MAPPING THE BATHYMETRY OF THE DEE ESTUARY USING WAVE INVERSIONS OF MARINE RADAR IMAGE SEQUENCES

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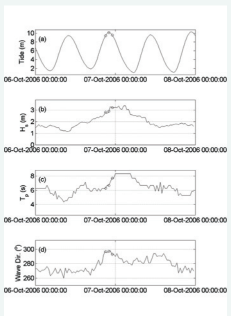
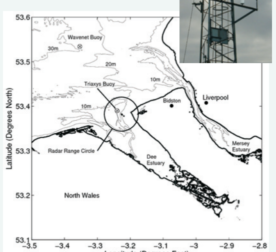
SUMMARY

The bathymetry of the Dee Estuary in Liverpool Bay has been mapped using a non-linear wave inversion of marine X-band radar data. Comparisons are made with survey data produced using a combination of multibeam sonar, airborne LIDAR and Admiralty charts. Radar derived depths are generally accurate in elevation to within +/-1m.





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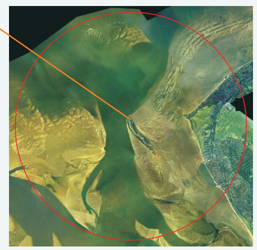

Aerial Photograph circa mid-1990s
Taken around spring low water

METHOD

Hourly sequences of 256 radar images, spanning about 10 minutes per sequence, are recorded routinely using a Wamos [4] radar recorder.

For this paper, three such records around a single high water during a wave event were processed using depth inversion algorithms.

Wavelengths were determined over a range of wave frequencies and a best fit to a non-linear wave dispersion equation performed, yielding a water depth map for each record.

Tidal elevations were subtracted from each record's map and the results combined to produce a map referenced to chart datum.

For the present work, currents are assumed to be zero, but a current resolving depth inversion is showing promising results.

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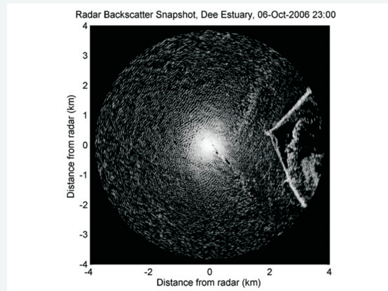

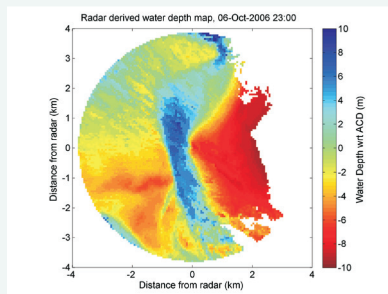

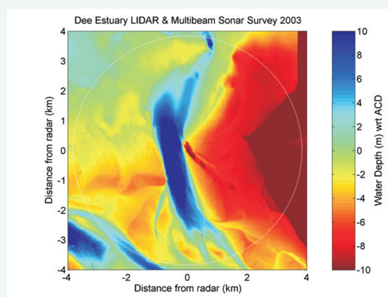

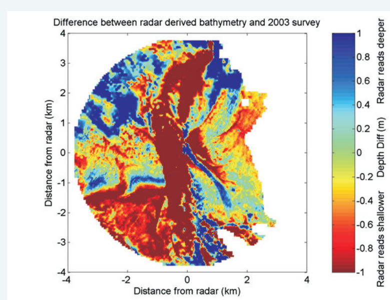

THEORY

Waves slow down and hence reduce their wavelength as they travel from the open ocean into shallower coastal waters. Linear wave theory has been shown to under predict water depths in shallow water [1][2]. If the wavelength, period and height of the waves can be determined from images of the sea surface then the water depth causing that wave behaviour can be calculated, even in very shallow water using the following equation [3]:

Water depth $$d = \frac{L}{2\pi}\tanh^{-1}\frac{2\pi L}{gT^2} - \frac{H_S}{2\sqrt{2}}$$

Where L = wavelength of the ocean waves
T = wave period
H_S = significant wave height
g = gravity

RESULTS

The radar derived bathymetric map is generally within +/-1m of the survey data where the water depth is less than about 15m, despite the survey being taken at least 3 years prior to the data.

The radar derived depths in the northern third of the plots highlight the flaws in the sparse chart derived survey data in this area.

Problem areas are the deep channels where the radar analysis is under-estimating the water depths significantly. This is because Liverpool Bay is relatively sheltered and waves are fetch limited to periods of about 8 seconds. Waves of such short period barely interact with the sea bed in such deep water (>20m) and so make accurate depth inversions difficult. The strong currents in the deep channels also introduce significant errors.

REFERENCES

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