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Project & Report Aims

Project:

This project aims to utilise marine radar-based remote sensing technology to instrument the coastal zone in the region of Hunstanton. This project is a feasibility study to demonstrate the ability of the radar to observe changes in various morphological features on that coastline.

Report:

Specifically, this report using data from the mobile radar system deployed to Hunstanton in Q3-4 2021 and aims to demonstrate:

- Ability of the radar to survey intertidal areas
- Ability to derive subtidal bathymetric patterns in the vicinity of Hunstanton
- Ability to monitor hydrodynamics
- Ability to track morphological change
- Storm Arwen and Barra impacts.

In intertidal areas, survey represents the average elevation above Admiralty Chart Datum (ACD) at each pixel within the radar image. Chapter 2 describes the surveys in more detail. Each pixel represents a 3m x 3m grid square.

Accompanying this document are a set of geotiff image files in WGS84 with elevations referenced to Holbeach tide gauge. These can be dragged and dropped into GIS platform and analysed as any rasterized DEM dataset.

In addition; a series of .png images and GIF animations (rd0012021_Banks_hunstanton.gif, rd0012021_Groynes_hunstanton.gif, rd0012021_IT_hunstanton.gif) are included to give more context.

Survey periods covered

Surveys are completed by analysing a series of time exposure images over the course of a spring-neap cycle (2 weeks), gaps may be present due to gaps in data availability and elevations represent the mean over two weeks.

Surveys were generated for the following periods:

Survey Period	Start	End	Notes
1	16/08/2021	29/08/2021	
2	30/08/2021	12/09/2021	Switched to Holbeach tide gauge
3	13/09/2021	26/09/2021	
4	27/09/2021	10/10/2021	
5	11/10/2021	16/10/2021	
6	25/10/2021	07/11/2021	Power loss
7	08/11/2021	21/11/2021	Power loss
8	22/11/2021	05/12/2021	
9	06/12/2021	19/12/2021	

Unfortunately, a power loss due to insufficient solar power as a result of non-optimal system orientation impacted the system during late October and early November preventing the collection of data. Power was restored after and data collection resumed for a compensatory period.

For most of the deployment the Holbeach tide gauge was used to provide levels for bathymetric and topographic elevation derivation. However; the EA gauge was out of commission in August. During that time Period the Marlan Tide gauge deployed on the navigation market near to the system was used. The disadvantage of this system was that at low water the sensor was unable to observe changing tidal water depths due to its location on the mid-beach.

As a result the first survey period is missing regions of the lower beach and sandbanks.

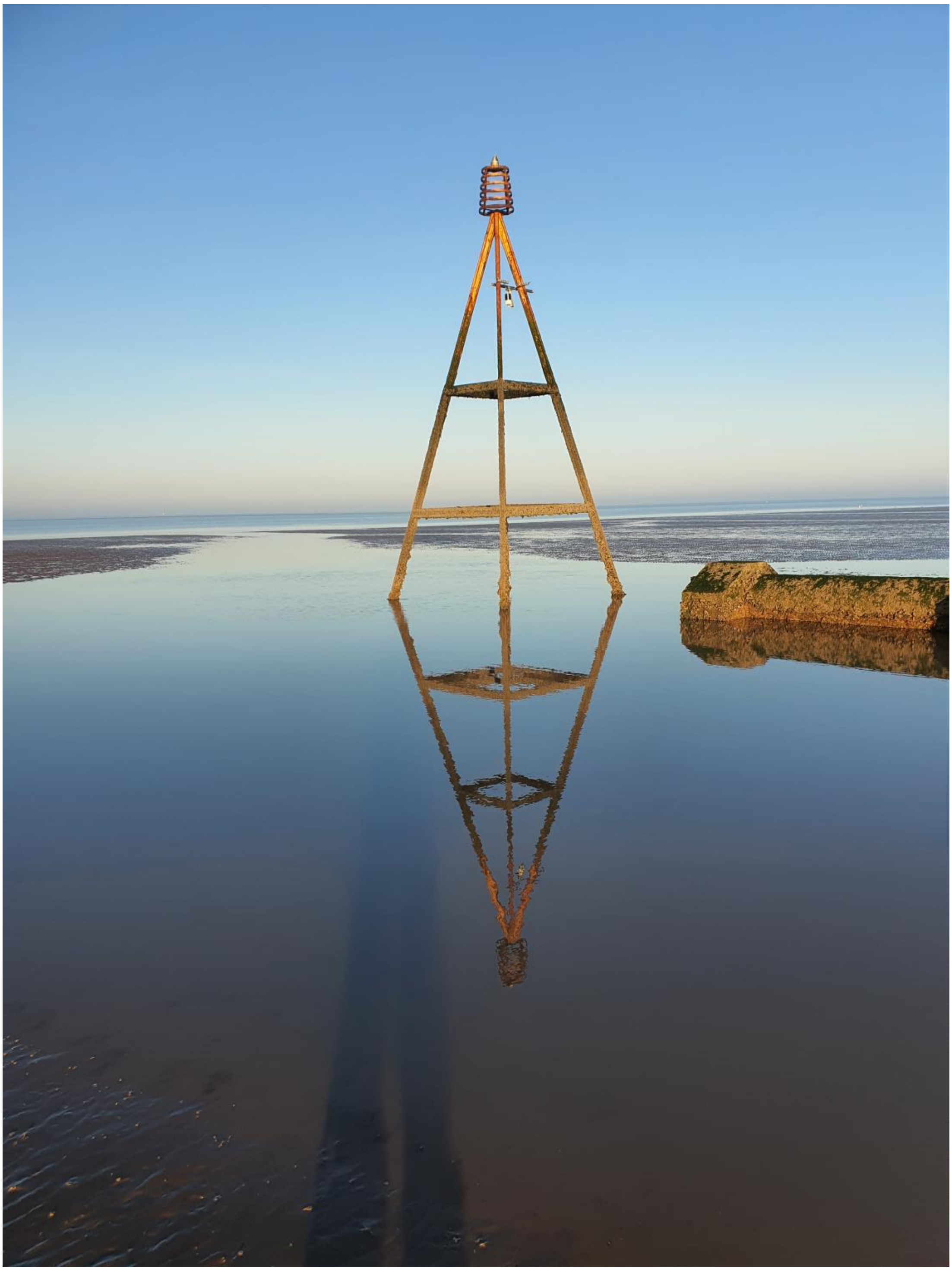

Figure 1: Location of tide gauge, not the body of water does not dry at low tide, resulting in a static reading

Study Area Hunstanton

The radar system at Hunstanton was located in the vicinity of the Ski Café and Bar Hunstanton at 52.931 N, 0.479 E. The plot below shows the system installed, and a snapshot of radar image data covering the area of the coast surveyed by the radar system.

