can be used to put recent satellite altimetry measurements in a historical context and track potential long-term changes and accelerations along the entire coastline in order to inform planners, policy makers and the general public as well.

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