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Dynamics and Sediment Dynamics in the East Frisian Wadden Sea

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The East Frisian Wadden Sea is a very flat area connecting land and ocean where dynamics is friction dominated. In this paper we demonstrate results from numerical simulations and observations, which facilitate the understanding of Wadden Sea dynamics. The numerical model is based on the 3-D primitive equation General Estuarine Transport Model (GETM) with a horizontal resolution of 200 m and terrain-following vertical coordinates. This model is online coupled with a sediment transport model. We analyse in the paper different characteristics of circulation, which are important for sediment dynamics. This includes the vertical overturning cell: landward motion in the upper layers and seaward motion in the deeper parts of the tidal channels. It is demonstrated that this vertical circulation is a consequence of the temporal asymmetry in the transport patterns, which is dependent on the local depth. We address the individual contribution of different properties of the velocity and turbulence for sediment dynamics. The sediment model driven only by turbulent kinetic energy fails to realistically simulate most of the characteristic temporal and spatial sediment patterns. It is also demonstrated that the velocity gradient in the vertical exerts an important control on the sediment dynamics. Furthermore, the individual and collective contribution of different forcing factors (tides, wind waves and sea-level rise) are studied. The wave-induced bed shear stress is formulated using a simple model based on the concept that the turbulent kinetic energy associated with wind waves is a function of the orbital velocity The inter-comparison between different scenarios demonstrates that the spatial patterns of erosion and deposition are very sensitive to the magnitude of wind waves and sea-level rise.