Figure 2: Picture of radar system in situ, snapshot radar image.

Morphology Introduction

The primary objective of this deployment is to capture data relating to morphological change along the stretch of coastline at Hunstanton to Heachem with the objective of demonstrating the capability of the radar system to observe changing morphology over a short period.

To investigate each of these areas in turn, several polygons in the intertidal area were extracted, the full intertidal beach polygon allows the wider area and dynamics to be observed, an extraction around the groynes shows focussed beach level changes at short range, and sediment movement around the sea wall. A further sub image is taken from further west around the sandbanks in an attempt to capture a dataset that could inform elevation change on these dynamic sandbanks.

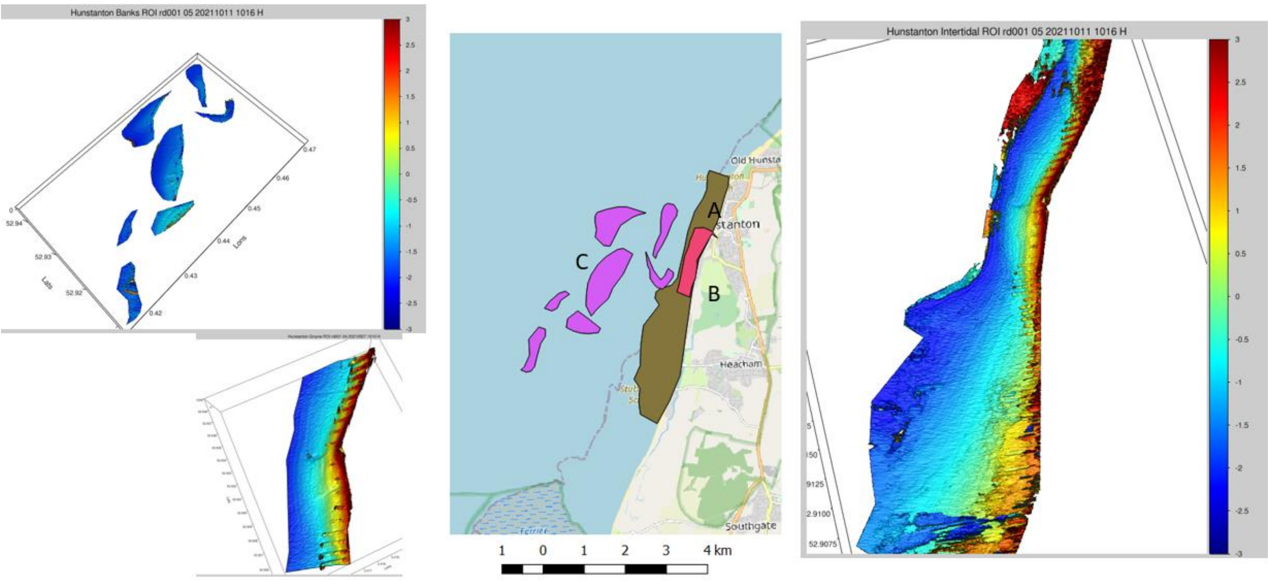

Figure 3 Regions of interest extracted from full intertidal digital elevation model. A- wide area intertidal, B- Groyne area intertidal, C- identified intertidal sandbanks.

Full intertidal area summary

The full extent of intertidal DEM data from the Hunstanton system is provided in animated form rd0012021_IT_hunstanton.gif [LINK] along with the latest image data. Convincing evidence of the relative stability of the system is shown, the cross shore bars (most clearly shown towards Hachem do show significant onshore movement, evidence of chronic erosion was not observed.

