Dunwich Shoreline Monitoring 2011 to 2016

May 2017 v.1.0

Introduction

This report presents the changes in elevation recorded from six LIDAR surveys of the Dunwich beach frontage on the Suffolk coast. This analysis covers a ~300 m stretch of beach directly in front of Dunwich village (Figure 1), as a follow up to the monitoring undertaken for the Dunwich Coastal Defence Demonstration Project (2007-2011, SC050071/R, available: https://www.gov.uk/government/publications/dunwich-coastal-defence-demonstration-project).

This report is produced as part of the Anglian Coastal Monitoring (ACM) project. The ACM project is a partnership programme of coastal surveys providing long term data for coastal monitoring and analysis. More information about the project can be found at: http://www.coastalmonitoring.org/anglia/ and at the East Anglia Coastal Group: http://www.eacg.org.uk/.

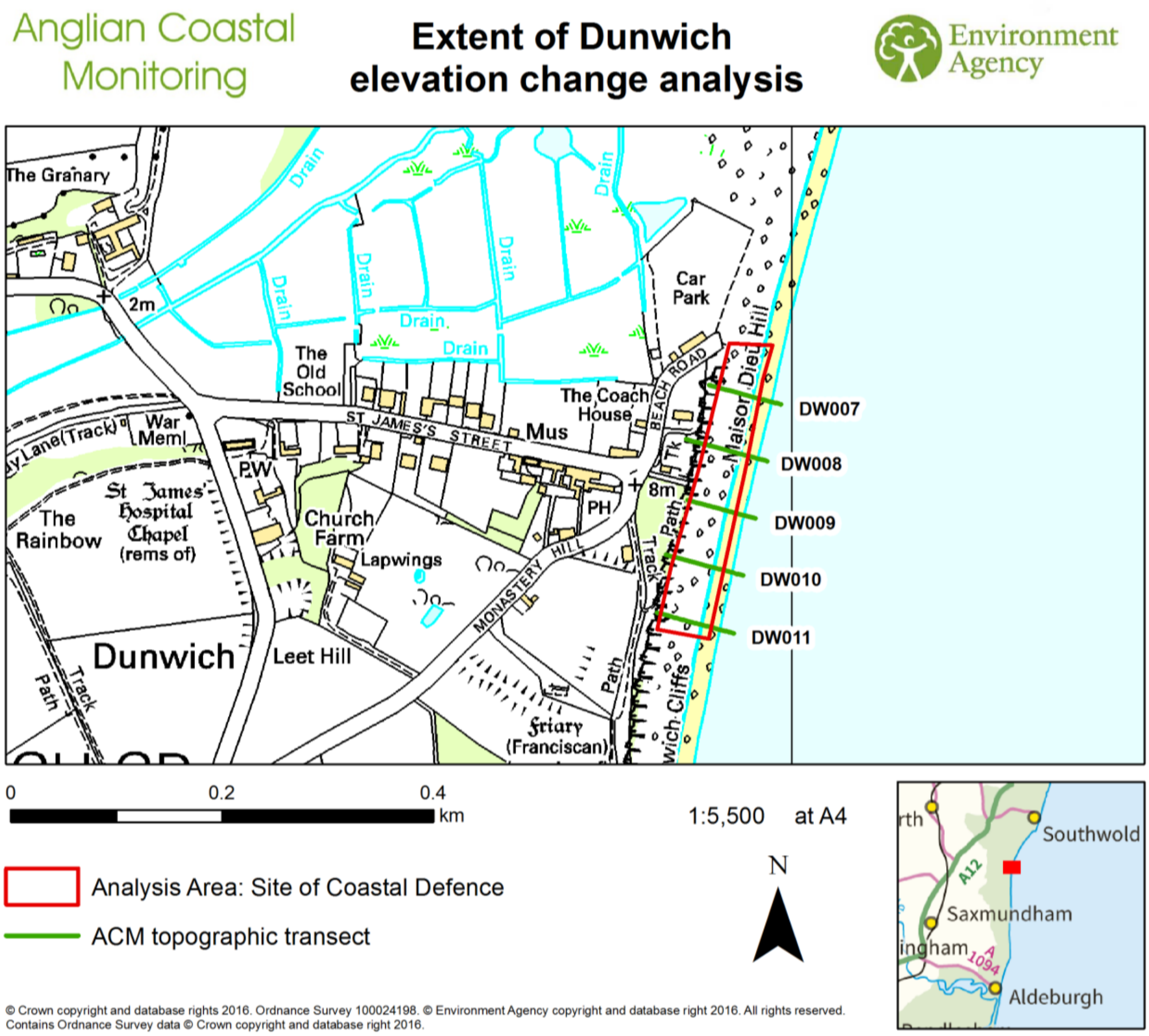

Figure 1: Extent of the Dunwich frontage analysed and the locations of the transects used to extract LIDAR data and produce beach profiles.

Dunwich coastal defence demonstration project

The joint Defra and Environment Agency Flood and Coastal Erosion Risk Management (FCRM) Dunwich coastal defence demonstration project, aimed to evaluate the success and economic viability of an innovative use of geomembrane structures – filled with locally sourced material – to maintain beach levels. This project trialled a low cost, environmentally sensitive approach to protecting the Dunwich to Walberswick coastal SSSI; where traditional 'hard engineering' methods were neither financially nor environmentally justifiable.

Subsequent to the installation of the geomembrane defences in March 2007, a five year monitoring program was undertaken to assess the utility and successes of the project. The monitoring included topographic beach profiles, aerial photography and visual inspections. The results of which indicated the method was an effective low cost option for beach stabilisation, and retention of material at the cliff toe. However, it was noted that the area could be experiencing a natural period of accretion (not retreat) which led to the project team to recommended further monitoring to investigate longer-term trends.

The full Dunwich coastal defence demonstration project can be accessed via: https://www.gov.uk/government/publications/dunwich-coastal-defence-demonstration-project.

Data collection and analysis

This report assesses change measured by six airborne LIDAR surveys captured on the following dates:

- November 2011
- February 2013
- October 2013
- November 2014
- November 2015
- November 2016

LIDAR was the preferred dataset - over the walked GNSS topographic transect data - for this analysis, due to its increased spatial and temporal resolution. Only one topographic transect within the study area - DW007 (Figure 1) - has complete a dataset for the 2011 - 2016 period, therefore the reliability and spatial representativeness are limited.

The LIDAR data are collected by the Environment Agency as part of the ACM project. Further information on the capture of airborne LIDAR as a method of measuring ground elevation can be found in our LIDAR survey information sheet, available from the project website or by request to ACM@environment-agency.gov.uk.

The output of the LIDAR survey is a point cloud of millions of data returns, each containing location, signal intensity and elevation information. From this we create a Digital Surface Model (DSM); this is an unfiltered representation of the beach and ground surfaces.

The LIDAR has a 1 m spatial resolution; this means an elevation measurement every metre on the ground. From this DSM cross sections or profiles, along 5 existing ACM transect lines (Figure 1) – used for the topographic surveys - are extracted. These beach cross sections are used to graphically display change in the beach profile over time. To minimise any errors caused by systematic offset between the two LIDAR datasets, the data are normalised based on areas of no change such as concrete and tarmac surfaces, before any analysis is carried out.

