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Holocene relative sea-level change, isostatic subsidence and the radial viscosity structure of the mantle of northwest Europe and the southern North Sea: Observational and model results

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A thorough understanding of the causes and effects of differential relative sea-level (RSL) rise in the southern North Sea region since the end of the Last Glacial Maximum is important to help predict future morphological development along the intensively utilised northwest European coastal zone. In this study, a comprehensive observational database of Holocene RSL index points from northwest Europe (Belgium, the Netherlands, northwest Germany, southern North Sea) has been compiled in order to compare and reassess the data collected from the different countries/regions and by different workers on a common time–depth scale. RSL-rise varies in magnitude and form between these regions, revealing a complex pattern of differential crustal movement which cannot be solely attributed to tectonic activity. It clearly contains a non-linear, glacio- and/or hydro-isostatic subsidence component, which is only small on the Belgian coastal plain but increases significantly to a value of ca. 7.5 m relative to Belgium since 8 cal. kyr BP along the northwest German coast. The subsidence is at least in part related to the post-glacial collapse of the so-called peripheral forebulge which developed around the Fennoscandian centre of ice loading during the Last Glacial Maximum. The RSL data have been compared to geodynamic Earth models in order to infer the radial viscosity structure of the Earths mantle underneath NW Europe (lithosphere thickness, upper and lower mantle viscosity), and conversely to predict RSL and reconstruct palaeoshorelines in regions where we have only few observational data (e.g. in the German Bight). A very broad range of Earth parameters fit the Belgian RSL data, suggesting that glacial isostatic adjustment (GIA) only had a minor effect on Belgian crustal dynamics during and after the last ice age. In contrast, a narrow range of Earth parameters define the southern North Sea region, reflecting the greater influence of GIA on these deeper/older samples. Modelled RSL data suggest that the zone of maximum forebulge subsidence runs in a relatively narrow, WNW–ESE trending band connecting the German federal state of Lower Saxony with the Dogger Bank area in the southern North Sea. Identification of the effects of local-scale factors such as past changes in tidal range or (neo-)tectonic activity on the spatial and temporal variations of sea-level index points based on model–data comparisons is possible but is still complicated by the relatively large range of Earth model parameters fitting each RSL curve, emphasising the need for more high-quality observational data.