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Quantifying vertical deformation of salt marsh substrates and their recovery during and after storm surge inundation

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Salt marshes are globally-distributed, intertidal wetlands. These wetlands provide vital ecosystem functions (providing habitats, filtering water and attenuating waves and currents) that can translate into valuable ecosystem services. Alongside the existence of suitable horizontal accommodation space, the ability of the salt marsh platform to accrete or increase in elevation at a rate commensurate with current and projected future rates of sea-level rise is critical to ensuring future saltmarsh functioning.

While several studies have assessed whether marsh surface and subsurface processes can keep pace with sea-level rise, few have measured whether, and to what extent, a marsh substrate may consolidate during a storm surge and whether such deformation is permanent or recoverable. This is of key importance given that the frequency and/or magnitude of storm surges is expected to change over the next few decades in some locations. We apply strictly-controlled oedometer tests to understand the response of salt marsh substrates to an applied normal stress (such as that exerted by a storm surge). We compare sediment samples from Tillingham marsh, eastern England, where the sediment is clay/silt-dominated, to samples from Warton marsh, Morecambe Bay, North West England, where the sediment is sand/silt-dominated.

This research provides, for the first time, insight into the response of two compositionally-different UK marsh substrates to the application of normal stress, such as that induced by hydrostatic loading during extreme inundation events. We demonstrate that both the expected magnitude of axial displacement and the potential to recover vertical deformation after the event are affected by the particle size distribution and the void ratio, as well as past stress conditions on the marsh (particularly as a result of desiccation). The potential for irrecoverable vertical deformation in response to storm surge loading has not previously been identified in salt marsh studies.

The results of this research will improve the ability of future models of marsh geomorphological evolution to better represent these dynamic responses and their implications for the provision of ecosystem services. This research also challenges existing studies which often do not fully parameterise these dynamic responses when considering salt marsh morphodynamics.