Additionally, the DSMs themselves are compared by creating a difference model, which shows the change between two DSMs from two LIDAR survey datasets. These difference models clearly identify areas of accretion and erosion and potential sediment movement alongshore. Six difference models are presented in this report. Producing a combination of the difference models and extracted beach profiles, provides a more thorough and representative analysis of the elevation change and sediment distribution.

LIDAR elevation change: Difference Models

The following difference models spatially represent the elevation change between 2011 and 2016. The data is overlain on the 2016 aerial imagery to provide context, and include the positions of the ACM transects used for the beach profile analysis. Areas of accretion – positive change in elevation resulting from deposition and accumulation of sediment – are coloured in blue, the greatest changes are represented by the darkest shades. Areas of erosion – negative change in elevation – are graduated from yellow (lowest erosion) to red (highest erosion). A threshold of (0 ±0.25 m), is used for 'No Significant Change' and this data is removed from the outputs. This threshold encompasses the vertical accuracy error of LIDAR products of ±0.15 m.

An overall difference image depicting the 6-year change in geomorphology of the Dunwich area is displayed in Figure 2. In addition to the coastal defence installation area (inset), Figure 2 shows the changes observed along the wider Dunwich frontage. The image clearly depicts two long linear bands of accretion running the length of the beach, with a parallel band of erosion sandwiched in between. The perspective of Figure 2 suggests observed changes within the analysis area are consistent with the sediment patterns observed in the wider beach zone – similar bands of erosion and accretion stretching both north and south of Dunwich village. Generally, the wider local beach zone appears to be experiencing a period of relative stability, with localised sediment movement predominantly in the magnitude of 0.25 - 0.75 m (accretion).

Figures 3 to 7 provide further detail of the observed annual changes in the defence installation location over the 2011 to 2016 period. The November 2011 to February 2013 difference image (Figure 3) depicts a speckled strip of low level (0.26 – 0.75 m) accretion on the landward edge of the beach, extending the length of the analysis area. Towards the southern extent of the frontage there is an area of erosion parallel to the accretion on the seaward edge.

Contrastingly, Figure 4 – February to October 2013 – indicates accretion where Figure 3 displays erosion, extending the length of the frontage. The band of accretion increasing in width from north to south and into the higher, 0.75 m – 1.25 m elevation class.

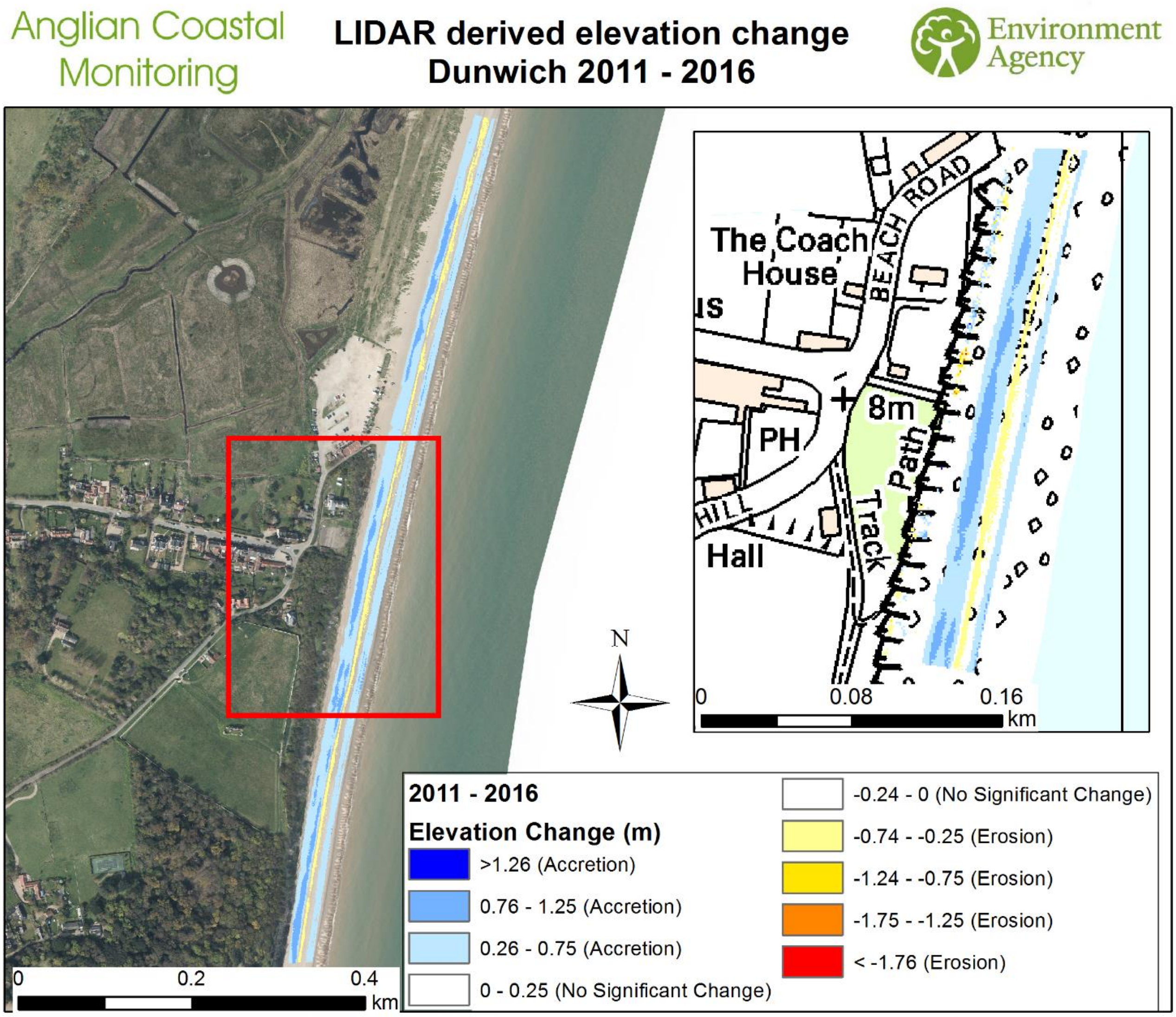

Figure 2: Difference model showing elevation change between November 2011 and November 2016 for the wider Dunwich frontage as well as the defence location (inset).

Figure 5 indicates greater geomorphological change between October 2013 and November 2014 than in previous years. Similarly to Figure 3, there appears to be parallel bands of erosion and accretion extending the length of the analysis area, on the seaward and landward edges, respectively. These bands are notably wider than those observed in previous years, covering a considerable width of the exposed beach, as shown by the underlying 2016 aerial imagery.

Furthermore, between October 2013 and November 2014 there were two notable weather events observed on the Anglian coast; the St Jude’s Day storm in late October and the December east coast storm surge. The St Jude’s Day storm had significantly higher wave energy than that of the December event leading to greater beach scour. However, the observations in Figure 5 show patterns characteristic of the consequences of the December storm surge – beach steepening caused by pushing of material from the lower to upper beach, thus the observations are attributable to the storm surge event.

