THE MORPHODYNAMICS OF A MIXED SEDIMENT EMBAYMENT IN A HIGH TIDAL RANGE ENVIRONMENT

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INTRODUCTION

As anthropogenic use of the coastal zone diversifies, for example marine energy extraction, the coastal environments of interest to coastal engineers and managers is becoming more varied. Increasingly, the morphodynamics of geomorphologically complex, mixed sediment and geologically constrained beaches are important. Even in areas where erosion and inundation risk is low, understanding of changes to morphodynamics is important to inform ecological studies for environmental impact assessments.
Modern measurement techniques allow for accurate and high resolution measurement of morphology. In addition, supplementary data channels such as RGB color information provide opportunities for innovative derivation of sedimentological information (Fairley et al. 2015). Here, a geologically constrained, mixed sediment embayment is investigated using a terrestrial laser scanner. The data can identify morphological change on a range of scales from cusps to embayment processes. RGB colour data and laser reflectance is used to discriminate between sand, gravel and bedrock.
A study site at Langland Bay, Swansea, UK is considered (Figure 1). The site is of industrial interest since the embayment may be impacted by changes to hydrodynamic and sedimentary processes caused by the proposed tidal lagoon in Swansea Bay. This work not only provides a baseline understanding of natural processes but develops a framework for monitoring of such high tidal range environments to be used in adaptive environmental monitoring plans. Equally important, the embayment represents the sort of high energy, geologically constrained environments found at many wave energy extraction areas. Fairley et al. (2016) suggested that better understanding of the baseline morphodynamics of these regions is required.
The site is located in the Severn Estuary and has a mean spring range of 8.46m. The site faces southwards and is exposed to both locally generated wind waves and swell waves from the North Atlantic. The sites location in the Severn Estuary means North Atlantic swell is somewhat directionally confined by both Ireland to the west and Cornwall to the south.

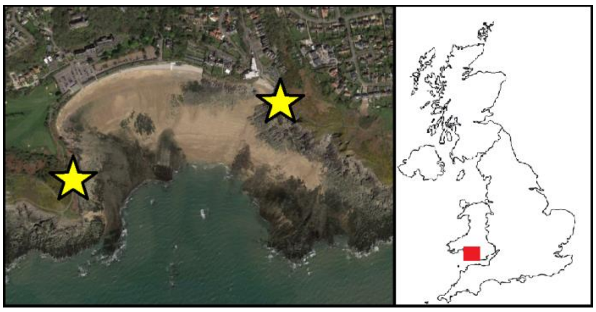

Figure 1 – An aerial photo of Langland bay with the two scan locations marked by stars (left) and a map of the UK indicating the study region in red (right).

METHODOLOGY

A Riegl vZ-4000 terrestrial laser scanner is used to measure the embayment. Wave forcing data is available from a DWR3 buoy and tide levels available from a nearby national network gauge. Surveys conducted on a monthly basis between February 2017 and March 2018 are analysed. Two scan positions are utilized, one on the eastern headland and one on the western headland (Figure 1). This approach has two benefits: firstly it avoids data loss in shadow regions and secondly scanning back towards the beach provides a positive gradient and better laser return signal. The two scans are then combined using scan to scan cloud matching in the Riegl RiScan Pro software. The same scan to scan matching is applied to the supratidal (unchanging) areas of consecutive scans to co-reference all scans into a project co-ordinate system. Point clouds are then exported to Matlab where the neural network pattern recognition tool is used to define areas of different sediment type (Figure 2). The definition of bedrock areas enables consideration of the impact of constraining geology on morphodynamics. Variation in distribution of gravel over the beachface can also be identified. This will allow better understanding of the combined morpho-sedimentary evolution of these beaches. The baseline data collected will mean in future any impacts of anthropogenic developments can be assessed.

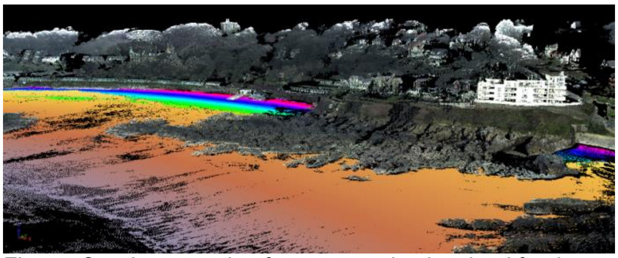

Figure 2 – An example of a measured point cloud for the study site with the different substrate types classified. Constraining geology is marked in true color while gravel in displayed in a rainbow colormap and sand in a golden colormap.

RESULTS

Figure 3 shows significant wave height and peak direction time series for the period analyzed with the survey dates indicated. Mean significant wave height during the studied period is 1.33m and mean peak period is 8.7s. It can be seen that stormy conditions ($H_s > 3$m) occur throughout the year with limited seasonality in wave height evident for the tested year. Wave directions are predominantly from the west but there are significant periods of time where waves are incident from the south east and the extent varies between survey dates.

