A novel shoreface translation model for predicting future coastal change

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Predicting changes to global shorelines presents a challenge that will become increasingly urgent over coming years as sea-level rise (SLR) accelerates. Current shoreline prediction models typically estimate the impact of SLR using variations of the ‘Bruun Rule’, which fails to account for many relevant processes, potentially producing erroneous results. To address this shortcoming, we introduce a simple rule-based model that predicts change across a wide variety of sand, gravel, rock and engineered (anthropogenic) coastal environments, at the scale of years to centuries, accounting for trend rates of change as well as natural short-term variability. Applying recent findings of laboratory and field-based research, the model translates 2D cross-sections of the shoreface, then integrates these changes across multiple alongshore profiles (into pseudo-3D). Uncertainty is accounted for using a probability distribution for inputs (e.g., rate of SLR, depth of closure, depth to bedrock). The model accounts for: (1) dune erosion and slumping [for large dunes]; (2) barrier rollback and overwash [for low barriers]; (3) aeolian dune accretion; (4) non-erodible bedrock layers, including those below ‘perched’ dunes; (5) seawall and revetment backed profiles; (6) onshore transport from the lower shoreface; (7) cross-shore variability due to storm erosion; (8) alongshore variability due to beach rotation; (9) alongshore re-distribution of dune erosion across the shoreface of a closed embayment; and (10) other sources and sinks (e.g., estuary infill, longshore flux, headland bypassing, biogenic production). We apply the model to two extensively monitored macrotidal embayments in the UK: Perranporth (sandy, dissipative, cross-shore dominant transport) and Start Bay (gravel, reflective, bi-directional alongshore dominant). For the dissipative sandy site, the primary modes of coastal change are predicted to be: (1) sea-level rise profile translation; and (2) extreme event cross-shore fluctuations. By contrast, for the reflective gravel site, the primary modes are: (1) short-term fluctuations in alongshore rotation; and (2) multi-decadal trends in longshore flux. For the steep gravel barrier, sea-level rise profile translation is important but secondary. Relative to the new model, the Bruun Rule underpredicts shoreline recession in front of cliffs and seawalls, and overpredicts where large erodible dunes are present. This new shoreface translation model is easily transferable to many coastal environments and will provide a useful tool for coastal practitioners to make rapid assessments of future coastal change.