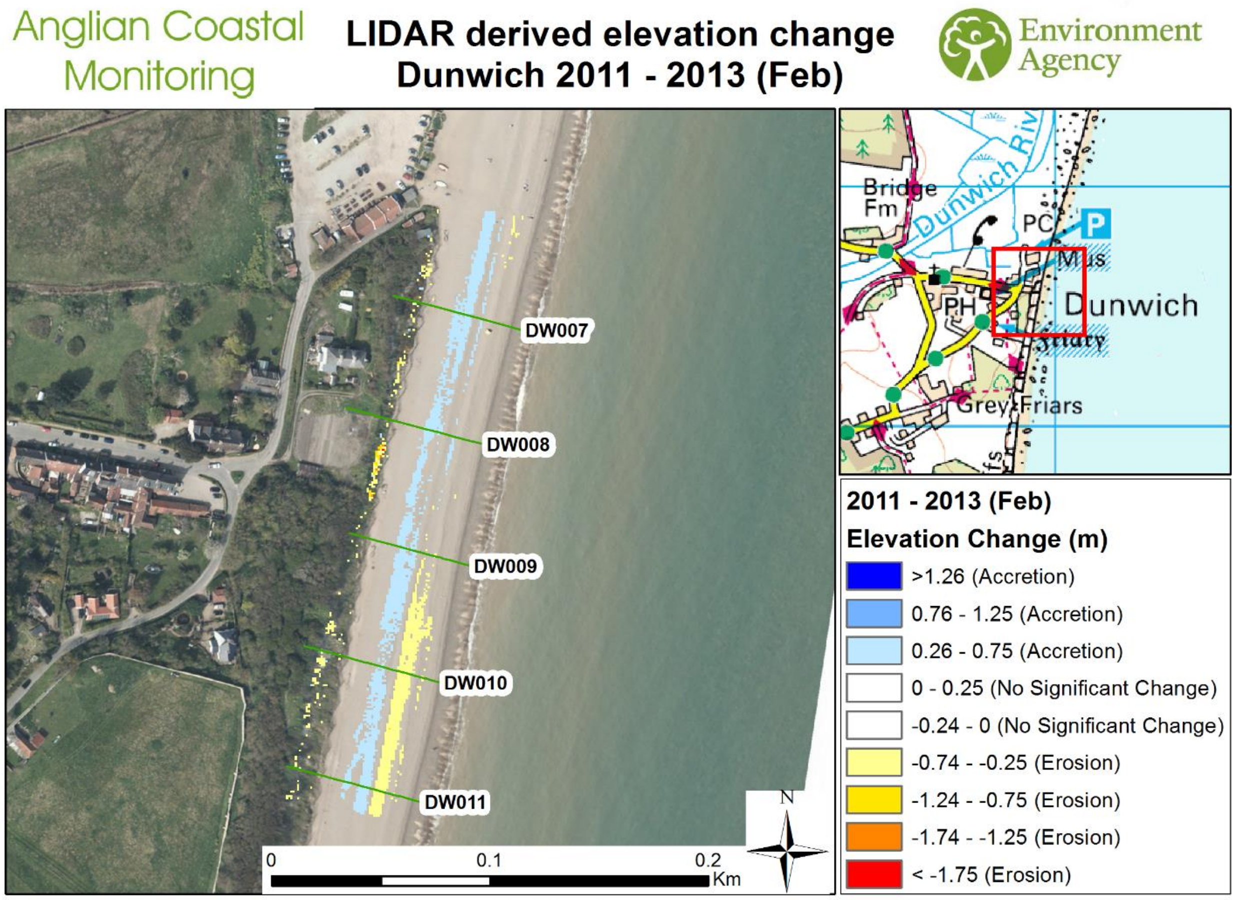

Figure 3: Difference model showing elevation change between November 2011 and February 2013.

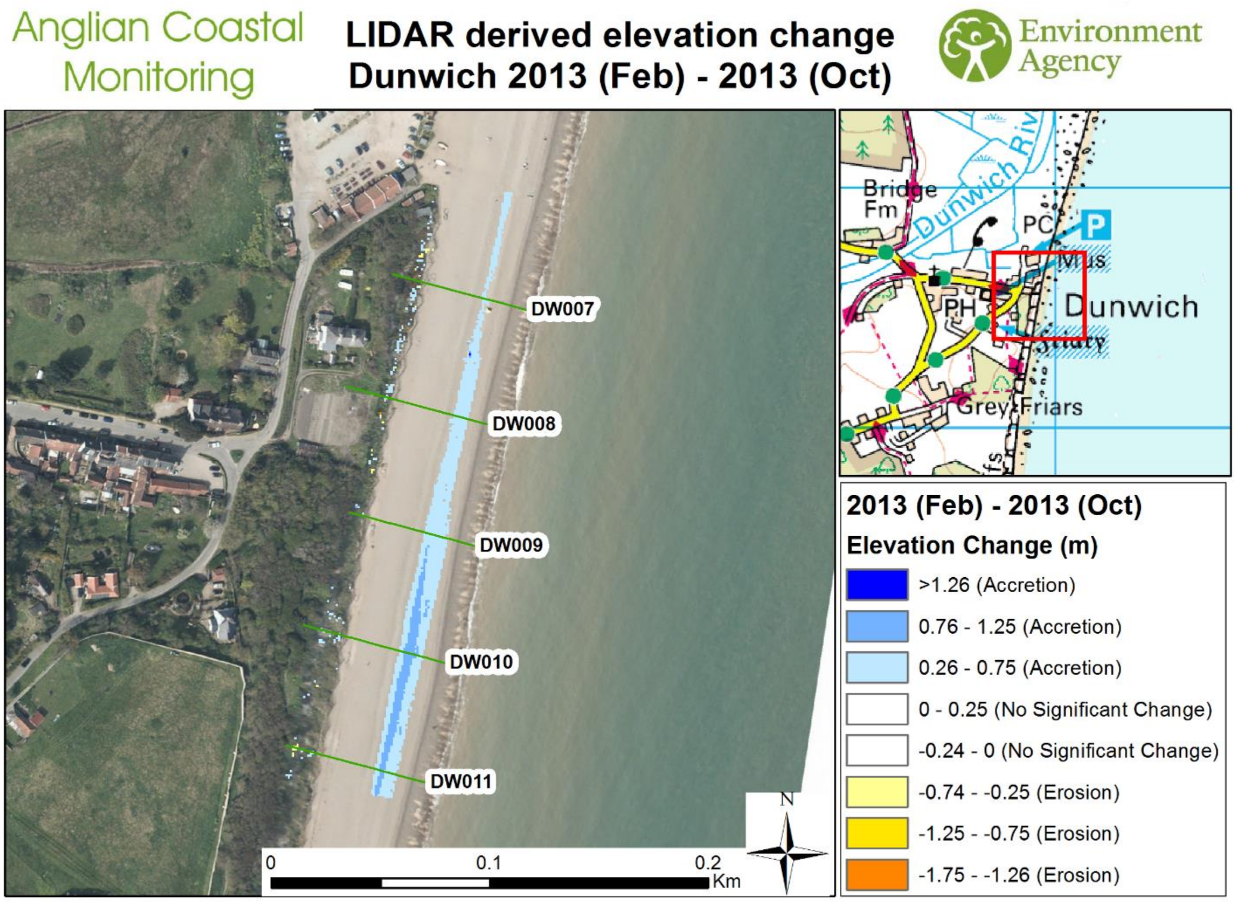

Figure 4: Difference model showing elevation change between February 2013 and October 2013.

