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Modeling the interaction between sedimentary organic carbon and infaunal macrobenthos and their temporal (1980–2000) variation in the southern North Sea

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The mutual dependency between sedimentary total organic carbon (TOC) and benthic macrofauna is here for the first time quantified by a mechanistic model. The model describes (i) the vertical distribution of infaunal biomass resulting from a trade-off between nutritional benefit (quantity and quality of TOC) and the costs of burial (respiration), and (ii) the variable distribution of TOC being in turn shaped by bioturbation of local macrobenthos. In contrast to state-of-the-art diagenetic models, our approach resolves variations of bioturbation both in space and time, which depend on the macrobenthic community structure and biomass. Our implementation of the dynamic interaction between sedimentary organic carbon and infaunal macrobenthos is able to capture a real-time benthic response to both depositional and erosional events and provides improved estimates of the material exchange flux at the sediment-water interface. Applications to literature data for the North Sea demonstrate the robustness and accuracy of the model and its potential as an analysis tool for the status of TOC as well as benthic infauna in marine sediments. The model was coupled to two different 3D hydrodynamic-ecological models (ECOSMO and MOSSCO for 10 x 10 and 1 x 1 km setups, respectively) to evaluate the robustness of the estimates with respect to variable forcings on different spatial scales. Hindcast simulations of the benthic status in the southern North Sea from 1980 to 2000 indicate a relatively stable pattern at large temporal and spatial scales but significant variations at small scales.