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A Novel Approach to Mapping Intertidal Areas Using Shore-Based X-band Marine Radar

Cai Bird (1) and Paul Bell (2)

(1) University of Liverpool, School of Environmental Science, United Kingdom (c.bird@liverpool.ac.uk), (2) National Oceanography Centre, Liverpool, United Kingdom (psb@noc.ac.uk)

Monitoring the morphology of coastal zones in response to high energy weather events and changing patterns of erosion and deposition over time is vital in enabling effective decision-making at the coast. Common methods of mapping intertidal bathymetry currently include vessel-based sonar and airborne LiDAR surveys, which are expensive and thus not routinely collected on a continuous basis. Marine radar is a ubiquitous technology in the marine industry and many ports operate a system to guide ships into port, this work aims to utilise this already existing infrastructure to determine bathymetry over large intertidal areas, currently up to 4 km from the radar. Standard X-band navigational radar has been used in the marine industry to measure hydrodynamics and derive bathymetry using empirical techniques for several decades. Methods of depth mapping thus far have relied on the electromagnetic backscattering from wind-roughened water surface, which allows a radar to gather sea surface image data but requires the waves to be clearly defined. The work presented here does not rely on identifying and measuring these spatial wave features, which increases the robustness of the method. Image data collected by a 9.4Ghz Kelvin Hughes radar from a weather station on Hilbre Island at the mouth of the River Dee estuary, UK were used in the development of this method. Image intensity at each pixel is a function of returned electromagnetic energy, which in turn can be related to the roughness of the sea surface. Images collected over time periods of 30 minutes show general patterns of wave breaking and mark the advance and retreat of the waterline in accordance with the tidal cycle and intertidal morphology. Each pixel value can be extracted from these mean images and analysed over the course of several days, giving a fluctuating time series of pixel intensity, the gradient of which gives a series of pulses representing transitions between wet and dry at each location. A tidal elevation record collected from a gauge at the Island is used to generate a similar series of pulses for each elevation above chart datum. A matching algorithm compares these pulse sequences at each tide level and determines a bed elevation value for each pixel location. Values derived have a maximum error of 1 m when compared to a LiDAR survey of the area during the same time period. Refinements of this technique could form the basis of a long-term automated monitoring system for the morphology of intertidal coastal areas allowing varying scales of sedimentary features to be tracked. This may allow the optimisation of maintenance dredging and quantify the effects of beach nourishment and capital dredging along a shoreline.