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Reconstructing large scale differential subsidence in the Netherlands using a spatio-temporal 3D paleo-groundwater level interpolation

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Subsidence is a land use problem in the western and northern Netherlands, especially where both shallow soft soil subsidence and deeper subsidence components, including glacio-isostatic adjustment (GIA), add up. The aim of this study is to improve the estimation of the GIA component within the total subsidence signal across the Netherlands during the Holocene, using coastal plain paleo-water level markers. Throughout the Holocene, the GIA induced subsidence in the Netherlands has been spatially and temporally variant, as shown by previous studies that used GIA modelling and geological relative sea-level rise reconstructions. From the latter work, many field data points are available based on radiocarbon dated coastal basal peats of different age and vertical position. These reveal Holocene relative sea-level rise to have been strongest in the Wadden Sea in the Northern Netherlands. This matches post-glacial GIA subsidence (forebulge collapse) as modelled for the Southern North Sea, being located in the near-field of Scandinavian and British former ice masses.

In this study, geological data analysis of RSL and other paleo-water level data available from the Dutch coastal plain for the Holocene period is considered in addition. The analysis takes the form of designing and executing a 3D interpolation (kriging with a trend: KT), where paleo-water level $Z_{(x,y,age)}$ is predicted and the field-data points are the observations (Age, X, Y and Z as knowns). We use a spatio-temporal 3D grid that covers the Dutch coastal plain, and reproduces and unifies earlier constructed sea level curves and high-resolution sampled individual sites (e.g. Rotterdam). The function describing the trend part of the interpolation separates linear and non-linear components of relative water level rise, i.e.: long-term background subsidence and shorter-term GIA subsidence signal and postglacial water level rise. The kriging part then processes remaining subregional patterns. The combined reconstruction thus yields a spatially continuous parameterization of regional trends that (i) allows to separate subsidence from water level rise terms, and (ii) is produced independently of GIA modelling to enable cross-comparison. Results are presented for the coastal plain of the Netherlands ([SW] Zeeland – Rotterdam – Holland – Wadden Sea – Groningen [NE]). The percentage of the total coastal-prism accommodation space that appears due to subsidence, from the south to the north of the study area increases by 20%. Holocene-averaged subsidence rates from the first analysis ranged from ca. 0.1 m/kyr (Zeeland) to 0.4 m/kyr (Groningen), which is 5-10 times larger than present-day GPS/GNSS-measured rates.

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