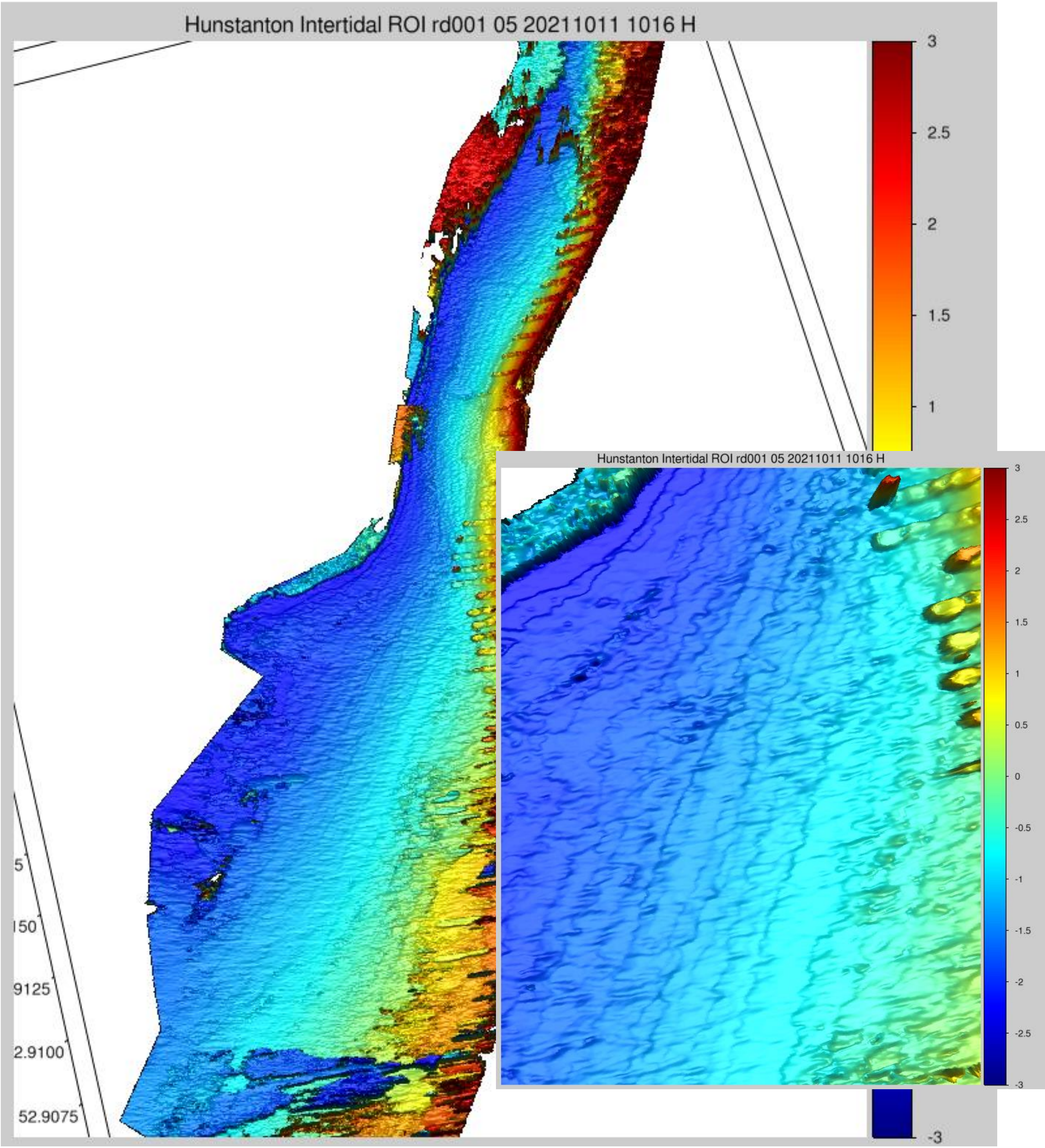

Figure 4: Wide area intertidal extraction, and zoomed subsection showing beach cusp detail north of the training wall

Survey period 02 in early September shows evidence of a short-lived drop in elevations, that immediately recovers on the next survey period, you can clearly see this in the gif linked [LINK].

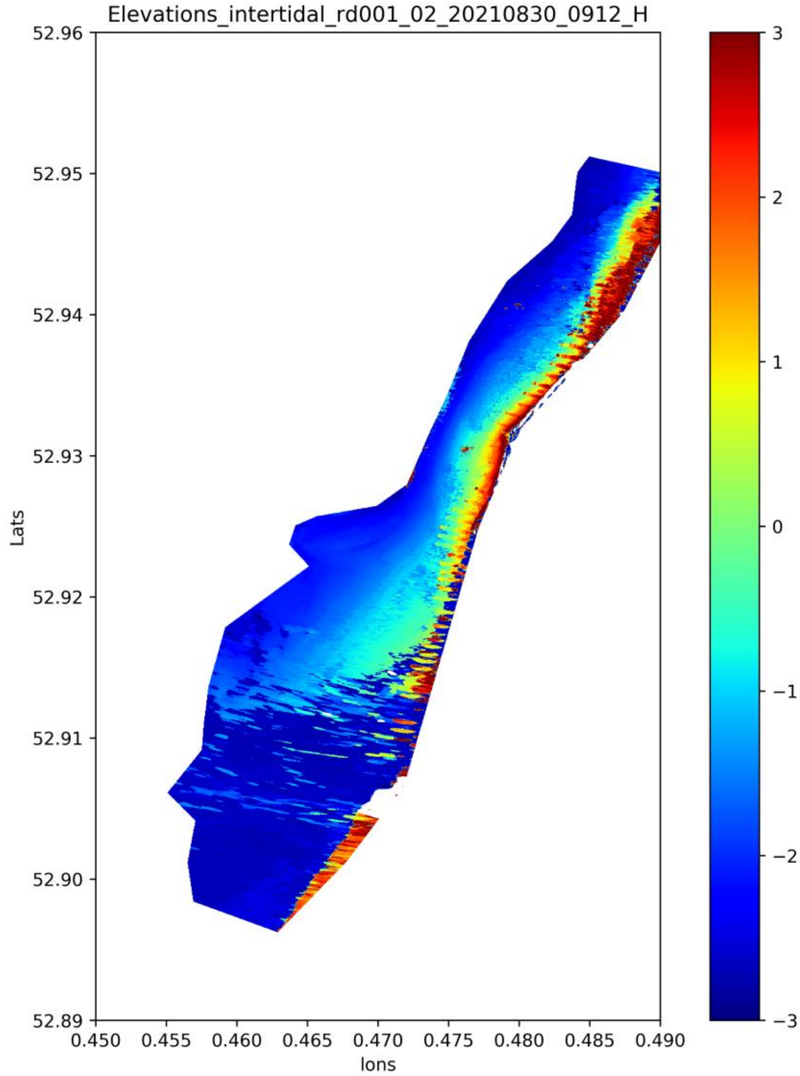

Figure 5: regions of erosion north and south of the radar on the foreshore

Groyne vicinity area summary

Zooming in on the area around the Groynes allows us to visualise the morphology close to the sea wall more clearly. The most striking feature at this location is the formation of ephemeral shore parallel bar system, that is not in the data at start in August, forms through September and October, and is flattened again towards the end of the deployment. Interestingly these features re appear as a result of storm Barra. Overall, there is evidence from these data that sediment transport from Hunstanton to Heachem does not occur via cohesive sediment feature migration in a long shore direction, and is likely more wave than tidally driven with mobilised sediment being deposited to the south [LINK].

