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Erosion-flooding interaction on a UK barrier

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Barrier islands are highly dynamic landforms across a range of spatial and temporal scales. Furthermore, many are densely populated, carrying critical infrastructure assets of national importance. Global environmental change is giving rise to non-stationary forcing conditions (accelerating sea-level rise, altered storm character and growing human pressures) with the potential to affect novel, and hence highly uncertain, interactions between barrier islands, their habitats and the human activities they support. The potential for hazardous outcomes (breaching, erosion, flooding) places substantial value on understanding barrier dynamics. The source-pathway-receptor concept underpins erosion-flooding interactions as erosion during storms changes the receptor characteristics, often making flooding more likely.

This paper presents a multi-temporal (centennial, decadal, event-based) analysis of Blakeney Spit, a mixed sand-gravel barrier located on the UK's east coast. Since 2006, Blakeney Spit has experienced a less interventionist management approach that contrasts with the earlier regime of periodically bulldozing parts of the barrier to maintain a steeper cross-shore profile. Given recent endorsements of coastal management schemes that work with, rather than against, nature this case study provides a valuable opportunity to quantify the impact of management regime change on shoreline erosion rates, overwash processes and associated flood hazard.

To assess shoreline change over centennial and decadal timescales, shoreline proxies were extracted from historical maps, vertical aerial photographs and LiDAR digital elevation models. We interrogated three shoreline proxies: the High Water Line, the vegetation line, and the barrier ridgeline. To quantify the sensitivity of Blakeney Spit to extreme water level events, we applied a numerical model chain whereby water levels are modelled using TELEMAC-2D, calibrated using observational tide gauge records. The water level model inform a nested SWAN wave model, the outputs of which drive XBEACH-G, a 1D gravel beach morphodynamic model. Morphologically representative frontages were forced with a series of synthetic and historically representative storm surge scenarios. This approach allowed us to quantify the sensitivity of profile response to initial morphology and forcing conditions.

Interrogation of three distinct shoreline proxies revealed that Blakeney Spit has retreated at approximately 1 m a-1 along its length over the period 1886 to 2016, whilst extending westwards. Within this period, we find evidence of reversing hotspots of erosion and accretion that extend several hundred metres in the alongshore direction. Furthermore, specific attention towards the vegetation line reveals approximately 50 distinct overwash deposits from 1992-2016, with the majority of these features appearing after the 2013 winter storm season. There is evidence of overwash reactivation during less extreme water level events in 2016 suggesting threshold exceedance and increased susceptibility to erosion and flood hazard. These alongshore patterns are complemented by cross-shore orientated numerical modelling which reveals an important role for both morphology and storm character in determining subsequent morphological change and overtopping volumes. This event-driven change in morphology alters the receptor configuration that then increases the associated flood hazard.