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Erodibility of salt marsh sediments under storm-surge conditions

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Salt marshes are unique habitats that provide diverse ecosystem services including coastal protection during storm conditions in addition to storing carbon from the atmosphere. The loss of salt marshes is a worrying phenomenon on a global scale and little is known about their likely response, in terms of likelihood of erosion, to predicted increases in storminess. We investigated the relationships between hydrodynamic forcing and the erosion of intertidal sediments during high-magnitude events in the Large Wave Flume (GWK) facility in Hannover.

A range of different intertidal sediments (sandy to clay-silt rich) were extracted from the field and exposed to a variety of true-to-scale simulation of storm conditions (inundation depth and wave height combinations). Sediment surfaces were exposed both horizontally and vertically to investigate sediment mobilisation from marsh platforms or mudflats and marsh edge scarps respectively.

We use structure-from-motion and laser scanning to quantify volumetric changes of the sediment surfaces and micro-CT scanning to characterise the internal structure of the sediments. We find erosion of sediment surfaces exposed under water depths commonly found during storm surge events to be minimal despite maximum bed velocities during the highest simulated energy conditions exceeding those recorded in field studies during storm conditions. For horizontal surfaces, the introduction of micro-topographic features through sculpting of the sediment surface is shown to increase the sediment volumes eroded. For vertical faces, sediment erosion was greatest when exposed at mean water level rather than at depth. A strong contrast in behaviour is also seen between sediment types.

We conclude that marsh sediments, both on the surface and at the margin, are likely to be relatively stable under storm surge conditions, despite significant hydrodynamic forcing. We find that sediment is mobilised when turbulence is introduced through the interaction between wave-driven near-bed current velocities and the bed characteristics themselves (e.g. micro-topography). These interactions are dependent on, inter alia, the elevation of the water level relative to the exposed surface. This suggests a strong feedback between landform structure and morphodynamic response for given conditions and implies that low-frequency, high-magnitude events may be less significant contributors to marsh erosion than more secular processes.