Satellite-derived shoreline dynamics at the German Baltic Sea

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INTRODUCTION

Dunes play a central role in the coastal protection strategy of the German part of the Baltic Sea coastline in the state of Mecklenburg Western Pomerania (MWP). 25% percent of the flat coast is solely protected by dunes as the only protection measure in these places. Along a further 20% of the coast, dunes provide protection in concert with other protection measures e.g., dykes, groynes, and wave breakers. Yearly a volume of 500.000 m³ of sand is required to sustain the dune volumes and replenish the shoreline in order to uphold the protection of the hinterland.

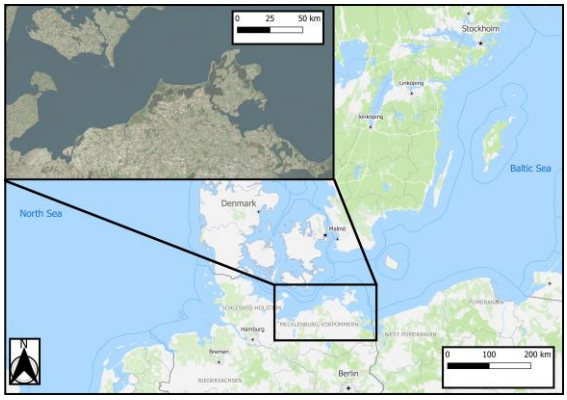

Figure 1 - The German coastline with a detailed map of the study area. Background images from GeoBasis-DE/BKG (©2009), Google and Bing Aerial/Earthstar Geographics SIO (©2022 TomTom).

Considering the sea level rise and the limited supply of sand a closer inspection of the sand nourishment strategy and its impact on the regional shoreline of MWP is needed. Data availability on the shoreline development is sparse and only recently have the authorities (StALU) in MWP started to increase the temporal and spatial resolution of measurements (StALU 2009). The Google Earth Engine (Gorelick et al. 2017) has facilitated the possibility to investigate shorelines at the planetary scale with freely available satellite images spanning more than 30 years. Luijendijk et al. (2018) and Bishop-Taylor et al. (2021) have demonstrated the need and feasibility of long-term time series that depict the shoreline development over large spatial scales. We present the results from the remote sensing of the shoreline development at the German Baltic Sea utilizing three decades of satellite images.

MATERIALS AND METHODS

The instantaneous shoreline is extracted from satellite images from the Landsat 5, 7 and 8 missions (1984-2022) utilizing routines from the CoastSat toolbox (Vos et al. 2019). From the extracted shoreline yearly seamless shoreline polygons are constructed. The influence of tidal fluctuations is limited by modelling the tide along the coast and limiting the selected satellite images to images taken close to mean sea level (<0.2m). The findings are validated by comparison to the mean sea level isoline identified from yearly digital terrain models provided by the coastal authorities.

RESULTS

Our preliminary results indicate that the share of receding (65%), advancing (13%) and balanced (22%) coastline has shifted to a system where 45% of the shoreline is receding, 40% percent is advancing and 15% is in balance (Fig. 2). Further work will attribute those changes to the metocean drivers and human influence at the Baltic Sea.

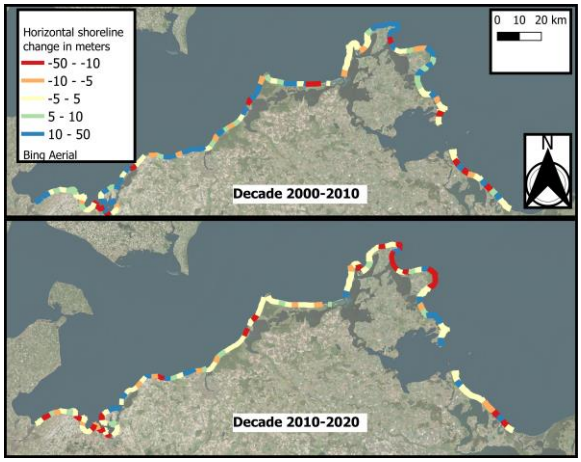

Figure 2 - Shoreline development during the decades 2000-2010 and 2010-2020. Background images from Bing Aerial/Earthstar Geographics SIO (©2022 TomTom). Positive values indicate a seawards move of the shoreline.

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