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Predicting future coastal erosion in Scotland: Process-driven modelling across decadal-centennial timescales

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Scotland has a varied and dynamic coast, with up to 19% of the coastline classified as soft and potentially erodible. These areas face an increased risk of coastal erosion and coastal flooding, driven by observed sea level rise that is predicted to accelerate and by changing frequency and intensity of extreme weather events. Historic rates of coastal change have now been quantified along the Scottish coast, and key socioeconomic assets at risk from future coastal erosion have been identified. While coastal evolution is complex and challenging to predict, there is an ever-increasing desire for robust models capable of quantifying coastal change over a range of timescales and scenarios. We aim here to make quantitative predictions of future coastal erosion and its uncertainty at several key sites in Scotland identified as the most economically and environmentally vulnerable. We adapted the Coastal One-line Assimilated Simulation Tool (CoSMoS-COAST) (Vitousek et al., 2017) to model the evolution of these coastal sites under scenarios presented by UK Climate Projections 2018 (UKCP18). The model uses a process-based approach to simulate shoreline change via wave-driven alongshore and cross-shore sediment transport processes, but also long-term shoreline migration driven by sea-level rise. Variations in modelled beach type (from fine sand sections to armoured and artificial coast fronts) allow for both greater complexity in the simulated processes and investigation into the extent of human influence on shoreline change. The model is calibrated by assimilating historic records of mean high water spring positions spanning the 20th Century and local records of relative sea level change and wave hindcast data. This is validated with recent shoreline position observations derived from high-resolution topographic surveys and satellite and aerial imagery. Shoreline change is then simulated to the year 2100 under low to high Representative Concentration Pathway scenarios within UKCP18, encompassing factors such as the intensification and proliferation of sea level rise and storm surge activity. We report anticipated future coastal erosion in Scotland at a diverse selection of sites where important coastal assets (e.g. transport infrastructure, tourism and cultural heritage) are at direct risk. Producing coastal change predictions for a range of coastal types and climate situations can then enable more accurate risk assessment and guide resilience and adaptation of Scotland's most vulnerable coastal areas.