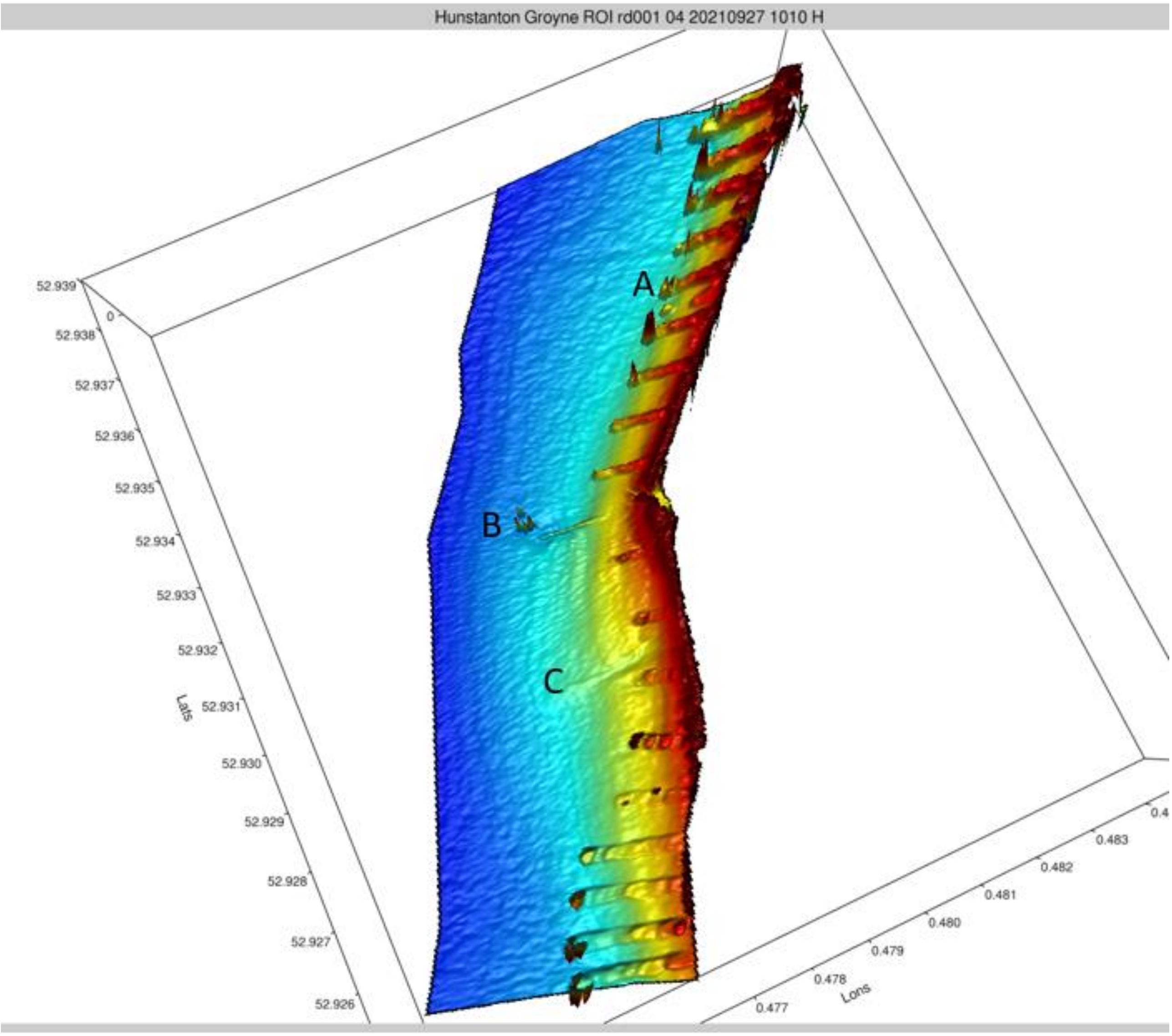

Figure 6: 3D model of morphology extracted near Hunstanton radar station, A Groynes to the north of the radar, B navigation marker where the tide gauge was deployed and C surface water run off channel.

Sand Bank area summary

The sand banks at Hunstanton are extensive and interesting. An attempt was made to isolate their elevation measurements during the deployment. While this effort was hampered by chronic low signal returns during spring tide lows (the only period where these features are revealed) we are able to see that these banks maintained fairly stable morphologies over the 3 months of monitoring data available [LINK].

Readings from the first survey period in mid-August should be ignored due to the inability of the tide gauge to see the low water spring tide elevations while the Holbeach gauge in the Wash was out of commission.