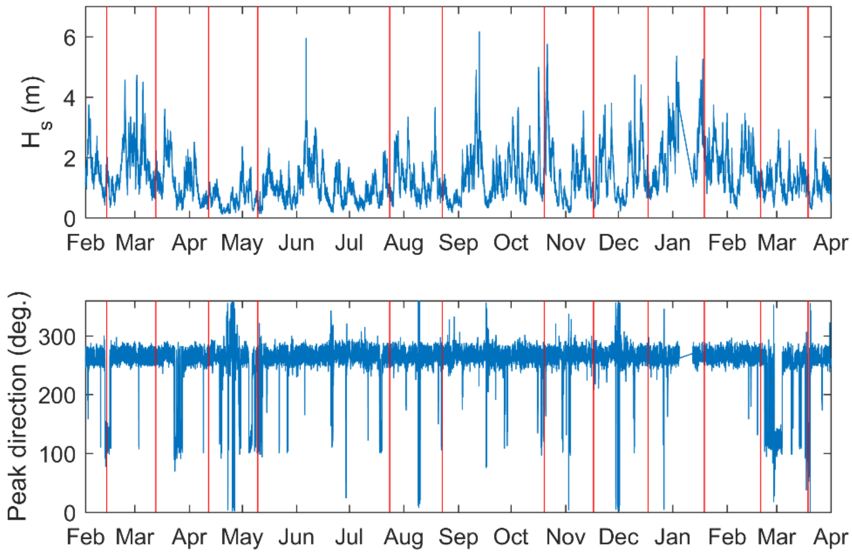

Figure 3 – Significant wave height (upper panel) and peak direction (lower panel) with survey dates indicated as red lines.

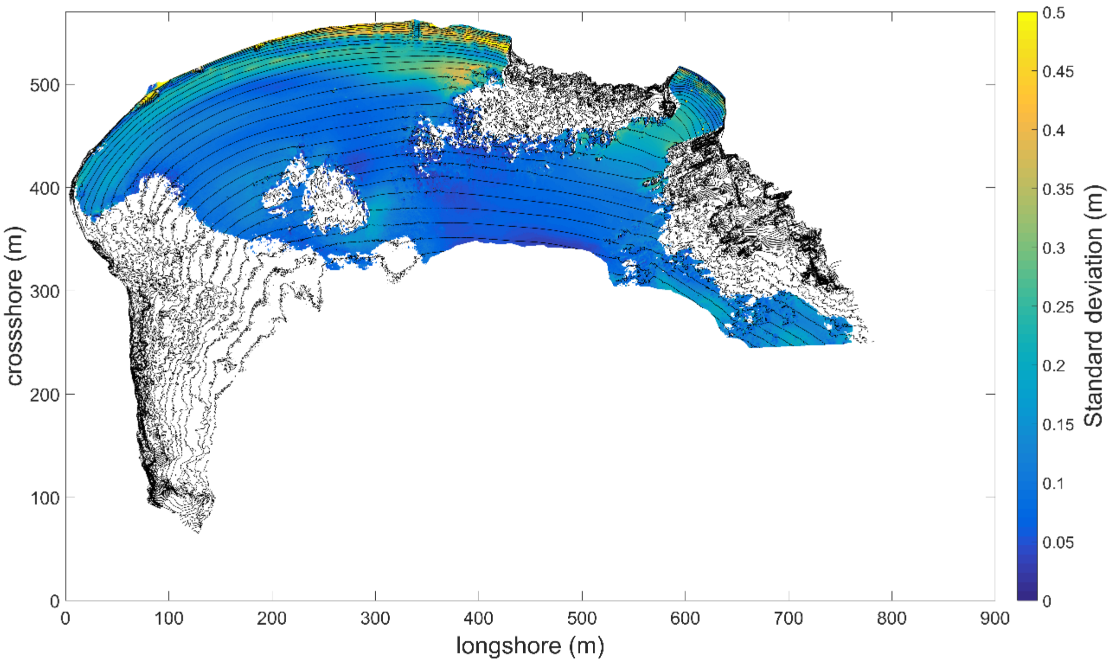

Figure 4 – Standard deviation in vertical beach level (color map) and mean intertidal topography (black contours).

Figure 4 shows the standard deviation in vertical elevation change for the mobile sediment portion of the beach. Color shading represents standard deviation and the black contours mean beach level, which shows the layout of the constraining geology Greatest values of standard deviation occur for the gravel portion of the upper intertidal of the primary embayment. Morphodynamic changes in this area consist of cross-shore exchange and embayment rotation processes. Also noticeable is increased standard deviation in the proximity of the rock outcrops suggesting that the rock outcrops cause greater variability in beach levels.

REFERENCES

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