Climate change as a mechanism for reducing coastal erosion rates

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1. Introduction

The Holderness coast of eastern Yorkshire, England, is the most rapidly eroding coastline in Europe. Erosion currently threatens local communities and infrastructure, including nationally important gas installations. Interventions to restrict local erosion usually result in enhanced erosion in adjacent, unprotected sections of coast, mirroring morphology seen on the large scale. Simulation of the coastal morphology has previously been undertaken using cliff stability models. These studies use two dimensional cross-section models to consider rotational and translational cliff failures, with topple as the prime coastal recession mechanism. Future erosion rates at each location were calculated by Castedo et al. (2012) for the remainder of this century and found to have a linear response to sea-level rise, however, the predicted response of the wave climate and its impacts on sediment transport for the future were not taken into account. The two dimensional, *plan-view,* coastal evolution model (CEM) is used to assess influences of wave climate (height and angle) variability on erosion and accretion rates along the coast.

For Europe, the North Atlantic Oscillation (NAO) is the dominant ocean mode, modifying the path of the prevailing westerly winds and the position of storm tracks with a quasi-decadal frequency. The influences of climate change on this mode and other influences on the subsequent wave climates for the forthcoming century and are studied using a multi-system modelling approach, however they have not been quantified with any degree of certainty. Values between the most extreme changes found in the literature are used to examine the effects of future wave climate on erosion. Results should be used in conjunction with studies that simulate the effects of sea level rise on erosion rates for the Holderness coast.

2. Modelling

An ensemble of 1,000 model runs was undertaken, each forced with a perturbed version of a measured wave climate representing the period 2010-2100. A baseline run was undertaken, without the application of climate factors, allowing the influences of the changing climate on future coastal morphology to be assessed relative to a baseline.

Landward retreat for the ensemble is fixed at near zero for the chalk outcrop, while the central till section exhibits the greatest sensitivity to wave climate. Totalling the relative change in erosion for each scenario allows the individual influences of wave rotation and wave height to be assessed (figure 1). Negative rotation broadly reduces the rate of erosion and positive values increase rates. Increased erosion is only possible within a narrow band of rotation. Rotations between +10^{o} and +15^{o} lead to a rapid reduction in erosion. Rotating the wave climate further in the positive direction has a minimal effect on the total relative erosion. The influence of a changing wave height factor shows a linear relationship between wave height and relative erosion, where increased wave heights lead to increased erosion rates. If the wave climate is sufficiently rotated in the positive direction the wave height factor has little influence on the erosion rate.

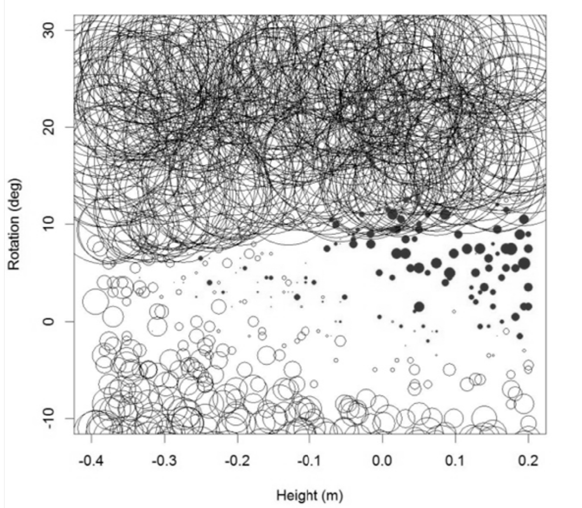

Figure 1: Change to wave height plotted against the wave rotation component. Point size is relative to average erosion rate (2100). Black dots represent increased erosion and empty circles reduced erosion.

3. Discussion

The sensitivity of the coastline to future climate is not uniform in either space or time. Under small rotational changes to wave climate, where the balance between the primary and secondary wave direction is not disrupted, changes in wave height dominate the influence on erosion. Under greater positive rotations, there is a strong indication that modifications to current wave climate could reduce the amount of erosion along the Holderness coastline towards the end of the century. Under these conditions, sediment that would otherwise be transported along the coastline towards the Humber Estuary under the primary deep water wave direction, is instead transported northwards by the secondary wave direction as the balance between the two is disrupted. Sediment becomes trapped along the central sections of the system and acts as a protective barrier against further erosion. Fundamental changes to the system do not occur in the first 40 years of simulation as modifications to the wave climate are applied linearly.

References

Castedo, R., Murphy, W., Lawrence, J., and Parades, C. (2012). A new process-response coastal recession model of soft rock cliffs. Geomorphology, doi: 10.1016/j.geomorph.2012.07.020