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The morphological characterisation of coastal cliff behaviour for risk assessment

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Spatially, cliffs can change through local or regional processes and mechanisms ranging from abrasive downwearing of cliff material to large coherent failures. Temporally, the patterns of erosion vary from long term, continuous adjustment to periods of quiescence punctuated by instantaneous rockfalls. The coarse resolution at which most coastal cliff studies are conducted and the gradual rate of averaged changes mean that short term (here defined as less than decadal) cliff fluctuations and hazards associated with rockfalls are poorly documented. In recent years the introduction of both airborne and terrestrial laser scanning has enabled the generation of detailed, quantitative measurements of cliff surfaces for the first time. Although these techniques have greatly improved the capacity to record change to cliffs, their application as a practical tool for the identification and prediction of rockfall potential over extensive sections of coastal cliffs has been limited to date. Terrestrial laser scanning is capable of providing high detail rock face measurements but is often restricted by time and practicality to the survey of relatively short sections of cliff within the tidal window. Aerial laser scanning generates terrain information over greater areas although the resolution at which it operates is insufficient to detect many of the failures that determine the short term behaviour of the cliff. Consequently, studies of coastal cliff behaviour are currently either coarse and generic, or detailed but highly localised.

This paper presents the results from research into the appropriate spatial and temporal scales at which to monitor coastal cliff behaviour. A three year monitoring programme has been conducted at Staithes, North Yorkshire (UK). Cliff profiles considered to be characteristic of those found within the study area have been surveyed using terrestrial

laser scanning at monthly intervals, providing detailed volumetric information on the processes associated with specific morphologies. Data are presented on in excess of 70,000 recorded failures, which have been correlated with physical attributes such as cliff materials, protrusion and foreshore properties. This high resolution information has been integrated with a wider scale but lower ($24\ \mathrm{ppm}^2$) resolution areal laser scanning survey of the coastline in order to develop an empirical morphology-based risk assessment of coastal change for the whole coastline. The conclusions from this paper question the current methods of coastal zone management, which are often sectored by socio-economic or political boundaries, introducing human constructs to the consideration of cliff erosion. The potential now exists to use quantitative measures of cliff behaviour to identify hazardous areas within the coastal corridor and to help guide management practices based on geomorphological rather than economic significance.