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Geomorphological Risk: investigating the relationship between geomorphology, erosion and flood risk at the coast.

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Risks relating to water oversupply (eg: extreme flood events) and undersupply (eg: drought) first appeared in the World Economic Forum's 'Top 5 Global Risks' in 2011 and have persisted in every year since then. Erosion and flooding resulting from events such as Hurricane Sandy or the UK's 2013/14 winter storms demonstrate how the sum of impact and consequence can be especially severe at the coast. Often, erosion and flooding risks are analysed separately owing to complex relationships between driving processes, morphological response and risk receptors. This complexity makes it difficult to extract general rules for erosion-flooding interaction; rather it demands detailed longitudinal studies with explicit attention to local setting.

In this paper, we characterise erosion-flooding interaction on the barrier coastline of North Norfolk, UK. This is achieved through collating and harmonising historical, remotely sensed and field datasets to establish forcing-response relationships over an extended (>120 year) period. Shorelines are extracted using semi-automated edge detection in ArcMap accounting for associated error terms. Shoreline change rates are then calculated at 10 m longshore resolution using the USGS Digital Shoreline Analysis System. Results of this high-resolution long-term shoreline change analysis demonstrate that the nature of erosion-flooding interaction is dependent upon the timescale of analysis. Centennial scale changes provide an erosional backdrop ($\sim$1 meter/year), narrowing the natural protection provided by coastal landforms and associated ecosystems seaward of settlements, land-based activities and infrastructure. Decadal changes reveal dramatic alongshore variability in shoreline retreat, indicative of erosional hotspots and sticking points. Given that the shoreline represents a 'pathway' capable of modifying extreme sea levels, an understanding of the morphological features and their permanence is critical in determining changing flood risk. At the event scale, this study captured the 2013-2014 winter storm season; an exceptional year in terms of hydrodynamic forcing. This season simultaneously evoked shoreline retreat, extensive overwash deposition and flooding of landward freshwater marsh demonstrating a tight coupling of erosion and flood risk.

Such longitudinal shoreline change analysis provides a basis for probabilistic predictions of future shoreline position and morphology. When combined with modelled extreme sea levels, the inclusion of (possible) future shoreline characteristics enables an assessment of future erosion-flooding interactions without the simplifying assumption of static shorelines. The pertinence of this research derives from simultaneous projections of intensifying hazards and coastal vulnerability and the need to deploy engineering solutions to address this increased risk.