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The role of vertical land movements on late 19th century sea level rise at Cuxhaven, Germany

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Tide gauges, located along the world's coastlines, represent one of the most important data sources with information about sea level change back into the 17th century, bridging the gap between paleo proxies and modern remote sensing data sources. While the worldwide coverage of tide gauges has increased considerably since the mid-20th century, there are only a few gauges available providing information about regional sea level changes before 1900. Furthermore, these tide gauge measurements are often contaminated by local vertical land movements (VLM) resulting from tectonic processes or local anthropogenic interventions. Such non-climatic effects need to be removed from the raw data to uncover climate signals, which are important, for instance, for answering the question whether and when sea level started to accelerate from the nearly constant rates over the past 2000 years.
Here we focus on one of these long tide gauge records: Cuxhaven, which is located in the German Bight and provides uninterrupted digital time series of tidal high and low water levels since 1843. The record has been extensively studied during the past decades with respect to regional and global sea level rise. However, a question that still remains is the role of local subsidence before 1900 at the lighthouse of Cuxhaven, located close to the tide gauge. In 1855 Lentz installed a granite height mark at the lighthouse, which was later used as a proxy for VLMs of the tide gauge itself. The height of the control mark was derived by a levelling between Hamburg and Cuxhaven. These levellings were repeated five times between 1855 and 1900 and later evaluated by Siefert and Lassen (1985) with respect to the role of local subsidence. Based on a linear regression of individual levellings Siefert and Lassen (1985) concluded that the lighthouse subsided by an average rate of 2.8 mm/yr (1855-1875: 4.2 mm/yr; 1876-1890: 2 mm/yr; 1890-1900: 1.2 mm/yr). However, due to the massive uncertainties of these early levellings (especially the first by Lentz in 1855), the correction has been questioned several times in the recent years (e.g. Jensen et al. 1992; Wahl et al. 2011; Jensen et al. 2011). Here, we choose a different approach and compare the record of Cuxhaven to 18 nearby stations from the North and Baltic Sea region. Based on visual inspections, linear regression and correlation analyses before and after applying the correction we find that the Cuxhaven record compares best to the other sites if the correction is not applied. Therefore, we conclude that the correction remains still questionable and should not be applied to the raw data.

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