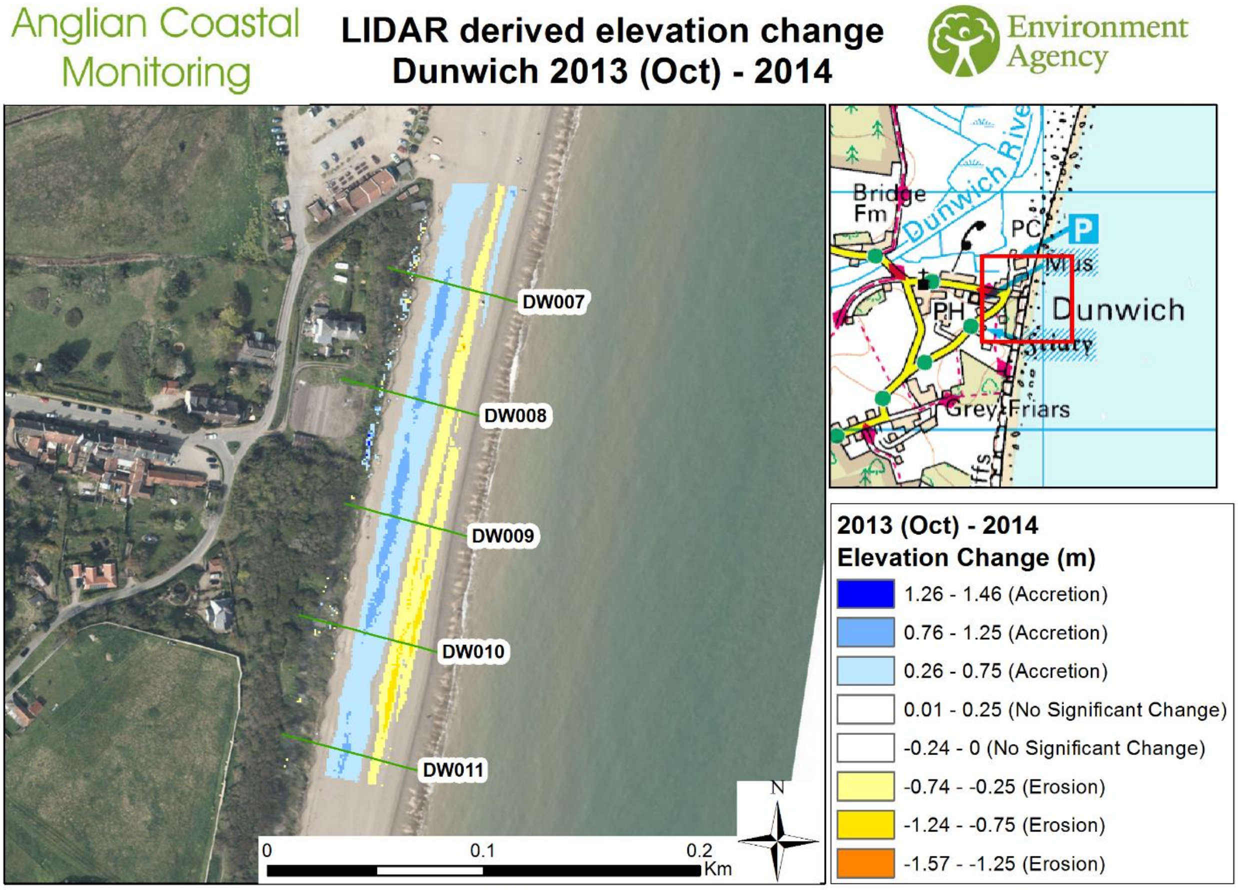

Figure 5: Difference model showing elevation change between October 2013 and November 2014.

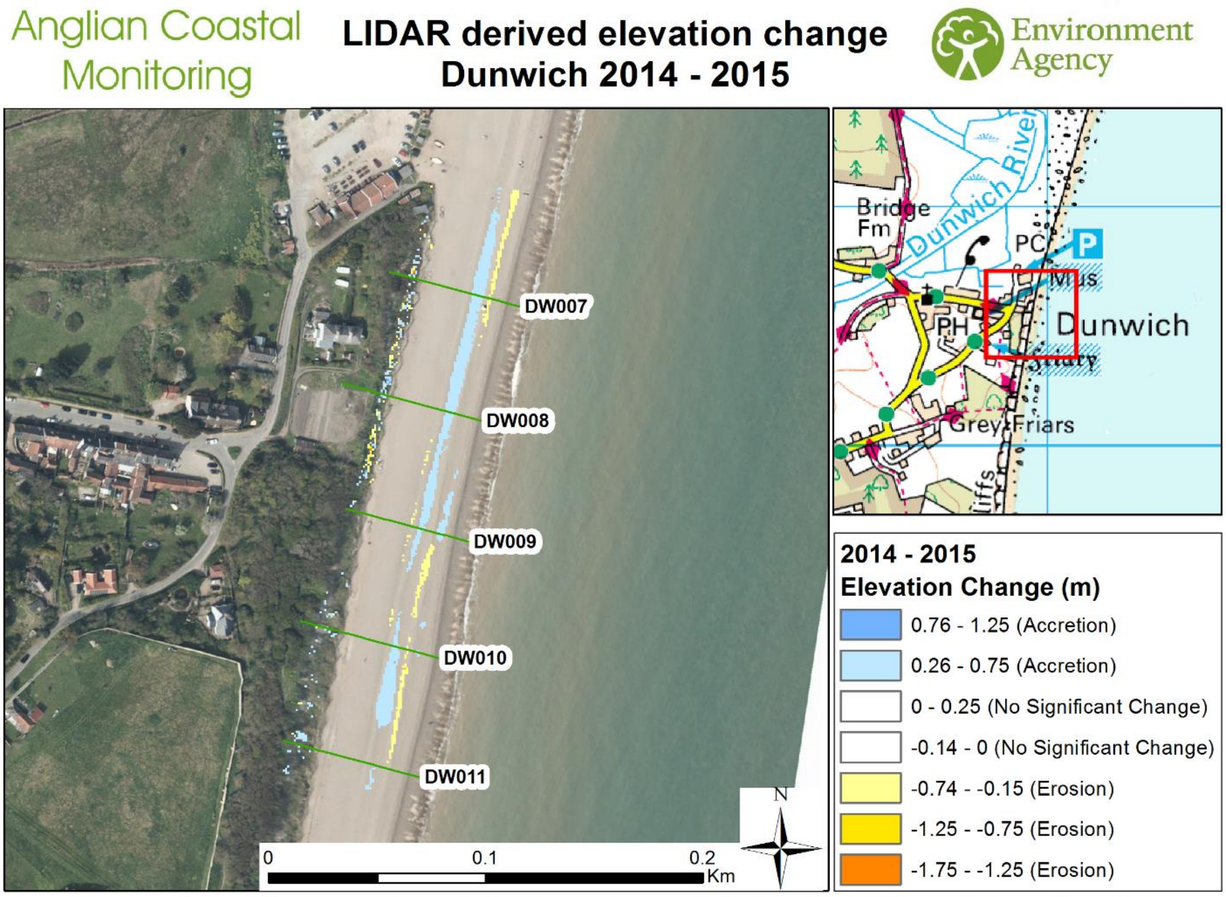

Figure 6: Difference model showing elevation change between November 2014 and November 2015.