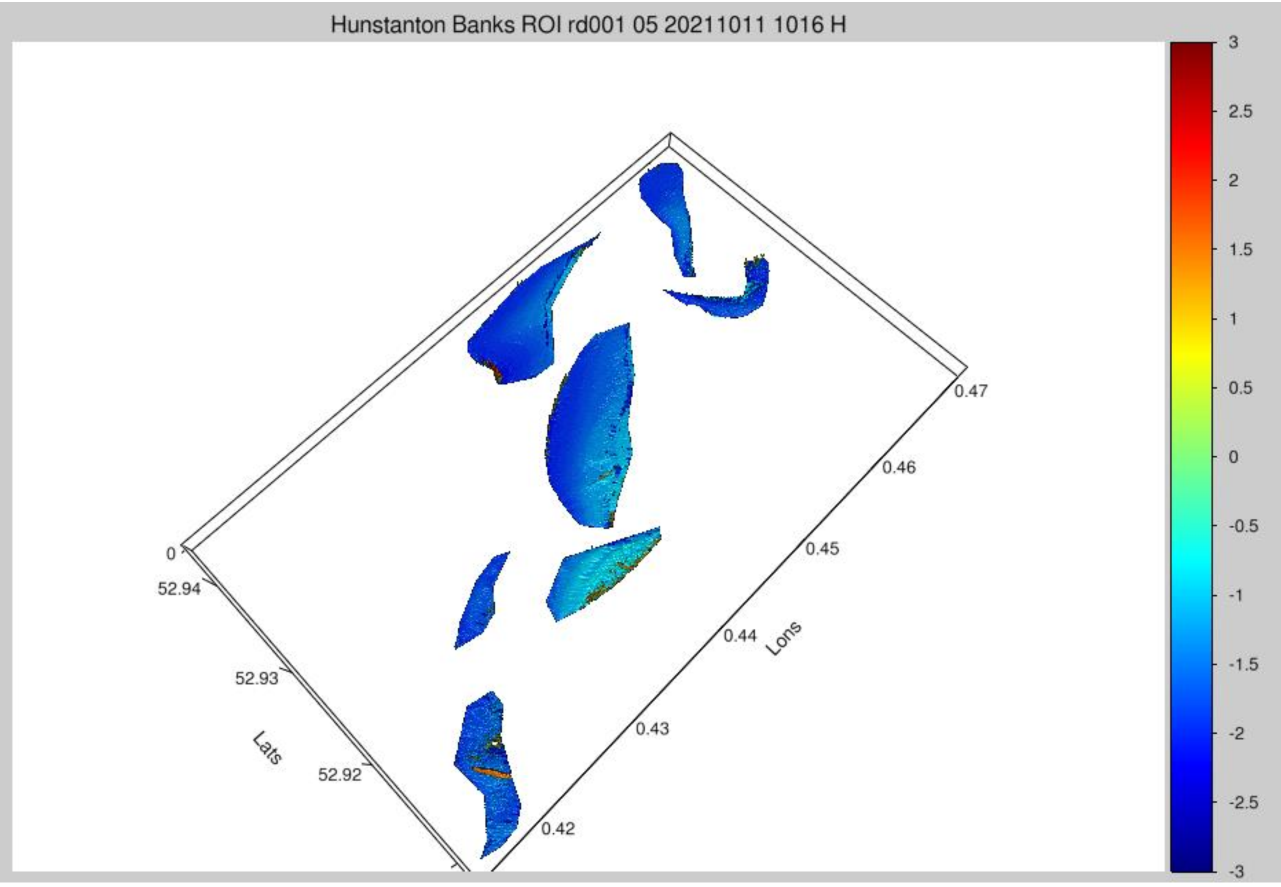

Figure 7: 3D model of radar-derived elevations from Hunstanton sandbanks.

Attempts are made in later sections to better monitor the morphology and spatial homogeneity of these features using different analysis techniques.

Bathymetry Overview

Subtidal bathymetry was derived using the wave inversion technique which analyses wave statistics and attempts to fit an estimated depth to each pixel based on the behaviour of waves in that pixel.

Derived bathymetries reflect well the local seabed morphology based on qualitative comparison with the fishing chart. Key features such as the banks and channels around sunk and south sunk sands are resolved clearly, and the channels running parallel to the beach are resolved well.

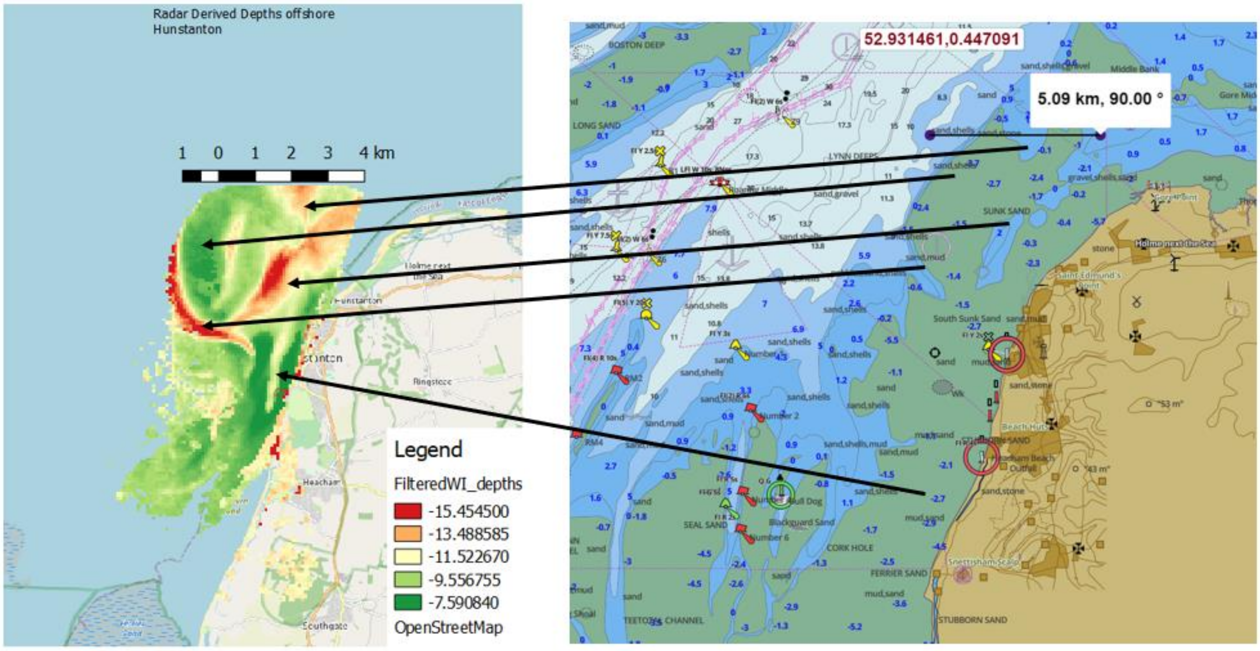

Figure 8: Bathymetry derived using the radar.

In order for the system to resolve these depths, a wave field is required to be imaged, waves of ~1.5m significant wave height and wind speeds of ~3 m/s provide ideal conditions to derived bathymetries.

During the deployment, conditions for bathymetry derivation were often marginal, such that we were unable to derive stable bathymetries at each week during this deployment. We have been working closely with the National Oceanography centre recently, and in partnership we were awarded a grant to pay for NOC scientist time to work on improving these datasets. The data are currently being re-processed with a new version of the software which should improve the stability of these results, improving stability over time is vital before we can comment on observed changes.

These results are estimated to be available within 3.5 weeks of this report.

Time Exposure Tidal Channel Visualisation

Due to the difficulty in reliably acquiring an intertidal signal during low spring tides, that are required to capture the sandbank morphology, and in the lack of stable bathymetry derivations we are required to visualise the channels in an alternative manner.

Radar images are collected every 2.5 seconds, the raw snapshot data can be noisy and difficult to interpret. However, when these images are averaged over time they become much smoother and reveal details about wetting and drying areas in range of the radar. Images are taken over 10 minutes and averaged into a single image to best see the morphology of the channels and banks.

In the attached .mp4 videos named rd001_hun_YYYY-MM-DD.mp4 we have extracted a day of data at each spring tide through the deployment see example here [LINK]. At low tide the locations of the sandbanks and channels can be easily seen.

