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Geologic records of Pleistocene, Holocene and Anthropocene beach profiles?

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The Anthropocene Working Group recently concluded that we have entered a new Epoch; starting during the last century when carbon dioxide, temperatures, and sea level all exceeding previous Holocene measurements. Climate change models predict a 1m rise in sea-level by 2100 coupled with increased storm intensity. Determining how vulnerable coasts will respond to global warming in the future, requires past records of sea-level and storm impacts to be deciphered. Paying specific attention to any changes prior to, and since, the onset of the Industrial Revolution. Coastal change over centennial time-scales has long fallen within a knowledge gap that exists between our understanding of shoreline behaviour measured over decades and that inferred from the landscape over millennia. Insight on shoreline behaviour across spatial and temporal scales is gained using computers to integrate models of short-term morphodynamics along beaches with longer-term coastal landscape evolution models. However, limitations exist as process-based engineering models depend on wave climate and beach profile data that is restricted to regional/historical records, while large-scale coastal behaviour models are based on general chronostratographic data from topographic profiles, interpolated cores, and isochrons extrapolated from deep radiocarbon ages.

Here we demonstrate a unique methodology combining state-of-the-art geophysics, luminescence, and remote sensing techniques on prograded barriers to extract comprehensive chronostratigraphic records. Ground Penetrating Radar (GPR) data document beach and dune stratigraphy at decimetre resolution. Optically Stimulated Luminescence (OSL) directly date the formation of paleo-beachfaces and dunes. Light Detection and Ranging (LiDAR) image the lateral extent of strandplain ridge morphology. The resulting record of paleo-beach profiles spanning from the present-day beach through Holocene and Pleistocene barriers, enables our in-depth understanding of morphodynamics to interpret paleoenvironmental histories. Data from prograded barriers in North America, New Zealand and Australia are used to illustrate the potential of utilizing GPR, OSL, and LiDAR. Exploiting the fundamental link between paleo-beachfaces and past ocean levels, new sea level curves were constructed by mapping their height over time. Examples from far-field sites capture Eemian and mid-Holocene highstands with a subsequent fall indicating a non-linear nature. The geometry of paleo-beachfaces, intrinsically linked to wave-energy, were analyzed in comparison to present-day beach profile data to extract storm records. The results yielded recurrence intervals with differing coastal impacts, which indicated storm intensity increased as frequency decreased. Volumes of the barrier lithesome were quantified to provide insight on sediment supply and accommodation space over time. Findings show sand supply increased drastically starting in the mid-19th century causing a shift in foredune evolution from previous millennia.

Do anomalous foredunes define Anthropocene coastal barriers in the geologic record? Global stratigraphic signatures, distinct from Holocene deposits, are needed to formally establish this ‘Human’ Epoch. Applying this novel methodology to the more than 300 prograded barriers around the world, including 50+ in Europe, can: 1) augment traditional proxy from ice and sediment cores to help delineate the Anthropocene, 2) determine changes in coastlines since the onset of global warming, and 3) provide insight, and input to forecasting models, needed to mitigate and manage future impacts of climate change.