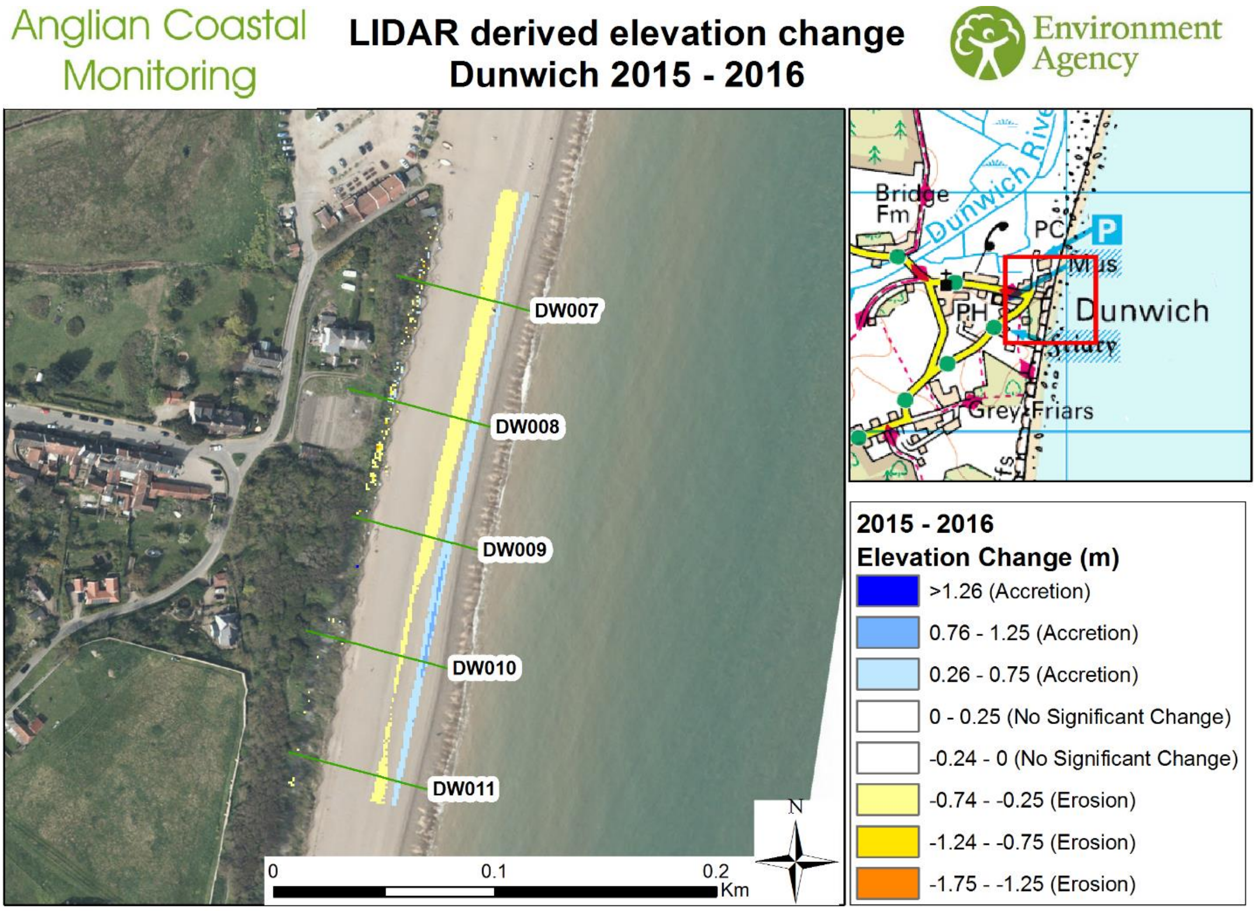

Figure 7: Difference model showing elevation change between November 2015 and November 2016.

Figures 6 and 7 depict the difference images for the 2014 – 2015 and 2015 – 2016 periods respectively, showing small scale fluctuations, typical of a relatively stable beach frontage. The pattern of erosion landward of the band of accretion in Figure 7, suggests that there may have been a series of small-scale beach profile changes occurring independently of one another.

Although the overall 6-year difference model (Figure 2) quantifies the change, it does little to explain the variation over time. Specifically, most of the observed survey differences are small scale cross shore changes reflecting the short term changes in beach profiles. The exception is the 2013 - 14 comparison showing the widespread accretion of a storm berm ~16 m wide and the length of the analysis area (and wider Dunwich frontage), caused by the east coast storm surge.

Overall, the LIDAR derived difference images suggest that along the Dunwich frontage, there is a relatively linear, uniform pattern of accretion and erosion. Sediment appears to be locally moved up the beaches (landward), helping to stabilise the cliffs by preventing undermining at the cliff toe. Although the stability of the upper beach could be partially attributable to the coastal defence installed in 2007, as previously mentioned, the pattern appears to be a continuation of the wider frontage thus more likely as a result of a period of natural accretion across the region. These observations therefore, appear aligned with those reported in the initial monitoring for the Dunwich coastal defence demonstration project (2013).

LIDAR elevation change: Beach profiles

The following five beach profiles have been extracted from the LIDAR DSM products along the existing ACM topographic transect locations as displayed in Figures 1 – 6. The profiles contain data for each year between 2011 and 2016 (inclusive), displayed graphically to effectively compare between all the years. The y axis displays the elevation, and the x axis shows the chainage – relating to the distance along the transect lines beginning at the landward end. As the LIDAR was captured at low tide, the profiles include measurements below Ordnance Datum (ODN). Additionally, the ACM transects extend beyond the cliff line therefore the profiles also include the cliff face and edge.

