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Validation of a biomorphodynamic model for biofilm biostabilization; the effects of varying substrata and seasons at the field scale

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Seasonal variations in biogeochemical processes are characteristic in temperate environments and are known to modulate the dynamics of intertidal channels. These changes are primarily caused by the seasonality of solar forcing that drives changes in temperature and light which alters primary production. The biostabilization in temperate tide-dominated channels induced by the presence of surface biofilm follows this seasonality, with lower surface biofilm growth in winter and higher values in summer. These patterns have also been associated with spring and early summer microphytobenthos blooms. Additionally, the seasonal patterns in wind and wave forcing, with higher frequency and magnitude storms in winter than summer, will contribute to the seasonality of bed stability. In fact, when strong hydrodynamic forces are acting on the bed, the surface biofilm can be completely removed, exposing the less well-consolidated sediment underneath, which is not influenced by the effect of biological cohesion. Furthermore, sediment particles often combine into larger aggregates, called flocs, that affects sediment transport processes. Flocculation efficacy depends on the cohesive forces of clay minerals and the influence of microbial products consisting of extracellular polymeric substances. The amount of biological material, regulated by seasonality, in turn affects floc size distributions, floc strength and density.

Herein we report on development of a physics-based model which includes these ecologically-driven processes in simulating sediment morphodynamics, allowing us to simulate the time evolution of these environments. Using hydro-sediment dynamic records from a field prototype, the primary objective of this study is to validate this bio-morphodynamic model which is coded to incorporate the effect of biostabilization due to the presence of microphytobenthos, and the effect of bio-flocculation on sediment transport. Field data from the Eden estuary (UK) provided the links between morphodynamics, hydrodynamic forcing and biological processes across the four seasons, and thus enable us to investigate the effect of seasonality on these processes. Samples from a sandy, mixed and muddy sites across the estuary will be used to improve our understanding of the interactions between flow, sediment transport and substratum properties. Furthermore, the model deals with the stratigraphy of the deposits over time, allowing us to compare predicted stratigraphy created from the model runs. This technique helps explore how a range of abiotic-biotic interrelationships in these tidal channels are recorded within the geological

rock record.