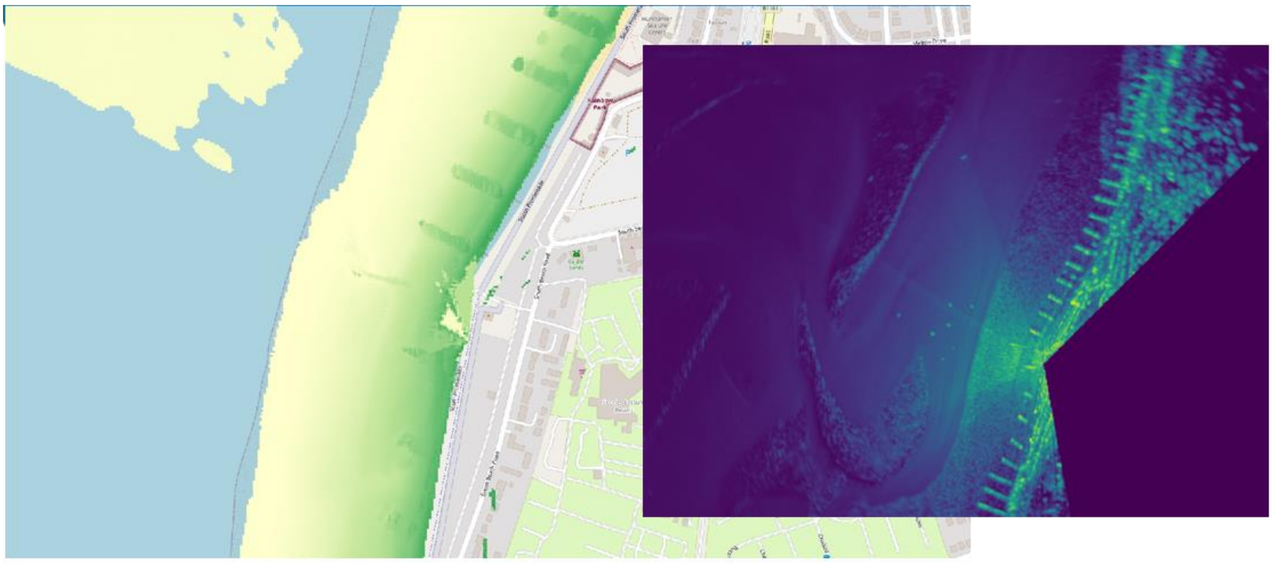

Figure 9: Intertidal elevations on Hunstanton beach and time exposure radar image showing locations of channels

Surface Roughness Overview

In addition to time exposure images, we can process these images in a different manner to reveal "roughness" signatures from the sea bed. Uneven features such as dunes and ripples in the sub and intertidal induce turbulence in the surface flow. This turbulence can be seen in radar images, if they are arranged correctly and fitted to the tidal curve, we can visualise the gradient of the seabed surface at high resolution.

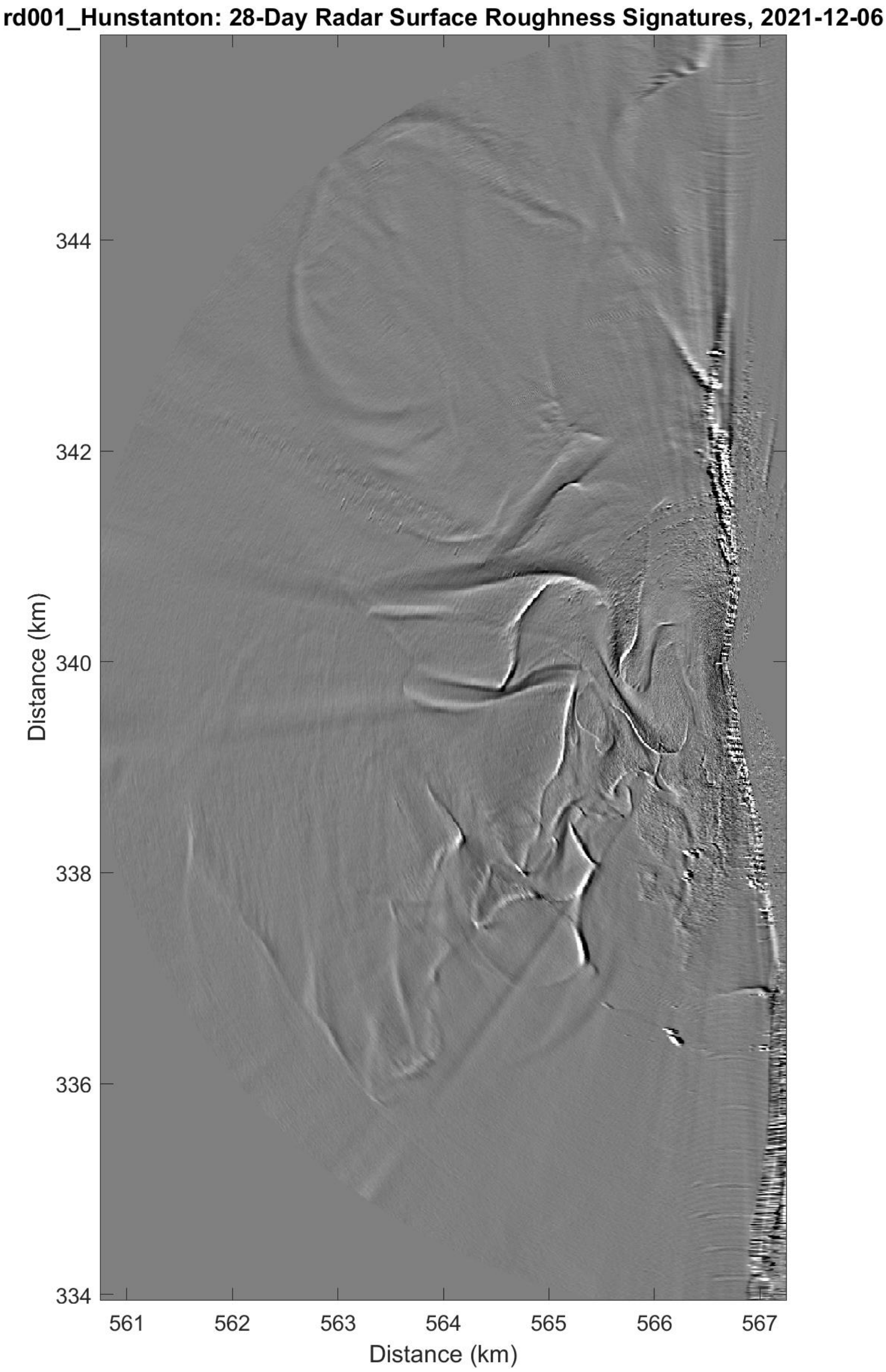

Figure 10: Roughness image showing channels and bars at Hunstanton

These images very clearly show the outlines of the channels and banks around Hunstanton. The video roughness_hunstantonDaily.gif [LINK] shows a sequence of daily roughness images, some channels clearly migrate and oscillate, other small channels close and reopen across the area periodically. We do not have a long enough timeseries to determine if these behaviours are seasonally driven oscillations or directional and systematic.