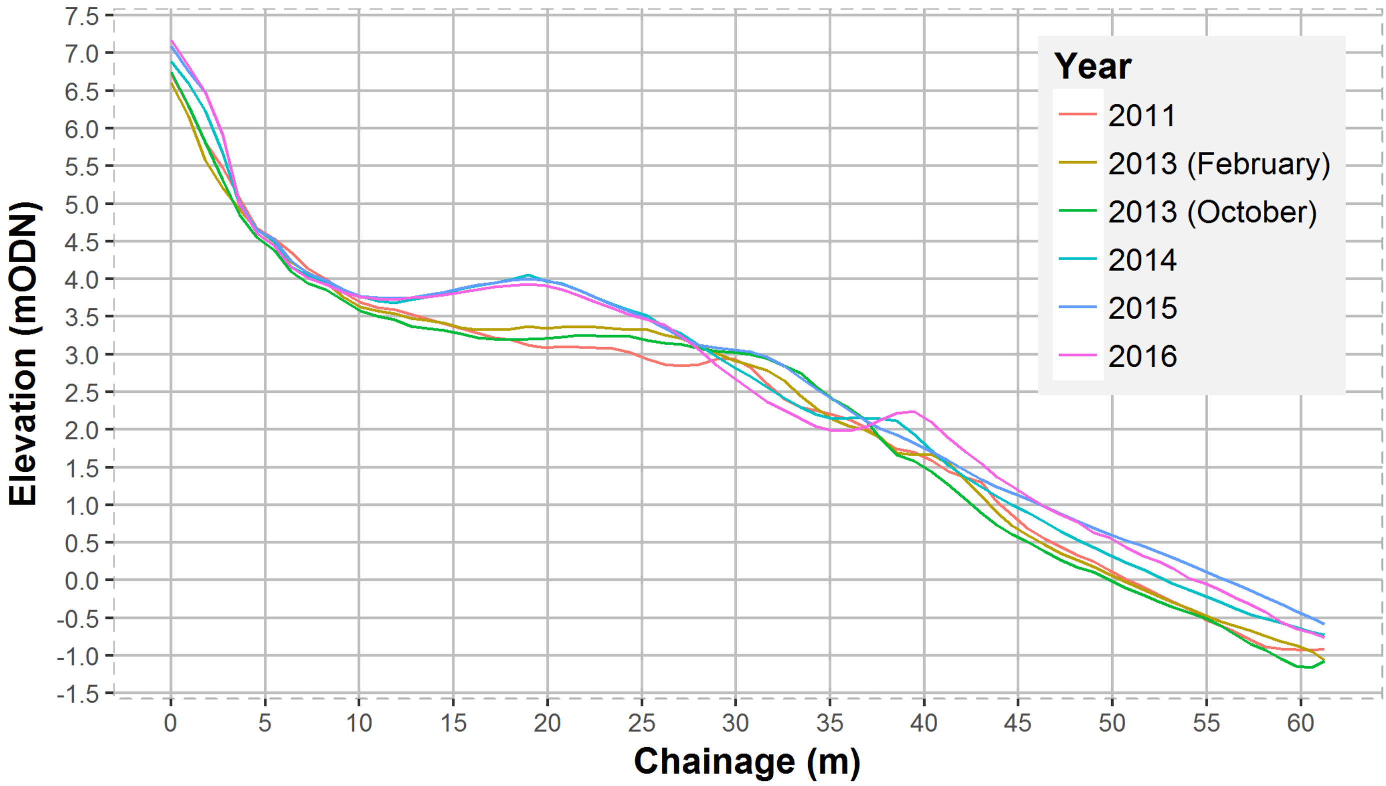

Figure 8: Beach profiles extracted from six LIDAR surveys along transect DW007 on Dunwich beach.

Figure 8 – transect DW007 – shows an area of sediment accumulation towards the upper beach (12 – 25 m chainage) of ~0.5 m between 2013 and 2014, remaining visible in 2015 and 2016. As previously mentioned, this area of accretion is the storm berm created by the December 2013 east coast storm surge. The 2016 profile shows an area of erosion at 35 – 40 m chainage, ~0.5 m below that recorded in 2015, and the lowest recorded in the 6 year period. This is followed by an area of accretion ~ 40 m chainage.

Similarly, this same upper beach accumulation is visible in transect DW008 (Figure 9) and DW009 (Figure 10). The 2016 elevation follows the same pattern as that in DW007 (Figure 8), though the area of accretion at ~40 m is more pronounced. As previously mentioned, the erosion and accretion visible in the 2016 profile likely occurred consecutively; a storm event may have first eroded the beach, followed by a period of calm when sediment was deposited. Figure 10 also highlights sediment loss in the lower beach in the 2014 profile, approximately 0.75 m and 0.5 m lower than the observed 2016 and 2013 profiles respectively.

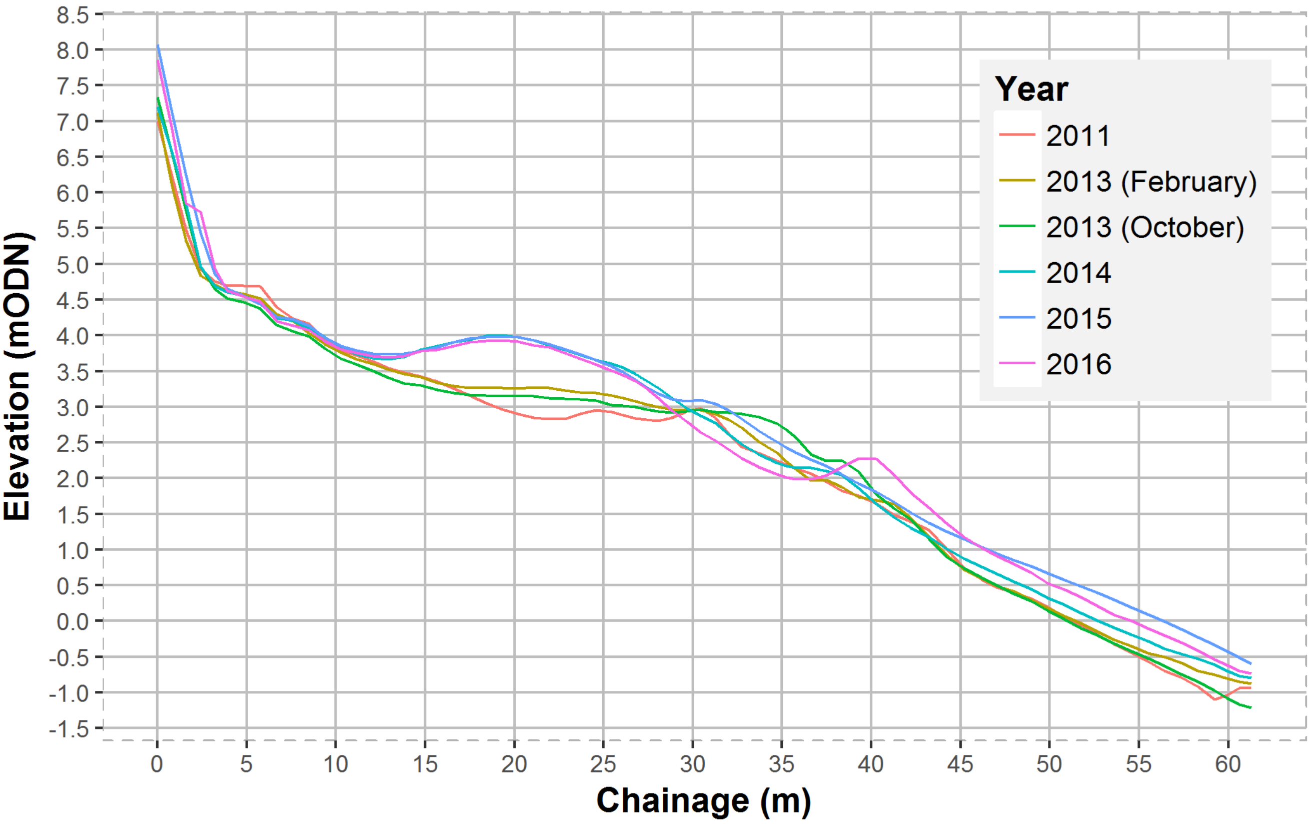

Figure 9: Beach profiles extracted from six LIDAR surveys along transect DW008 on Dunwich beach.

