Seasonal stratification and biogeochemical turnover in the limnic reach of a partially mixed dredged estuary

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The Elbe estuary has often been described as being well mixed; however, both observations and model results show buoyancy-induced stratification. There are two sources of buoyancy. One is from rivers and is responsible for the salinity front, and the second is associated with heating from the atmosphere and is more important in the low-salinity area. Observations demonstrate systematic along-channel temperature gradients, particularly during summer between the shallow and deepened regions of the tidal channel. At the bathymetric jump, the advection of warmer upper river water over the water in the estuarine middle reaches induces the stratification of the water column. In this study, we use an unstructured three-dimensional coupled physical-biological model downscaling a regional operational product to quantify the strength and area of stratification in the Elbe estuary, focusing on limnic and low-saline reaches, including the port area. Coupled simulations demonstrate that this region is a hotspot of heterotrophic decay of diatoms and organic matter advected from the shallow productive upper estuary and the tidal weir. The model is validated against long-term stationary observations. Model simulations reveal that summer stratification intensifies particle trapping in the port area and promotes remineralisation and oxygen depletion. This study highlights that the vertical resolution is important for coupled estuarine models because stratification and vertical exchange impact biogeochemical turnover, particularly in deepened navigation channels and port areas.