Hydrodynamics Overview

As mentioned in the bathymetry section earlier, these data are being reprocessed to extract more stable bathymetry and hydrodynamics. However, the attached videos demonstrate surface current derivation during adequate wave conditions, the low tide time periods show currents running through channels around Sunk Sands and South Sunk Sands, while high tide data shows currents at all areas.

Data to the south west is less reliable due to the incoming wave directions. See the video here [LINK]

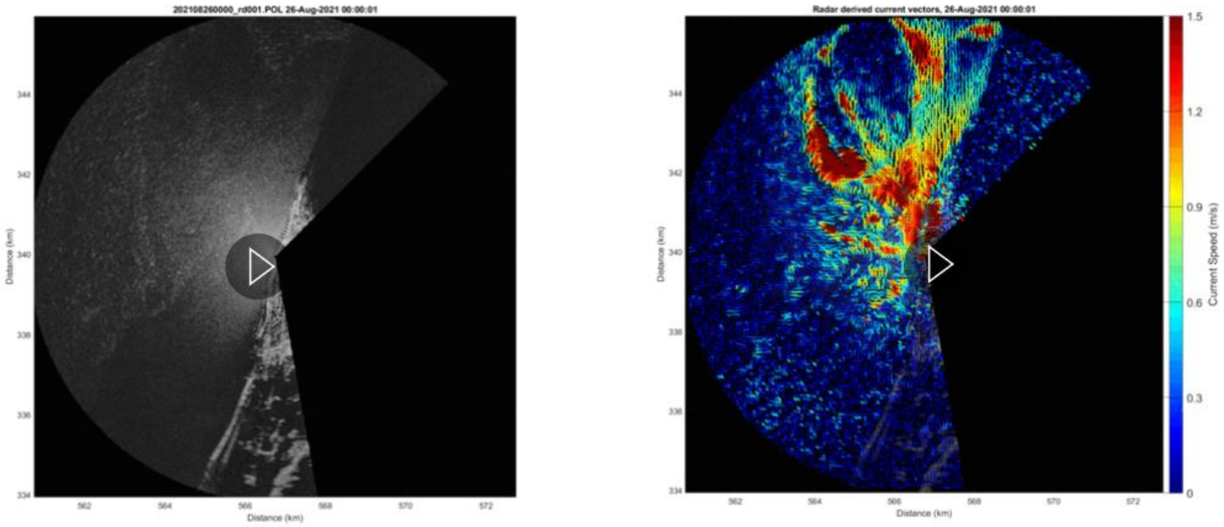

Figure 11: example radar imagery and derived surface currents.

Storm Impact Overview

Storm Arwen

Storm Arwen occurred over the 26-27th November 2021 and a snapshot of mean elevations of the 3 days before and the 3 days after were processed to look at differences resulting from the storm.

The trade off resulting from this much higher temporal resolution technique (normally we apply 2 week averages to enable the full spring neap cycle to be observed) is a poorer signal to noise ratio meaning results may be less smooth.

However, each pixel is analysed independently, so spatial clustering of erosion and accretion is likely to indicate true hotspots despite potentially reduced accuracy.