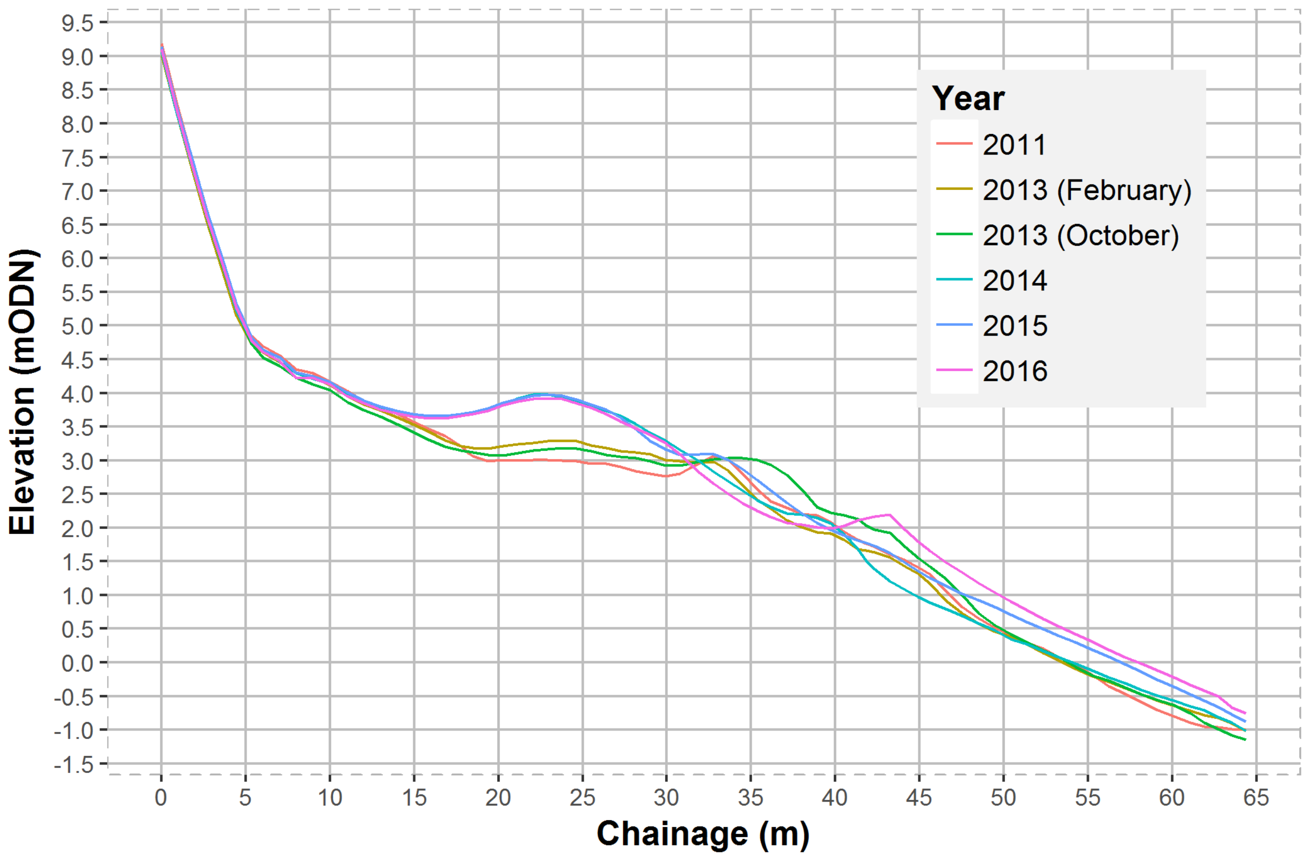

Figure 10: Beach profiles extracted from six LIDAR surveys along transect DW009 on Dunwich beach.

