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The effect of tides and storm surges on sediment transport during overwash events

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Storm events generally result in elevated water levels at the meso-tidal Wadden Sea coast, the Netherlands. This can lead to overwash and inundation of parts of the barrier islands. Currently, large parts of the Dutch barriers are closed off by artificial dunes which prevent overwash during storms. In view of future sea-level rise measures to heighten the hinterland of the barriers island are investigated. A hypothesis is that on the long term the cross-shore sediment transport, caused by overwash and inundation events, can contribute to the vertical accretion of the barriers. Therefore, the partial re-opening of the dunes on the barrier island is considered by the Dutch management authorities.

We identify the dominant cross-shore hydrodynamic and sediment transport processes during an overwash event to study the potential long-term sediment transport. In addition, we focus on the role of the back-barrier basin on overwash dynamics. An XBeach model was set-up and validated against field data collected during overwash on East-Schiermonnikoog, a non-vegetated tip of a barrier island. The simulated wave heights, periods, water levels and flow velocities agree well with the field data. With the validated XBeach model, simulations are executed for a wide variety of storm and tidal characteristics. From the model simulations we conclude that: (1) The erosion and transport of sediment across the beach crest is mainly driven by the cross-shore currents. Infragravity waves and short waves are less important for the sediment transport over the barrier island. (2) Maximum onshore transport occurs during more gentle storms (storm surge level of 1.5-2.0 m) instead of severe storms (storm surge level of 2.5-3.0 m). (3) For mixed-energy, meso-tidal barrier systems like the Wadden Sea, the dynamics of the back-barrier basin have to be taken into account. Water level gradients across the barrier island are strongly influenced by the tidal phase propagation and the difference in storm surge height between the back-barrier basin and adjacent sea.