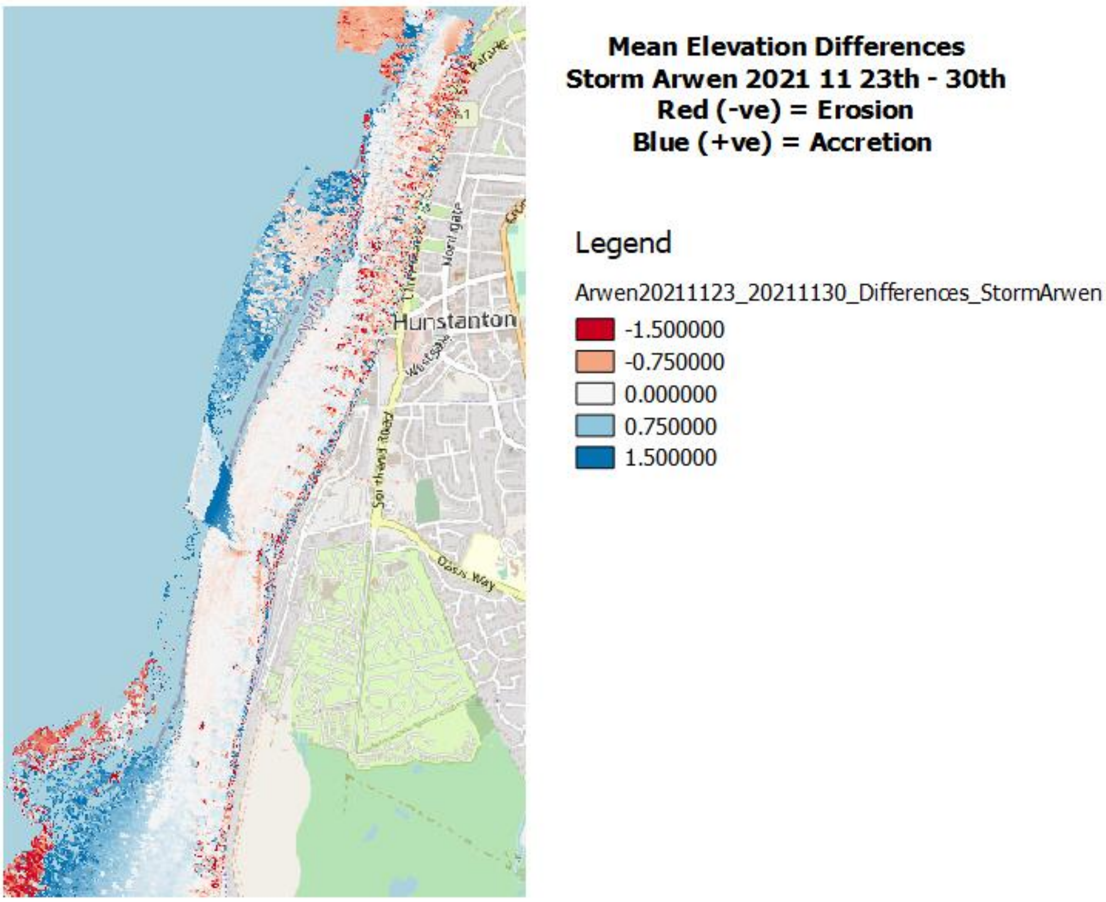

Figure 12: Differences from Storm Arwen

Arwen appears to have caused relatively minor systemic drawdown across much of the local beach face (between 0 – 0.75m) with some hotspots around the groynes and to the north. Correspondingly the concentration of blue pixels indicating accretion to the south nearer

Heachem indicates potential sediment redistribution in a long shore direction resulting from the storm event.

There is an area of noise to the north-east of the radar in a wedge shape of blue indicating unrealistic erosion, this area should be ignored, it is likely due to the interference on the radar image due to the steel navigation marker.

Storm Barra

Storm Barra occurred over the 7-8th December 2021 and a snapshot of mean elevations of the 3 days before and the 3 days after were processed to look at differences resulting from the storm.

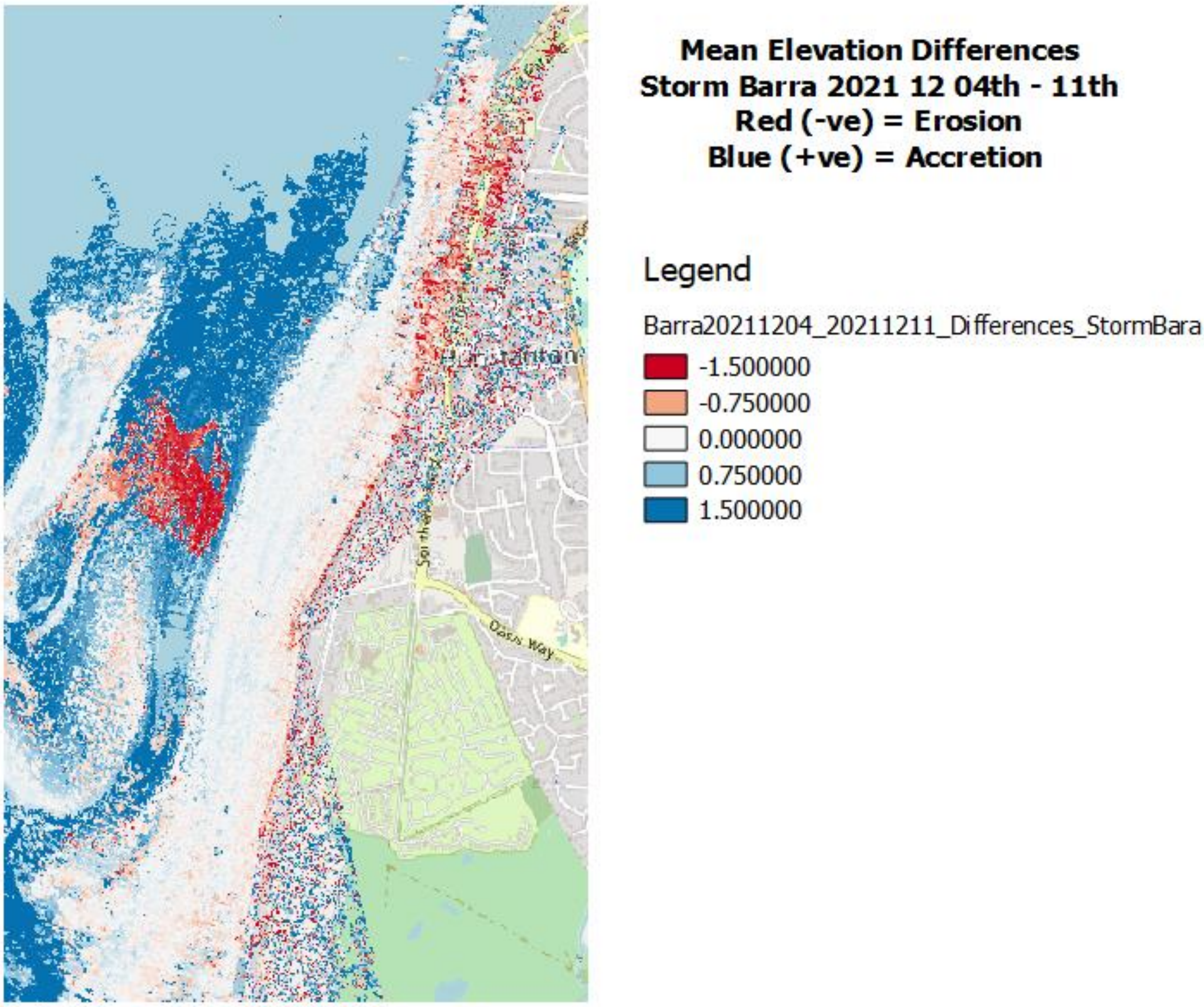

Figure 13: Differences from storm Barra

As discussed above, these shorter timeframe analyses result in more noise, specifically in the subtidal channels on this occasion, the concentrations of strong blue and red offshore should be ignored.

In contrast to the effects of Arwen, Barra appears to have built up a series of intertidal shore parallel bars evidenced by the blue ridges running along the beach in a north-south orientation, parallel to the shoreline. Evidence of erosion is constrained to the higher region of the beach and between/around the groynes.

Next Actions

Proposed below are a series of next actions and further work which can be refined in coming meetings.

- Deliver remaining hydrodynamics data.
- Establish IT protocol to transfer data to EARMP.
- Review further Monitoring needs at Hunstanton and Heachem.
- Review of regions of interest.
- Discuss areas for improvement.