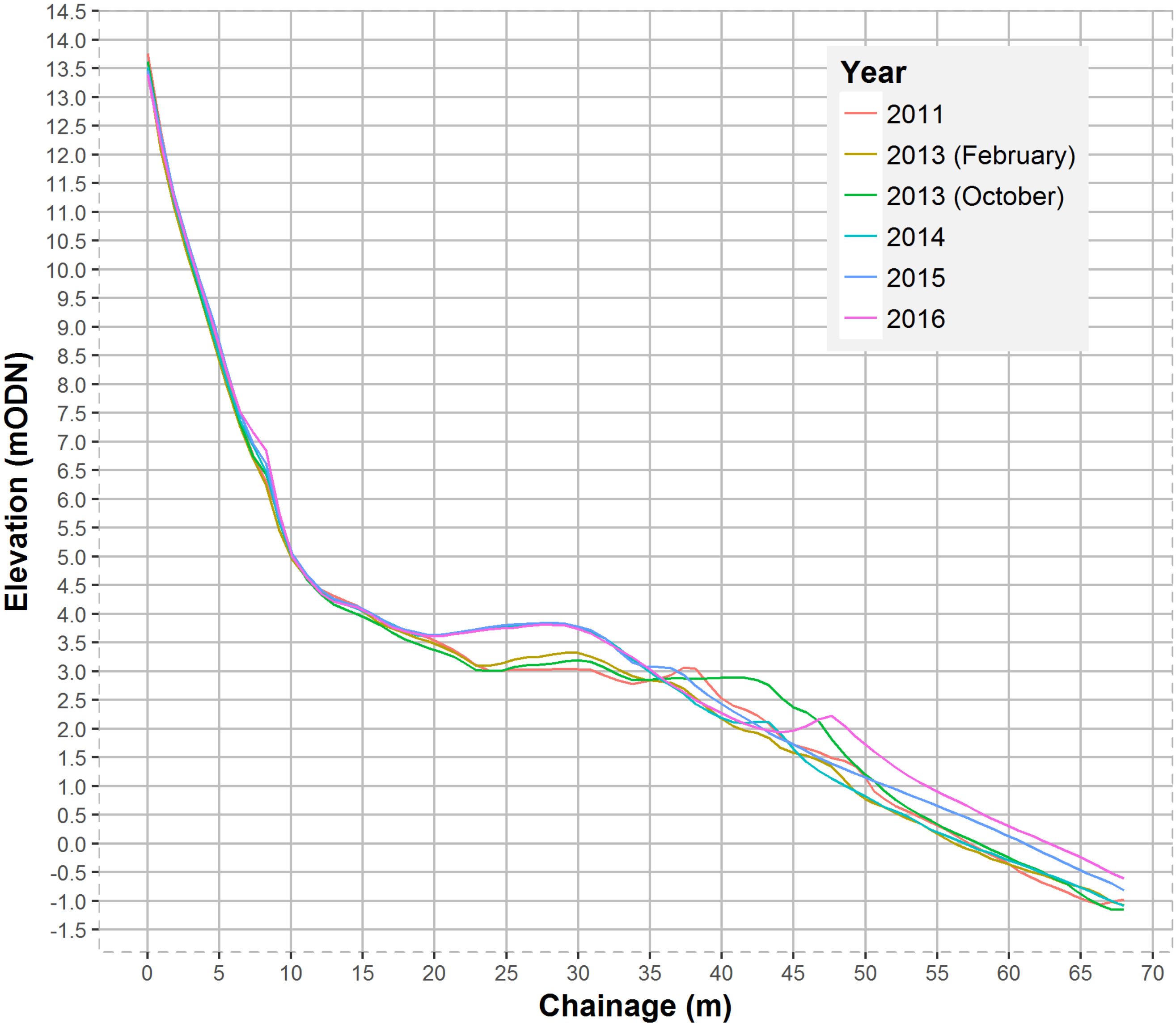

Figure 11: Beach profiles extracted from six LIDAR surveys along transect DW010 on Dunwich beach.

Transects DW010 (Figure 11) and DW011 (Figure 12) towards the southern end of the study area have distinctly higher cliffs - ~12 – 15 m as opposed to 7 – 8 m observed in the previous 3 transects. The upper beach accumulation of sediment is pronounced, though the feature in DW011 does not appear to support the cliff toe to the same extent as observed at the other transects. DW010 shows an area of accumulation in 2013 distinct from the general beach level observed at ~40 m chainage.

Overall, across each of the transects, the upper beach area accreted between 2011 and 2013 (October), followed by the significant change in the 2014 profile, resultant from the east coast storm surge. The lower beach has displayed more fluctuation – both eroding and accreting – but within the boundaries of typical beach sediment fluctuation.

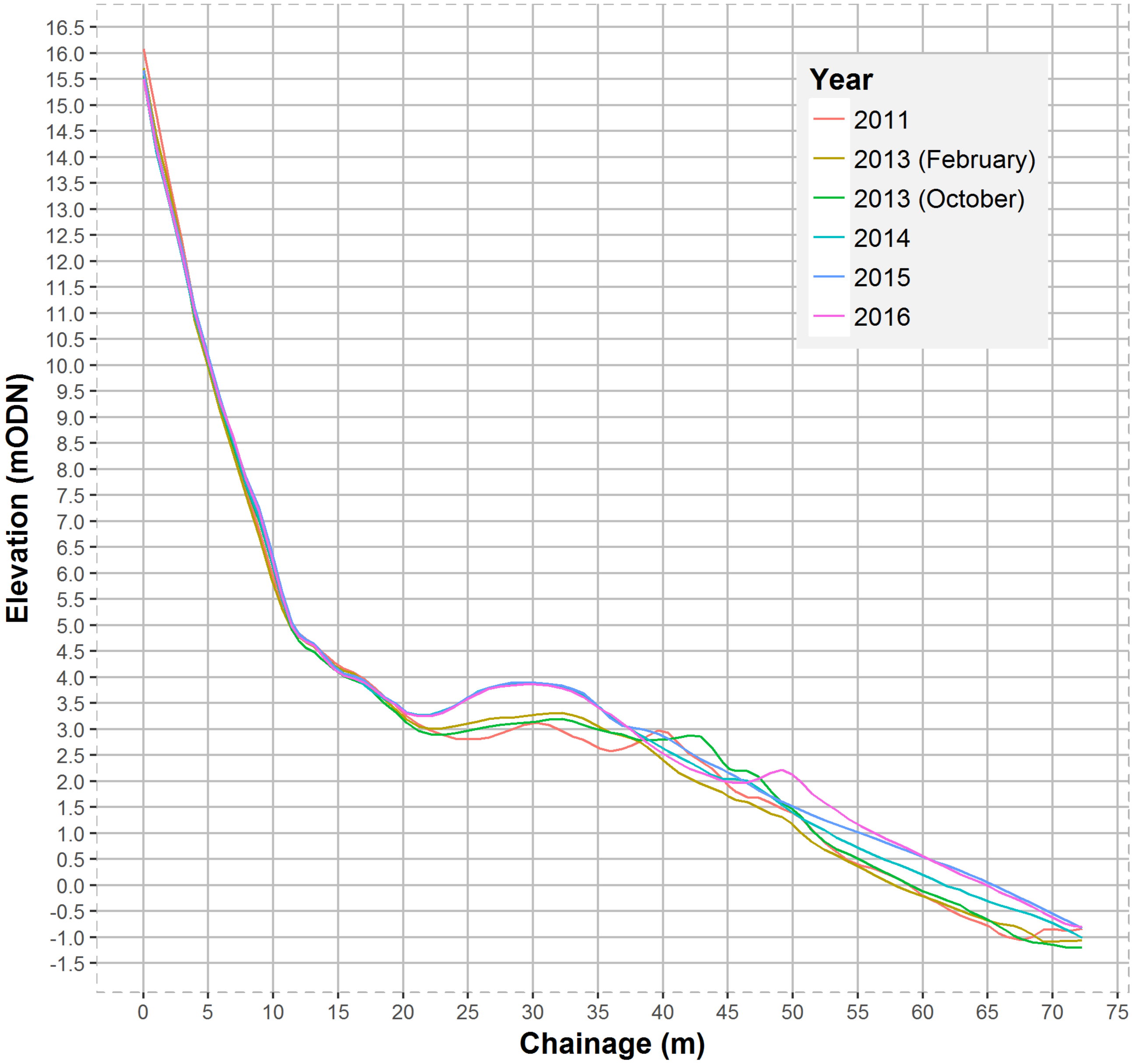

Figure 12: Beach profiles extracted from six LIDAR surveys along transect DW011 on Dunwich beach.

Summary

This analysis successfully used the ACM's archived LIDAR data to determine the change in beach geomorphology at Dunwich village, presenting two different illustrations of the data – difference image maps and beach profiles. The analysis forms a continuation of the monitoring undertaken as part of the Dunwich Coastal Defence Demonstration Project, and has found results in line with those previously observed; that the trends of sediment movement do not appear to be impacted by the installation of the geomembrane defence. The area of the defence has seen further accretion in the upper beach sustaining the stability of the cliff toe. This observation is a continuation of the trend of the wider Dunwich beach frontage, suggesting, as previously, that the changes are not as a result of the geomembrane defences. Furthermore although sediment movement looks relatively cross-shore the origins of the sediment cannot be determined without looking at the wider coastal area and sediment budget.

The December 2013 East coast storm surge, appears to have significantly increased the volume of beach material towards the cliff toe between the 2013 and 2014 LIDAR data capture. Conversely, other smaller storm events may have contributed to the erosional trend observed towards the lower beach.